IPA® /
DOUBLE IPA®

Integrated Patch Amplifier

ELECTROPHYSIOLOGY
PATCH -CLAMP SYSTEM
WITH
SutterPatch® SOFTWARE

Operation Manual

SUTTER INSTRUMENT

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CE EU Declaration of Conformity

Application of Council Directives:
2014/30/EU (EMC), 2014/35/EU (LVD), and 2015/863/EU (RoHS 3)

Manufacturer's Name:	Sutter Instrument Company
Manufacturer's Address:	One Digital Drive Novato, CA. 94949 USA Tel: +1 415 883 0128
Equipment Tested:	**IPA** and **Double IPA** Integrated Patch Amplifiers
Model(s):	Controller, headstage, and expansion panel
Conforms to Standards:	EMC IEC 61326-1: 2020, including: EMC Emissions: EN 55011: 2016+A2:2021, Class A RE & CE, EN 61000-3-2:2019+A1:2021, & EN 61000-3-3:2013+A1:2019 EMC Immunity: EN 61000-4-2:2009, EN 61000-4-3:2021, EN 61000-4-4:2012, EN 61000-4-5:2014+A1:2017, EN 61000-4-6:2013, EN 61000-4-8:2010, & EN 61000-4-11:2020 LVD (Safety): EN 61010-1:2010+A1:2016 Cor. 1/2019
Tested/Verified (based on dPatch) By:	ITC Engineering Services, Inc. 9959 Calaveras Road, PO Box 543 Sunol, CA 94586-0543 USA Tel. +1 925 862 2944 Fax: +1 925 862 9013 Email: itcemc@itcemc.com Web: www.itcemc.com Sutter Instrument
Test Report(s):	EIC 61326-1:2020 EMC requirements 20210922-01; EIC 610101-1:2010 LVD requirements 20210922-01; and RoHS Compliance Statement

Sutter Instrument Company hereby declares that the equipment specified above was tested and conforms to the EU Directives and Standards listed above, and further certifies conformation to the requirements of the European Union's Restriction on Hazardous Substances in Electronic Equipment Directive 2015/863 (2011/65/EU Annex II) for RoHS 3.

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DISCLAIMER

The **IPA** system consists of one electronic amplifier with integrated digitizer and one headstage. The **Double IPA** system consists of one electronic amplifier with integrated digitizer and two headstages. All references to an IPA system also include a Double IPA system, unless otherwise noted. The purpose of the system is for the stimulation and measurement of cellular preparations. No other use is recommended.

This instrument is designed for use in a laboratory environment. It is not intended for, nor should it be used in human experimentation or applied to humans in any way. This is not a medical device.

Do not open or attempt to repair the instrument.

Do not allow an unauthorized and/or untrained operative to use this instrument.

Any misuse will be the sole responsibility of the user/owner, and Sutter Instrument Company assumes no implied or inferred liability for direct or consequential damages from this instrument if it is operated or used in any way other than for which it is designed.

SAFETY WARNINGS AND PRECAUTIONS

Electrical

- **Operate the IPA system using 100 – 240 VAC, 50 - 60 Hz line voltage. This instrument is designed for use in a laboratory environment that has low electromagnetic noise and mechanical vibration. Surge suppression is recommended at all times.**

Fuse Replacement: Replace only with the same type and rating:

Line Voltage: 100 – 240 VAC	
Fuse Rating	Manufacturer Examples RoHS Compliant (Lead Free)
T2.0, 250V	Bussmann: GMC-2-R, S506-2A Littelfuse: 239.002.P

Table 0-1. IPA & DIPA Fuses

Type: 5 x 20 mm glass tube, Medium Time Delay (Slow Blow), RoHS compliant.

Rating: T2.0A 250V (Time Delay, 2 Amps, 250 Volts)

Examples: Bussmann: GMC-2-R, S506-2A
Littelfuse: 239.002.P

Avoiding Electrical Shock and Fire-related Injury

-  **Always use the grounded power cord provided to connect the Sutter system's power adapter to a grounded/earthed mains outlet. This is required to protect you from injury in the event that an electrical hazard occurs.**

- **Do not disassemble the system. Refer servicing to qualified personnel.**

-  **To prevent fire or shock hazard, do not expose the unit to rain or moisture.**

Operational

Failure to comply with any of the following precautions may damage this instrument.

- **This instrument is designed for operation in a laboratory environment (Pollution Degree I) that is free from mechanical vibrations, electrical noise and transients.**

- **Operate this instrument only according to the instructions included in this manual.**

-  **Do not operate this instrument near flammable materials. The use of any hazardous materials with this instrument is not recommended, and if undertaken, is done so at the users' own risk.**

-  **Do not operate if there is any obvious damage to any part of the instrument.**

Other

- **Retain the original packaging for future transport of the instrument.**

- **Sutter Instrument Company reserves the right to change specifications without prior notice.**

- **Use of this instrument is for research purposes only.**

Handling Micropipettes

Failure to comply with any of the following precautions may result in injury to the users of this instrument as well as those working in the general area near the instrument.

- **The micropipettes used with this instrument are very sharp and relatively fragile. Avoid contact with micropipette tips to prevent accidentally impaling yourself.**

- **Always dispose of micropipettes by placing them into a well-marked spill-proof "sharps" container.**

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1. INTRODUCTION

Welcome to the latest breakthrough in patch-clamp technology! With over two centuries of combined experience from across the patch-clamp industry, our passion is creating the finest available electrophysiology research instrumentation. Our expert team has designed world class microelectrode amplifier-recording systems that are powerful enough to satisfy experienced patch-clampers, yet easy-to-use for recent entrants.

Sutter Instrument Company is a leading manufacturer of innovative precision instrumentation in the neuroscience field. We have a worldwide reputation for the highest quality and performance of pipette pullers, micromanipulators, microscopes, light sources and wavelength switchers. We are proud to apply this same commitment of excellence to the next generation of patch-clamp instrumentation.

1.1 Overview

Advanced Design

The IPA® Integrated Patch Amplifier is the world's first fully integrated microelectrode patch-clamp system, which facilitates and streamlines your experimental setup. All of the electronics (amplifier and digitizer) used in stimulating, compensating and recording from cells are integrated by design into a single printed circuit board (the Double IPA adds a second PCB).

The accompanying SutterPatch® software brings the controls and displays for full-featured data acquisition, data analysis, and graphics/layout together into a single, unified program, including a software control panel for direct access to all of the IPA amplifier functions.

The SutterPatch software was developed in the powerful Igor Pro® system environment. Igor Pro, by WaveMetrics®, Inc., is a data collection, management and analysis platform with a rich set of built-in functions and routines for scientific programs.

From hardware to software, these fully integrated systems provide leading-edge patch-clamp systems that are affordable, easy-to-setup and to use.

1.2 Software Highlights

- Full-featured electrophysiology package
- Single program for data acquisition, analysis and hardware control
- Complex experimental automation
- Publication-quality graphics

Convenient: All SutterPatch software is run by a single application. No need to launch multiple programs or to move data between programs.

Comprehensive: All data recordings, analyses, graphs, layouts, configurations and controls are saved in a single experiment file. This ensures that data are kept together with their complete contexts.

Automation: Automate your experiment using a rich set of data acquisition, data analysis, and amplifier controls. Create complex "Paradigms" that can respond to changing conditions via conditional steps and loops.

1.3 Experiment Structure

Experiment:

An Experiment is the highest-level structure in the SutterPatch world. An Experiment file can encompass all SutterPatch activity for the entire day, such as instructions (Paradigms), data acquisition parameters (Routines), recorded data (Series), execution settings, history, and comments. During reanalysis, data can be included from multiple experiments.

Typically, one Experiment is created for each cell or preparation recorded from per day. These saved Experiments can then be imported into a larger combined Experiment for data analysis. For large files, this helps to keep the saved data manageable.

Paradigm:

A Paradigm is a sequence of control instructions used in an Experiment. Every Experiment contains at least one Paradigm, whether pre-planned by the user or automatically created by the system.

A loaded Paradigm "pool" file can contain multiple Paradigms for rapid access and execution. Such "planned" Paradigms can contain simple sequences, or sophisticated control structures, using a rich set of operations, such as conditional "If-then" decisions, nested loops, user-defined variables, hardware commands, and data acquisition Routines.

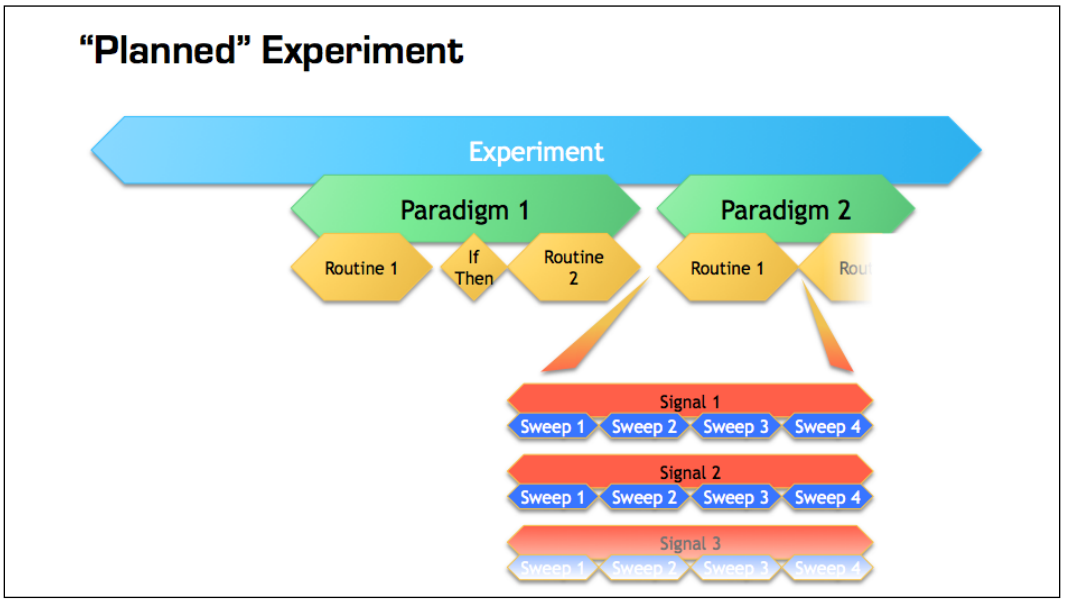

Figure 1-1. Data Structure - Planned Paradigms

An illustration of an Experiment with two "planned" Paradigms running Routines.

However, if a Routine is manually run in the Scope window, an "auto-triggered" Paradigm is created as a container. This default Paradigm ensures that each Series is associated with a Paradigm in the context of an Experiment. If an auto-triggered Paradigm is already the active Paradigm, it is used for subsequent manually-run Routines.

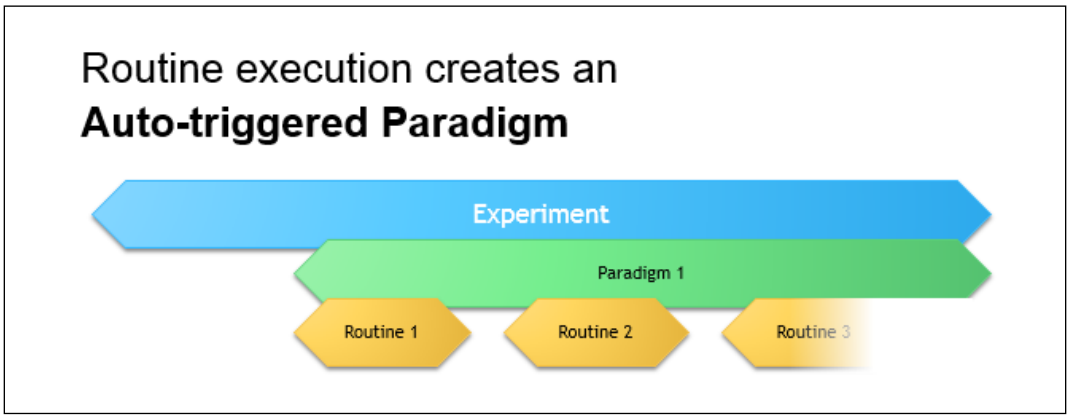

Figure 1-2. Data Structure - Auto-triggered Paradigms

An illustration of an Experiment with manually run Routines using an "auto-triggered" Paradigm.

A Paradigm's "data" includes all data points, variable values, and metadata tags from the course of a Paradigm. Altogether, this allows reconstruction of the exact course of an experiment. While a Paradigm could be compared to an itinerary, the Paradigm data correspond to the route a journey actually took. If conditional control is used in a Paradigm, e.g., for the

number of loop cycles or a decision in an "If-then" step, these actions are recorded in the Paradigm metadata.

Routine Parameters:

A Routine is the set of data acquisition and data analysis parameters that control input and output channel timing, triggering, command waveforms, display and real-time analysis.

A loaded Routine "pool" file can contain multiple Routines for rapid access and execution.

Series (Routine Data):

Recording Routine data creates a Series composed of all sweeps of data from all input signals. Multiple runs of a Routine create multiple Series of data. All Series are automatically stored in the current Experiment file.

Channel:

A Channel corresponds to a physical output (digital-to-analog), or a physical (analog-to-digital) or virtual input of the IPA system.

Analog input channels are used to record data, and are displayed in their own panes in the Acquisition Scope window. There are two dedicated internal analog input channels '(Current' and 'Voltage') for each attached headstage. General-purpose Auxiliary analog input channels ('AuxIN') allow recording from external instruments. Virtual input channels allow further creative processing of any input channels.

Analog output channels are used to send electrical stimuli, such as analog command waveforms to the preparation. There is a dedicated, internally configured, analog output channel ('StimOUT)' for each attached headstage. General-purpose Auxiliary analog output channels ('AuxOUT') can send output signals to external instruments.

Digital Output bits are also referred to as digital output channels ('DigOUT').

All 'Aux' and 'DigOUT' channels are available via an included BNC "octopus" breakout cable.

Signal:

Named analog input and output channels are referred to as Signals. A Signal is either the scaled representation of a physical channel, or the virtual result of a computation.

Sweep:

A Sweep is the sum off all data points from all Signals, acquired from time zero, for a fixed duration. In SutterPatch Software, the Sweep Duration is determined by the duration of the command waveform.

Trace:

A Trace is a Sweep applied to a single Signal. Therefore, a Sweep can be described as the collection of Traces across all Signals.

Segment:

A Segment exists as a user-defined section of the command waveform. Each Segment has a waveform type, amplitude and duration.

Metadata

Metadata are additional information associated with stored data. These can include such information as the preparation (cell, tissue, animal), instrumentation (hardware, software), environmental parameters (temperature, atmospheric composition), stimuli (chemical compounds, light, acoustic) and other parameters. Metadata information is associated with the running of Paradigms and Routines, and their resulting data.

Metadata are recorded with a timestamp during an experiment. Information that can be determined by the system, such as the connected hardware, SutterPatch version, user Login Name, or the change of a digital output level, are automatically recorded without user intervention. In addition, the user can enter values for a large number of user-defined Metadata parameters, such as identifiers for the experimental animal or cell, the animal species, age and genotype, information about the recording solutions, and the electrodes or stimuli applied during the experiment. SutterPatch currently keeps track of ~ 600 Metadata parameters.

Terminology Comparison

A table of equivalent terms to other electrophysiology software packages:

SutterPatch	**PATCHMASTER**	**pCLAMP**
Experiment	Compound Data	N/A
Paradigm	Protocol	Sequencing Keys
Routine	PGF Sequence	Protocol
Series	Series	Trial
Sweep	Sweep	Sweep
Signal	Signal	Signal
Trace	Trace	Trace
Segment	Segment	Epoch

Table 1-1. Software Terminology

Note: "IPA" figures and examples in this manual may be from either an IPA or Double IPA system.

2. INSTALLATION

2.1 Computer Requirements

Minimum Configuration

OS (Operating System): Windows: Version 10 (64-bit versions) or later

Most language packs are compatible.

< see the Windows OS: Settings > Time & language > Language & region >

Warning! Microsoft OneDrive is not supported. Do not use to store program files or to acquire data to, or unexpected problems can occur.

macOS: Version 10.13 (High Sierra) to 10.15 (Catalina)

< listed in OS: Apple > About this Mac >

Virtual machines and OS emulators, such as Parallels and VMWare Fusion, are not supported.

CPU (Central Processing Unit): Dual-core i5

RAM (Random Access Memory): 3 GB

Hard Disk (Free Space): 500 GB

This drive should be configured as the primary system drive.

Display Resolution: XGA (1024 x 768)

Computer Ports: (1) USB 2.0 High Speed port

The newer USB 3.x ports are backwards compatible to USB 2.0 ports, with an appropriate cable.

To check for High Speed USB 2.0 ports on a PC computer, look in the Windows Control Panel / Device Manager / Universal Serial Bus controller section for “Enhanced” host controllers.

Cables extenders, cables longer than 10 feet, external USB hubs and docking stations are not supported, as they can cause timing issues.

USB cables must have a Type-B connector for the amplifier and be rated for USB 2 High Speed or higher.

Computer USB add-in cards or adapters are not recommended, as compatibility can be problematic.

Note: USB 2.0 computer ports are usually implemented with a 'High Speed' transfer rate, but a slower 'Full Speed' specification can sometimes be found on old computers or USB 2.0 add-in cards.

Also, sometimes BIOS settings, virus scanners and/or Windows updates can put a USB port to sleep.

< see Troubleshooting: Startup Q&A 'USB Communication Fails' >

Recommended Configuration < for Bandwidths > 50 kHz >

CPU (Central Processing Unit):	Dual-core i5 or higher
RAM:	8 GB
Hard Disk (Free Space):	SSD (Solid State Drive) 500 GB or greater. The drive should be configured as the primary system drive.
Display Resolution:	Full HD (1920 x 1080) High resolution (> 96-DPI) displays, such as Retina, 4K, 5K, Quad-HD and Ultra-HD are not supported.

2.2 SutterPatch System Environment

The SutterPatch software runs in the Igor Pro 10 (64-bit) system environment. Igor Pro is widely used by scientists to acquire and analyze data, and to create publication-quality presentation graphics.

Igor Pro Features

- High-speed data display
- Large data set handling
- Waveform arithmetic

- Extensive set of built-in data analyses
- Image display and processing
- High-quality presentation graphics
- Graphical and command-line user interfaces
- Automation
- Python support
- Extensibility via C and C++ modules
- Extensive online Help

2.3 Mounting Instructions

Rack Mounting: The IPA amplifier is ready for mounting in a standard 19" wide equipment rack in a 1U (DIPA: 2U) space. A rack mount hardware kit consisting of hex screws, washers and cage nuts is included.

Benchtop Usage: Attach the four included stick-on feet to the bottom of the IPA amplifier.

2.4 Electrical Connections

AC Power: 60 Hz
50 Hz

The IPA amplifier runs on AC power from 100 to 250 VAC - no switches need to be set.
The AC power should be as clean as possible:

- At a minimum, a surge protector should be used to protect against high-voltage spikes; if lightning strikes are a concern, it should be rated > 1000 joules and > 40 kA.
- If you experience brownouts or voltage sags, a switching power supply (SPS) can be used to supply clean power to your instruments.
- To protect against power interruptions, use a universal power supply (UPS) for uninterrupted clean power.

2.5 Install Hardware

Rack-mounting hardware are included with the instrument.

FRONT PANELS

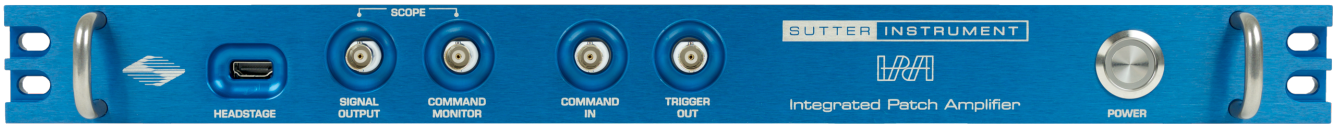

Figure 2-1. IPA Front Panel

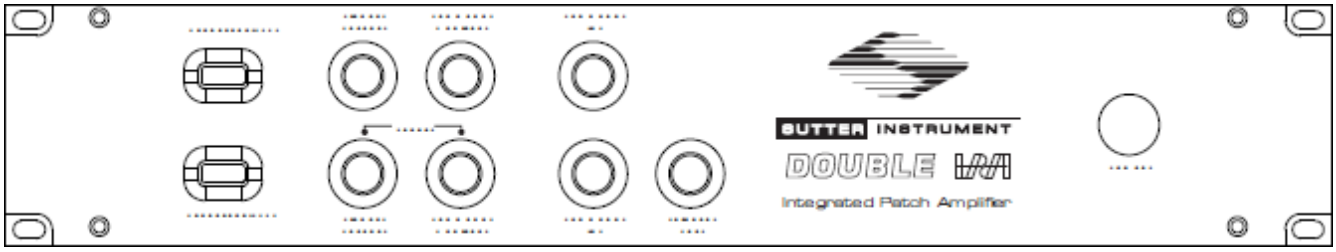

Figure 2-2. Double IPA Front Panel

REAR PANELS

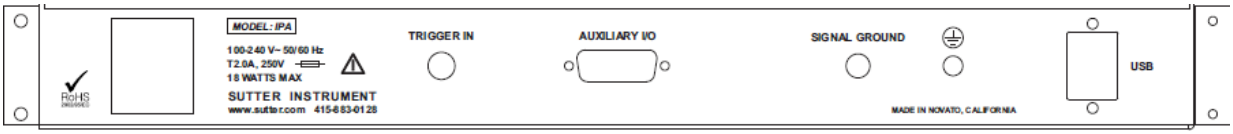

Figure 2-3. IPA Rear Panel

< Double IPA Rear Panel is similar to the IPA rear panel >

1. Plug the male end of the included power cord into a grounded electrical mains outlet, and plug the female end of the power cord into the IPA rear-panel power receptacle.

2. Make sure the IPA power button on the front panel is OFF (unlit position).

3. Plug the IPA headstage into the HEADSTAGE port on the front of the IPA amplifier - the amplifier and headstage serial numbers should match.

   For a Double IPA system, attach the lower serial-numbered headstage to HEADSTAGE 1, and the higher serial-numbered headstage to HEADSTAGE 2, as each headstage is individually tuned to its channel.

WARNING! **Hot-swapping of headstages should be avoided – components can be damaged. Turn off the IPA system power before handling headstages.**

4. Plug the included I/O "octopus" breakout cable or the optional Patch Panel cable into the AUXILIARY I/O port on the back of the amplifier.
5. Connect the supplied USB 2.0 cable to your computer's USB port and the amplifier's rear-panel USB port.
6. Push the Dendrite power button on the front panel to ON (lit position).

2.6 Install Software

A. Locate the Files

Use your web browser to locate the latest version of the SutterPatch v3 installer software at:

https://www.sutter.com/AMPLIFIERS/SutterPatch.html

and choose the 'Download' tab.

The SutterPatch v3.1 'Release Notes' for recent fixes and changes can also be downloaded here.

Note: If internet access is not available, attach the included USB flash drive to your computer USB port, and navigate to the flash drive installer files.

B. Choose Installer File

It is strongly recommended to run the 'Full installer for Windows, Igor Pro 10' for optimum data processing performance.

However, if desired, multiple versions of Igor Pro and SutterPatch can be installed on your computer, each with independent settings and parameters.

Note: Japanese versions of Igor Pro are not supported by SutterPatch.

Windows Installers (Windows 10 or 11, 64-bit)

"Full" Windows installers install 64-bit English-language versions of Igor Pro 9 or 10 and SutterPatch v3.1.

"Updater" installers update the existing SutterPatch software to v3.1 in Igor Pro 9 or 10.

- Full installer for Windows, Igor Pro 9 > [Download]

- SutterPatch Updater for Windows, Igor Pro 9 > [Download]
- Full installer for Windows, Igor Pro 10 > [Download]
- SutterPatch Updater for Windows, Igor Pro 10 > [Download]

We do not recommend using the SutterPatch Updater on an existing "standalone" installation of Igor Pro. If you already have Igor Pro (without SutterPatch) on your computer, either:

- Use a Full installer to update Igor Pro 9 or 10 and install SutterPatch v3.1.
- Uninstall Igor Pro and use a Full installer to reinstall Igor Pro 9 or 10 and install SutterPatch 3.1.

  Remember to back up your Igor user files before uninstalling!
- Create a second installation of Igor Pro using a Full installer.

  This should only be done in special cases and is not advised.

Macintosh Installers (OS X 10.14 or newer)

- Full installer for OSX, Igor Pro 9 > [Download]

C. Install the Software

Warning! Before launching the installer, make sure that SutterPatch is not running, or file version errors will occur, and require a re-install.

Use your file browser to navigate to the installer file and run it.

1. Install the Full software for 'All Users' by double-clicking on:

   Windows: SutterPatch_Installer_with_Igor10.exe

   macOS: SutterPatch_mac_full_IG9.dmg

2. Follow the installer prompts:
   - We recommended replacing any prior versions of Igor Pro with the latest version of Igor Pro 10, after making a backup copy of all user files and parameter files in the program folder and its sub-folders.
   - Prior versions of Igor Pro can be kept if desired, as different versions of Igor Pro can coexist on the same computer.
   - If an existing version of Igor Pro is found, the Igor Pro Preferences are overwritten.

- If an existing version of SutterPatch is found, SutterPatch sample files are over-written.

3. Upon completion, the installer will report a successful installation. The following files and folders are also installed:

   - IPA Quick Start Guide — PDF file with installation instructions.
   - SutterPatch manual — PDF file of the IPA Operation manual.

   Windows folders

SutterPatch code:	C:\Program Files\SutterPatch3\
SutterPatch sample files:	C:\Users\<User Account Name>\Documents\SutterPatch\
Igor Pro code:	C:\Program Files\Wavemetrics\Igor Pro 10 Folder\

   macOS folders

SutterPatch code:	Applications/SutterPatch3 /SP_Code/
SutterPatch sample files	Applications/SutterPatch3/SutterPatch/
SutterPatch XOP:	Applications/SutterPatch3/SP_Drivers/

4. Launch Igor Pro by clicking on its icon: 

5. Go to the SutterPatch menu 'Help > License' and enter your licensing information.

   Use the Igor Pro **Serial Number** and **Activation Key** on the sticker in your printed IPA **Quick Start Guide** pamphlet.

   Alert! Store your Quick Start Guide in a safe place!

   Your Igor Pro **serial number** and **activation key code** are located in it.

6. Click on [Install License for All Users] to activate your license.

   The included Igor Pro three-seat license has a 30-day trial period where Igor Pro is fully functional and fully supports SutterPatch. After 30-days, if the Igor Pro license has not been activated, Igor Pro runs in a demo mode with limited functionality that does not support the SutterPatch application.

Note: Multiple Igor Pro licenses in a lab can be combined into a single multi-user license. Contact WaveMetrics, Inc. (sales@wavemetrics.com) for more information.

2.7 Test System

2.7.1 Install Model Cell

1. Attach the model cell to Headstage 1 and tighten the screw collar.

2. Plug the supplied 1 mm grounding wire into the gold sockets on the headstage and model cell.

3. If the headstage is not inside a Faraday cage, completely surround the model cell/headstage assembly with alternative electromagnetic shielding, such as aluminum foil, and connect the shielding material to the headstage ground - a short wire with a metal alligator clip on each end makes a convenient shield-ground connector.

2.7.2 Startup

1. Power on the IPA amplifier by pressing the silver POWER button on its front – it lights up as blue. (It can take a few seconds for the USB connection to be established.)

2. Launch the SutterPatch application by clicking on the 'Igor Pro' icon: 

   An Igor Pro "splash screen" temporarily displays in the Igor Pro window while Igor Pro files are loading:

Figure 2-2. Igor Pro Splash Screen

Then the 'Welcome to SutterPatch' screen displays with launch options:

Figure 2-3. Welcome Screen.

[Igor Only] Run Igor Pro (without launching SutterPatch).

[Open] Launch SutterPatch from a saved Experiment file.

[Start] Launch SutterPatch for a new Experiment.

3. Click the [Start] button and a progress bar displays while compiling SutterPatch files, and then the Welcome screen closes.

4. Next, if the IPA amplifier is OFF or disconnected from the computer, the 'No USB Connection' pane allows you to re-establish the USB connection, or to select a hardware emulation mode:

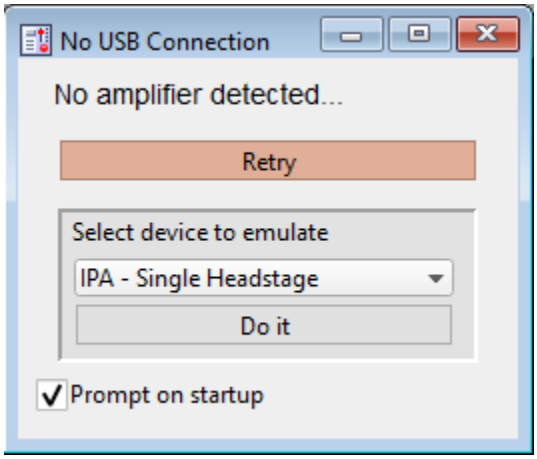

Figure 2-4. Emulation Modes.

   a. Reconnect the amplifier, and then click [Retry], or

   b. Click in [Select device to emulate] and select 'IPA' or 'DIPA',

      then click [Do it].

      [ ] Prompt on startup — If no Sutter hardware is attached, and this prompt is disabled, the program will automatically startup in the last known emulation state.

5. And then a 'Summary of Major Preferences' window displays:

      [ ] Show on startup — Enable display of the Preferences "Summary" window at startup.

6. Other windows that also display are:

IPA Control Panel	(control the amplifier hardware)
Acquisition Control Panel	(for Paradigms, Routines and Tags)
Command window	(execute native Igor Pro commands)
Dashboard	(floating toolbar)
Notebook	(laboratory notebook)
Summary of Major Preferences	(from Set Preferences)

Additional SutterPatch windows display if they were open in the prior Experiment.

7. Click on the ‘Control Panel’ icon:

in the Dashboard floating toolbar:

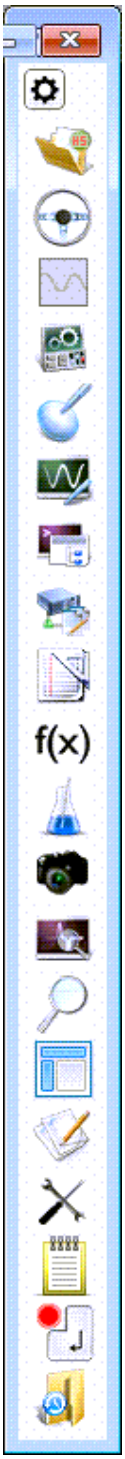

Figure 2-5. Dashboard Toolbar

8. The IPA Control Panel is displayed:

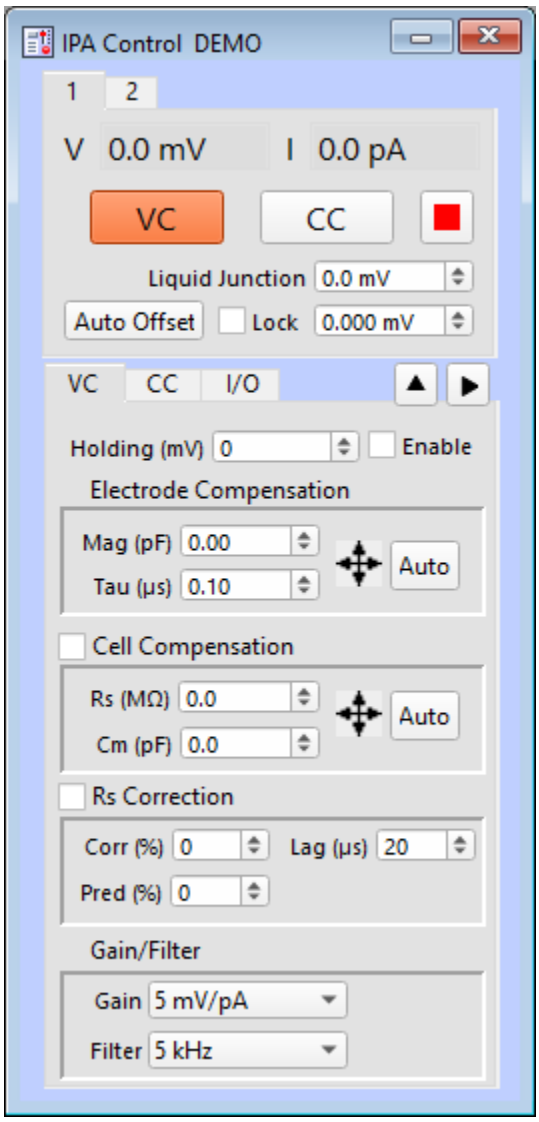

Figure 2-6. IPA Control Panel

If "DEMO" displays in the IPA Control Panel title bar, you are running in a hardware emulation mode. To run the physical instrument, ensure that the amplifier is powered on and its USB cable is connected, then choose "File > New Experiment" from the main menu, and configure as "IPA".

Alert! If running with an attached amplifier, and the USB communications square button is red instead of green, then the USB link is not working.

< see the Troubleshooting section Startup Issues Q&A's 'USB Communication Fails' and 'USB 3 Port Disconnects' >

2.7.3 Run a Membrane Test

The Membrane Test is useful for a quick check of the IPA system functionality. It tests the three basic steps necessary for recording in a whole-cell configuration.

First make sure that the IPA Control Panel is in voltage-clamp mode – the "VC" button at the top of the IPA Control Panel should be highlighted in red. Then, attach the model cell to the headstage.

1. Go to the Dashboard floating toolbar and click on the 'Membrane Test' icon.

The following test values assume a 5 kHz filter.

2. Test the BATH mode:

   This mode simulates placing an electrode into the bath solution and sending a voltage pulse through the solution.

   a. Set the Model Cell switch: Bath

   b. Click on the Membrane Test [Bath] button.

   c. Verify readings: Pipette Resistance: ~10 MΩ

3. Test the SEAL mode:

   This mode simulates an electrode making contact onto a cell and forming a high-resistance gigaohm seal with the membrane.

   a. Set the Model Cell switch: Seal

   b. Click on the Membrane Test [Seal] button.

   c. Verify reading: Seal Resistance: ~1 GΩ to 1 TΩ

4. Test the CELL mode:

   This mode simulates an electrode breaking into a cell and achieving a successful whole-cell patch.

   a. Set the Model Cell switch: Cell

   b. Click on the Membrane Test [Cell] button.

   c. Verify readings: Series Resistance: ~10 MΩ

      Membrane Resistance: ~500 MΩ

Membrane Capacitance: ~28 pF

5. For a dual-headstage system:

    a. Move the model cell, ground wires and shielding to Headstage 2.

    b. Set the Acquisition scope window to ‘Headstage 2’.

    c. Repeat steps 3 – 5.

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3. HARDWARE OPERATION

3.1 IPA Front Panel

The front panel of the IPA system is used for the headstage(s), external I/O connections and a power button.

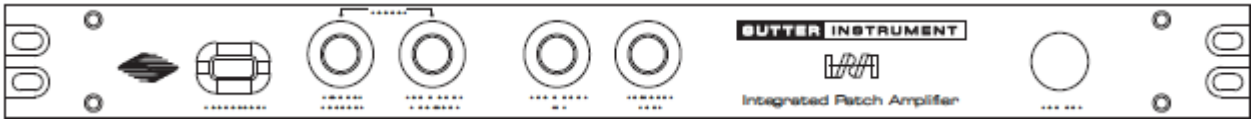


Figure 3-1. Front of IPA Cabinet

The front panel connections from left to right:

Label	Connector		
HEADSTAGE:	HDMI Type A		Headstage receptacle.
SCOPE-SIGNAL OUTPUT:	BNC		A scaled analog output signal of the headstage response signal.
• VC mode:	mV/pA		Variable gain. < in Amplifier Control Panel >
	Example		< for Membrane Test >
	Model Cell:		10 MΩ (BATH position)
	Amplitude:		10 mV
	Current response (I)	=	V/R
		=	10 mV/10 MΩ
		=	1 nA
	Gain:		5 mV/pA
	Scaled output voltage	=	I * Gain
		=	1 nA * 5 mV/pA
		=	5 V

• CC mode:	mV/mV		Variable gain. < in Amplifier Control Panel >
	Example		
	Gain:		100 mV/mV
	Response signal:		10 mV
	Scaled output voltage	=	V * Gain
		=	10 mV * 100 mV/mV
		=	1 V
SCOPE-COMMAND MONITOR:	BNC		A scaled analog output of the headstage Stimulus signal (StimOUT).
• VC mode:	10 mV/mV		Constant gain.
	Example		
	Command voltage:		10 mV
	Scaled output voltage	=	V * Gain
		=	10 mV * 10 mV/mV
		=	100 mV
• CC mode:	0.5 mV/pA		Constant gain.
	Example		
	Command current (I):		200 pA
	Scaled output voltage	=	I * Gain
		=	200 pA * 0.5mV/pA
		=	100 mV
COMMAND IN:	BNC		A scaled analog input that adds an external signal to the headstage Stimulus signal (StimOUT).
• VC mode:	10 mV/mV		Constant gain.
	Example		
	External Command:		5 mV

	Stimulus signal:		20 mV (StimOUT)
	Total stimulation	=	(V * Gain) + StimOUT
		=	(5 mV* 10 mV/mV) + 20 mV
		=	70 mV
• CC mode:	2 pA/mV		Constant gain.
	Example		
	External Command:		1 mV
	Stimulus signal:		5 pA (StimOUT)
	Total stimulation	=	(V * Gain) + StimOUT
		=	(1 mV * 2 pA/mV) + 5 pA
		=	7 pA
TRIGGER OUT:	BNC		Digital Trigger pulse output. A 100 µs square pulse is automatically sent at the start of continuous acquisition or each triggered sweep (including Membrane Test).
POWER:	Button		Power the unit On/Off. Lights up blue when "On".

3.2 IPA Rear Panel

The rear panel of the IPA system is used for I/O, USB and grounding connections.

The rear panel of the Double IPA amplifier is essentially the same as for the IPA amplifier.

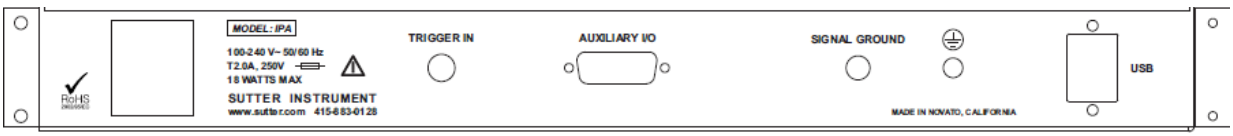


Figure 3-2. Rear of IPA Cabinet

The rear panel connections from left to right:

Label	Connector	
[unlabeled]:	Power-entry receptacle	For AC power cord.
TRIGGER IN:	BNC	Digital input trigger.
AUXILIARY I/O:	DA-15 D-sub	External analog input and output channels, digital output channels, signal ground. < see Appendix E for pin definitions >
SIGNAL GROUND:	4 mm banana socket	Low-voltage grounding.
EARTH GROUND:	4 mm banana socket	Instrument grounding.
[unlabeled]:	USB Type B receptacle	USB 2.0 computer communication.

3.3 Double IPA Front Panel

The front panel of the Double IPA system has an upper row of connectors to support a second headstage.

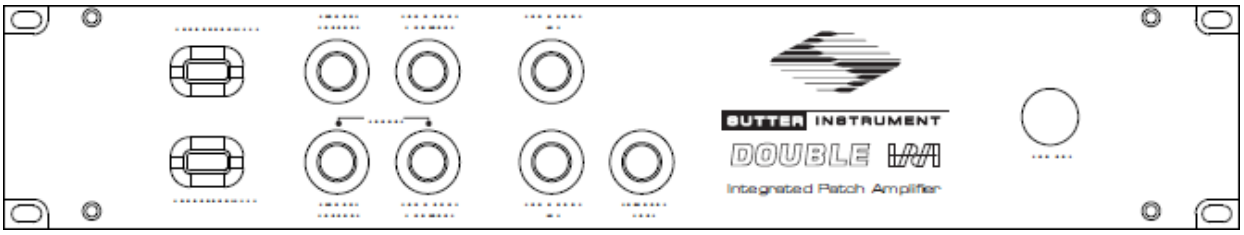


Figure 3-3. Front of Double IPA Cabinet

The extra front panel connections from left to right:

Label	Connector	< see above for details >
HEADSTAGE 2	HDMI Type A	Headstage 2 connector.
SCOPE-SIGNAL OUTPUT	BNC	A scaled analog output signal of the headstage response signal.

SCOPE-COMMAND MONITOR	BNC	A scaled analog output of the headstage Stimulus signal (StimOUT).
COMMAND IN	BNC	A scaled analog input that adds an external signal to the headstage Stimulus signal (StimOUT).

3.4 Double IPA Rear Panel

The rear panel of the Double IPA system duplicates the IPA system.

< see IPA Rear Panel >

3.5 Grounding

Proper grounding is essential for the integrity of an electrophysiology laboratory setup. It greatly affects the "noise" within your system, and hence the quality of your data recordings. Low noise levels are especially needed for miniature post-synaptic recordings. While AC (mains) line-noise can be software-filtered out of a data signal, it is much more desirable to have a well-grounded electromagnetically clean hardware environment to start with.

For a properly grounded laboratory, an electrical connection is needed from your laboratory's electrical system to an "earth" ground. If your building's electrical grid does not provide an good earth ground, you can create your own earth ground by making use of the building's plumbing system, or by inserting a heavy metal bar deep into the earth.

The equipment in a rig should all be grounded to a single point to avoid ground loops. Installing a bus bar to the earth ground also helps to prevent ground loops. Consider standardizing your set-ups by using a GP-17 Ground Point on each rig.

"Signal" ground is a sensitive ground for very low voltages:

- BNC shields: Hard-wired to signal ground (single-ended).
- Bath ground electrode: Connect to the headstage signal ground jack.
- Shielding (Faraday cage): Connect to the rear panel SIGNAL GROUND socket.

However, due to the complexity of grounding factors, you may need to test various strategies for the best grounding configuration for your system. For example, when multiple headstages are used, one or both headstages might need to be grounded.

A grounded power cable is provided with this instrument.

3.6 Headstage

The IPA headstage supports both voltage- and "true" current-clamp in the same headstage.

Feedback resistor:	500 MΩ	
Whole-cell capacitance compensation:	0 – 100 pF	
Current-clamp rise time:	17.5 µs	(100 MΩ load, 20 kHz filter)

The headstage noise, as measured with an 8-pole Bessel filter:

Bandwidth	Open-Circuit Noise (RMS)
0.1 – 1 kHz	< 0.25 pA
0.1 – 5 kHz	< 0.75 pA
0.1 – 10 kHz	< 1.4 pA

Measuring "open-circuit", i.e., with no attachments so the headstage input is exposed to the air, provides a fairly consistent baseline for such headstage noise measurements. Conversely, measuring noise with an electrode in the bath generates the worst noise conditions.

A 1 mm gold pin signal-ground socket is on the back of the headstage.

The IPA headstage cable length can be increased with a 6-foot HDMI (non-powered) extension cable.

Note: DIPA headstages are serialized, whereby the lower-numbered headstage is matched to the HEADSTAGE 1 port, and the higher-numbered headstage is matched to the HEADSTAGE 2 port.

WARNING! **Hot-swapping of headstages should be avoided – components can be damaged. Turn off the IPA system power before handling headstages.**

3.7 Holder

A "holder" attaches a microelectrode pipette to a headstage. It provides mechanical stability for the pipette, low-noise for the electrical circuit, and chemical inertness from its physical components.

Our pipette holders accept electrode glass in the range of 1.0 – 1.7 mm OD (Outer Diameter) using sized-by-color silicone gaskets.

Holder:	The standard pipette holder included with the IPA amplifier is composed of low-noise polycarbonate and Teflon.		
	Note: While polycarbonate is a proven material for patch pipette holders, it undergoes significant thermal expansion. Uneven warming can lead to motion of the pipette tip, and is often incorrectly perceived as drift in the micromanipulator.		
Lockdown ring:	The lockdown ring is a threaded collar on the holder that attaches it to the headstage.		
Suction tube:	Projects at a right angle from the middle of the pipette holder barrel. Attach tubing to apply suction when applying a seal onto the membrane or breaking into the cell.		
Tubing:	Sized by inner diameter (ID):	1/32”	< preferred >
		0.025”	< alternate >
Electrode glass:	Sized by outer diameter (OD):	1.0 – 1.7 mm	
Silicone gaskets:	Sized by inner diameter (ID):	1.1, 1.2, 1.5, 1.75 mm (color coded)	

3.7.1 Assembly

The holder is assembled from 8 parts incorporated into a main barrel:

End Cap – Gasket – Silver Wire – Barrel – Tubing – Gold Pin – Pin Cap - Lockdown Ring

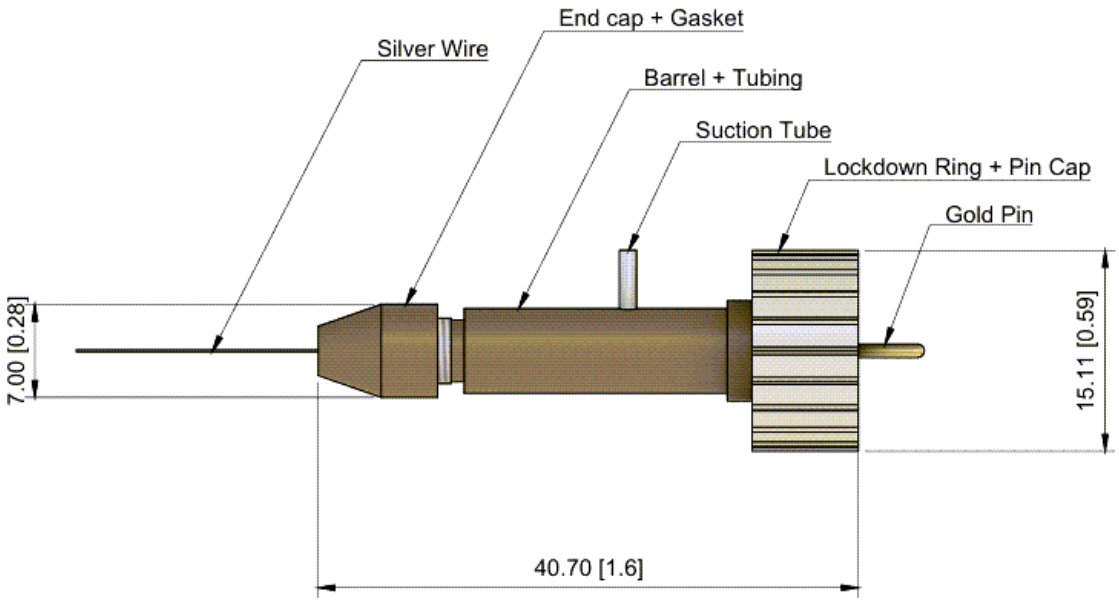


Figure 3-2. Electrode Holder

Dimensions are in “mm [inches]”.

Assembly Tips

- Silver wire should be kept straight – do not bend or twist it.
- Fire-polish glass electrodes on both ends to prevent scratching the silver wire or the holder barrel when inserting the electrode into the end cap.

Assembly Procedure

1. Cut the silver wire to size, about 1 ½ times the length of the Barrel. Check for proper wire length when assembled - avoid excess or insufficient amounts of wire.
2. Chloride the silver wire. < see below >
3. Thread the silver wire through the Barrel.
4. Cut a small piece of clear tubing (~0.2 mm).
5. Slip the cut piece of tubing over the silver wire on the end of the Barrel with the thinner screw, and seat it into the end-cup of the Barrel.
6. Crimp the end of the silver wire just slightly (~0.1 mm) over the seated piece of tubing.
7. Slide the narrow end of the Lockdown Ring over the crimped-wire end of the Barrel.
8. Insert the Gold Pin into the screw end of the Pin Cap (has a collar), and push it through the pin hole until it stops.
9. Screw the Pin Cap onto the Barrel so that pressure from the compressed snippet of tubing ensures good electrical contact between the silver wire and the Gold Pin.

   For the most stable configuration, before screwing the Pin Cap onto the Barrel, solder the crimped silver wire to the end of the Gold Pin. Apply only a small bead of solder in the very middle of the top of the pin to avoid any excess solder interfering with the parts properly mating, as excess solder can result in air or solution leaks.

   Be careful not to overtighten the Pin Cap onto a quartz Barrel, as it is fragile and can crack. If proper tightening is a concern, Teflon tape or vacuum grease can also be applied.
10. Find a silicone Gasket with an ID (inner diameter) just greater than your pipette OD (outer diameter):

Gasket ID	Color
1.1 mm	Clear
1.2 mm	Green
1.5 mm	Orange-Red
1.75 mm	Blue

Note: The Gasket will wear out over time and will need to be periodically replaced.

11. Slip the gasket onto the long end of exposed silver wire and seat it into the end-cup of the Barrel.
12. Slip the End Cap onto the silver wire, and loosely tighten until it makes contact with the Gasket.
13. Carefully slip a solution-filled micropipette over the silver wire and push it through the Gasket into the Barrel until it stops a little past the Suction Tube.
14. Tighten the End Cap onto the Barrel.
15. Attach the assembled Holder to a headstage with the Lockdown Ring.

3.7.2 Chloriding Silver Wire

The silver wire should be chlorided before first-time use, and then re-chlorinated monthly, or as needed.

Chemical Method

1. If needed, use a razor blade or fine sandpaper to rub off any insulation.
2. Optionally clean the silver (Ag) wire with ETOH (ethanol) to remove finger oils.
3. Immerse the silver wire in common household bleach (sodium hypochlorite) in glassware for 5 – 30 minutes until it turns purple-gray in color.
4. Remove the chlorided silver wire and rinse in distilled water.
5. Dry for storage.

Electrochemical Method

1. If needed, use a razor blade or fine sandpaper to rub off any insulation.
2. Optionally clean the silver (Ag) wire with ETOH (ethanol) to remove finger oils.
3. Connect a silver wire to each pole (positive & negative) of a household battery (1.5 V – 9 V).
4. Immerse the two silver wires in a solution of KCL (3 M) in glassware for 5 – 10 minutes. The wires should not touch each other. Bubbling around the silver wire indicates electroplating is occurring.

   Alternatively, use HCL (1M) with a 2 hour immersion time.
5. The charging polarity for the wires should be reversed a few times during the process.
6. A fully chlorided silver wire should be purple-gray in color. Remove the chlorided silver wires and rinse in deionized water.
7. Dry for storage.

Note: The electrochemical method creates a deeper amount of chloriding than the chemical method.

Re-Chloriding Silver Wire

1. Pass the used silver wire through a flame - the wire should become bright silver in color.

   Alternatively, use a razor blade or fine sandpaper to scrape off any existing chloride.

2. Chloride the wire as described above.

3.7.3 Holder Maintenance

Holders must be properly maintained for good noise performance.

Storage:

1. Holders should be clean and dry.
2. Store in a container with desiccant.

Before 1st time use:

1. Disassemble the holder.
2. Rinse the polycarbonate parts in 70% ethanol.
3. Blot dry.
4. Store in a container with desiccant overnight.

After daily use:

1. Rinse holders with distilled water. For more thorough cleaning, wash with ethanol.

   Caution! Washing with soapy water can leave a film.

   Continual cleaning with ethanol can degrade the polycarbonate parts.

   Do not clean with methanol or strong organic solvents such as acetone.

2. Blot dry.

Weekly Cleaning:

1. At least once per week, disassemble holder.
2. Clean the polycarbonate parts with 10 – 20 s sonication in distilled water.
3. Blot dry.
4. Store in a container with desiccant overnight.

3.8 IPA Amplifier Control Panel

SutterPatch: Hardware Control: Amplifier Control Panel

This software interface controls the IPA amplifier settings. It replaces all physical knobs, dials and meters, such as found on manually-controlled amplifiers.

Most of these settings can also be programmatically controlled via a Paradigm.

Most editable numeric fields can also be adjusted via a control panel with three slider bars (for 3 significant digits) by right-clicking on the field.

Figure 3-3. Amplifier Control Panels

General Controls

[1 - 4] Headstage # tabs

When there is only a single headstage for the system, i.e., only a single IPA amplifier is attached, headstage selection tabs are not displayed.

When multiple headstages or amplifiers (IPA and/or Double IPA) are used, multiple headstage tabs will display. Each headstage maintains its own settings.

Clicking on a headstage tab will open its last-used active mode (VC or CC) settings. This will also blink the power light of the attached amplifier, which is useful in identifying which headstages are associated with which amplifiers.

Note: If a headstage is unattached while an IPA or Double IPA amplifier is in use, its input channel will be at "ground". For older IPA amplifiers, the channel might appear as saturated.

V	[# V]	'V' meter displays the Voltage input channel level.
I	[# A]	'I' meter displays the Current input channel level.
[VC]	'VC' button:	Click to switch the IPA amplifier from Current Clamp to Voltage Clamp mode. The button for the active mode (VC or CC) is highlighted in red. To switch modes during acquisition, hold down the Shift key when selecting the mode button. Tags are inserted into the data record with the new Control Panel settings. < see "Show Gentle Switch" in the Control Panel Settings >
[CC]	'CC' button:	Click to switch the IPA amplifier from Voltage Clamp to Current Clamp mode.
	Warning!	If the headstage is left in open-circuit current-clamp mode for an extended period of time, there is a possibility that internal components can be damaged. As a precaution, the resistance meters will display "OVLD", and the Scope VU meters show a red bar. After 5 minutes in this condition, an alert displays; after 10 minutes, the headstage is automatically switched into voltage-clamp mode.

 'Settings' button Additional amplifier settings.

Show Gentle Switch

Control VC ← → CC mode switching. Displays below the Filter field.

Use to protect cells against transition spikes that could degrade the electrode seal and integrity of the recording. The amount of current to hold the voltage steady is

automatically injected into the cell during the transition (< 100 ms), before stepping to the new current command level.

If the mode is switched during acquisition, tags are inserted into the data record with the new Control Panel settings.

- Reset USB button

Click to re-establish the USB connection to a disconnected Sutter amplifier.

All USB channels are reset.

A green button  indicates that a stable USB connection to the amplifier has been established:

It can take several seconds for the USB connection to be re-established.

A red button indicates that there is no USB connection to the amplifier.

When multiple amplifiers are connected, if any one instrument loses its connection, the Reset button turns red.

If an amplifier is attached while in Demo mode, to exit Demo mode and run the hardware, you need to start a new Experiment.

Right-click menu — Click on any blank space in the Amplifier Control Panel to access:

- Reset USB < same as above >
- Reset Amplifier Controls

  Reset all hardware settings of attached Sutter amplifiers and their headstages to factory defaults.

Liquid junction — [< ±250.0 mV >]

Enter an estimated Liquid Junction Potential (LJP) value for the bath and pipette solutions in use. This value is used by 'Auto Offset' to apply LJP correction for whole-cell experiments.

A liquid junction offset occurs when an "open" micropipette is placed into the bath, and an ionic potential forms between the two dissimilar solutions in the bath and micropipette. This potential contributes to the system offset of the amplifier, and needs to be specially handled.

Commercial calculators are available to determine a correct estimated

LJP value. An LJP value of "+5" to "+15" mV is not uncommon.

Note: 'Liquid Junction Potential (LJP)' values are calculated, by convention (Barry), with an opposite polarity to membrane voltage measurements and system offsets. This LJP polarity difference is accounted for by 'Auto Offset' for the whole-cell patch configuration.

[Auto Offset] [< ±250.0 mV >]

Click to automatically tune the amplifier. The hardware portion of the system offset populates the Offset field.

This feature requires an "open" pipette in the bath, in voltage-clamp mode.

First set the 'Liquid junction' value. Then click the 'Auto Offset' button to apply Liquid Junction Potential (LJP) correction, so that voltage and current levels are accurate when recording from a whole-cell patch.

Note: Once a seal forms on a cell, a liquid junction and its offset no longer exist. This is corrected for, in the whole-cell patch configuration, where:

$V_{memb} = V_{cmd}$ - LJP

< see the 'Liquid Junction' section for additional information >

< see Appendix F: SutterPatch Algorithms Auto Offset algorithm >

[ ] Lock

Once a system offset has been applied, enable the 'Lock' check box to prevent accidental changes to the "Offset" value.

The 'Lock' is automatically enabled whenever a Routine starts to acquire data.

[< ±250.0 mV >]

The system offset field is to the right of the 'Lock' button.

It is independent of the holding potential.

<u>"Auto" Use</u>

An 'Auto Offset' automatically populates this field with the hardware offset portion of the system offset.

<u>"Manual" Use</u>

Use for manual tuning of the amplifier.

Place an “open” micropipette into the bath, run ‘Free Run’, and adjust the “Offset” field until the ‘Current’ signal is zero - this compensates for the hardware and liquid junction portions of the system offset.

Values can be directly typed into the numeric field.

For fine adjustments, use the up / down spinners to increase / decrease the setting by ~0.015 mV.

The Offset spinner step size is based on the 16-bit resolution of a 1 V DAC. The actual spinner step size resolution is 0.01525878 mV.

For moderate adjustments, increase the spinner increment by 10x (~0.15 mV) by holding down the Shift key and clicking on the spinners.

For fastest operation, select the offset field, hover the cursor over the numeric field or spinners, and hold down the Shift key while simultaneously scrolling up or down with the mouse wheel.

Voltage Clamp Controls

VC The 'VC' tab displays amplifier Voltage Clamp controls:

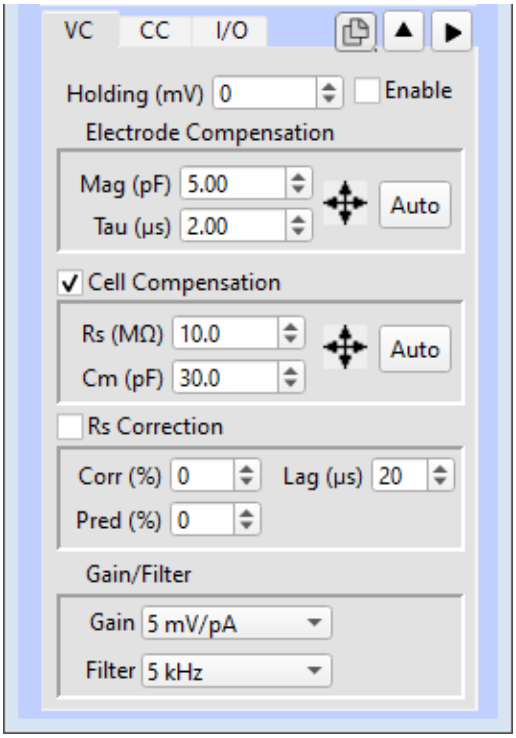


Figure 3-4. VC Control

Holding (mV): [< ±1000 >]

After achieving a seal, the holding voltage is typically set to the cell's equilibrium or "resting" membrane potential (typically -60 to -80 mV for neurons). This control is active during acquisition - changes are applied to the next sweep.

Numeric values can be directly typed into the numeric field, or

For fine adjustments, use the up / down spinners to increase or decrease the setting by 1 mV.

For moderate adjustments, increase the spinner increment to 10 mV by holding down the Shift key and then clicking on the spinners.

For fastest operation, select the offset field, hover the cursor over the numeric field or spinners, and hold down the Shift key while simultaneously scrolling up or down with the mouse wheel.

[ ] Enable Use the Enable checkbox to activate Holding.

If Holding is not enabled, the holding level is zero volts.

The holding value is written at the start of Routine acquisition to the metadata as 'Command Holding Value'.

Whenever this button is activated or de-activated during acquisition, a 'Command Holding Value' tag is inserted into the data recording and written to the metadata.

Electrode Compensation

Electrode capacitance compensation section.

Mag (pF): [< 0.00 – 25.00 >] < shared with CC mode >

Compensation magnitude.

Tau (µs): [< 0.10 – 4.50 >]

Click to open a 2-D slider panel for simultaneous tuning of both parameters.

Alert! When dragging with a mouse, slow down when approaching panel boundaries, else undershoot or overshoot of the values can occur.

[Auto] Click to automatically set approximate values.

After making an on-cell gigaohm seal, large microelectrode capacitance spikes are visible. To remove the transients, click the 'Auto' button at least twice. Then, zoom in on the signal,, and if needed, adjust the 'Mag' and 'Tau' controls (separately, or with the slider panel for a combo control), until the signal is adequately compensated. For a square pulse command (such as a Membrane Test 'Seal command), the goal is to eliminate the edge-effect spike transients.

< see Appendix F: SutterPatch Algorithms: Auto 'Electrode Compensation' Algorithm >

Note: IPA Compensation controls do not affect demo data.

[ ] Cell Compensation

Enable whole-cell capacitance compensation.

Rs (MΩ): [< 0 – 100.0 >]

Series resistance.

Cm (pF): [< 0 – 500.0 >]

Membrane capacitance.

Click to open a 2-D slider panel for simultaneous tuning of both parameters.

Alert! When dragging with a mouse, slow down when approaching panel boundaries, else undershoot or overshoot of the values can occur.

[Auto] Click to automatically set approximate values using small “gentle” steps to avoid hyperpolarization.

After breaking into a cell, i.e., going “whole cell”, additional large capacitive transients are now generated by the entire membrane of the cell.

To remove the transients, click the ‘Auto’ button. Then, zoom in on the signal, and if needed, adjust the ‘Rs’ and ‘Cm’ controls (separately, or with the slider panel for a combo control), until the signal is adequately compensated. For a square pulse command, the goal is to eliminate the edge-effect transients with minimal distortion of the response signal.

The IPA system is optimized for real-world measurements from real electrodes, so when used with the model cell, the compensation might need several more ‘Auto’ adjustments to compensate the model cell capacitance.

Alert! ‘Cell Compensation’ should be disabled when running a Membrane Test in Cell mode, else results will not be valid.

Note: The IPA Compensation controls do not affect demo data.

[ ] Rs Correction

Enable whole-cell Series Resistance compensation.

“Rs Correction” is used to correct command potential voltage drops, to minimize rise-time delays and slow decay phases in the current response, and to reduce unwanted filtering effects, caused by Series resistance.

Corr (%): [< 0 – 100 >]

Rs correction.

Pred (%): [< 0 – 99 >]

Rs prediction.

Lag (µs): [< 20 – 200 >]

RC filter component.

Control the speed of the correction while avoiding possible oscillations.

< see Appendix F: SutterPatch Algorithms: Rs Correction >

Alert! If set too high, filtering can hide ringing.

Rs Correction requires that the Electrode and Cell Compensations are first applied.

Then, set the Prediction (Pred) to "supercharge" the command potential. Small transients should become visible at the start and end of the current response.

Next, increase the Correction (Corr) current injected into the membrane to sharpen the rise time. As the Corr setting is increased, the current response transients also increase in size. Avoid overshooting - if the correction is set too high, internal feedback can lead to oscillation of the circuit, i.e., "ringing", and loss of a patch.

Reduce oscillation of the circuit by adjusting the 'Lag' setting - larger values increase the stability of the circuit, but also increase the rise time.

Remove the Prediction/Correction transients in the signal by reducing the Cell Compensation 'Rs' setting until a minimum value is found. Then adjust the Cell Compensation 'Rs' setting again until the best result is achieved, or try over again with lower Prediction/Correction settings.

Alert! 'Rs Correction' should be disabled when running a Membrane Test in Cell mode, or results will not be valid.

Note: The IPA Correction controls do not affect demo data.

Gain/Filter

Gain [gain] [↓] Analog Input Gain

mV/pA	Signal Range
0.5	± 20 nA
1	± 10 nA
2.5	± 4 nA
5	± 2 nA
10	± 1 nA

25	± 400 pA

New voltage-clamp gain settings are applied to headstage Current input signals when new Acquisition: Scope windows are created.

Filter [filter] [↓]

Input Filter (low-pass 4-pole Bessel)

kHz	Data Point Interval
0.5	2 ms
1	1 ms
2	500 µs
5	200 µs
10	100 µs
20	50 µs

This low-pass filter is applied to the active headstage input signals, and serves to reduce the headstage input sampling rate (as set in Routine Editor / Acquisition & Routine Parameters.)

Filter settings are shared between the voltage- and current-clamp modes. New filter settings are applied when new Acquisition: Scope windows are created.

Tip! For experiments where the shape of the response is of interest, an input filter rate of 10 kHz is commonly used.

However, for very long stimuli, you might want to use a lower input filter rate.

Note: The Demo mode does not apply filtering - demo data uses the sampling rate timing (set in Routine Editor: Acquisition & Routine Parameters, or Membrane Test Editor: Settings: Signal Parameters).

Current Clamp Controls

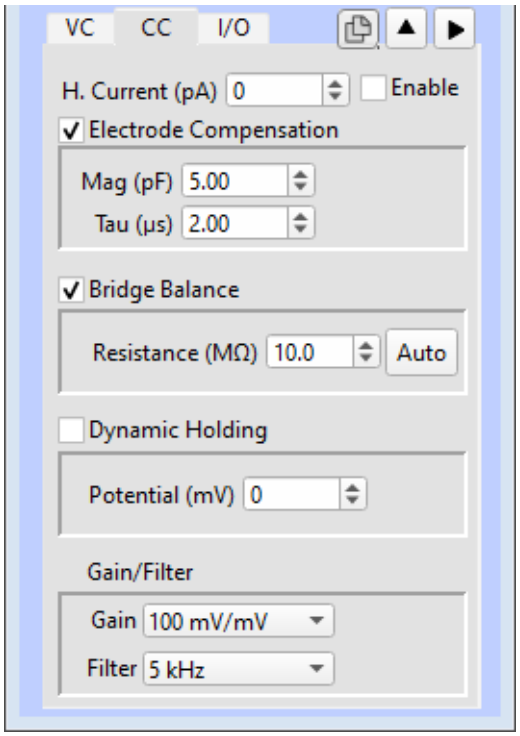


Figure 3-5. CC Control

CC — The 'CC' tab displays the IPA Current Clamp controls:

H. Current (pA): [< ±1000 >]

A Holding Current can be preset here.

[ ] Enable — Use the 'Enable' checkbox to activate H. Current.

If H. Current is not enabled, the holding level is zero amperes.

The holding level value is written at the start of Routine acquisition to the metadata as 'Command Holding Value'. Whenever this button is activated or de-activated during acquisition, , a 'Command Holding Value' tag is inserted into the data recording and written to the metadata.

[ ] Electrode Compensation

Enable electrode capacitance compensation.

Mag (pF): [< 0.00 – 25.00 >] < shared with VC mode >

Compensation magnitude.

Tau (µs) [< 1.00 – 4.50 >]

To remove microelectrode capacitance-charging transients and reduce their filtering effects (increased signal amplitudes and rise-times), click the 'Auto' button. Then autoscale the signal, and if needed, adjust the 'Magnitude' control.

CC mode Electrode Compensation is also known as "Capacitance Neutralization".

Tip! If you consistently lose cells when switching into CC mode, consider adjusting the CC mode electrode compensation value in Set Preferences / Hardware / Stability Control.

Note: IPA Compensation controls do not affect demo data.

[ ] Bridge Balance — Enable "bridge balance" correction.

Resistance (MΩ): [< 0 – 200.0 >] < shared with VC mode 'Cell Compensation' >

< Bridge Balance correction requires Electrode Compensation to be enabled and set >

Bridge Balance is an adjustment to remove voltage-drop effects due to the electrode Series resistance, when command current is flowing into the preparation. Voltage readings from the cell during current flow (injection) are corrected.

If you are simply recording voltage (I=0) without any current injection, then Bridge Balance can be ignored or left disabled.

To manually determine the Bridge Balance value, run the Membrane Test and zoom in on the initial rising phase. With Bridge Balance disabled, there is a DC shift visible at the beginning of the rising signal. Enable Bridge Balance and adjust until the DC shift disappears.

However, after adjustment, there may be a small glitch at the beginning of the rise, due to electrode and headstage capacitance that doesn't entirely go away. (Further adjustments to the Electrode Compensation may need to be made.) In some cases, it can be difficult to determine the exact Bridge Balance value, but as long as the Series resistance is significantly smaller than the cell resistance, the errors are very small.

[Auto] — Click to approximate the correction value. For larger steps, it is recommended to run the 'Auto' function twice in a row.

[ ] Dynamic Holding

Enable dynamic holding to maintain the membrane holding potential at a set target level without it drifting over time.

Dynamic Holding applies to Routine, Membrane Test and Free Run acquisitions in voltage- and current-clamp modes.

Target (mV): [< ±1000 >]

Enter the voltage level to be maintained.

When Dynamic Holding is enabled, the Holding Current is automatically disabled, as the current output is dynamically adjusted by the system.

If the amplifier is accidentally disconnected, when the USB connection is restored, Dynamic Holding will be disabled.

Note: The IPA 'tau' is fixed at ~18 ms. This tracking time constant (tau) is "how fast" it takes to reduce the difference between the actual voltage and the target voltage by 64%.

Gain/Filter

Gain [gain] [↓] Analog Input Gain

mV/mV	Signal Range
10	±1 V
20	± 500 mV
50	± 200 mV
100	± 100 mV
200	± 50 mV
500	± 20 mV

New current-clamp gain settings are applied to headstage Voltage input signals when new Acquisition: Scope windows are created.

Filter [filter] [↓]

Input Filter (low-pass 4-pole Bessel)

kHz	Data Point Interval
0.5	(2 ms)
1	(1 ms)
2	(500 µs)

5	(200 µs)
10	(100 µs)
20	(50 µs)

Apply a low-pass filter to the active headstage input signals.

Filter settings are shared between the voltage- and current-clamp modes. New filter settings are applied when new Acquisition: Scope windows are created.

In general, it is recommended that the Input Filter Rate be greater than or equal to the Output Sampling Rate.

Tip! For experiments where the shape of the response is of interest, an input filter rate of 10 kHz is commonly used.

However, for very long stimuli, you might want to use a lower input filter rate.

Note: Filtering is not applied in Demo mode. Demo data uses the sampling rate, as set in Routine Editor / Acquisition & Routine Parameters, or in Membrane Test Editor: Settings: Signal Parameters.

Input/Output Controls

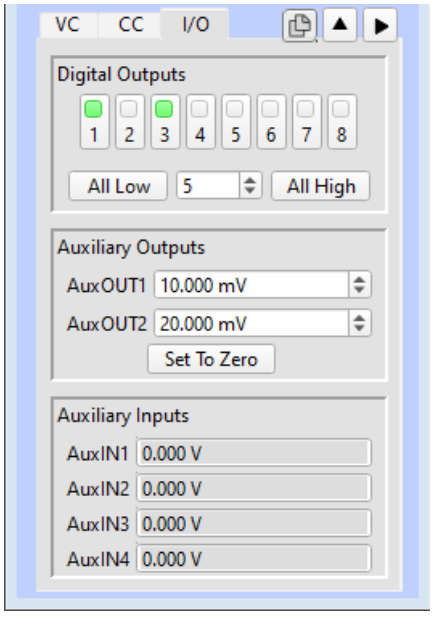


Figure 3-6. I/O Control

I/O The 'I/O' tab contains the Digital Output and Auxiliary I/O controls. For a Double IPA system, the I/O tab is only visible when Headstage 1 is selected.

Digital Outputs

This section controls the holding bit pattern generated by the Digital Outputs of the IPA amplifier. Eight TTL-compatible digital channels are displayed.

[o] [1 – 8] Switch between digital states by clicking on a channel button. When a dot changes color, its channel state changes to:

Green dot	On	High	(+3.3 V)
White dot	Off	Low	(0 V)

[All Low] Click to set all digital channels 'Off'.

[0 – 255] Edit the decimal value of the bit pattern.

[All High] Click to set all digital channels 'On'.

Note: When multiple Sutter amplifiers are connected, the Digital Outputs are only active for the main amplifier.

Auxiliary Outputs

General purpose "auxiliary" analog output channels are available.

AuxOUT 1 & 2: [< ±10.000 V >]

Select an auxiliary analog output channel, and directly edit its voltage level, or use the spinners to change the value in 1 mV increments.

Note: a) Demo-mode output channels are reset to zero when selected.

b) If an auxiliary output (holding) level is changed during continuous acquisition, the only system notification of this is a tag in the metadata of the recording.

Tip! When the IPA system is used as a data acquisition system for external instrumentation, the auxiliary outputs can be used as holding levels.

[Set To Zero] Click to reset all auxiliary output channels to 0 V.

Auxiliary Inputs

AuxIN[1 – 4] [±10.000 V]

< read only fields >

Auxiliary analog input channels.

Read Click the 'Read' button to display a single-point reading of the selected

input channel.

Tip! This is useful for monitoring slow-changing parameters, such as temperature.

The up-down “Show/Hide” button displays/hides the tabbed controls [VC | CC | I/O] below this button.

The horizontal “Show/Hide” button displays/hides the Double IPA input monitor, which displays the real-time Voltage and Current input channel values for both headstages.

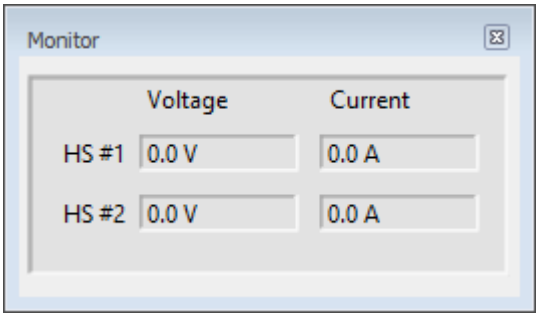


Figure 3-7. Headstage Input Monitor

3.9 Liquid Junction Potentials

A "liquid junction" is an electrochemical boundary between two solutions (actually a “liquid-liquid” junction), which produces an unwanted voltage offset between the two liquids. When this occurs between the bath and electrode solutions, the liquid junction potential (LJP) is included in the System hardware offset. As this distorts headstage output levels, the LJP should be corrected for.

LJP Correction

SutterPatch LJP correction is applied during acquisition for automatic correction of whole-cell voltage levels.

1. Place an “open” micropipette into the bath in voltage-clamp mode.
2. Disable the Amplifier Control Panel offset ‘Lock’ control.
3. In the Amplifier Control Panel ‘Liquid junction’ field, enter your estimated bath-pipette solutions LJP value.
4. Click the Amplifier Control Panel ‘Auto Offset’ button.

   The amplifier is automatically tuned and LJP correction applied, and the hardware portion

of the system offset populates the Offset field.

The amplifier is now ready for recording in a whole-cell patch-clamp configuration.

< see Appendix F: SutterPatch Algorithms: Liquid Junction Potentials for additional information >

3.10 Lock-In Adjustments

SutterPatch: Hardware Control: Lock-In Adjustments

The "lock-in" system is used to detect very small changes in membrane capacitance measurements, such as for single-vesicle fusion and retrieval measurements. Our system uses a digital implementation of phase-sensitive detection (PSD) to make its measurements.

1) To perform lock-in analysis, a reference waveform needs to be supplied to the headstage. Configure a lock-in sine wave in the Routine Editor / Waveform Editor / Sine / Sine Wave Cycles / For LockIn. <also see Membrane Test>

2) The lock-in response signal is then processed via a virtual input channel. Measurements, such as membrane conductance, are reported. Calculations are made using 'conductance' (1 / resistance) instead of 'resistance'.

   Setup in the Routine Editor / Input Channels / Virtual#:

   Math Type [↓] LockIn

   Current Channel [↓]
   Select a (source) input channel with a current (amperage) signal.

   Trace Kind [↓] Select the LockIn measurement to perform.

   The selected 'Trace Kind' is automatically set as the Virtual Channel label.

CM	Computed membrane capacitance.
GM	Computed membrane conductance.
GS	Computed series conductance.
DC	DC component of measured signal.
RealY	Real number part of the lock-in response signal.
ImagY	Imaginary number part of the lock-in response signal.

   Cycles to Average [< 1 – 1000 >]

Cycles to Skip [< 1 – 1000 >]

V-reversal [±1000 mV]

When using a calculated stimulus trace, enter the reversal potential for the ion under study, such as for (Na+) sodium spikes or (K+) potassium tail currents.

3) The lock-in phase detection can be manually tuned via the menu item SutterPatch / Hardware Control / Lock-In Adjustments. Phase adjustments are made to optimize the headstage signals, and should be done in voltage-clamp mode.

[ ] Enable Manual Adjustments

Adjustments can be made using direct field editing, spinners, or a field right-click slider panel.

Phase Delay Adjustment

[±1.00 µs]

Apply a phase delay to the calculations.

[Reset] Reset to '0.00 s'.

[ ] Attenuation Adjustment

[< 0.001 – 9.999 >]

Apply a gain to the calculations.

[Reset] Reset to '1.000'.

[ ] List Results Display results in the Command window.

The lock-in computation is quite stable - its calibration values do not change day-to-day. However, lock-in measurements can be affected by experimental conditions, including the amplifier itself. In particular, the electrode compensation has a large influence on the results, and needs to be properly set - run the electrode compensation on a pulse, and then disable it, before running LockIn adjustments.

Start with the Phase Delay Adjustment, and then follow with the Attenuation Adjustment.

The sensitivity of the SutterPatch software lock-in results is as good as for a hardware lock-in amplifier.

When making absolute capacitance measurements, you can improve the consistency of the measurements by adjusting the lock-in phase adjustment to a known reference capacitance, such as with the model cell.

The SutterPatch lock-in calculations are based on the Lindau/Neher method of time-resolved capacitance measurements in single cells.

< see Appendix F: SutterPatch Algorithms: LockIn Computation >

Note: Demo mode is not designed to respond to lock-in phase and attenuation adjustments.

3.11 System Integration

IPA systems can be integrated with other suitable laboratory equipment.

3.11.1 Peripheral Equipment

IPA systems can control peripheral equipment, such as:

- Cameras
- Light sources
- Pulse generators
- Solution changers
- Wavelength switchers

IPA systems interface to external instrumentation via front- and rear-panel BNC connections.

Auxiliary analog output signals can be used to control other instruments within a range of ±10 V. Digital outputs use TTL-compatible voltage (+3.3 V) signals. Analog and digital holding levels are set in the Amplifier Control Panel.

The digital command output can be formatted as a single "bit" or an 8-bit "word", as selected in the Routine Editor / Output Channels & Waveform section.

All command output patterns are configured in the Waveform Editor.

Note: The analog and digital controls in the Amplifier Control Panel provide a way to quickly and easily test the behavior and operation of peripherals, without the need to create or modify Routines.

3.11.2 Multiple Sutter Amplifiers

Any combination of two IPA or Double IPA amplifiers can be connected to the same computer and run simultaneously by the SutterPatch program.

When a computer is powered on, its USB ports (and attached hardware) are detected by the operating system and enumerated in a particular order. The resulting amplifier sequence numbers are listed with their associated model and serial number in the Help / About SutterPatch dialog. This sequence should not change after installation, unless the attached equipment is changed or the USB ports are re-configured.

The amplifier with sequence number "1" is designated the "Main" amplifier, and provides a trigger signal to start a sweep acquisition by the secondary "Triggered" amplifier. To setup, install the amplifiers, and then connect the main amplifier front panel TRIGGER OUT BNC to the secondary amplifier rear panel TRIGGER IN BNC.

When multiple IPA amplifiers are attached, the Routine Editor also displays their sequence in the 'Acquisition & Routine Parameters' section, along with their serial and headstage numbers in the 'Routine Settings' overview of the 'Input Channels' and 'Output Channels Waveform' sections.

Digital Outputs are only available from the "main" (#1) amplifier.

When more than one IPA headstage is attached, the Amplifier Control Panel displays each headstage in a numbered tab [1 – 4].

Up to 16 analog input channels can be configured, using a mix of headstage, auxiliary and virtual input channels from either amplifier.

Note: Demo mode does not support multiple amplifier configurations.

3.11.3 Non-Sutter Amplifiers

An IPA or Double IPA system can also be operated as a stand-alone data acquisition system interfacing to non-Sutter amplifiers. The amplifier's digitizer section is controlled via the SutterPatch software Amplifier Control Panel.

The IPA digitizer interfaces to external amplifiers via panel BNC connectors and/or the Auxiliary I/O Cable and/or an optional Patch Panel:

AuxOUT1 & 2	These two auxiliary analog output channels can be used to send stimulus waveforms to external instruments, such as non-Sutter microelectrode amplifiers.
AuxIN1 – 4	These four auxiliary analog input channels can be used to digitize signals from external instruments, such as non-Sutter microelectrode amplifiers.
DigOUT1 – 8	Digital output patterns can be sent via eight digital output channels to a variety of peripheral equipment.

Auxiliary analog and digital holding levels are set in the Amplifier Control Panel I/O tab.

Note: Sutter amplifier output levels into Sutter systems attenuate by < 0.2%.

HEKA amplifier output levels into Sutter systems attenuate by 0.5%.

Axon Instruments amplifier output levels into Sutter systems attenuate by 5%.

3.11.4 Non-Sutter Data Acquisition Systems

The IPA or Double IPA system can also be operated as a stand-alone amplifier using non-Sutter data acquisition systems, while the Sutter amplifier continues to be controlled via the Amplifier Control Panel.

IPA System Front Panel Connections

BNC	Channel
COMMAND IN	Stimulus to the preparation. Combines the analog input signal from an external source with the stimulus (command waveform) sent to the preparation. The Command In external signal is summed with the IPA internal StimOUT output signal, and is then sent to the IPA headstage.
SCOPE - SIGNAL OUTPUT	Data from the preparation. This BNC supplies the response from the IPA preparation. The current or voltage response from the headstage is directly available from this analog BNC output, and can be connected to an external data acquisition system for digitization and recording.
SCOPE - COMMAND MONITOR	Data from the Stimulus signal. This BNC allows you to monitor the stimulus channel. The analog stimulus delivered to the IPA headstage (voltage or current) is directly available on this BNC, and can be connected to an external data acquisition system for digitization and recording.

3.12 IPA Maintenance

This unit should require minimal maintenance when operated according to specifications.

3.12.1 Inspection

Periodically inspect all cables and connections to make sure that all cables are sound and that all connections are firm and evenly seated.

Warning! Turn off the IPA power before plugging / unplugging headstages.

3.12.2 Cleaning

Routine cleaning of the IPA system is required to prevent excessive dust accumulations. Wipe all exterior surfaces with a dry, soft, cotton cloth.

3.12.3 Calibration

The IPA amplifiers do not support user calibration.

4. SOFTWARE OPERATION

4.1 Acquisition

SutterPatch acquisition operations.

4.1.1 Acquisition Control

SutterPatch: Acquisition Control

The interactive acquisition controls for both Routines and Paradigms are grouped into this control panel.

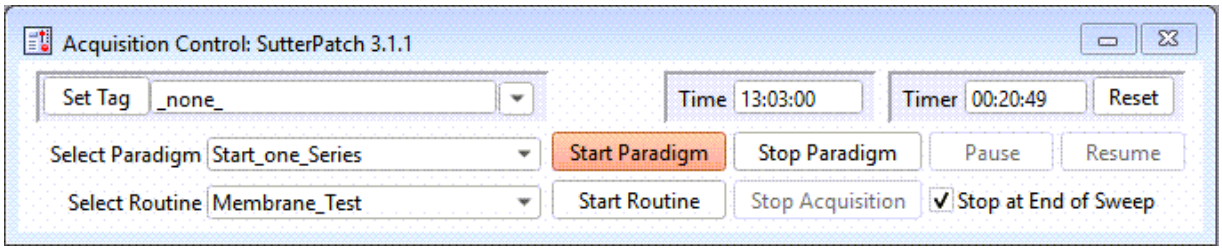


Figure 4-1: Acquisition Control

[Set Tag] [< text >] [↓]

Click the Set Tag button to create a time-stamped text comment in the Paradigm metadata at any time.

Note: Tag timing is not accurate in hardware emulation mode.

Enter the comment text into the field, or select a comment from a drop-down list of recently used entries The drop-down list is saved with the SutterPatch preferences.

When run during acquisition, the comment tag is also written to the Routine. When the data is opened in a Reanalysis Scope window, the tags are only visible in the Time Course and Concatenated display modes. Tags are also visible in the Data Navigator's Paradigm Review and Routine Review windows.

- _none_ A special case text entry, as a tag is not generated.
- Clear Menu Erase the text comments from the drop-down list.
- Cycle to Next Cycle through the drop-down list of text comments each time the Set Tag button is clicked, starting from the displayed comment. When the last comment in the list is reached, it cycles back to the

first comment in the list.

Time [hh:mm:ss]

The system time.

< only displays if enabled in Set Preferences / General / 'Show time in Acquisition Control window' >

Timer [hh:mm:ss]

A running clock displays the time in "hh:mm:ss" since the last timer reset, or since a new experiment established a USB connection or emulation mode.

[Reset] Click to reset the Timer to 00:00:00.

Select Paradigm [< Paradigm >] [↓]

The last loaded Paradigm is displayed. Select a Paradigm from the loaded 'Paradigm Pool' list.

[Start Paradigm] Click to manually run the selected Paradigm and create a user-named "planned" Paradigm.

A Paradigm can be started while Free Run or Membrane Test are running. When the Paradigm ends, its Scope window closes and acquisition ends.

A Paradigm cannot be started if an Acquisition Scope window is acquiring Routine data.

[Stop Paradigm] Click to terminate the current Paradigm.

The next Paradigm to run starts a new "planned" named Paradigm. Otherwise, the next Routine to run starts a new date/time-stamped "auto-triggered" Paradigm.

[Pause] Click to temporarily halt a running Paradigm or Routine.

[Resume] Click to continue running the paused Paradigm or Routine.

Select Routine [< Routine >] [↓]

The last executed or activated "Routine" is displayed. Select Free Run, Membrane Test, or an active Routine from the loaded 'Routine Pool' list.

- Membrane_Test
- Free_Run

- Routine list

[Start Routine] Click to manually run the selected "Routine" item. Any acquisition in a Scope window is stopped.

When you click the 'Start' button, the Scope window is cleared, and data recording starts after ~300 ms. When acquisition is running, the Scope window updates every 200 ms.

If the Sweep Start-to-Start time is ≥ 5 s, the "Time to next sweep: # s" is reported below the Start / Stop buttons.

If Metadata prompts are configured for Routines or Paradigms, the Confirm Metadata Settings dialog displays just before recording begins.

If measurement graphs are enabled, a docked "child" Analysis window opens and plots sweep-by-sweep measurements.

The custom function 'UserAnalysis' can be automatically called after each sweep is collected, before any real time analysis is performed.
(see the Programming chapter: SutterPatch Hooks)
If no prior auto-triggered Paradigm is running, a new date/time-stamped Paradigm is created.

[Stop Acquisition] Click to terminate any running data acquisition.

[ ] Stop at End of Sweep

When this option is disabled, and you click the 'Stop Acquisition' button (or Scope 'Stop' button) in the middle of a sweep, acquisition stops immediately and the partial sweep is discarded.

When 'Stop at End of Sweep' is enabled, and you click the 'Stop Acquisition' button (or Scope 'Stop' button) in the middle of a sweep, the sweep completes before data acquisition is stopped.

To override this option and stop the acquisition immediately, Shift-click the 'Stop Acquisition' button.

Note: Data files are stored in the file path specified in the menu item SutterPatch / Set Preferences / Files and Naming.

Default file path

Windows: C:\Users\<User Account Name>\Documents\SutterPatch\Data\

macOS: Applications/ SutterPatch3/SutterPatch/Data/

Acquisition Measurements & Graphs

Make real-time changes to the measurements and graphs, even during data acquisition, with this dialog.

To access this dialog, click on the Acquisition Scope window button 'Measurements / Edit Measurements'.

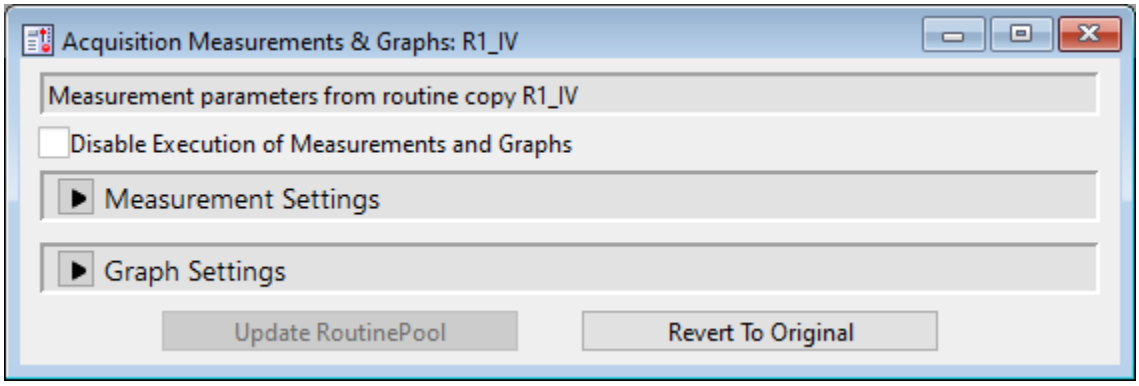


Figure 4-2: Acquisition Measurements & Graphs

This dialog is the same as in the Routine Editor / Real Time Measurements & Graphs dialog, with two extra buttons:

[Update Routine Pool]	Save your edits to the Routine.
[Revert to Original]	Discard any edits.

4.1.2 Acquisition: Scope

The Acquisition: Scope window is used for viewing and recording digitized time-series data, displayed as a smooth interpolated line.

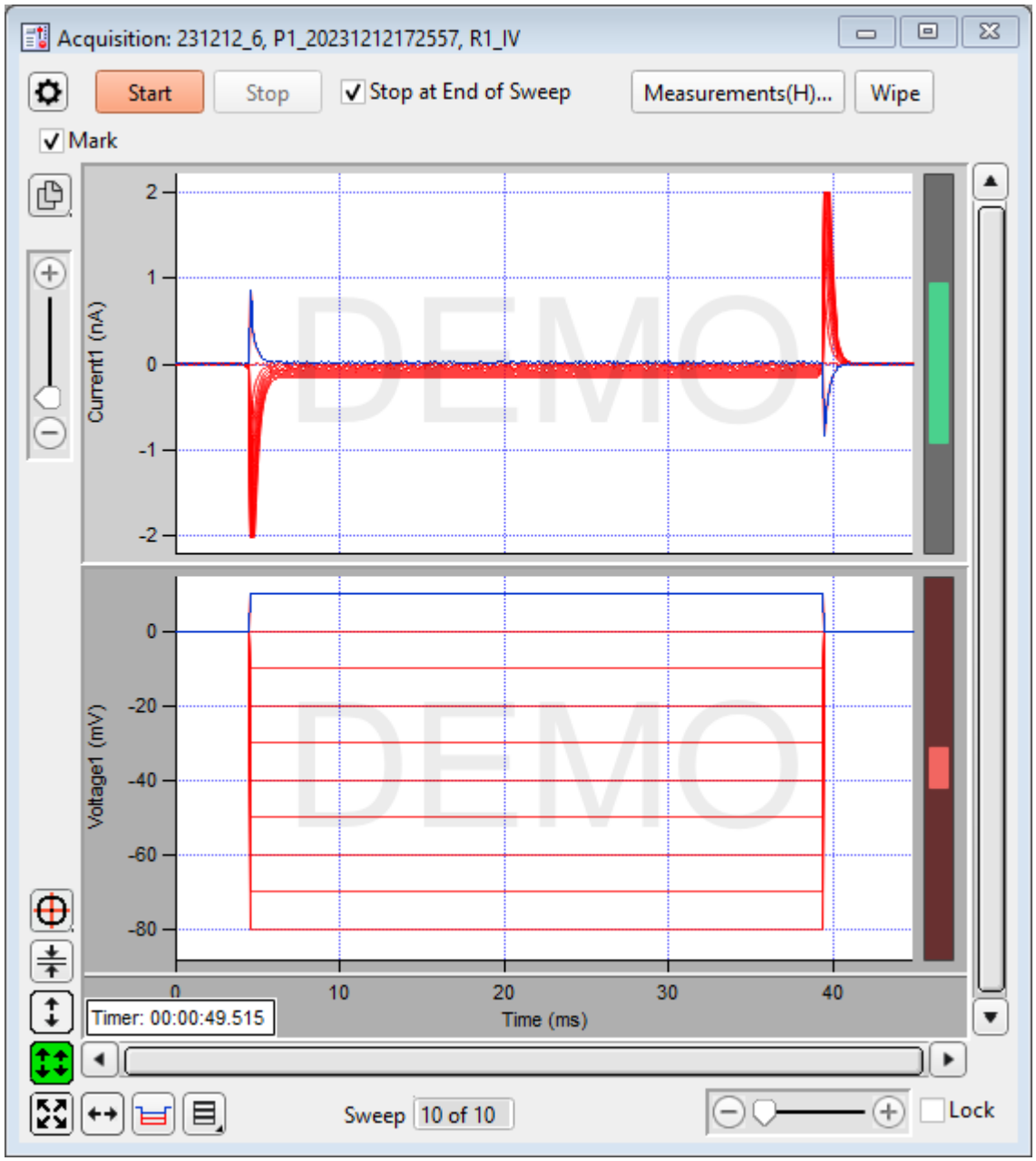


Figure 4-3 Acquisition: Scope Window

The Scope window is titled with the active Paradigm sequence number + Routine name.

Note: Only one Scope window can be open at a time. For example, if an Acquisition: Scope window is open for data acquisition, then opening Membrane Test, Free-Run, or the

Reanalysis Scope will close the Acquisition: Scope window, and re-open it as the new type of Scope window.

Channels

The central area of the Scope window graphically displays data signals in up to 16 separate input channel panes. Click on a channel pane to make it "active" - the Y-axis border area displays in a lighter color, and the Y-axis controls (magnify, scroll) apply to it. Non-active panes display with a darker Y-axis border area.

If multiple channels are displayed stacked on top of each other, you can vertically resize the panes by clicking and dragging them with a resizing cursor. Position the mouse cursor over a pane separator (the horizontal area between panes) to change it to the resizing cursor (a horizontal line with a vertical double-headed arrow.)

If a channel name bleeds into other channel panes, you can:

- Increase the size of the Scope window.
- Increase the size of the signal pane.
- Supply a shorter input channel label in the Routine Editor.

Note: Two additional data points are appended to the sweep data to support post-sweep holding levels and segment boundary rounding issues.

Signal Controls

Signals can be magnified or unmagnified using several X- and Y-axis display controls in the scope window. Any magnification applied to the signals persists during acquisition.

- Y Magnification Combo

Click on the "+" and "-" buttons to magnify/unmagnify by steps, or click and drag the slider to smoothly zoom/unzoom the active signal.

The Y-axis magnification only controls the active pane.

- X Magnification Combo

Click on the “+” and “-“ buttons to magnify/unmagnify by steps, or click and drag the slider to smoothly zoom/unzoom signals.

The X-axis magnification controls all panes.

- Axis Zoom

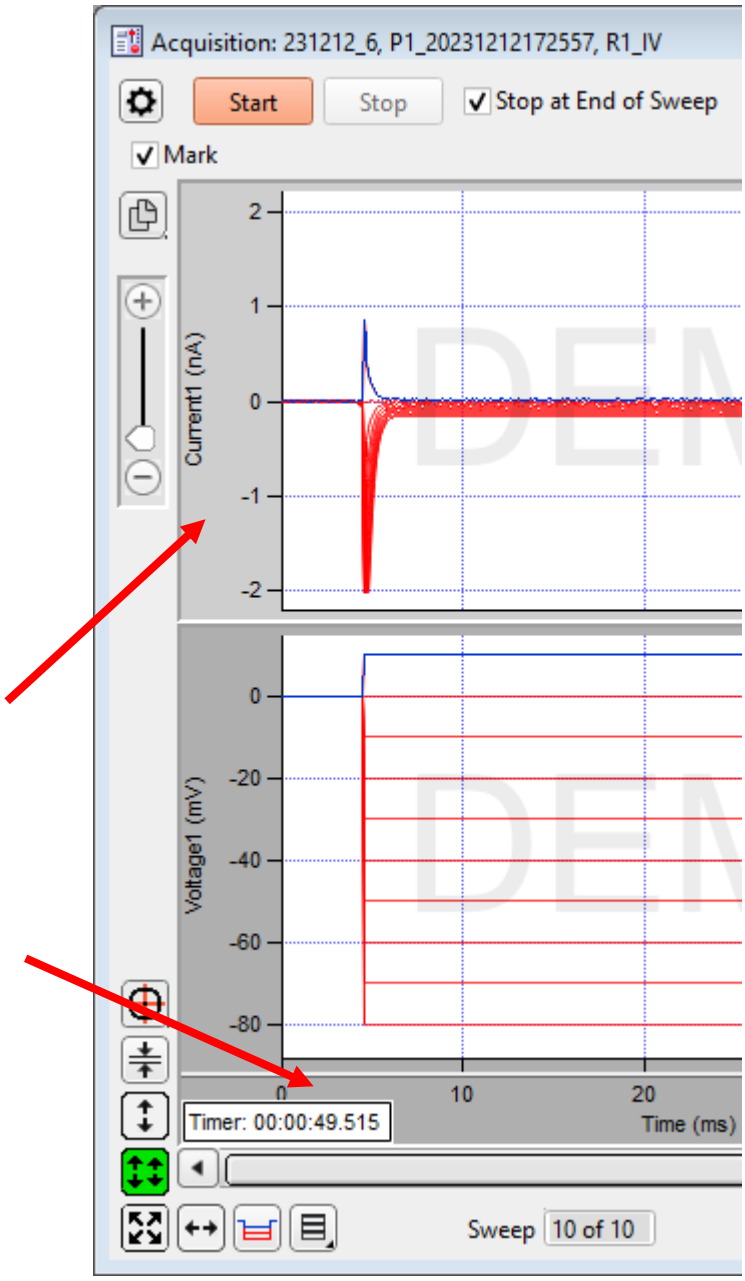


Figure 4-4. Axis Magnification

When the mouse is moved into the X- or Y-axis areas, the cursor changes to a double-headed arrow. As you click and drag the mouse cursor, a dark bar displays in the axis showing the magnification area; or scroll the mouse wheel up/down to expand/shrink the X-axes or the active Y-axis.

- Area Zoom

  Any area of interest in a signal pane can be graphically selected and expanded:

  1. Move the mouse cursor into a signal pane - it changes into a large “+”.
  2. Click and drag a bounding box around the desired data. (This box is also referred to as a “marquee”.)
  3. Right-click in the marquee and select the desired action.

Expand	Applies to all signals.
Horiz Expand	Applies to all signals.
Vert Expand	Applies to active signal.
Shrink	Applies to all signals.
Horiz Shrink	Applies to all signals.
Vert Shrink	Applies to active signal.

- Axis Scroll Bars

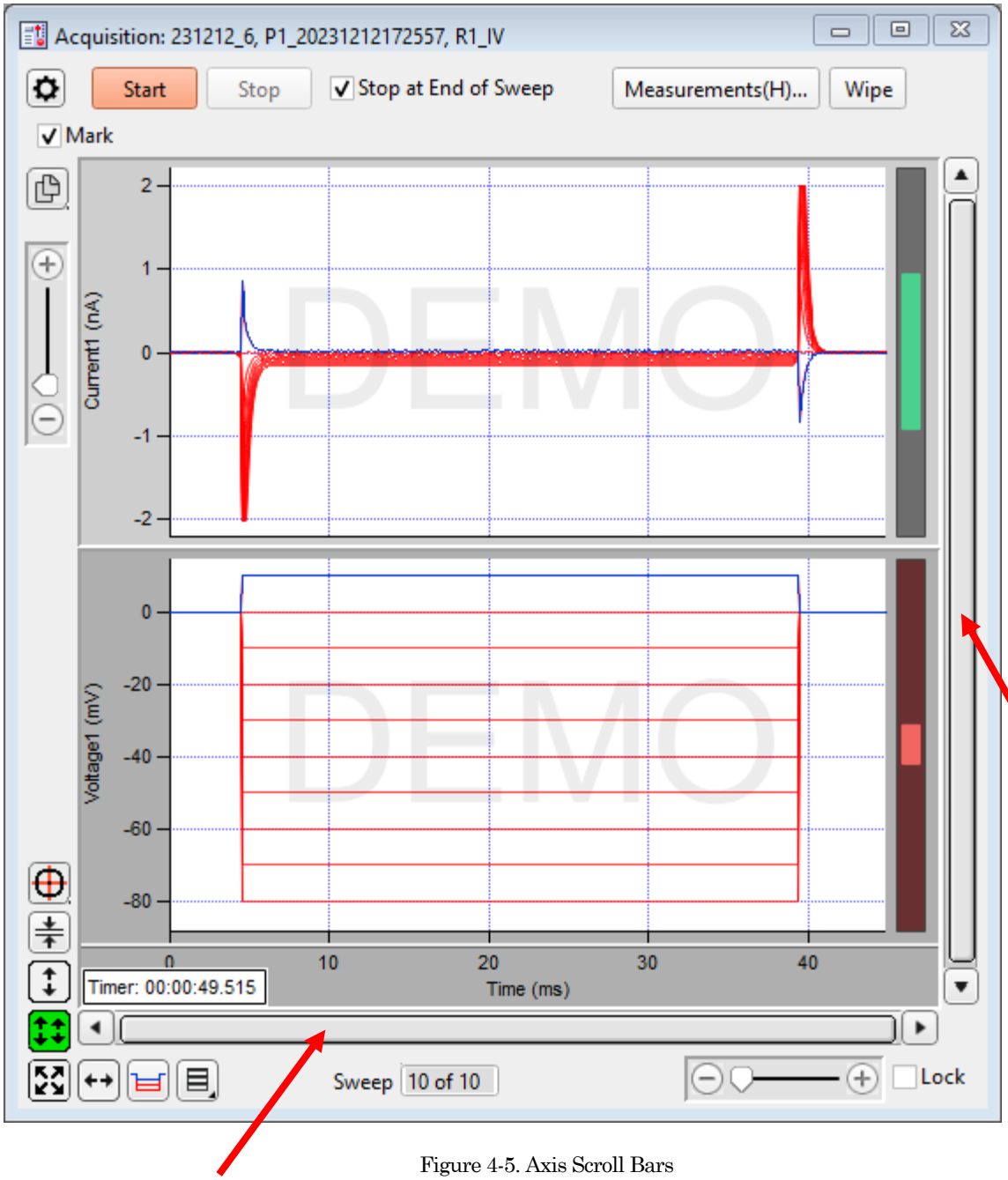


Figure 4-5. Axis Scroll Bars

The X-axis scroll bar is directly underneath the X-axis, while the Y-axis scroll bar is on the far right-edge of the scope window. Click and drag the scroll bar slider buttons, or use their directional buttons to move the displayed signals in the desired direction. (The size of the X- and Y-axis scroll bar slider buttons reflects the amount of signal magnification.) The Y-axis scroll bar controls the active signal pane; the X-axis scroll bar controls all panes.

- Measurement Cursors

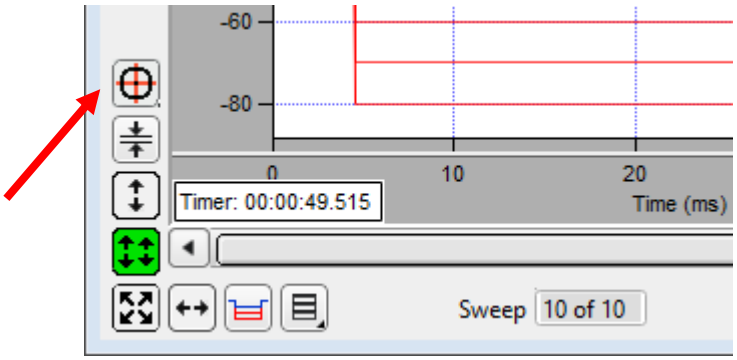


Figure 4-6. Measurement Cursors

Scan, fit or extract signal data

- Scan signal data

  Open a floating window to manually measure X-Y data in the last acquired sweep.

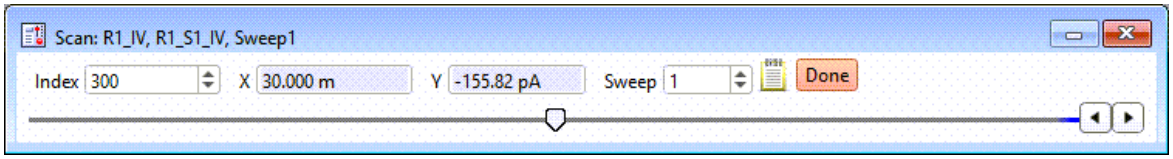


Figure 4-7, Scan Signal Data Control

Scan: Routine#_Routine name, Routine#_Signal_#_Routine name, Sweep #

Index [<#>]

The selected data point number in the sweep.

A data point number can be entered, or use the increment/decrement controls to increase/decrease the selected data point by one point.

X [#]

The X-axis value of the selected data point.

Y [#]

The Y-axis value of the selected data point.

Sweep [<#>] [↓]

Select the sweep number to scan.

Write to Notebook

Click to write to the Notebook:

Routine#_Routine_name	Name.
sweep=#	Sweep.
index [signal name]=#	Point.
x [signal name]=#	X data value.
y [signal name]=#	Y data value.

If the Shift key is pressed, write the information for all signals to the Notebook.

Click to close the “Scanner” floating window.

This window also automatically closes when you click in another window.

X-slider bar

Click and drag the slider for the data-point cursor.

The data cursor display mode is set in ‘Set Preferences / Graphs and Layouts’.

Click to decrement/increment the data cursor by one point at a time, or with the Shift-key, by 10 data points.

Or, the keyboard left/right-arrow keys decrease/increase the data selection by one point; with the Shift key, they decrease/increase the selection by 10 points.

Or, the keyboard Up/Down/Up-arrow keys increase/decrease the data selection by 10 points.

Additional Scope Window Controls

Additional controls are also added to the top of the Scope window, until its 'Done' button closes Scan mode.

Done — Click to close the Scan mode.

? — Click to redisplay the "Scanner" floating window.

[< signal >] [↓]

Signal selector drop-down list.

Sweep [#]

The active sweep selection.

Index [#]

The selected data point number in the sweep.

A data point number can be entered, or use the increment/decrement controls to increase/decrease the selected data point by one point.

X [#]

The X-axis value of the selected data point.

Y [#]

The Y-axis value of the selected data point.

 Write to Notebook

Click to write to the Notebook:

Routine#_Routine name	
sweep=#	sweep
index [signal name]=#	point
x [signal name]=#	data value
y [signal name]=#	data value

If the Shift key is pressed, write the information for all signals to the Notebook.

Alert! If magnifying the plot, it is recommended to use the X and Y range controls in the Scope window vs. using the marquee "Expand" controls, which can result in out-of-bounds points in the graph.

- Fit signal data

  < unavailable, use the Reanalysis Scope window >

- Extract signal data

  < unavailable, use the Reanalysis Scope window >

- Center:

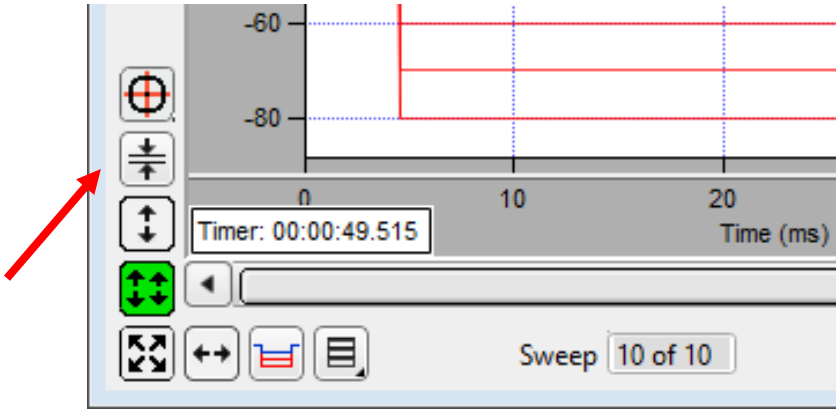


Figure 4-8. Center Button

Center Signal.

Center the Y-range of the X-axis data in the active signal pane. The Y-axis offset is automatically adjusted, while the X-axis scaling is unchanged.

To center all signals, shift-click the button.

- Y-Autoscale

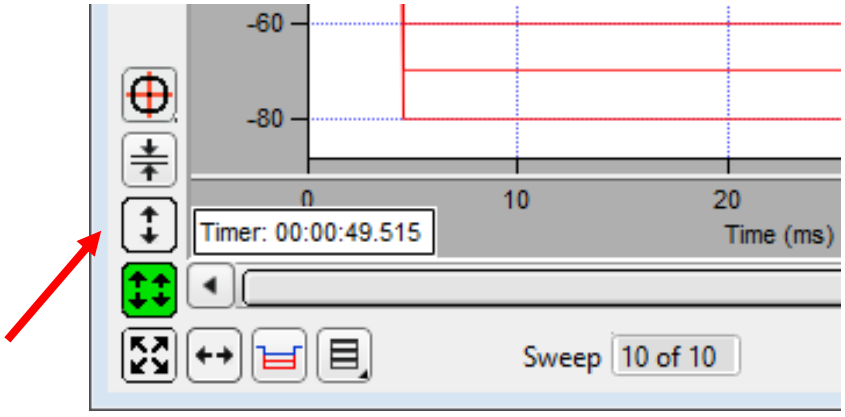


Figure 4-9. Y-Autoscale

Autoscale Y-axis.

Click to autoscale the Y-axis of the selected signal to its visible sweeps data limits.

To autoscale the Y-axes of all visible signals, in “Windows” Shift-click the button, or in “macOS” Control-click the button.

To include the zero amplitude in the Y-ranges, enable “Include zero when autoscaling” in Set Preferences / Scope Window / General.

Tip! To invert the Y-axis of the active signal, such as for data with reversed polarity from an outside-out patch, right-click in the Y-axis of the signal and select Axis Properties / Axis Range. Either reverse the Manual Range Settings / Minimum and Maximum values, or disable the Manual Range and enable the Autoscale Settings / Reverse axis.

- Continuous Y-Autoscale

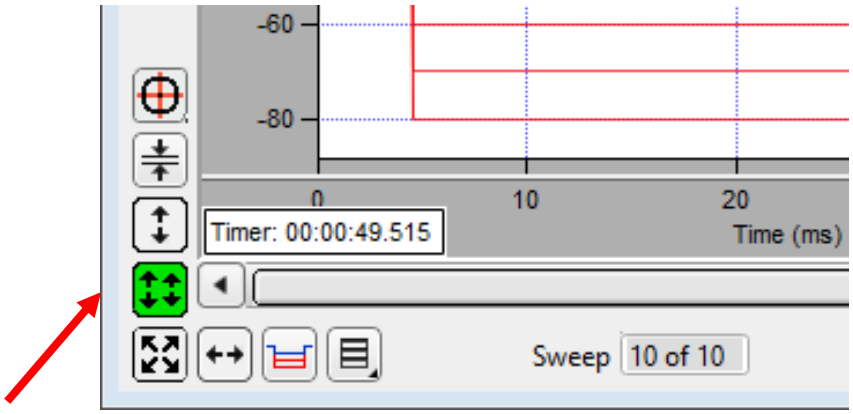


Figure 4-10. Continuous Autoscale All Axes

Continuously autoscale all Y-axes.

Click to continuously autoscale the Y-axes of all signals to their visible sweeps data limits during acquisition. Scaling updates when there is a ~20% change from the previous update.

The Continuous Autoscale button remains enabled (green) in this state. However, continuous autoscaling is disabled by any changes to the Scope window Y-axis scaling or offset.

To include the zero amplitude in the Y-ranges, enable "Include zero when autoscaling" in Set Preferences / Scope Window / General.

- Autoscale All

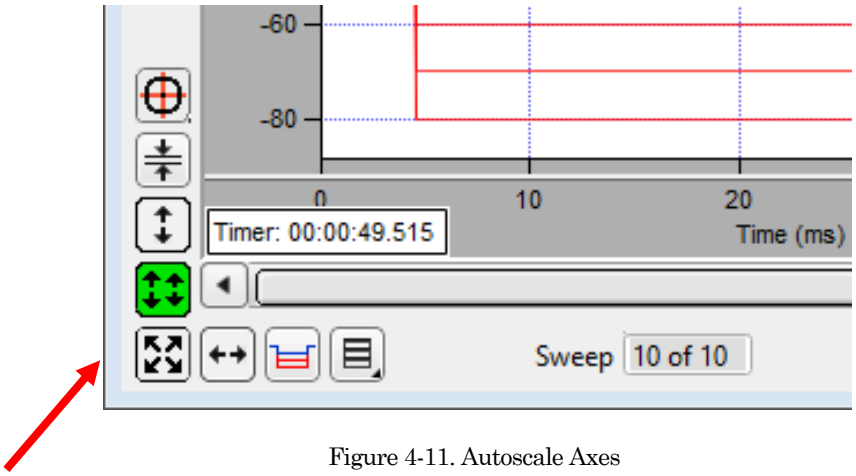


Figure 4-11. Autoscale Axes

Autoscale all axes

Click to one-time autoscale the Y-axes of all signals to their visible sweeps data limits and to set the X-axis range to the maximum defined sweep duration for all signals.

To include the zero amplitude in the Y-ranges, enable "Include zero when autoscaling" in Set Preferences / Scope Window / General.

- X-Autoscale

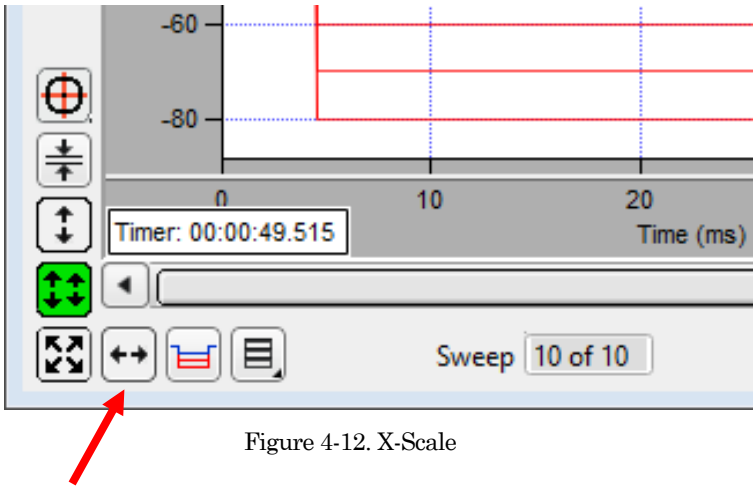


Figure 4-12. X-Scale

Autoscale the X-axis.

Click to set the X-axis range to the maximum defined sweep duration for all signals.

Shift-click the button to access additional X-axis scaling options:

Autoscale the X-axis	Maximize the X-axis range.
Set X-axis scale	Manually set the X-axis range.
X-min	[#]
	Enter the minimum time point.
X-max	[#]
	Enter the maximum time point.

Note: The X-min and X-max values can use different time units.

- Persistence

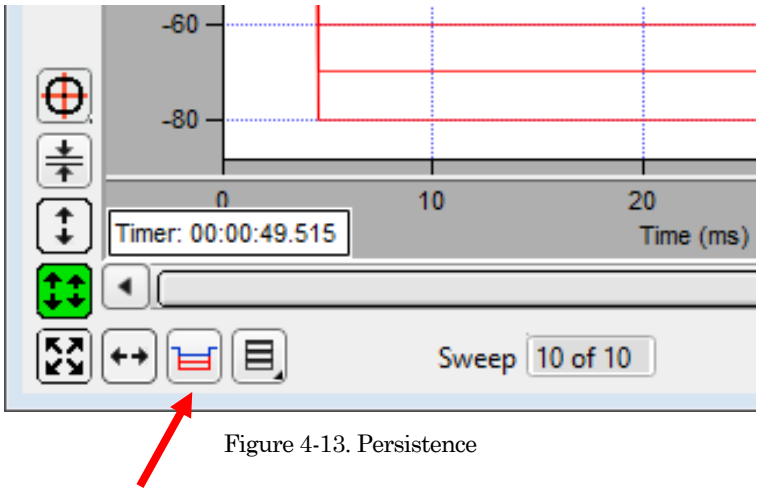


Figure 4-13. Persistence

Persistence data display.

Enable: Overlay each new sweep of data onto the display of any prior sweeps (per Scope Preferences limits).

Disable: For each new sweep, all prior sweeps are cleared, and only the newest sweep is displayed.

Also applies to the Scope window Measurements graphs:

Parametric Plot

Amplitude Histogram Plot

Color Plot

Power Spectrum

- Signal Layout

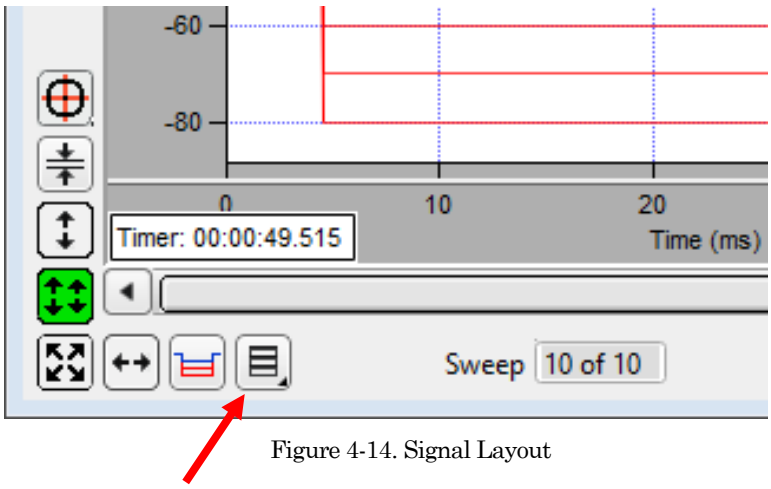


Figure 4-14. Signal Layout

Signal layout.

Set how the input signal panes are graphically arranged:

- Stack Vertical column of signals
- Single Only the active signal
- [m x n] Tiled array of signals in 'm' rows and 'n' columns

- Amplitude Meters

  Amplitude meters are displayed on the right border of input channel panes for physical (non-virtual) channels. They provide visual feedback on the integrity of your data recordings, similarly to how audiometers monitor audio signals.

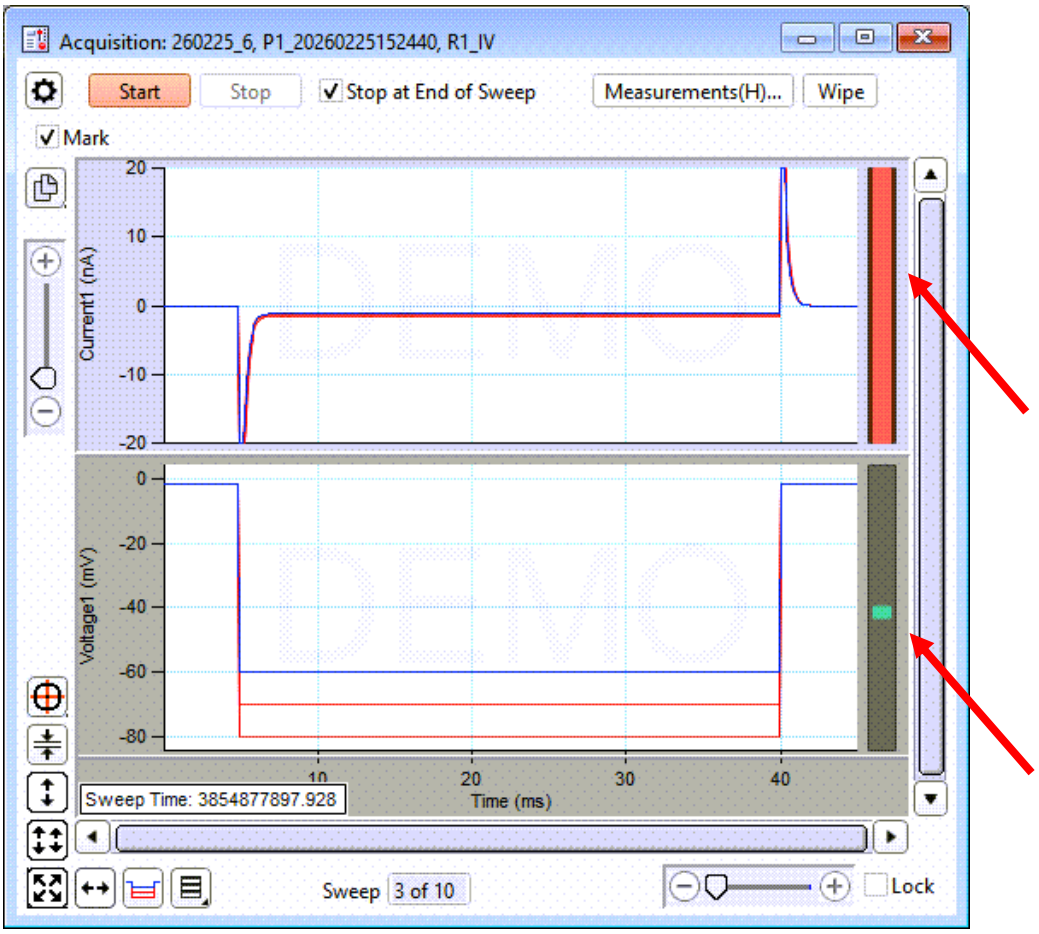


Figure 4-15. Amplitude Meters

For the Triggered Sweeps acquisition mode, headstage and auxiliary input signals have their own Y-axis amplitude meter on the inner-right side of their channel pane.

The height of the colored meter bars represents a signal's data range vs. the full recording range of the IPA amplifier. The color of the meter bar corresponds to the data "health":

- Green: Good — Signal within appropriate range.

  When the recorded data are within acceptable amplitude limits, the amplitude meter displays as green.

- Red: Danger — Signal too large.

  < signal within 10% of range limit >

  When an amplitude meter is displayed in red, it indicates that the data is in danger of going out of range (positive or negative) and becoming invalid.

  When the acquired signal is in danger of saturating, your data can reach or exceed the amplitude limit of the digitization circuitry. If the data saturates, those data points are substituted with the maximum amplitude of their input channel.

  In this case, reduce the input gain for the channel.

- Yellow: Caution — Signal getting small.

  < within 5% range of zero amplitude >

  The recorded signal is approaching a level of insufficient resolution for accurate measurement.

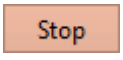
  In this case, increase the input gain for the channel.

  Note: Insufficient gain is only checked for in the headstage input channels, i.e., 'Current' signals in VC mode, and 'Voltage' signals in CC mode, and does not apply to auxiliary input channels.

- Black: N/A — No signal.

  When a new Scope window is activated, its amplitude meters are darkened out, until the first signal is acquired.

Other Scope Controls

 Scope Settings	"Marks" selectively flag sweeps for later reanalysis. Marks are stored with the data, but can be changed during reanalysis. • Set all marks in sweeps of active series • Clear all marks in sweeps of active series • Set all marks in sweeps of active series by equation < see below > ---------- • Begin with all marks set (in sweeps of active series) • Begin with all marks cleared (in sweeps of active series)
[ ] Mark	Enable/disable to "mark/unmark" the current (or upcoming) sweep. This is useful for quality control during slow acquisition of signals. See the Data Navigator 'Available Actions' or use the Reanalysis Scope window to analyze or process marked sweeps.
	Start recording and displaying digitized analog data in the Scope window input channels. When you click the 'Start' button, the Scope window is cleared, the Control Panel Offset is locked, and data recording starts. When acquisition is running, the Scope window updates every 200 ms. If the Sweep Start-to-Start time is ≥ 5 s, the "Time to next sweep: # s" is reported below the Start / Stop buttons. If Metadata prompts are set for Routines or Paradigms, the Confirm Metadata Settings dialog displays just before recording occurs. If measurement graphs are enabled, a docked "child" Analysis window opens and plots sweep-by-sweep measurements. If no paradigm is running, an "Auto-triggered Paradigm" is generated and assigned a Paradigm name with the current Date/Time.
	Stop recording data immediately. If in the middle of a sweep, the partial sweep in progress is also saved. If external triggering is configured, after clicking 'Stop', click the 'Do Trigger' button, and then 'Stop' again.

[ ] Stop at End of Sweep	If the 'Stop at End of Sweep' checkbox is enabled, then the current sweep will complete before data acquisition is stopped, and the last recorded sweep will be a complete sweep of data. The message 'Waiting to stop' displays below the Stop / Start buttons, until the last sweep completes and acquisition stops. If no sweep is in progress, acquisition stops at the end of the next sweep to be recorded.
Measurements	Show Cursors: Display measurement cursors in the Scope window as light gray vertical bars in the signal panes. Each measurement region is bounded by a start-time cursor (the left edge) and an end-time cursor (the right edge). To move a measurement region, click and drag it with the mouse - the region briefly turns dark when selected. To resize a measurement region, click and drag an end-time cursor (the right edge of a region.) Hide Cursors: Do not display cursors in the Scope window. Button displays as "Measurements(H)". Lock Cursors: Prevent cursors from being moved or altered. Button displays as "Measurements(L)". --- *< only available in the Reanalysis Scope >* *Clear Measurements and Graphs* *Analyze with Active Measurements* *Analyze with Original Routine Measurements* *Analyze with Routine Last Executed Measurements* --- Edit Measurements: Open a special Reanalysis Measurements & Graphs dialog, where edits apply instantly to the measurements and graphs during acquisition. These changes override the loaded Routine for quick interactive control. < see below >

	Parametric Plot Plot the relationship between two signals. < see below > Amplitude Histogram Plot Plot an amplitude histogram. < see below > Color Plot Map the data to a color table. < see below > Power Spectrum Plot power spectrum data in a graph of magnitude vs. frequency. < see below > Show Paradigm Overview Scope Enable to display a Paradigm Overview Scope window with data from all Routines in the Paradigm. < if there is no acquired data in the Paradigm, the window does not display > If the Paradigm Overview Scope window is closed while this feature is enabled, it will re-open when data acquisition re-occurs. Hide Paradigm Overview Scope Close any existing Paradigm Overview Scope window, and prevent it from re-opening.
[Wipe]	The 'Wipe Scope' button clears the Scope window of all sweeps before the active sweep, and also clears any corresponding measurements from the Analysis window.
[Do Trigger]	< this green button displays when acquisition is started for a Routine configured with an external trigger >

	Provides a manual trigger option. The message "Waiting for trigger…" also displays.
	Copy graphs To Notebook (as text) < unavailable > To Notebook (as graph) Copy the active signal as a graphic to the Notebook; to copy all visible signals, press with "Shift" key. To Clipboard (as text) < unavailable > To Clipboard (as graph) Copy the active signal as a graphic to the system clipboard; to copy all visible signals, press with "Shift key". k To Printer (as text) < unavailable > To Printer (as graph) Print the active signal directly to the default printer as raw output; to print all visible signals, press with "Shift" key. To Layout (as graph) Copy all visible signals and analysis graphs as a graphic into a new Layout window, or append to an existing Layout page.
Sweep # of #	The active sweep number vs. the total number of configured sweeps is reported. If multiple cycles are set, the active sweep cycle number is inserted between them.
[ ] Lock	Lock the X-axis range Enable this checkbox to retain the X-axis scaling and position for the next activated or created scope window (Acquisition, Free Run, Membrane Test, Reanalysis). However, any changes to the X-axis duration (rescaling or autoscaling) or position (scrolling) disables the 'Lock' option.

Table 4-1. Other Scope Buttons

Analysis Window — If graphs are enabled in the Routine, a real-time 'Analysis window' is docked by default to the right of the Acquisition Scope window.

< see the 'Analysis window' in the Analysis section >

 Scope Settings: "Set all marks in sweeps of active series by equation"

< continued from above >

Sweep Mark: Equation Editor

Enter an equation for the sweeps to mark.

Equation [ ]

value >= 0.1 = 1 (marked)

value < 0.1 = 0 (unmarked)

[Undo] Remove all edits to the equation.

[Check Equation] Check the equation syntax. The equation is evaluated, and if valid, it reports "Syntax is ok."

[Insert special identifier]

Click to make sweep selections:

sweep

Odd(sweep)

Even(sweep)

[Do Mark] Evaluate the equation and update the sweep marking.

[status message]

Measurements and Plots

< continued from above >

Edit Measurements & Graphs

Make real-time changes to the measurements and graphs, even during data acquisition, with this dialog. Edits can instantly override the loaded Routine settings for fast responses.

To access this dialog, click on the Acquisition: Routine Scope window button 'Measurements / Edit Measurements'.

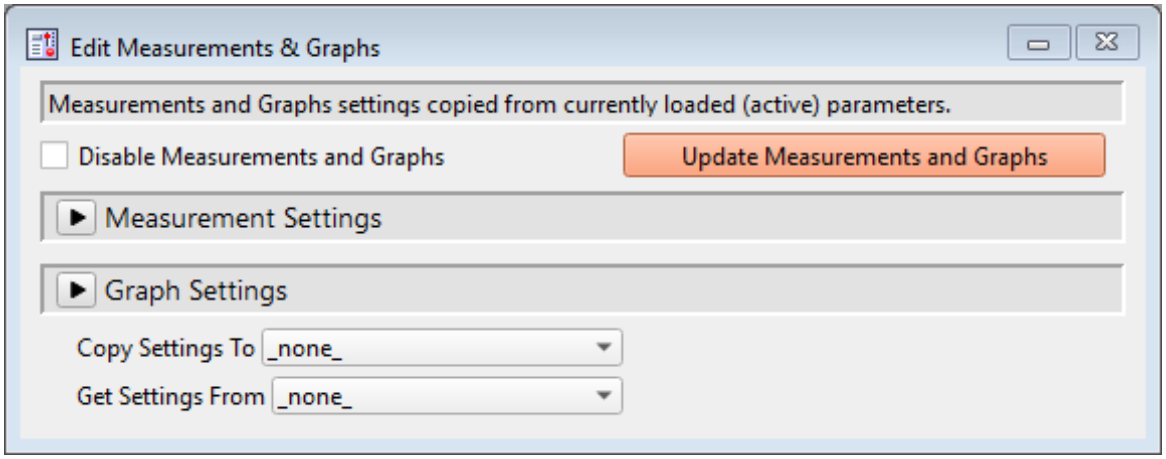


Figure 4-16. Edit Measurements & Graphs

This dialog is the same as in the Routine Editor / Routine Settings / Real Time Measurements & Graphs dialog, with an extra control:

[Update Measurements and Graphs]

Click this button to update the settings for the next data acquisition.

Parametric Plot — Display a graph of X vs. Y input signals in a separate window.

Note: If this window is open when the Scope window is closed, it will also close, but then re-opening the Scope window will also re-open the Parametric Plot window.

Y-signal [< signal >] [↓]

Select an input signal for the Y-axis.

X-signal [< signal >] [↓]

Select an input signal for the X-axis.

Time Range [< range >] [↓]

The time range of the data to be plotted.

Full Sweep — Use the entire sweep for the time range.

Sweep Time — Set relative to the start time of a sweep (time zero).

Start Time [< # s >]

Set the starting time.

Once the Start Time is within 2 ms of the End Time, further Start Time increments will increase the End Time by the same amount.

End Time [< # s >]

Set the ending time.

Once the End Time is within 2 ms of the Start Time, the End Time cannot be decremented.

Segment Time — Set the time range as a ratio of the Segment duration.

Segment [< 1 – 50 >]

Select the Segment number.

Start Ratio [< # >]

Set the starting time ratio.

0.000 = beginning of Segment

End Ratio [< # >]

Set the ending time ratio.

1.000 = end of Segment

[ ] Autoscale Y Range

Enable to keep the data visible by automatically scaling the vertical axis.

Disable to manually scale the Y-axis.

Y-min	[#]
	Manually set the Y-axis minimum.
Y-max	[#]
	Manually set the Y-axis maximum.

 Copy the parametric plot

To Notebook (as text)	Copy the Parametric Plot sweeps value pairs as text to the Notebook.
To Notebook (as graph)	Copy the Parametric plot as a graphic to the Notebook.
To Clipboard (as text)	Copy the Parametric Plot sweeps value pairs as text to the system clip-board.
To Clipboard (as graph)	Copy the Parametric plot as a graphic to the system clipboard.
To Printer (as text)	Print the Parametric Plot sweeps value pairs as text to the default printer.
To Printer (as graph)	Print the Parametric plot a directly to the default printer as raw output.
To Layout (as graph)	Copy the Parametric plot as a graphic into a new Layout window, or append to an existing Layout page.

 Scan or extract data

• Scan data	Open a floating window to manually measure X-Y data points in the active sweep. < see 'Scan signal data' above >
• Fit data	Open a floating window to fit the data. < see the Reanalysis Window 'Signal Data /Fit signal data' >
• Extract data	Open a floating window with data

extraction controls.

< see the 'Analysis Window/Extract analysis data' >

Alert! If magnifying the plot X-range, it is recommended to use the Time Range control in the plot (vs. using the marquee "Expand" controls, which can result in non-optimal axis settings or out-of-bounds points in the graph).

[Plot] Click to update the plot using the new parameters.

[graph pane] Displays the plotted data.

Amplitude Histogram Plot

Open a real-time histogram plot window. The amplitude data are plotted (during or after acquisition) as samples are binned. The window is cleared at the start of a new Series.

Note: If this window is left open when the Scope window is closed, it will also close, but then re-opening the Scope window will also re-open the Amplitude Histogram Plot window.

Y-signal [< signal >] [↓]

Select the input signal to be analyzed.

Histogram Bins [< 50, 100, 200, 500, 1000, 2000, 4000 >] [↓]

Select the number of bins for the amplitude range (X-axis). Changes instantly update the plot.

Time Range [< range >] [↓]

The time range of the data to be plotted.

Full Sweep Use the entire sweep for the time range.

Sweep Time Set relative to the start time of a sweep (time zero).

Start Time [< # s >]

Set the starting time.

End Time [< # s >]

Set the ending time.

Segment Time — Set the time range as a ratio relative to the Segment duration.

Segment — [< 1 – 50 >]

Select the Segment number.

Start Ratio — [0.000 = beginning of Segment]

Set the starting time ratio.

End Ratio — [1.000 = end of Segment]

Set the ending time ratio.

[ ] Autoscale X Range

Enable to keep the data visible by automatically scaling the horizontal axis.

Disable to manually scale the X-axis.

X-min — [#]

Manually set the X-axis minimum.

X-max — [#]

Manually set the X-axis maximum.

Copy the amplitude histogram

To Notebook (as text) — Copy the Amplitude histogram amplitude/bin count values as text to the Notebook.

To Notebook (as graph) — Copy the Amplitude histogram as a graphic to the Notebook.

To Clipboard (as text) — Copy the Amplitude histogram amplitude/bin count values as text to the system clipboard.

To Clipboard (as graph) — Copy the Amplitude histogram as a graphic to the system clipboard.

To Printer (as text) — Print the Amplitude histogram directly to the default printer as raw output.

To Printer (as graph) — Print the Amplitude histogram directly to the default printer as raw output.

To Layout (as graph) — Copy the Amplitude histogram as a graphic into a new Layout window, or append to an existing Layout page.

Scan or extract data

Scan data — Open a floating window to manually measure X-Y data points in the active sweep.

< see 'Scan signal data' above >

Fit data — Open a floating window to fit the histogram data.

< see the Reanalysis window 'Signal Data/Fit signal data' >

Extract data — Open a floating window with data extraction controls.

< see the Reanalysis Window 'Signal Data/Extract signal data' >

Alert! If magnifying the plot X-range, it is recommended to use the Time Range control in the plot vs. using the marquee "Expand" controls, which can result in non-optimal axis settings or out-of-bounds points in the graph.

[ ] Cityscape — Enable to show the plot in a stair-step "cityscape" display (vs. a smooth interpolated line.)

[Plot] — Update the plot using the new parameters.

[graph pane] — Displays the plotted data.

Color Plot — Plot amplitude data (during or after acquisition) in a false-color graph of Sweep vs. Time.

The data display for a sweep is centered on its Y-axis whole number tick mark (±0.5).

Tip! This "heat map" display mode is commonly used in fast-scan cyclic voltammetry.

Note: If this window is left open when the Scope window is closed, it will also close - then re-opening the Scope window will also re-open the Color Plot window.

Signal [< signal >] [↓]

The color graph is based on the selected input signal.

If no such signal name exists in the current Series, the color graph is blank.

[< range >] [↓] Select the Y-axis data range to be used for a Plot.

Auto Range Use an autoscaled Y-axis range for the data to be mapped into the color lookup table (CLUT).

Scope Y Axis min and max

Use the Scope's lower and upper Y-axis limits for the color mapping.

Given min and max Manually set the Y-axis data limits for the color mapping.

Min [#]

Manually set the Y-axis minimum.

Max [#]

Manually set the Y-axis maximum.

Color Table [< color >] [↓]

Color lookup table.

Reverse Reverse the color lookup table.

 Copy the false color graph

To Notebook (as text) < unavailable >

To Notebook (as graph) Copy the Color graph as a graphic to the Notebook.

To Clipboard (as text) < unavailable >

To Clipboard (as graph) Copy the Color graph as a graphic to the system clipboard.

To Printer (as text) < unavailable >

	To Printer (as graph)	Print the Color plot directly to the default printer as raw output.
	To Layout (as graph)	Copy the Color graph as a graphic into a new Layout window, or append to an existing Layout page.
	Scan data or extract plot	
	Scan data	Open a floating window to manually measure X-Y data points in the active (last) sweep. < see 'Scan signal data' above >
	Extract plot	Open a floating window with data extraction controls. < see the Analysis Window 'Extract analysis data' >

Alert! If a plot region is magnified with the marquee "Expand" controls, the entire graph is still extracted.

[Plot]	Update the false-color graph using the new parameters.
[graph pane]	Displays the color graph.

Power Spectrum — Plot power spectrum data (during or after acquisition) in a graph of Magnitude vs. Frequency.

Note: If this window is left open when the Scope window is closed, it will also close, but then re-opening the Scope window will also re-open the Power Spectrum window.

FFT output mode	[< mode >] [↓]
	Real output
	Magnitude
	Magnitude squared
	Scaled magnitude
	Scaled magnitude squared
Signal	[signal] [↓]

The Power Spectrum is based on the selected input signal.

If no such signal name exists in the current Series, the Power Spectrum graph is blank.

Copy Power Spectrum

To Notebook (as text)	Copy the Power Spectrum frequency/magnitude values as text to the Notebook.
To Notebook (as graph)	Copy the Power Spectrum as a graphic to the Notebook.
To Clipboard (as text)	Copy the Power Spectrum frequency/magnitude values as text to the system clipboard.
To Clipboard (as graph)	Copy the Power Spectrum as a graphic to the system clipboard.
To Printer (as text)	Print the Power Spectrum frequency/magnitude values as text to the default printer.
To Printer (as graph)	Print the Power Spectrum directly to the default printer as raw output.
To Layout (as graph)	Copy the Power Spectrum as a graphic into a new Layout window, or append to an existing Layout page.

Scan or extract data

• Scan spectra	Open a floating window to manually measure X-Y data points in the active sweep. < see 'Scan signal data' above >
• Fit spectra	Open a floating window to fit the power spectrum data. < see the Reanalysis Scope window 'Signal Data / Fit signal data' >
• Extract spectra	Open a floating window with data

extraction controls.

< see the Reanalysis Window 'Signal Data / Extract signal data' >

Alert! If magnifying the plot X-range, it is recommended to use the Time Range control in the plot vs. using the marquee "Expand" controls, which can result in non-optimal axis settings or out-of-bounds points in the graph.

[graph pane] Displays the power spectrum graph.

Show/Hide Paradigm Overview Scope

Plot the data (during or after acquisition) from all Routines in the Paradigm in a modified Scope window.

The Paradigm Overview Scope window has similar controls to the Acquisition Scope window, with a couple of new controls:

Auto Width — Continuously increase the X-axis scaling to accommodate new data within the window.

Fixed Width (s) — [< 10 – 3600 >]

In 'Continuous Mode' sweeps display, keep the X-axis range at the specified width.

Right-click Menus

X Axis

Autoscale All Axes — Scale all signals Y-axes to their data, and set the X-axis range for all signals to the maximum defined sweep duration.

Autoscale X Axis — Set the X-axis range for all signals to the maximum defined sweep duration.

Set X Scale — Manually set the X-axis range.

X-min — [< # >]

Enter the minimum X-axis value.

X-max — [< # >]

Enter the maximum X-axis value.

Axis Properties — Open the 'Modify Axis' window to set the axes styles and components.

Y Axis

Autoscale All Axes — Scale all signals Y-axes to their existing data, and set the X-axis range for all signals to the maximum defined sweep duration.

Continuous Autoscale Y Axis — Continuously scale the signal's Y-axis to its data until the end of the recording.

Autoscale Y Axis — Autoscale the signal's Y-axis to its existing data.

Full scale Y Axis — Set the signal's Y-axis to its full-scale range.

Use Last Y Scale — Maintain the Y-axis scaling at its existing range, overriding any prior Y-axis scaling settings.

Set Y Scale — Manually set the Y-axis range.

Y-min [<#>]

The Y-axis minimum value.

Y-max [<#>]

The Y-axis maximum value.

Copy Y scale of signal [< signal >] [↓]

Apply the Y scaling from another signal.

Axis Properties — Open the 'Modify Axis' window to set the axis style and components.

Can use to reverse the Y-axis polarity (such as for inside-out or cell-attached patches).

Axis Range tab

Manual Range Settings

[ ] Minimum: [#]

Enable and enter a positive number.

[ ] Maximum: [#]

Enable and enter a negative number.

Or, if Y-axis autoscaling will be used:

Click the 'Uncheck Both' button, and use

Autoscale Settings

[x] Reverse axis: Enable.

[ ] Autoscale Only Visible Data: Disable.

Hide Signal < name >	Hide the selected signal in the scope window.
Show Signal < name > Only	Show the selected signal in the scope window and hide all other signals.
Stack All Signals	Display all signals stacked in a single column layout.

Main Window

Limited data modification menu

Right-click in the blank area in a signal pane.

Tip! If you click too close to the signal data, the full data modification menu displays instead; if this occurs, click near a horizontal or vertical edge of the signal pane.

Autoscale All Axes	Scale all signals Y-axes to their data, and set all signals X-axes to their full-scale range.
Add Annotation	Add a floating text-box label to the signal pane. To edit or delete an annotation, double-click on it.
Export Graphics	Copy the signal to

To Standalone Graph

To Notebook

To Clipboard

To Printer

Colors	Adjust the colors used by the active signal pane:
graph background	The background of the pane.

all axes	The X- and Y-axis areas.
all grids	The grid lines in the pane.
all tick labels	The tick labels in the X- and Y-axis areas.
all axis labels	The axis labels in the X- and Y-axis areas.

Hide Signal < name >	Hide the selected signal in the scope window.
Show Signal < name > Only	Show the selected signal in the Scope window, and hide all other signals.
Show Last Sweep of < name> Only	< displays when “All Sweeps” are shown > Display only the last [marked] sweep of the selected signal.
or	
Show All Sweeps of < name >	< displays when “Last Sweep” is shown > Restore the display of all [marked] sweeps in the selected signal.
Stack All Signals	Display all signals stacked in a single column layout.

Marquee

Click and drag the mouse to surround a region of interest, and right-click for a context menu:

Expand	Set the signal’s Y-axis range from the marquee vertical data limits, and set all signals X-axes ranges from the marquee horizontal data limits.
Horiz Expand	Set all signals X-axes ranges from the marquee horizontal data limits.
Vert Expand	Set the signal’s Y-axis range from the marquee vertical data limits.
Shrink	Move the signal’s Y-axis current limits to the position of the marquee vertical data limits, and move all signals X-axes current limits to the position of the marquee horizontal data limits.

Horiz Shrink	Move all signals X-axes current limits to the position of the marquee horizontal data limits.
Vert Shrink	Move the signal's Y-axis current limits to the position of the marquee vertical data limits.
Extract Template	Copy the last sweep to the Template Editor.
Extract To Graph	Display the first trace in a floating window, using all data within the X-range.

Signal Data

Full data modification menu

Right-click on or near the data to display this context menu, which includes options to modify sweeps and data points, such as marker symbols and lines.

Recent additions include:

Export Graphics	Duplicates the 'Copy to' button.

4.1.3 Camera Control

SutterPatch: Camera Control

The Camera Control window displays still pictures or live video.

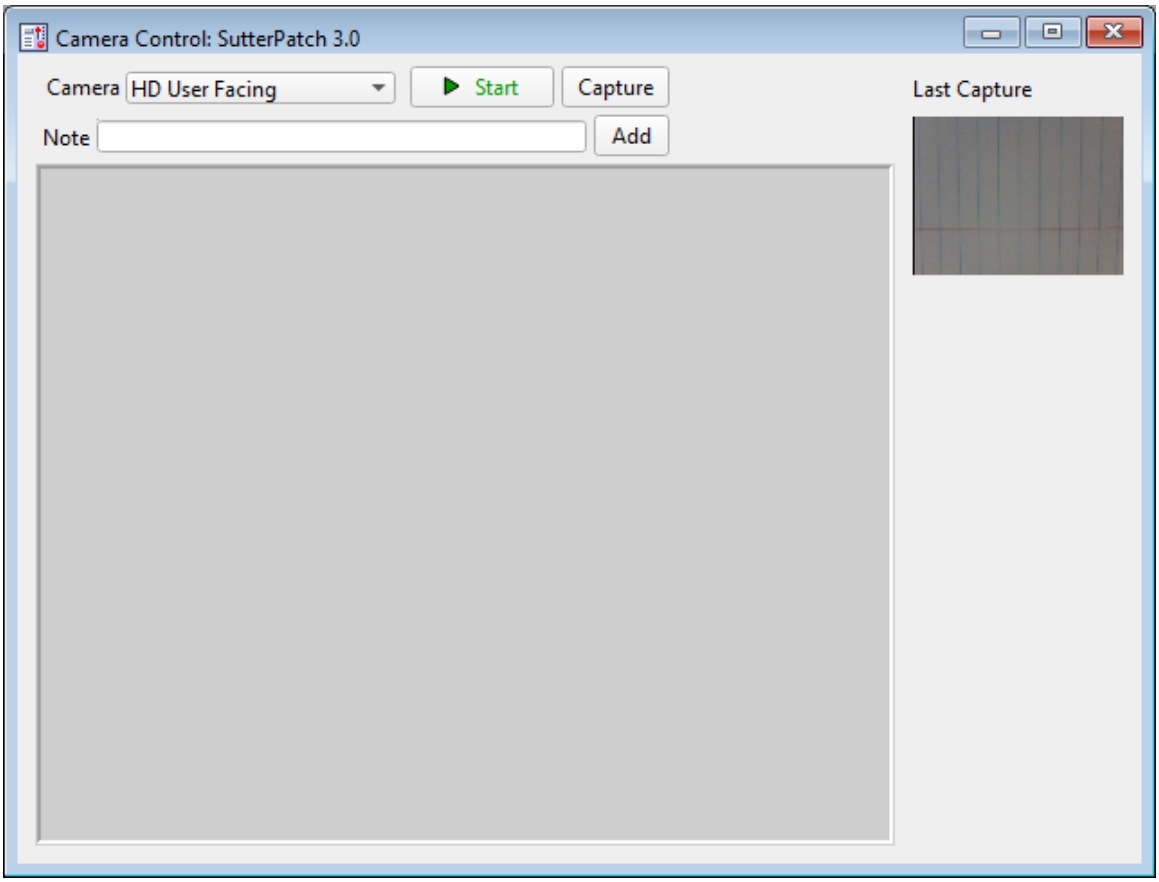


Figure 4-17. Camera Control

Camera [< camera >] [↓]

Select a camera name from those attached to the computer.

[Start] View live video. This data is not stored.

[Capture] Take a single picture. If live video is running, this will take a picture while live video continues to run. The image time-stamp is reported in the Log window.

Last Capture A thumbnail of the last picture taken in the Experiment is displayed.

All pictures are stored in the current Experiment. To review pictures, go to the Data Navigator and select a Paradigm or Routine. Any associated images are listed in the Preview pane. Click on an image

name to display the image.

Note [< text >]

Enter a text message for the 'Last Capture' image.

[Add] Update the 'Last Capture' image with the Note text.

Notes are visible in the Data Navigator 'Images' preview windows.

[video screen]

Tip! For dark-room experiments, the window background color can be adjusted by the operating system.

Windows: In the Windows Control Panel (Appearance and Personalization) Ease of Access Center window, in 'Make the computer easier to see', select Colors > Personalization > Colors > Choose your mode > Dark.

macOS: Press 'Control-Option-Command-8' to set the System Preferences / Accessibility / Display / Invert Display colors option, or open its menu with 'Command-Option-5'.

Drivers

Full-camera drivers have been successfully tested for the following camera models:

Sentech drivers:

STC-MC33USBVGA
STC-MCS231U3V
STC-MB83USBVGA
STC-MBCM401U3V
STC-MBCM401U3V-NIR
STC-HD203DV

Photometrics PVCAM drivers:

Photometrics: Prime 95B
Prime 95B 25mm

Qimaging: Electro

Controls for contrast and saturation will display for cameras that support them.

4.1.4 Free Run (Scope)

SutterPatch: Free Run

The Free_Run Scope window simulates a one-channel oscilloscope, and is a quick method of viewing repetitive or scrolling data.

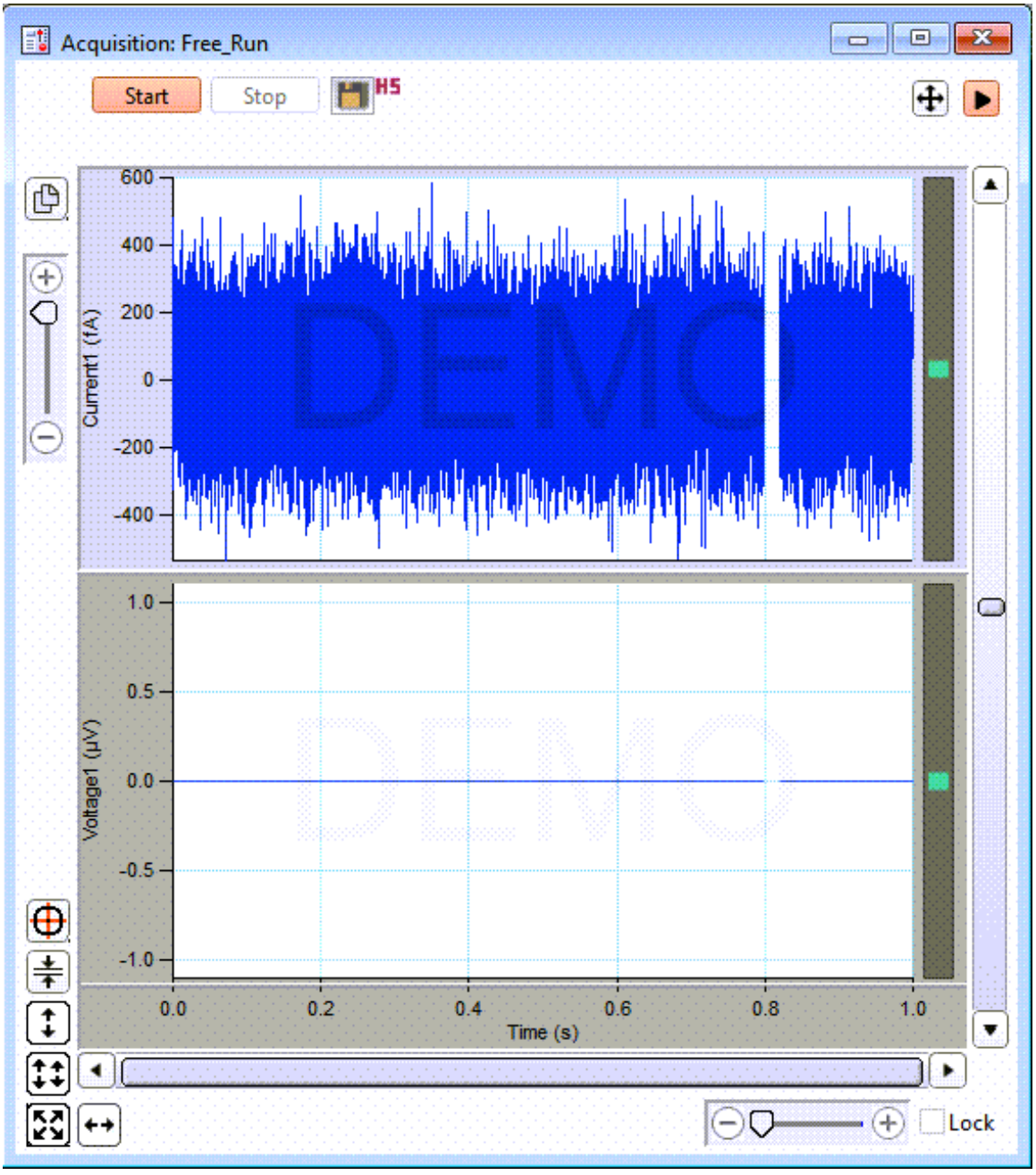


Figure 4-18. Free Run Scope

This window operates similarly to the Acquisition: Scope window, with unsupported controls removed or disabled.

However, when this Scope window is initially created, the Autoscale button is set to the last used state, instead of using a Preferences setting.

Note: Copying to the clipboard can temporarily pause the Free Run display for several seconds, until the display catches up to the actual acquisition.

Free Run Settings panel

Signal Parameters

Channel	[< Current1 – 2, Voltage1 – 2, AuxIN1 – 4 >] [↓] Select an input channel to monitor Channel labels depend upon the number of configured headstages. The default channel is 'Current1' in VC mode, and 'Voltage1' in CC mode.
Duration	[< 0.1, 0.2, 0.5, 1.0, 2.0, 5.0, 10.0, 20.0, 50.0, 100.0 s >] [↓] The duration of the data sweep.
Sampling rate	[< 5, 10, 20, 50 kHz >] [↓] The sampling rate of the selected input channel.

4.1.5 Membrane Test

SutterPatch: Membrane Test

The Membrane Test is primarily used to monitor seal formation and cell health in a voltage-clamp whole-cell patch-clamp configuration.

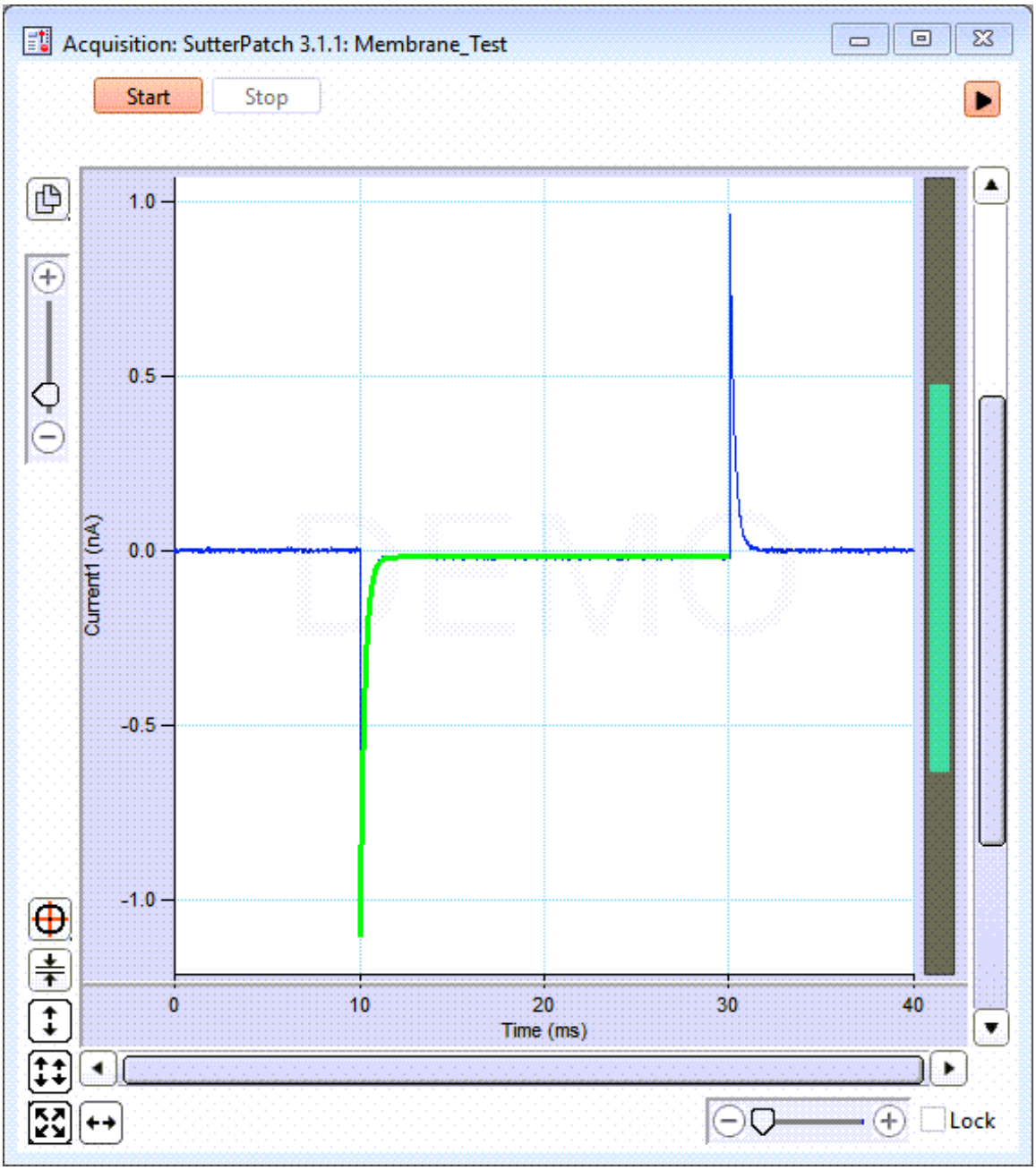


Figure 4-19. Membrane Test Scope

Acquisition: Membrane_Test

This Scope window operates similarly to the Acquisition: Scope window.

Differences to the Scope window for the Membrane Test:

- Unsupported buttons and controls were removed (Persistence Display, Signal Layout, Sweeps Counter).
- The Sweeps Counter only displays when the Membrane Test is run from a Paradigm with numbered "Repeats" configured.
- By default, the Scope window displays the Current signal from the active Sutter head-stage.
- The Membrane Test always opens in a "running" state.
- During an Experiment, the Autoscale button is set to the last used state, instead of using a Preferences setting.
- If a signal is hidden via the right-click menu, retrieve it by using the right-click menu item 'Stack All Signals'.

Note: Current-clamp mode operation is also supported if 'Electrode Compensation' (capacitance neutralization) is perfectly set.

Membrane Test Settings

Configure all Membrane Test parameters in the Membrane Test Settings panel. This panel automatically opens when the Membrane Test is opened or started.

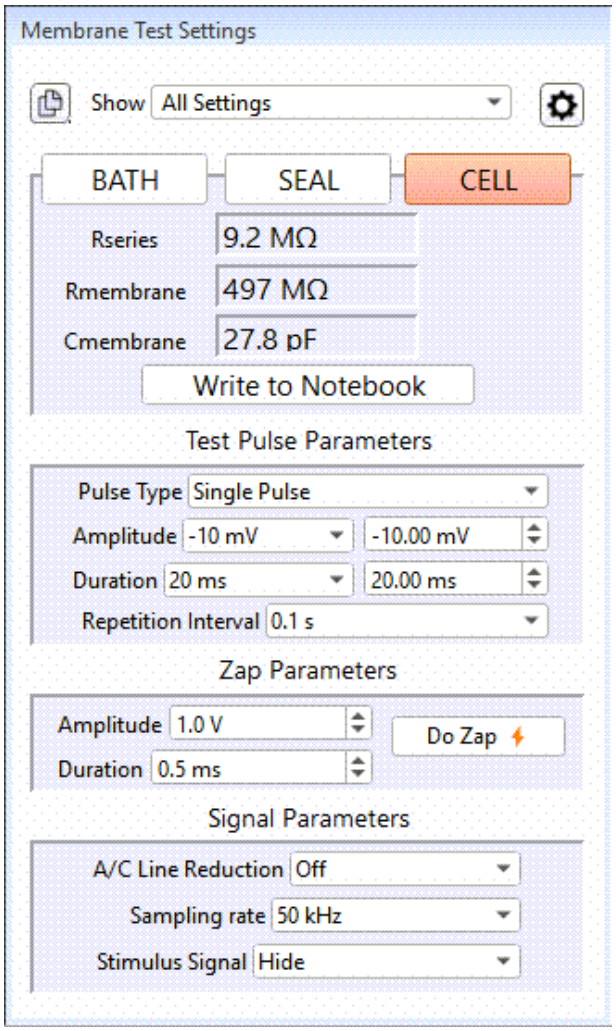


Figure 4-20. Membrane Test Settings

Copy measurements	Results are from the last executed Membrane Test, and are date and time stamped.
To Notebook (as text)	Copy the results and test pulse settings as text to the Notebook.
To Notebook (as graph)	Copy the Settings panel as a graphic to the Notebook.
To Clipboard (as text)	Copy the results and test pulse settings as text to the system clipboard.
To Clipboard (as graph)	Copy the Settings panel as a graphic to the system clipboard.

To Printer (as text)	Print the results and test pulse settings as text directly to the default printer as raw output.
To Printer (as graph)	Print the Settings panel directly to the default printer as raw output.
To Layout (as graph)	< unavailable >

The following measurements are copied:

Bath mode:	IHold, IDiff, Rpipette
Seal mode:	IHold, IDiff, Rseal
Cell mode:	IHold, Tau, Qt, Rt, Rs, Rm, Cm

< for more information, see the Membrane Test algorithms in Appendix F >

Show [< display >] [↓]

- Monitor Only — Display the numeric meters only.
- All Settings — Display the numeric meters and parameter sections per the Membrane Test Preferences.

Show settings menu

- Show Analysis Fit Trace

The Membrane Test Settings panel contains “mode” buttons for the three basic steps to form a whole-cell seal:

1) Bath — With a new pipette in the bath solution, a low-resistance square pulse is visible. The pipette resistance should be very low if the tip is not clogged.

   For whole-cell patch clamping of dissociated/cultured cells, typical pipette resistances are 1 – 5 MΩ. For brain slice recordings, pipette resistances up to 20 MΩ or higher are used.

2) Seal — When an on-cell patch is formed between the pipette and the cell, voltage transition spikes are visible. The seal resistance increases as the seal forms. The goal is to achieve a “gigaseal” with a resistance above 1 GΩ.

3) Cell — After breaking through the cell membrane and creating a whole-cell patch, membrane resistance and capacitance measures are calculated from the resulting capacitance spikes.

The Membrane Test calculations are displayed in real-time numeric fields. The refresh rate is ~ 3 Hz for readability.

Click these buttons to switch the test mode.

[Bath]	Rpipette (MΩ)	Pipette Resistance meter. (Model cell = ~10 MΩ)
[Seal]	Rseal (MΩ)	Seal Resistance meter. (Model cell = ~1 GΩ to 1 TΩ) < in "open circuit" >
[Cell]	Rseries (MΩ)	Series Resistance meter. (Model cell = ~10 MΩ) < 'Series Resistance' and 'Access Resistance' are equivalent terms > Monitoring the Series Resistance is helpful, as healthy isolated cells typically range up to 10 MΩ, while for hERG cells, up to 20 MΩ. This value should remain stable over the course of the experiment. If the Series Resistance increases by more than 5%, the electrode tip might be clogged.
	Rmembrane (MΩ)	Membrane Resistance meter. [Model cell = ~500 MΩ]
	Cmembrane (pF)	Membrane Capacitance meter. [Model cell = ~28 pF]

Tip! Capacitance values should be periodically checked to monitor the health of the cell due to osmosis and swelling.

Alert! 'Cell Compensation' and 'Rs Correction' (in the Amplifier Control Panel) must be disabled, so that uncompensated whole-cell capacitance spikes are generated for the calculation of the Series Resistance and Membrane Capacitance ; if not disabled, the Rseries and Cmembrane values are reported as "OFF".

Note: Demo values for Cell mode can vary from the model cell values. Reported values are dependent upon experimental variables and settings, such as cell and pipette size, solution conductivity, test pulse duration, etc.

The demo input signal is computed for the selected bath/seal/cell configuration and the following parameters:

Sampling rate: 10 kHz	Set in Amplifier Control Panel.
Averaging: 10	Set in MT Measure Parameters 'Num to Average'.

Also, these amplifier settings are applied to the given simulation:

CSlow = 30 pF	
RSeries = 10 MOhm	Cell Compensation Rs
CFast = 5 pF	Electrode Compensation Mag
CFastTau = 4 µs	Electrode Compensation Tau
PipResistance = 10 MOhm	Rpipette
SealResistance = 1 GOhm	Rseal
CellResistance = 500 MOhm	Rmembrane

[Write to Notebook] Click the 'Write to Notebook' button to write the last acquired measurements for that mode to the Notebook window. Valid measurements are logged for the active headstage.

Test Pulse Parameters

Pulse Type [< type >] [↓]

- Single Pulse — A single unidirectional square pulse.
- Double Pulse — Two contiguous symmetrical bipolar square pulses.
- Triangle — A train of 5 contiguous symmetrical bipolar triangular pulses.
- RMS Noise — A zero amplitude stimulus to allow RMS noise calculations.

  Only the holding level is output, no test pulse is generated, and the RMS noise of the response sig nal is measured

  An 'RMS noise' field replaces the first real-time numeric field.

The noise is measured 5 – 10x per second, and a running average is displayed from the last 10 repeats.

Amplitude [< Other, -100, -50, -20, -10, -5, -2, -1, 0.1, 1, 2, 5, 10, 20, 50, 100 mV] [↓]

VC mode: [< ±1.00 V >]

A pulse amplitude is required.

Any value less than |0.1| mV (absolute) is reset to ±0.10 mV.

CC mode: [±2000.00 pA]

A pulse amplitude is required.
Any value less than |0.1| pA (absolute) is reset to ±0.10 pA.

Amplitude is relative to the 'Holding' level in the Amplifier Control Panel.

Duration [< 1, 2, 5, 10, 20, 50, 100, 200, 500 ms >] [↓]

Set long enough for the signal to reach its asymptote, or measurements can be incorrect.

Repetition Interval

[< Shortest Possible; 0.1, 0.2, 0.5, 1.0, 2.0, 5.0, 10 s >] [↓]

Sweep start-to-start interval.

Note: The "Shortest Possible" fastest timing is ~40 ms.

Also, the shorter intervals might not be available for Windows 10 or earlier.

Zap Parameters

After a gigaohm patch has been achieved, use Zap in the Seal mode to disrupt the cell membrane, as an alternative to suction in creating a whole-cell patch.

"Zap" sends a single square wave voltage pulse from the IPA headstage to the preparation.

Amplitude [< 0.1 - 1.0 V >]

Set the amplitude of the zap pulse.

Duration [< 0.1 – 2.0 ms >]

Set the duration of the zap pulse.

[Do Zap] Click this button to send the pulse(s) to the preparation.

Signal Parameters

Channel [< channel >] [↓]

< only displays for DIPA systems >

- Headstage 1
- Headstage 2

Select the headstage input channel to display in the Scope window.

< the following settings apply to both headstages >

A/C Line Reduction [↓]

< set Hz in Set Preferences / Hardware >

- Off Do not apply A/C line noise filtering.
- 50 Hz Use a power line frequency of 50 Hz,

  or
- 60 Hz Use a power line frequency of 60 Hz.

Alternating current (AC) power contains 50 or 60 Hz oscillations that can cause sinusoidal line-frequency noise in recorded signals. This FFT-based filter reduces such noise by > 90% over 6 harmonics.

The adjusted signal is displayed in real time.

Sampling rate [< rate >] [↓]

10 kHz

20 kHz

50 kHz

Stimulus Signal

[< status >] [↓]

Show

Hide

4.1.6 Paradigm Editor

SutterPatch: Paradigm Editor

The Paradigm Editor is an advanced feature that opens up a world of complex experimental control via Paradigms and Paradigm Pools. A rich set of operators and actions are available to control and/or automate data acquisition and analysis.

The Paradigm Editor allows you to create "Planned Paradigms", which offer almost unlimited flexibility in creating and/or automating your patch-clamp experiments, such as running Routines and directly controlling amplifier settings.

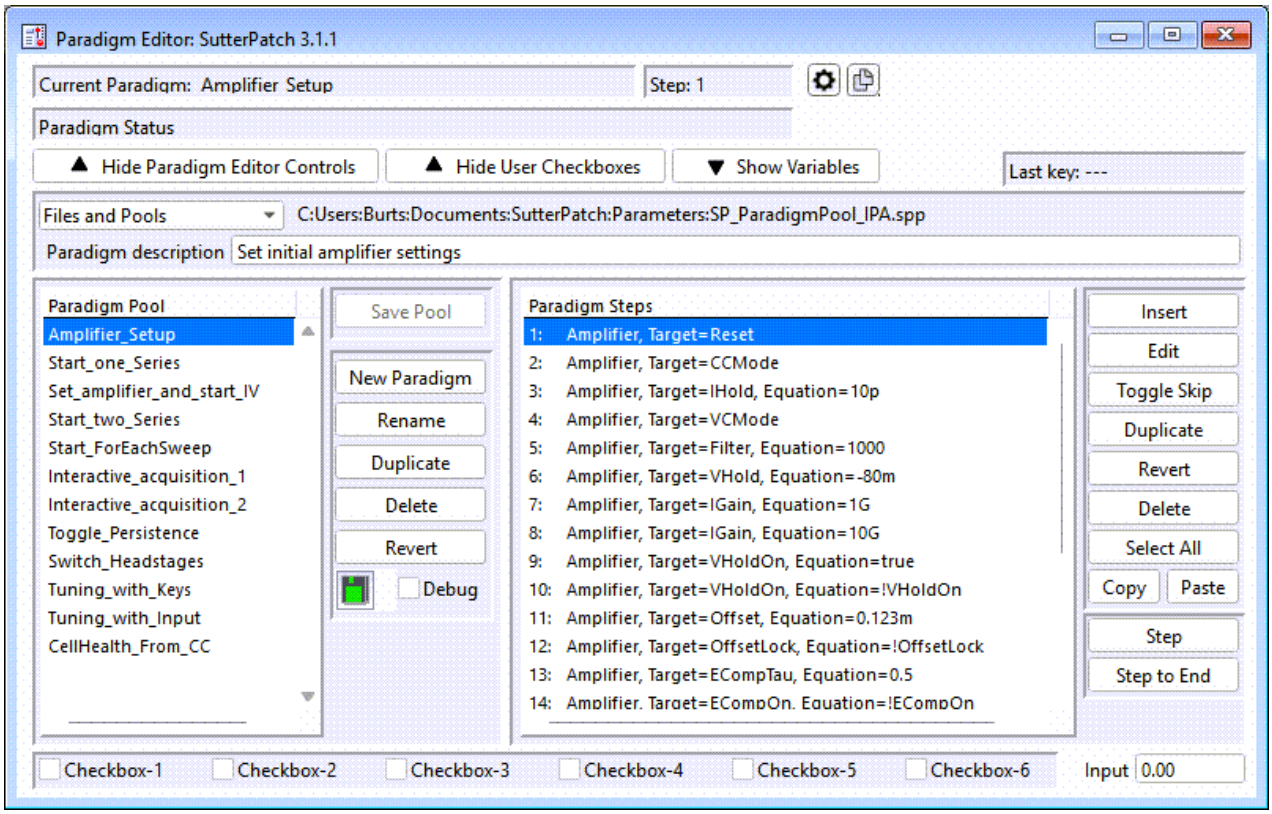


Figure 4-21. Paradigm Editor

Loaded Paradigms display on the left, while loaded Paradigm Steps display on the right. A bottom section can display interactive checkbox controls and/or variables.

Controls

[Current Paradigm: < name >]

The name of the currently loaded Paradigm.

[Step: #] The highlighted Paradigm Step.

 Settings

Write steps to notebook

Write no steps to metadata

Write main steps to metadata

Write all steps to metadata

Slow speed (slow down execution to one step per second)

Pause between Steps	Press the Acquisition Control 'Resume' button to execute each Step one at a time.

Edit titles of user checkboxes.

Edit the checkbox titles in the Paradigm Editor window.

Edit User Checkbox Titles

Number of checkboxes to show	[< 6, 12 >] [↓]
	Select how many checkboxes to display in the Paradigm Editor window.
Title of checkbox-#[1 – 12]	[< title >]
	If left blank, it reverts to the default "Checkbox-#".

 Copy steps

To Notebook (as text)	Copy the Paradigm steps as text to the Notebook.
To Notebook (as graph)	Copy the Paradigm steps as a graph to the Notebook.
To Clipboard (as text)	Copy the Paradigm steps as text to the system clipboard.
To Clipboard (as graph)	Copy the Paradigm steps as a graph to the system clipboard.
To Printer (as text)	Print the Paradigm steps as text directly to the default printer as raw output.

To Printer (as graph) — Print the Paradigm steps as a graph directly to the default printer as raw output.

To Layout (as graph) — < unavailable >

[< Paradigm Status >] — Status information about Paradigm execution.

[Show/Hide Paradigm Editor Controls]

The Paradigm Editor controls (and checkboxes) for the Paradigm Pool and Paradigm Steps can be displayed or hidden.

Additional manual controls are located in the Acquisition Control panel:

Start/Stop Paradigm

Set Tag

Reset Timer

[Show/Hide User Checkboxes]

Checkbox controls are displayed at the bottom of the Paradigm Editor controls, for use in conditional Paradigm step execution. This display is dependent upon Show Editor Controls.

[Show/Hide Variables] — A Variables table can be displayed at the bottom of the Paradigm Editor. These paradigm variables can be utilized in any equation.

Variable names can be edited to any label, but they are only informational, and are not supported in equations.

[Last key: "< key > "] — < this entry is cleared at the start of a Paradigm >

The last key (or key combination) pressed on the keyboard (when SutterPatch has the system focus) is displayed here. This is used in the 'If" and 'ElseIf" Paradigm steps condition "Check for key pressed".

All lower case keys (except "\") plus "Caps Lock" enabled alphabet letter keys are supported.

Function keys unassigned to a Shortcut are supported. However, the <FN> Function key is not supported, and does not display when used in a key combination.

Key combinations are supported with the <Shift> and <Alt> keys, and with unassigned (Shortcut and system) <Ctrl> key combinations.

< see sample Paradigm 'Tuning with Keys' >

[Files and Pools] [↓] These file operations affect "Paradigm Pools", which can contain multiple Paradigms.

Warning! Microsoft OneDrive is not supported. Do not use to store program files or to acquire data to, or unexpected problems can occur.

[< file names >] Most recently used list of the last 5 Paradigm Pool file names.

To manually remove a file from the list, Shift-click it.

Note: Path names have a limited number of characters to use. While file names are preserved, path names are shortened by removing excess characters from their ends.

Load Paradigm Pool Load the Paradigms of a previously saved Paradigm Pool file into the Paradigm Pool.

New Paradigm Pool Create a new blank Paradigm Pool and optionally copy Paradigms into it from the existing Paradigm Pool.

The suggested name is auto-incremented from the previously loaded Paradigm Pool name.

Get Sample Paradigm Pool Load the sample Paradigm Pool file SP_ParadigmPool_IPA.spr. This file is used for both IPA and DIPA systems.

Revert to Last Saved Undo any unsaved changes to the Paradigm Pool.

Save Paradigm Pool Save the Paradigm Pool using its existing file name and path.

Save Paradigm Pool As Save the Paradigm Pool to a new file, and switch to the new file. The default file name is the same as the original file name.

Save Paradigm Pool Copy Save the Paradigm Pool to a new file, but do not switch to the new file. The default file name has 'Copy of' prepended to it.

Merge Paradigm Pools Insert the Paradigms from a previously saved Paradigm Pool file into the loaded Paradigm Pool.

Send Last Used List to Command

Copy the path name of the Files and Pools' last used Paradigm Pools list to the Command window history.

Clear Last Used List — Clear the "Last Used" Pool list of all entries.

Sort Paradigm Pool – Ascending Order

Sort the 'Routine Pool' list in increasing order.

Sort Paradigm Pool – Descending Order

Sort the 'Routine Pool' list in decreasing order.

[< file path >] File path of the loaded Paradigm Pool file.

Paradigm description: [< text >]

Enter a description of the active Paradigm.

Paradigm Pool — A column of Paradigm names from the loaded Paradigm Pool.

Click on a Paradigm name to highlight it as the active Paradigm and display its steps.

Double-click on a Paradigm name to display its steps and execute the Paradigm.

Click-and-drag a Paradigm name to change its position in the column.

To select multiple Paradigms, use a Shift-click mouse drag, or individually Shift-click the Paradigm names. Multiple Paradigms can thus be deleted, or saved to a new Paradigm Pool.

[Save Pool] — Save the Paradigm Pool using its existing file name.

[New Paradigm] — Create a new blank Paradigm in the Paradigm Pool.

[Rename] — Rename the selected Paradigm.

Valid characters are alphabetic and numeric (A-Z, a-z, 0-9), and the underscore "_".

Invalid characters at the start of a name are replaced by an 'x'; invalid characters and spaces within a name are replaced by an underscore.

Names starting with a number are prepended with an 'x' to the name.

Duplicate names are not allowed in a Paradigm Pool; if encountered, an underscore and autoincrement number are appended to the duplicate name.

The minimum name length is 2 characters; a single character is appended with an 'x'.

The maximum name length is 26 characters; extra characters are truncated.

Reserved Names	If you rename a Paradigm to one of these specially named Paradigms, it will automatically execute whenever you click its associated Membrane Test Settings mode button.
Paradigm_Bath	Execute this Paradigm when the Membrane Test 'Bath' button is clicked.
Paradigm_Seal	Execute this Paradigm when the Membrane Test 'Seal button is clicked.
Paradigm_Cell	Execute this Paradigm when the Membrane Test 'Cell button is clicked.

[Duplicate] Add a copy of the selected Paradigm to the Paradigm Pool. The Paradigm name number is appended or incremented.

[Delete] Remove the selected Paradigm from the Paradigm Pool.

[Revert] Select a Paradigm and click the 'Revert' button. All editable steps are reset to their originally loaded or last saved values, as long as another Paradigm Pool has not been loaded.

 Create separate Paradigm entry in data tree

A new Paradigm node is automatically appended to the Data Navigator data tree whenever a Paradigm is run.

Toggle this button OFF to run the selected Paradigm without having a new Paradigm entry added to the data tree. Any new data will be added to the last Paradigm in the data tree; however, if no Paradigm exists in the Experiment, an automatic Paradigm node will first be created.

Paradigm Steps A column of instructions from the active Paradigm is displayed. These instructions are sequentially run by the Paradigm.

Click on a Paradigm step to highlight it as the active step.

Double-click on a Paradigm step to view or edit its settings.

Click-and-drag a Paradigm step to change its position in the column.

To select multiple steps, click each step with a Ctrl-click.

The Paradigm step instructions are displayed in a scrollable Paradigm Steps panel. If the panel size is too small for the text, increase the width of the Paradigm Editor window.

Note: Step values are usually in SI standard units, i.e., "Volts" and "Amperes".

The following buttons can handle multiple steps.

Use a Shift-click to select each step.

Use a Shift-Alt-click to deselect a step when multiple steps are selected.

Toggle Skip

Duplicate

Delete

Copy

Paste

[Insert] Insert a Step command into the Paradigm Steps column:

< see details below >

Amplifier

Each Sweep

Routine

Analysis

Camera

Clear Key

Copy Signals

Execute

Export

Front Window

Hide Window

Reset Timer

Scope Operation

Select Node

Set Axis

Set Checkbox

Set Mark

Set Metadata

Set Solution

Set Tag

Set Variable

Set Write Steps

Sound

Start New Paradigm Data

Update Inputs

View Last

Write to Log

Write to Notebook

Alert

Beep

Comment

Pause

Wait

Wait for Trigger

Flow Control

Break

Chain

For Loop

Jump

Label

Condition

If

ElseIf

Else

< see details in Insertable Steps list below >

[Edit] — If a highlighted Step is configurable, click the Edit button to open it in the Paradigm Steps Editor for configuration.

Also, if a highlighted Step's text is partially hidden, use the Edit button to view the entire entry.

[Toggle Skip] — Mark a step so it is not executed.

A semicolon is prepended to the Step number to "comment out" the instructions, and a Skip status is appended to the Step text.

Example: A 'Beep' command in Paradigm step #2:

; 2 Beep, Skip=true

The leading semicolon ";" prevents this step from being executed by the instruction queue, and the 'Skip' status is displayed.

[Duplicate] — Insert a copy of the selected step after the selected step.

Multiple selected steps are inserted after the last selected step.

[Revert] — Select a Step to undo changes, and click the Revert button. Editable fields are reset to their last saved values, as long as an intervening Paradigm has not been saved.

[Delete]	Delete the selected step. For multi-line steps, optionally delete the step without deleting the contents of the step.
[Select All]	Select all steps in the loaded Paradigm.
[Copy]	Select a step to copy to the clipboard.
[Paste]	Select a step and paste the copied step below it. Multiple steps are pasted as a group.
[Step]	Execute the selected step, and select the next step (if any). Executing a single step does not terminate a running Paradigm, even for the last step in the Paradigm. Note: A 'For' loop is processed as a single step.
[Step to End]	Execute the selected step and all following steps as fast as the system allows.

Insertable Steps

Amplifier

Control the IPA amplifier hardware.

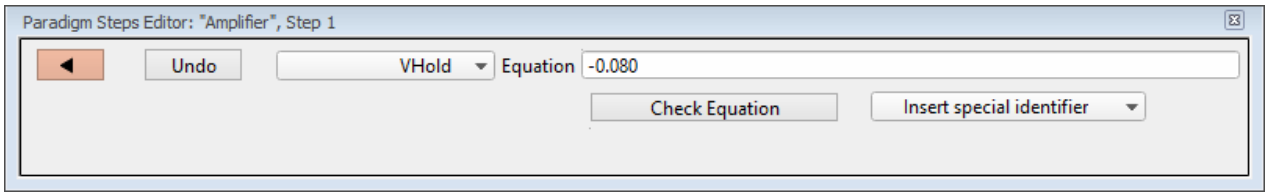


Figure 4-22. Paradigm Step: Amplifier

Default Setting: *Amplifier, Target=VHold, Equation=-0.080*

◀ Close the 'Paradigm Steps Editor'.

[Undo] Remove any unsaved edits to this step.

[< amplifier setting >] [↓]

Amplifier options display.

Headstage

SelectProbe (select active headstage)

[1 - 4]

Most Paradigm Step commands apply to the “active” probe, the Sutter headstage presently controlled by the Amplifier Control Panel. Select the target headstage.

For a single headstage system, the active probe is always headstage number "1".

IPA Settings

CCMode (amplifier current clamp)

Place the amplifier into Current-Clamp mode.

VCMode (amplifier voltage clamp)

Place the amplifier into Voltage-Clamp mode.

Hold (IHold in CC-mode, VHold in VC-mode)

[±0.000,000,020 A (±20 nA), or ±1.000 V (±1000 mV)]

Set the active headstage holding level.

IHold (amplifer holding current, A)

[± 0.000,000,020 A (±20 nA)]

Set and enable the active headstage holding level in Current-Clamp mode.

IHoldOn (amplifier holding current On)

Enable the active headstage holding level in Current-Clamp mode.

VHold (amplifier holding voltage, V)

[±1.000 V (±1000 mV)]

Set and enable the active headstage holding level in Voltage-Clamp mode.

VHoldOn (amplifier holding voltage On)

Enable the active headstage holding level in Voltage-Clamp mode.

IGain (amplifier current gain, V/A)

Set the gain for the active 'Current' input channel using standard unit numbers (V/A) or scientific notation (1 mV/pA = "1e9"). The value is converted to a preset Gain level:

- 0.5 mV/pA
- 1 mV/pA
- 2.5 mV/pA
- 5 mV/pA
- 10 mV/pA
- 25 mV/pA

To help reduce signal saturation from too high a gain, a 90% threshold promotes the equation value to the next higher Gain setting.

VGain (amplifier voltage gain, V/V)

Set the gain for the active 'Voltage' input channel using standard unit numbers (V) or scientific notation (1 mV = "1e3"). The value is converted to a preset Gain setting:

- 10 mV/mV
- 20 mV/mV
- 50 mV/mV
- 100 mV/mV
- 200 mV/mV
- 500 mV/mV

To help reduce signal saturation from too high a gain, a 90% threshold promotes the equation value to the next higher Gain setting.

Filter (amplifier input filter, Hz)

Apply a preset filter level to the input channels:

- 500 (500 Hz)
- 1000 (1 kHz)
- 2000 (2 kHz)
- 5000 (5 kHz)
- 10000 (10 kHz)
- 20000 (20 kHz)

To help prevent over filtering, a 10% threshold promotes the equation value to the next higher filter level.

Offset (amplifier pipette offset, V)

[±0.5 (±500 mV)]

OffsetLock (amplifier pipette offset lock On)

[1 = On, 0 = Off]

IPA Compensation

ECompMag (amplifier electrode compensation magnitude, F)

ECompTau (amplifier electrode compensation tau, s)

ECompOn (amplifier electrode compensation On in CC-mode)

[1 = On, 0 = Off]

CmComp (amplifier cell compensation Cm, F)

Set a cell capacitance value and enable cell capacitance compensation.

RsComp (amplifier cell compensation Rs, Ohm)

Set a series resistance value and enable cell capacitance compensation.

RsCompOn (amplifier cell compensation On)

[1 = On, 0 = Off]

Bridge (amplifier bridge balance, Ohm)

BridgeOn (amplifier bridge balance On)

IPA Correction

RsCorr (amplifier Rs correction, fraction)

[0.00 – 1.00] Converted to a percentile

RsPred (amplifier Rs prediction, fraction)

RsLag (amplifier Rs correction lag, s)

RsCorrOn (amplifier Rs correction On)

[1 = On, 0 = Off]

IPA Auto and Reset Functions

AutoEComp (amplifier auto electrode compensation)

AutoCellComp (amplifier auto cell compensation)

AutoOffset (amplifier auto pipette offset)

AutoBridge (amplifier auto bridge compensation)

Reset (reset amplifier controls)

Dynamic Holding

DynHoldOn (amplifier dynamic holding On)

DynHold (amplifier dynamic holding potential, V)

Auxiliary Output

AuxOUT1 (Auxiliary Output-1, V)

AuxOUT2 (Auxiliary Output-2, V)

Digital Output

DigOUTWord (Digital Output Word)

Set an 8-bit word for output.

DigOUT1 - 8 (Digital Output-1 - 8)

Set a single bit for output.

Lock-In

LockInAdjustOn
(set Lock-In adjustments On)

LockInPhaseAdj
(set Lock-In phase delay adjustment)

LockInAttenAdj
(set Lock-In attenuation adjustment)

Equation [equation field]

A free-form text field. This field is evaluated and its value passed to the "target" function.

Errors are reported under this field.

Values are configured in standard units (Amperes, Volts).

[Check Equation] Check the equation syntax. The equation is evaluated for sweep #1, and if valid, it reports "Syntax is ok."

[Insert special identifier] [↓]

SutterPatch acquisition, amplifier and reference settings are available for use in equations.

< see list below >

Each Sweep

Control the Paradigm operations on a “per sweep” basis of a Routine.

Commands to be executed are inserted between the “EachSweep, Target” line and the “ForEachEnd” line.

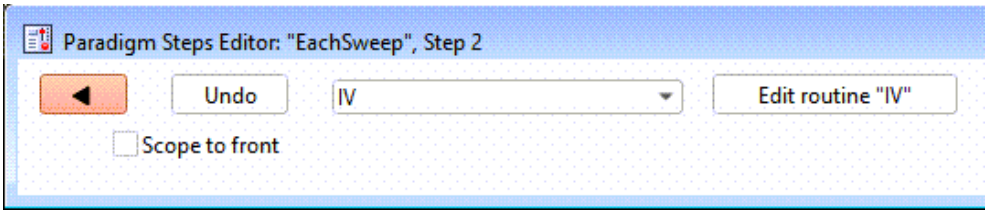


Figure 4-23. Paradigm Step: Each Sweep

Default Setting: *ForEachSweep*
EachSweep, Target= Amplitude_Equations
ForEachEnd

◀ Close the ‘Paradigm Steps Editor’.

[Undo] Remove any unsaved edits to this step.

[< name >] [↓] Select a Routine name from the loaded Routine Pool.

[Edit routine < name >]
Open the Routine in the Routine Editor.

[ ] Scope to front Enable to bring the Scope window forward.

Note: When using ‘Each Sweep’ to record data, the minimum sweep start-to-start time is +200 ms.

Routine

Start a Routine, Membrane Test or Free Run.

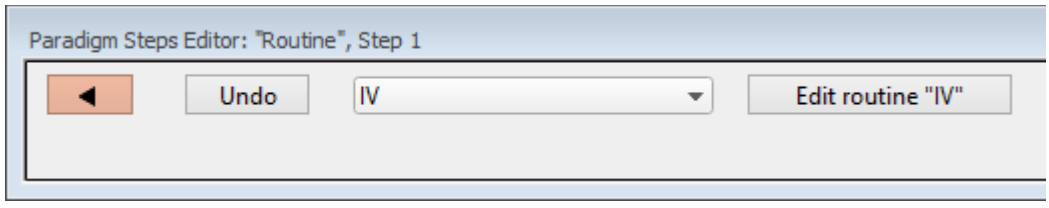


Figure 4-24. Paradigm Step: Routine

Default Setting: *Routine, Target=untitled*

Close the 'Paradigm Steps Editor'.

[Undo] Remove any unsaved edits to this step.

[< type >] [↓] Select an Acquisition type, or a Routine to record a data Series.

Note: The time from starting this command to recording data is +300 ms.

- Membrane Test

  Repeats [< 1 – 999 >]

  [ ] Indefinitely Repeat an "infinite" number of times.

  [ ] Write to Notebook

  Write any measurements to the Notebook window.

  [ ] Scope to front The Scope window appears where the last "Acquisition" Scope was located.

  Test Amplitude [< No change, ±100 mV, ±2000 pA >] [↓]

  Test Duration [< No change, 0.5 – 500 ms >] [↓]

  Pulse Type [< type >] [↓]

  - No change
  - Single Pulse

    A single unidirectional square pulse.

  - Double Pulse

    Two contiguous bidirectional bipolar square pulses.

  - Triangle

    A train of 5 contiguous bipolar triangular pulses.

- RMS Noise

  A zero amplitude stimulus to allow RMS noise calculations.

[ ] Hide Settings — Hides the settings panel when the Membrane Test Scope is opened.

Configuration — [< configuration >] [↓]

- No change
- Bath
- Seal
- Cell

[Add Channel] [↓] — < only displays for multiple headstages >

Select an input channel to modify. Channel labels depend upon the number of configured headstages.

- Clear < default >

  Clear the selected channels list.

- Active Headstage
- Headstage1 – 4

  Select from the available input channels.

[selected channel]

< only displays for multiple headstages >

- Free Run

Total Duration — [< 100 ms – 999.9 s >]

The total acquisition time.

[ ] Indefinitely — Acquire for an “infinite” duration.

[ ] Scope to front — The Scope window appears where the last “Acquisition” Scope was located.

Scope Duration [< No change; 0.1 s, 0.2 s, 0.5 s, 1.0 s, 2.0 s, 5.0 s, 10.0 s, 20.0 s, 50.0 s, 100.0 s >] [↓]

The time range of the Scope window.

[Add Channel] [↓] < only displays for multiple headstages >

- Clear

  Set the “selected channel” list to the “default”.

- Current1 – 2
- Voltage1 – 2
- AuxIN1 – 4

  Select from the available input channels.

  Adding a channel appends it to a list, and removes the first item in a fu list. Channel labels depend upon the number of configured headstages.

[selected channels]

< only displays for multiple headstages >

[ ] Hide Settings Hides the settings panel when the Free Run Scope is opened.

- [< Routine name >] [↓]

  Routine names from the loaded Routine Pool.

  These Routines must be valid for the system (i.e., no conversion needed by the Routine Editor), and must be stored to a file.

[Edit routine ”name”] Open the selected Routine for

editing in the Routine Editor.

[ ] Scope to front — The Scope window appears where the last "Acquisition" Scope was located.

Stop at end of sweep [< No change, off, on >] [↓]

If enabled, only full sweeps of data are acquired.

Note: "Single-stepping" this command (when no Paradigm is running) will create an auto-triggered Paradigm.

Analysis

Save an analysis to the Analysis Editor, or combine it with prior analyses.

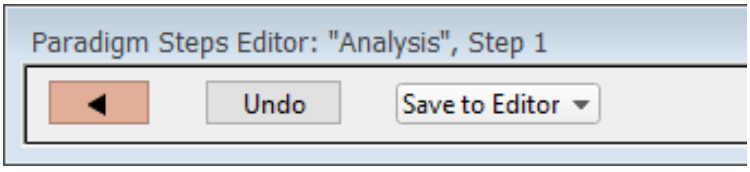


Figure 4-25. Paradigm Step: Analysis

Default Setting: *Analysis, Operation=Save to Editor*

◄ — Close the 'Paradigm Steps Editor'.

[Undo] — Remove any unsaved edits to this step.

[< operations >] [↓]

- Analyze Selected Node
- Save to Editor — Save the analyses in the Acquisition Analysis window to the Analysis Editor.
- Append to Last — Append to the prior analysis.
- Average with Last — Average with the prior analysis.
- Concatenate

  [< state >] [↓]

  - true — Enable the 'Concatenate' checkbox in the Acquisition Analysis window..

New acquisitions will concatenate their analyses with the existing analyses in the Analysis window.

- false — Disable the 'Concatenate' checkbox in the Acquisition Analysis window.

  New acquisitions will replace the existing analyses in the Analysis window with the new analyses.

- Show Table — Display the analyses as a numeric table.
- Show Graph-[1 – 8] — Display the analysis as a visual graph.

Camera

Take a single picture and/or run a live video preview. A Camera window is opened behind the Paradigm Editor window.

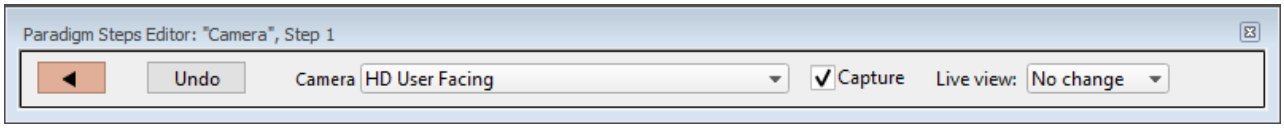


Figure 4-26. Paradigm Step: Camera

Default Setting: *Camera, Camera=_Camera_Name, Capture =true*

◀ — Close the 'Paradigm Steps Editor'.

[Undo] — Remove any unsaved edits to this step.

Camera — [< camera >] [↓]

Select a camera on the computer system.

[ ] Capture — Take a picture when executed.

Live view: — [< state >] [↓]

Configure the state of the live view:

- No Change — Keep last settings.
- Stop — Stop live view.
- Start — Start live view.

Clear Key

Clear the 'Last key' field in the Paradigm Editor, which holds the last-pressed keyboard key since the start of the Paradigm.

Default Setting: *ClearKey*

Copy Signals

Consolidate data from two instances of SutterPatch.

Combine two instances of amplifier systems (dPatch, IPA, Dendrite) and collect the acquired signals into one instance and display and analyze all signals in one Scope window.

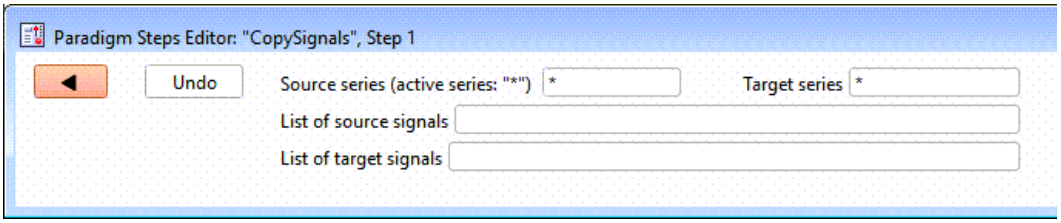


Figure 4-27. Paradigm Step: Copy Signals

< requires File Control to be active >

< see Set Preferences / File Control >

Source series (active series: "*") [ ]

Target series [ ]

List of source signals [ ]

List of target signals [ ]

Example

1) Start SutterPatch in dPatch demo mode.

2) Make a triggered IV Routine with 2 channels: Current and Voltage.

3) Duplicate the Routine and add 2 virtual input Equation channels.

4) Start a second instance of SutterPatch for the dPatch.

5) Connect the two instances by FileControl.

6) Start the Routine with the two signals in instance 2

7) Start the Routine with the four signals in instance 1

8) Click on the “Do Trigger” on the Scope window of instance 2:

   ⇨ both instances acquire one sweep.

9) Trigger until the Routine is acquired.

10) Make a “Copy Signals” Paradigm step:

    Source signals 1 and 2.

    Target signals 3 and 4.

11) Execute it.

12) The signals 1 and 2 of instance 2 are copied into signals 3 and 4 of instance 1.

Execute

Extend the functionality of SutterPatch by running an Igor Pro command.

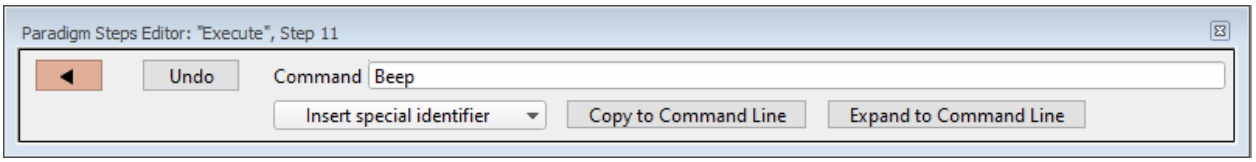


Figure 4-28. Paradigm Step: Execute

Default Setting: *Execute, Command=Beep*

◀ Close the ‘Paradigm Steps Editor’.

[Undo] Remove any unsaved edits to this step.

Command [command]

Insert any Igor Pro command accepted by the Command window, including user-created Functions.

Note: Igor Pro syntax usually requires that open/close parentheses "( )" be appended to the end of a command. However, exceptions include the "beep" and "print" commands, for which no parentheses are used.

[Insert Special Identifier] [↓]

Special references can also be used within commands.

- Abort selection

- s[SeriesNo,SweepNo,SignalNo]

  (trace of specified series)

  Reference an input trace in an open Scope window via counts of Series#, Sweep#,Signal# (scope channel position).

  Any fractions in count numbers are truncated to integers.

  Acquisition Scope window

  The active trace has a count value of zero. If a count number is non-zero, it is used as a relative offset (positive or negative) from the active trace.

  Ex: s[0,0,0,]

  The Acquisition Scope window active Series, active sweep, and active signal of the active Routine.

  Reanalysis Scope window

  The first Series/Sweep/Signal has count values of one. All counts are positive relative to the first trace.

- t[#]

  (n'th input trace)

  Reference the input trace in the open Scope window channel position "#", for the active

sweep of the active Series of the active Routine.

- a[Name]

  (name of analysis wave)

- copy[1..16]

  (nth trace retrieved via File Control)

- p[1..16]

  (n'th Paradigm variable)

- eq[equation]

  (result of the given equation)

- if[selector ? true-branch : false-branch]

  The expression is evaluated and returns a value. If the expression in "selector" is true, i.e., non-zero, the result is the content of the "true-branch", otherwise the result is the content of the "false-branch".

[Copy to Command Line]

Append the Command text to the Command window's Command line.

[Expand to Command Line]

Append the Command entry to the Command window's command line, after processing it to be compatible with Command window execution, i.e., any variables are replaced by their values.

Example 1: Reset the Timer.

Set the Execute 'Command' to:

Paradigm_ResetTimer()

Note the open and close parentheses at the end.

Example 2: Create an FFT graph of your data.

The Paradigm Steps:

1. ForEachSweep

2. EachSweep, Target=*YourRoutineName*

3. Execute, Command=FFT/OUT=3/DEST=Voltage1_FFT t[2]

4. If, Left=sweep, Operation="=", Right=1

5. Execute, Command=Display Voltage1_FFT

6. EndIf

7. Execute, Command=SetAxis Bottom 0,60

8. ResetTimer

9. ForEachEnd

In Step 2: Replace "*YourRoutineName*" with your own Routine name, or use the sample "IV" Routine.

In Step 3: The Igor Pro 'FFT' command is run, and "t[2]" retrieves the Acquisition: Scope window's second input trace.

Export

Export data graphs into a new or open Layout window.

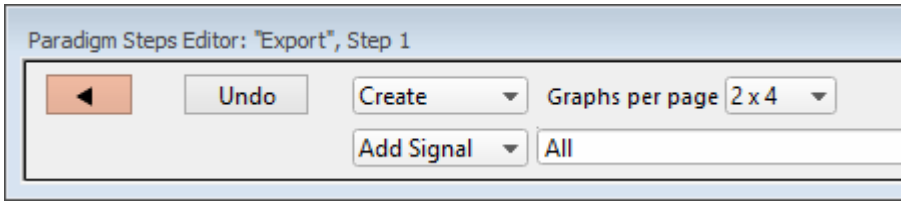


Figure 4-29. Paradigm Step: Export

Default Setting: *Export, Signal=Layout*

◀ Close the 'Paradigm Steps Editor'.

[Undo] Remove any unsaved edits to this step.

Graphs per page [< # >] [↓]

Set the graph layout configuration for new Layout windows:

- 1 Graph fills entire page.
- 2 Vertically stacked graphs.
- 3 Vertically stacked graphs.
- 2 x 2 matrix
- 2 x 4 matrix

[Add Signal] [< signals >] [↓]

Select signals to be exported from a list of default names.

- Clear

  Clear the signal field, set it to 'off".
- All
- Select all entries.
- All Signals

  Select all input signals.
- Voltage1 – 2, Current1 – 2, AuxIN1 – 8, Virtual1 - 10

  Select a signal.

- All Analyses

  Select all analysis graphs
- Analysis1 – 8

  Select an analysis graph.

[selected signals and analyses]

User-edited names can also be directly entered into this export list field.

Note: The sequence of signals is not used for positioning in the

Layout window – signal positioning is based on their Scope window sequence.

Front Window

Set the specified window as the front window.

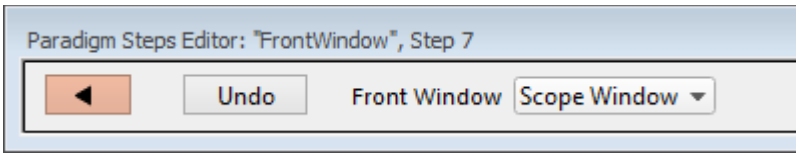


Figure 4-30. Paradigm Step: Front Window

Default Setting: *Front Window, Target=Scope Window*

◄ Close the 'Paradigm Steps Editor'.

[Undo] Remove any unsaved edits to this step.

Front Window [< target >] [↓]

- Analysis Editor
- Acquisition Control
- Camera Window
- Control Panel
- Dashboard
- Data Navigator
- Equation Editor
- Lock-in Adjustments
- Log Window
- Paradigm Editor

  Variables [< status >] [↓]

  - No Change
  - Show
  - Hide

Checkboxes [< status >] [↓]

- No Change
- Show
- Hide

- Routine Editor
- Scope Window
- Shortcut Editor
- Solution Editor
- Template Editor

Hide Window

Hide the specified window.

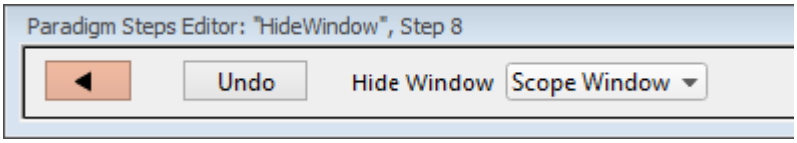


Figure 4-31. Paradigm Step: Hide Window

Default Setting: HideWindow,Target=Scope Window

◀ Close the 'Paradigm Steps Editor'.

[Undo] Remove any unsaved edits to this step.

Hide Window [< target >] [↓]

- Analysis Editor
- Acquisition Control
- Camera Window
- Control Panel
- Dashboard
- Data Navigator

- Equation Editor
- Lock-in Adjustments
- Log Window
- Paradigm Editor
- Routine Editor
- Scope Window
- Shortcut Editor
- Solution Editor
- Template Editor

■ Python

Execute Python code.

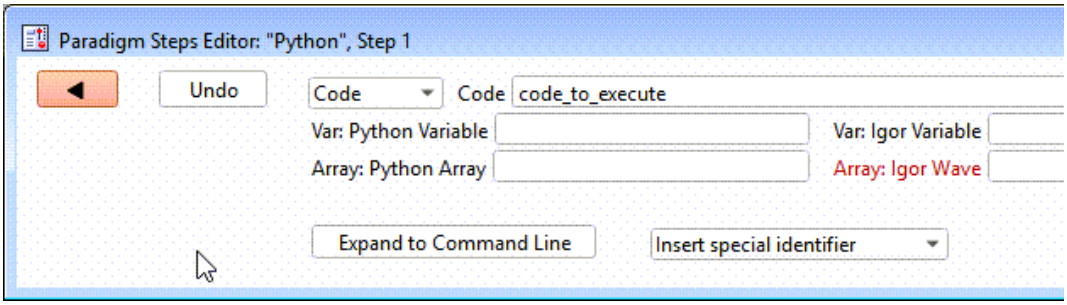


Figure 4-32. Paradigm Step: Python

Default Setting: Python, Code=code_to_execute

◀ Close the 'Paradigm Steps Editor'.

[Undo] Remove any unsaved edits to this step.

[< Code, File >] [↓]

- Code [code_to_execute]
- File [file_name]

Var: Python Variable

[var]

Array: Python Array

[array]

Var: Igor Variable [var]

Array: Igor Wave [array]

[Expand to Command Line]

[Insert special identifier] [↓]

- Abort selection

- s[SeriesNo,SweepNo,SignalNo]

  (trace of specified series)

  Reference an input trace in an open Scope window via counts of Series#, Sweep#, Signal# (scope channel position).

  Acquisition: Routine Scope window

  The active trace has a count value of zero. If a count number is non-zero, it is used as a relative offset (positive or negative) from the active trace.

  Ex: s[0,0,0,]

  The Acquisition: Routine Scope window active Series, active sweep, and active signal of the active Routine.

  Reanalysis Scope window

  The first Series/Sweep/Signal has count values of one. All counts are positive relative to the first trace.

  Any fractions in count numbers are truncated to integers.

- t[#]

  (n'th input trace)

Reference the input trace in the open Scope window channel position "#", for the active sweep of the active Series of the active Routine.

Reset Timer

Reset the Paradigm Editor Timer to 00:00:00.

Default Setting: *ResetTimer*

Scope Operation

Control which Scope window signals are displayed, and how the sweep display operates.

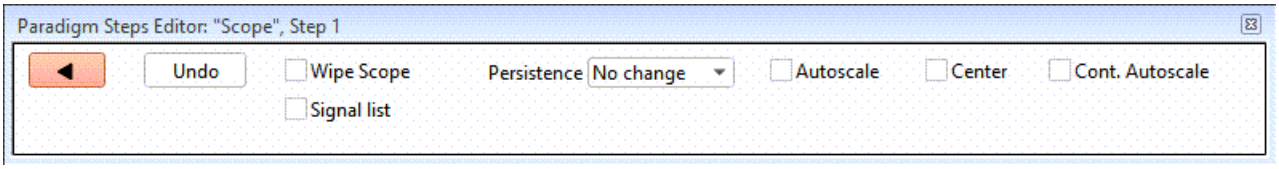


Figure 4-33. Paradigm Step: Scope Operation

Default Setting: *Scope, Wipe=false*

◀ Close the 'Paradigm Steps Editor'.

[Undo] Remove any unsaved edits to this step.

Wipe Scope Clear the Scope window of all sweeps, except the last one.

Persistence: [< status >] [↓]

- No change
- On
- Off

[ ] Autoscale A one-time autoscale of the Y-axes of all selected signals to their incoming data, i.e., to their visible sweeps data limits, and resets the X-axes to the full sweep duration.

[ ] Center Center the active signal so the mean of the Y-axis data is vertically centered in the signal pane. Only

the Y-axis offset is automatically adjusted, not the scaling; the X-axis is unaffected.

[ ] Cont. Autoscale — Enable the Scope "continuous autoscale Y-axis" button.

[ ] Signal list: [Add Signal] [↓]

Enable to display a list of input signals

- Clear

  Clear the signal list.

- All Signals

  Select all available signals.

- Voltage1 – 2
- Current1 – 2
- AuxIN1 – 8
- Virtual1 – 10

[selected input signals]

You can directly edit this list. User-defined signal labels can also be used.

Select Node

In the Data Navigator data tree, move the highlight to another node.

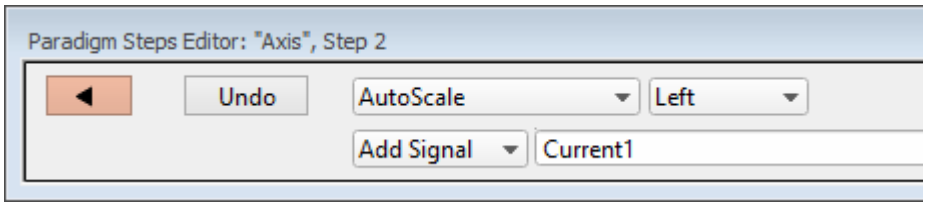


Figure 4-34. Paradigm Step: Select Node

Default Setting: *Select Node, Target=Routine, Move=Following, Count=1, Mark*

◀ Close the 'Paradigm Steps Editor'.

[Undo] Remove any unsaved edits to this step.

Node Level [< level >] [↓]

Select the node level to move within.

- Paradigm
- Routine
- Signal
- Sweep

Move [< target >] [↓]

Select a node in relation to the existing highlighted node.

- First Highlight the first node in the Experiment.
- Preceding

  Move to a particular node before the highlighted node

  Count [1+]

  Enter the number of nodes to move from the highlighted level.
- Following

  Move to a particular node after the highlighted node

  Count [1+]

  Enter the number of nodes to move from the highlighted level.
- Last Highlight the last node in the Experiment.

[ ] Marked only Enable to only move the highlight amongst the marked nodes.

Note: If this Step is used by itself in a Paradigm, disable the button "Create separate Paradigm in data tree" in order to select nodes in

prior Paradigms.

Set Axis

Modify the axis scaling of selected signals in the open Scope window.

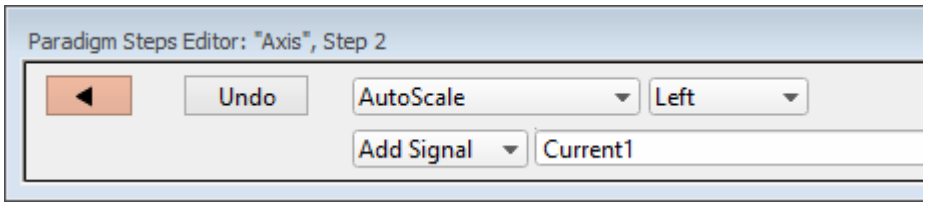


Figure 4-35. Paradigm Step: Set Axis

Default Setting: *Axis, Axis=Autoscale, Kind=Left, Target=Current1*

◀ Close the 'Paradigm Steps Editor'.

[Undo] Remove any unsaved edits to this step.

[< scaling >] [↓] Select the type of X- or Y-axis scaling to apply.

- Set scale
  Enter X- or Y-axis custom range settings:

  Min. [#]

  Max. [#]
- Autoscale
  Match the X- or Y-axis range to the data range.
- Autocenter
  Center the Y-range of the X-axis data.

[< axes >] [↓] Select the axes orientation.

- Left Select the Y-axes.
- Bottom Select the X-axis.

[Add Signal]] [↓]

< only displays for 'Left' axis >

Edit the signal list.

- Clear

  Clear the signal list.

- All Signals

  Add all available signals.

- Voltage1 – 2
- Current1 – 2
- AuxIN1 – 8
- Virtual1 – 10

[< selected signals >]

Signal names can be directly edited; user-defined signal labels can be used.

Set Checkbox

Set Checkbox uses simple “on / off” toggles. Checkbox status can be read by ‘If” and ‘ElseIf’ steps to make “yes/no” decisions and control the execution path of the Paradigm. If the equation evaluates to a non-zero value, the checkbox is enabled, i.e., ”on”.

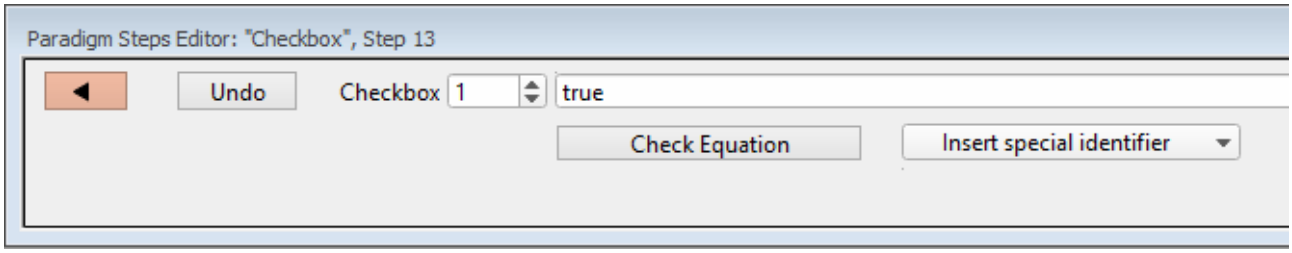


Figure 4-36. Paradigm Step: Set Checkbox

Default Setting: *Checkbox, Count=1, Equation=true*

◀ Close the ‘Paradigm Steps Editor’.

[Undo] Remove any unsaved edits to this step.

Checkbox [< 1 – 12 >]

1 – 3 These checkboxes are “local”; they are cleared whenever a Paradigm is started.

4 – 12	These checkboxes are “global”; their status persists across all Paradigms in the Experiment.
[equation]	A free-form field, evaluated to a value, and applied to the checkbox status.
Set Title	[text] Enter a text title for the selected checkbox in the Paradigm Editor window.
[Check Equation]	Check the equation syntax. The equation is evaluated for sweep #1, and if valid, it reports "Syntax is ok.” Otherwise, errors are reported under this button. The constant “True” evaluates to ‘1.000’. The constant “False” evaluates to ‘0.0000’.
[Insert special identifier] [↓]	SutterPatch acquisition, amplifier and reference settings are available for use in equations. < see list below >

Set Mark

The ‘Set Mark’ step marks or unmarks (enables or disables) sweeps or nodes s for processing.

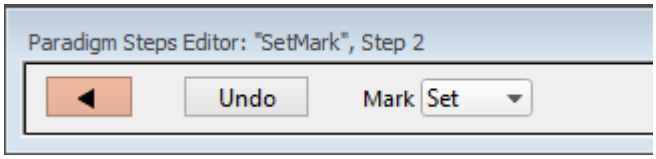


Figure 4-37. Paradigm Step: Set Mark

Default Setting:	*SetMark, Value=Set*
◀	Close the ‘Paradigm Steps Editor’.
[Undo]	Remove any unsaved edits to this step.
Target	[< target >] [↓]

- Scope — Set the 'Mark' checkbox in the Acquisition Scope window.
- Data Tree — Set the 'Mark' checkbox for the Data Navigator's active node.

Mark [< status >] [↓]

- Set — Enable the 'Mark' checkboxes.
- Clear — Disable the 'Mark' checkboxes.
- Toggle — Toggle the state of the 'Mark' checkboxes.

This can be used within a conditional Paradigm step to mark or unmark a sweep based upon experimental conditions.

For example, when used within an 'If' step, if the leak current is too high, unmark the sweep, 'Else' mark the sweep. This is an easy way to process just the sweeps that have a reasonable leak current.

Marks are used by these Data Navigator 'Available actions':

Action Potential Analysis

Synaptic Event Analysis

Average Selected Sweeps

Display Signal/Sweep

Export Data

Set Metadata

Define Metadata parameter values to apply to the data during acquisition.

The “Set Metadata Paradigm Step Value” dialog opens for configuration:

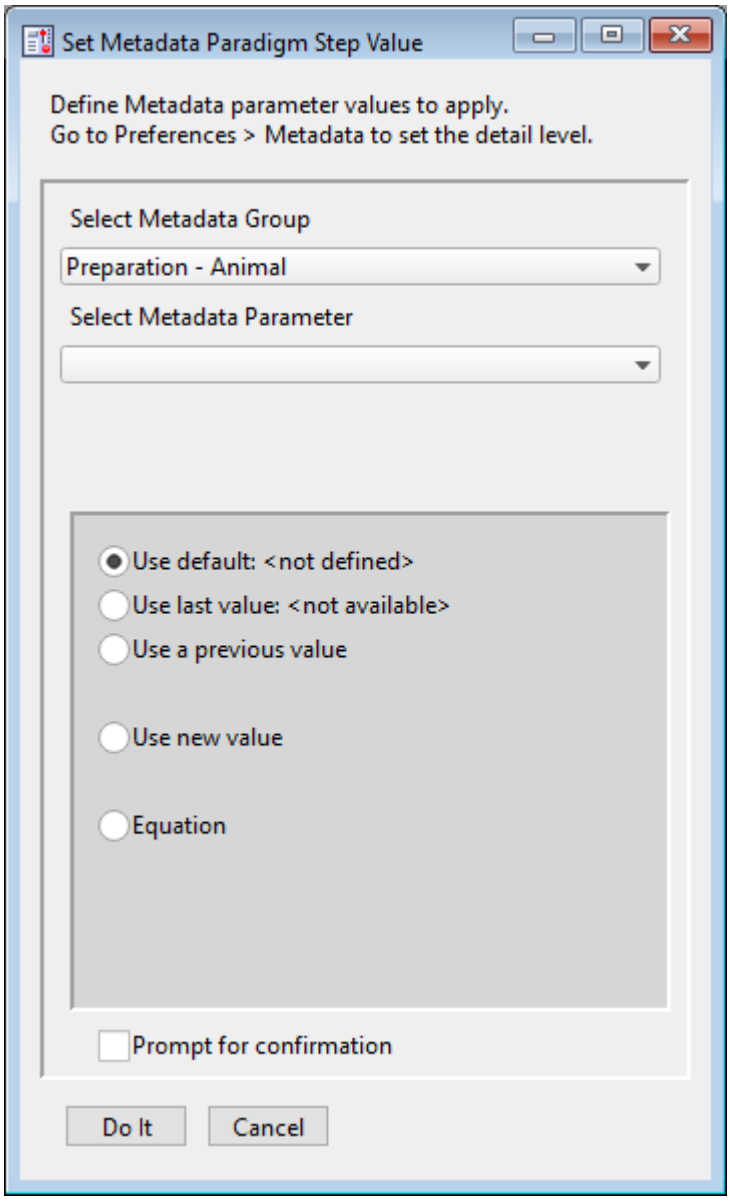


Figure 4-38. Paradigm Step: Set Metadata

Default Setting: *Metadata, Value*=

Select Metadata Group

[< group >] [↓]

To change the metadata detail level, go to Preferences > Metadata.

	Detail Level
• Operator	Full
• Preparation – Animal	Basic
• Preparation – Tissue	Basic
• Preparation – Cell	Basic
• Experiment	Basic
• Electrode	Extended
• Recording Solutions	Extended
• Paradigm	Full
• Cell Health / Quality Control	Full
• Series (= Routine Data)	Full
• Stimulus	Basic

Select Metadata Parameter

[< parameter >] [↓]

Visible entries depend on the selected Group.

- Use default:
- Use last value:
- Use a previous value

[< values >] [↓] Select a value.

- Use new value [value] Enter a value.
- Equation [equation] Enter an equation.

[Check] Check the equation syntax. The equation is evaluated for sweep #1, and if valid, it reports "Syntax is ok."

[Special identifier] [↓]

SutterPatch acquisition, amplifier and reference settings are available for use in equations.

< see list below >

[ ] Prompt for confirmation — Enable to display a metadata prompt before acquisition starts.

Set Solution

A "solution" command is used to turn solution valves 'on' or 'off' in perfusion systems. A predefined digital pattern or analog level can be automatically output with this step. Solution settings are configured and numbered in the Solution Editor.

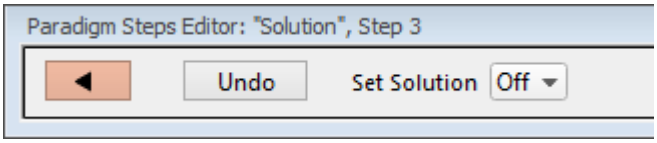


Figure 4-39. Paradigm Step: Set Solution

Default Setting: *Solution, Target=Off*

◀ Close the 'Paradigm Steps Editor'.

[Undo] Remove any unsaved edits to this step.

Set Solution [< solution >] [↓]

Activate a valve by selecting an action or solution number.

Off — Close the valve.

Increment — Increase the solution number by one.

Decrement — Decrease the solution

number by one.

[1 – 24] Select a solution number. The number of available solutions depends on the Solution Editor configuration.

Alert! It is up to you to keep track of valid solution numbers, i.e., when incrementing in a loop, etc., as invalid numbers such as "out of range" valve numbers issue no warning messages while the last valid setting is retained.

Set Tag

A comment tag is automatically written to the Paradigm metadata with this step. Enter the comment into the 'Tag text' field.

When run during acquisition, the comment tag is also written to the Routine metadata, and when the data is opened in a Reanalysis Scope window, a vertical cursor displays at that time point.

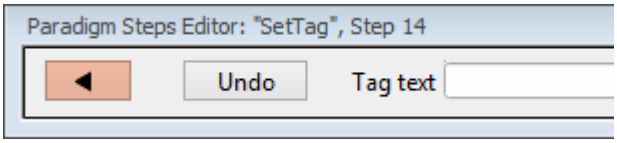


Figure 4-40. Paradigm Step: Set Tag

Default Setting: *SetTag, Text=*

◀ Close the 'Paradigm Steps Editor'.

[Undo] Remove any unsaved edits to this step.

Tag text [text]

Enter the comment text.

Note: The comment text for this Paradigm step is maintained separately from the manually triggered Acquisition Control 'Set Tag' button text.

Set Variable

Variables allow flexible control of any operation using equations.

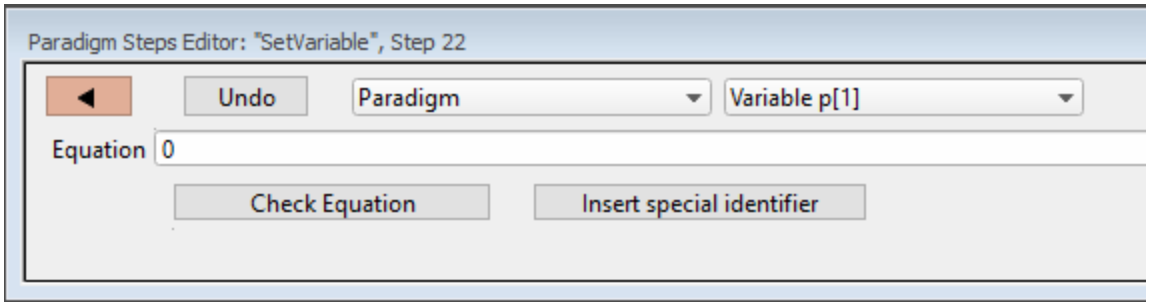


Figure 4-41. Paradigm Step: Set Variable

Default Setting: *SetVariable, Target=Paradigm, Count=1, Equation=p[1]*

◄ Close the 'Paradigm Steps Editor'.

[Undo] Remove any unsaved edits to this step.

[< target >] [↓]

- Paradigm [Variable p[1 – 16], All Variables]

  Select a Paradigm to set the values of its Variables.

  When 'All Variables' is selected, if varying values are desired, enter their values into the Equation field as a comma-separated list; simple equations (those without internal commas) can also be used in place of a value.) If there are more variables than list values, the "extra" variables are unused and unchanged. If a list value is blank, the corresponding variable is unchanged.

- Paradigm_Input

  Set the value of the Paradigm Editor 'Input' control.

- Routines: [Variable r[1 – 16], All Variables]

  Select a Routine to set the values of its Variables

  When 'All Variables' is selected, if varying values are desired, enter their values into the Equation field as a comma-separated list; simple equations

(those without internal commas) can also be used instead of a value.) . If there are more variables than list values, the “extra” variables are unchanged. If a list value is blank, the corresponding variable is unchanged.

Equation [< equation >]

Evaluates to a value to set variables or the Paradigm Editor ‘Input’ control.

You can likewise set the value of a variable by inserting special identifiers; for example, ‘Input’ reads the ‘Input’ control.

< see sample Paradigm ‘Tuning_with_Input’ >

[Check Equation] Check the equation syntax. The equation is evaluated for sweep #1, and if valid, it reports "Syntax is ok.”

[Insert special identifier]

SutterPatch acquisition, amplifier and reference settings are available for use in equations.

< see list below >

Set Name < only displays for “Paradigm” option >

Enter a text name for the selected variable in the Paradigm Editor window.

Set Write Steps

Configure the level of logging Paradigm metadata.

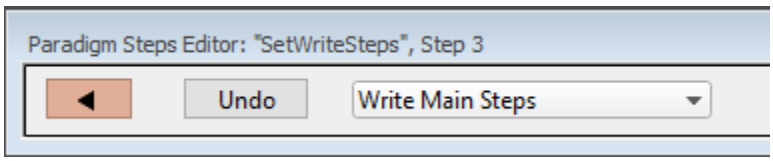


Figure 4-42. Paradigm Step: Set Write Steps

Default Setting: *SetWriteSteps, Value=Main*

◀ Close the ‘Paradigm Steps Editor’.

[Undo] Remove any unsaved edits to this step.

[< write >] [↓]

- Write No Steps
- Write Main Steps

  The main action-oriented steps are recorded in the Data Navigator Paradigm metadata (using its 'By Event' view).

  Amplifier

  Break

  Camera

  Chain

  Execute

  For Each Sweep

  Reset Timer

  Routine

  Set Checkbox

  Set Solution

  Set Variable

  Wait

- Write All Steps

  Log the main steps and additional steps into the Data Navigator Paradigm metadata (using its 'By Event' view.)

Sound

Output a note from the computer speaker.

The frequency can be defined by a fixed value or an equation.

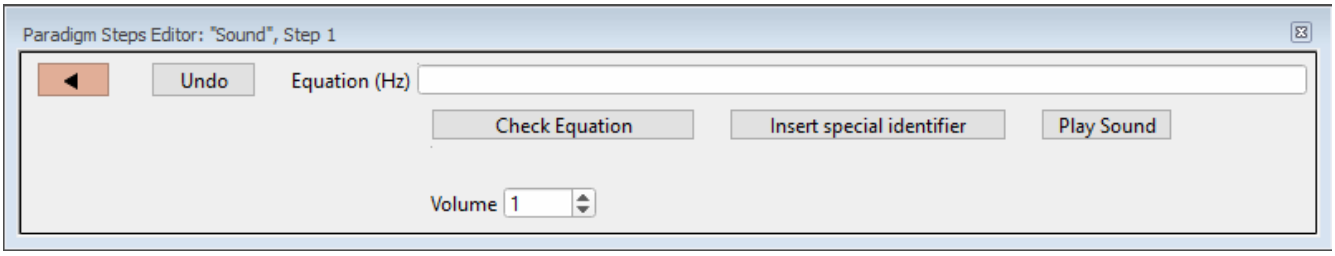


Figure 4-43. Paradigm Step: Sound

Default Setting: *Sound, Equation=, Volume=1*

◀ Close the 'Paradigm Steps Editor'.

[Undo] Remove any unsaved edits to this step.

Equation (Hz) [< 250 – 8000 >]

Specify as an equation or fixed value.

The sound output has a linear frequency response range within its limits.

< 250 Hz:	two clicks
250 Hz – 8 kHz	frequency tone
> 8 kHz:	8 kHz tone

[Check Equation] Check the equation syntax. The equation is evaluated for sweep #1, and if valid, it reports "Syntax is ok."

[Insert special identifier] [↓]

SutterPatch acquisition, amplifier and reference settings are available for use in equations.

< see list below >

[Play Sound] Test the sound output.

Note: Lower frequency tones are attenuated in volume on lower-quality speakers.

Volume [< 0.1 – 1.0 >]

Use the spinners for 10% increments, or directly edit the field.

Output is via the standard sound output that Igor Pro uses:

- Windows: Built-in speakers, or a computer sound card with external speakers.
- macOS: Built-in speakers

This paradigm step can also be utilized as an Igor Pro programming command. For instance, using an equation, one could listen to the membrane resistance of the cell under investigation.

Example: Output a note.

Enter this equation in the Command window command line:

SutterPatch#Paradigm_PlaySound(400, 1)

Start New Paradigm Data

Stop the current Paradigm and start a new Paradigm.

This forces a new Paradigm node to be created in the Data Navigator.

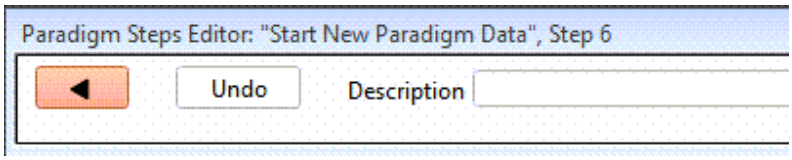


Figure 4-44. Start New Paradigm Data

Default Setting: *Start New Paradigm Data, Text=*

◀ Close the 'Paradigm Steps Editor'.

[Undo] Remove any unsaved edits to this step.

Description: [< text >]

Enter a text description for the Data Navigator preview.

Update Inputs

Reads a “live” data point from all auxiliary and headstage input channels and displays them in the Amplifier Control Panel monitor.

This is useful for monitoring slowly changing parameters, such as temperature, without acquiring an entire sweep of data, or when the Amplifier Control Panel Setting “Read signal inputs...” is disabled.

Default Setting: *Update inputs*

View Last

Display the last recording in a Reanalysis Scope window.

Default Setting: *ViewLast*

Write to Log

Enter text to be written to the Log window.

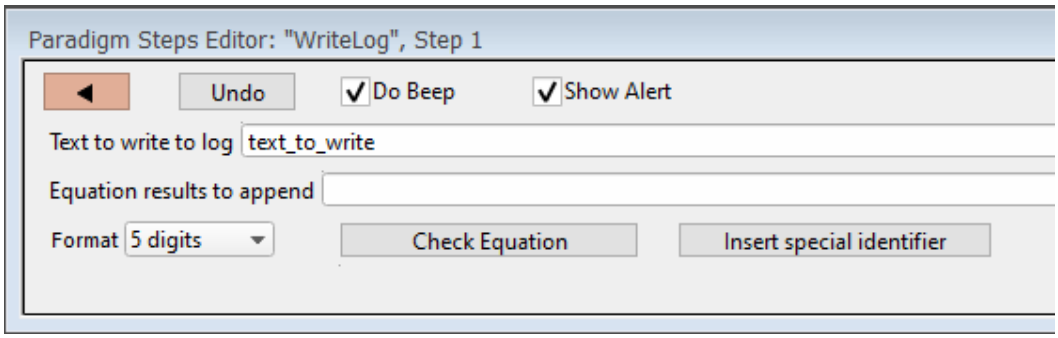


Figure 4-45. Paradigm Step: Write to Log

Default Setting: *WriteLog, Alert=true, Text=text_to_write, Equation=, DoBeep*

◀ Close the ‘Paradigm Steps Editor’.

[Undo] Remove any unsaved edits to this step.

[ ] Do Beep Generate a beep before writing.

[ ] Show Alert Display and/or edit the Alert text, then write it to the Log window.

Text to write to log [< text >]

Enter text to write to the Log window.

Equation result to append

[< equation >]

Multiple equations in a comma-separated list can be evaluated.

Format [< format >] [↓]

- Time In the 'Time' format, seconds are converted into Hours:Minutes:Seconds.Milliseconds .
- Date In the 'Date' format, seconds are converted into Year-Month-Day as XXXX-XX-XX. The starting date is "1904-01-01". No rounding is done.
- 3 – 12 digits

  For numbers, set the number of significant digits to display in scientific exponential notation.

[Check Equation] Check the equation syntax. The equation is evaluated for sweep #1, and if valid, it reports "Syntax is ok."

[Insert special identifier]

SutterPatch acquisition, amplifier and reference settings are available for use in equations.

< see list below >

Paradigm: Write to log

< this run-time dialog only displays when the 'Write to Log' Paradigm step is executed >

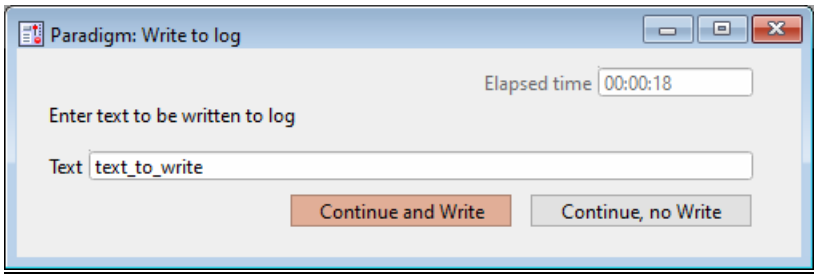


Figure 4-46. Paradigm Write to Log Run-Time Window

Elapsed time	[< hh:mm:ss >]
	A time counter for the Alert.
Text	[< text >]
	Enter the text message.
[Continue and Write]	Write to the Log window.
[Continue, no Write]	Do not write to the Log window.

Write to Notebook

Enter text to be written to the Notebook.

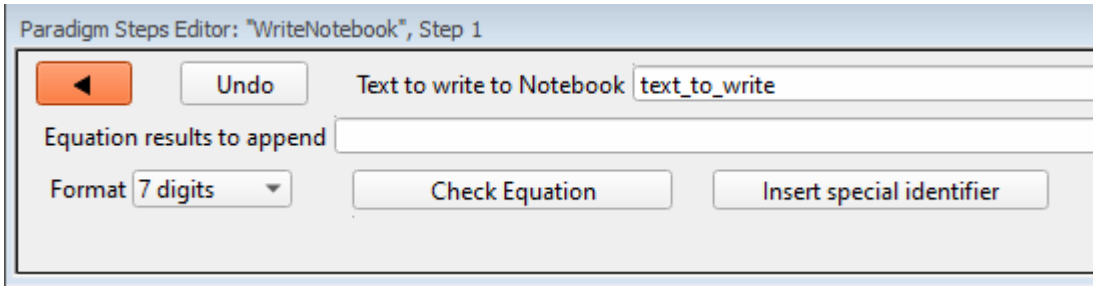


Figure 4-47. Paradigm Step: Write to Notebook

Default Setting:	*WriteNotebook, Text=text_to_write, Equation=*
	Close the 'Paradigm Steps Editor'.
[Undo]	Remove any unsaved edits to this step.

Text to write to Notebook

[< text >]

Equation results to append

[< equation >]

Format [< format >] [↓]

- Time
- Date
- 3 – 12 digits]

In the 'Time' format, seconds are converted into Hours:Minutes:Seconds.Milliseconds.

In the 'Date' format, seconds are converted into Year-Month-Day as XXXX-XX-XX. The starting date is "1904-01-01". No rounding is done.

For numbers, set the number of significant digits to display in scientific exponential notation.

[Check Equation] Check the equation syntax for sweep #1. The equation is evaluated, and if valid, it reports "Syntax is ok."

[Insert special identifier]

SutterPatch acquisition, amplifier and reference settings are available for use in equations.

< see list below >

Alert

Display an "Alert" dialog box that pauses Paradigm execution until manually dismissed.

Figure 4-48. Paradigm Step: Alert

Default Setting: *Alert, Text=alert_text, DoBeep=true*

◀ Close the 'Paradigm Steps Editor'.

[Undo] Remove any unsaved edits to this step.

[ ] Do Beep Enable to sound a "beep" from the computer.

Text to show in Alert

[< text >]

Enter a message to the user.

Beep

Generate a "beep" sound from the computer speaker.

Default Setting: *Beep*

If 'Beep' steps are listed one after another, a single beep sound is produced. To play separate individual notes, add a wait step in-between each note.

Comment

A text message can be displayed in a floating window.

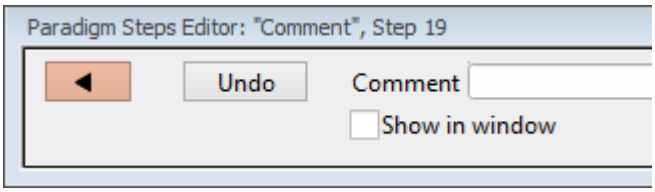


Figure 4-49. Paradigm Step: Comment

Default Setting: *Comment, Text=*

◀ Close the 'Paradigm Steps Editor'.

[Undo] Remove any unsaved edits to this step.

Comment [< text >]

Enter the comment text.

To display multiple lines of text (up to 3), use "\r" as a line separator. Enter up to 40 characters per line, with a maximum of 100 characters per

Comment.

Note: Text characters are from the ANSI character set.

[ ] Show in window < ungrays when Comment text is entered above >

A 'Paradigm Comment' window is displayed with the comment text.

Note: This window closes when the Paradigm ends, so if this is the last step of a Paradigm, you might need to append a "Wait" step to see it.

Pause

Pause execution of the Paradigm until the Resume button is manually clicked.

Default Setting: *Pause*

Wait

Temporarily pause execution of the Paradigm for a defined duration.

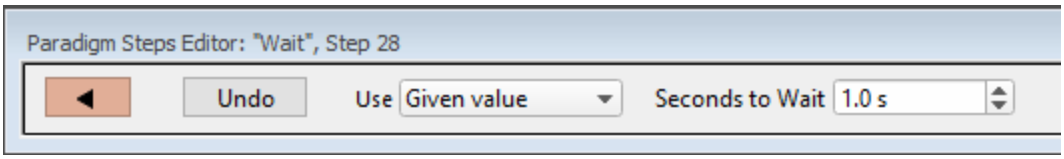


Figure 4-50. Paradigm Step: Wait

Default Setting: *Wait, Time=1*

◀ Close the 'Paradigm Steps Editor'.

[Undo] Remove any unsaved edits to this step.

Use [Given value, Variable p[1 –16]] [↓]

Seconds to Wait < displays for "Given value" >

[0 - ∞]

Click the spinners for 0.1 s increments, or type in a value. The precision of the wait time is 5 ms.

Wait for Trigger

Temporarily pause execution of the Paradigm until an external input trigger is received.

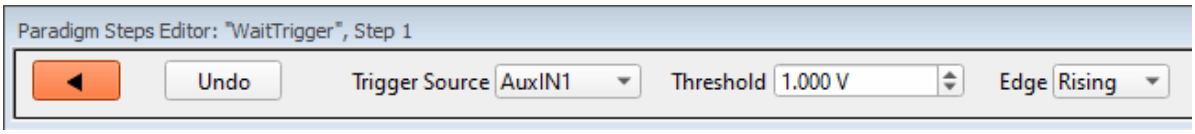


Figure 4-51. Paradigm Step: Wait for Trigger

Default Setting: *WaitTrigger, Source=AuxIN1, Threshold=1, Edge=Rising*

◀ Close the 'Paradigm Steps Editor'.

[Undo] Remove any unsaved edits to this step.

Trigger Source [< AuxIN1 – 4 >] [↓]

Threshold [±5.000 V]

Click the spinners for 0.001 V increments, or type in a value.

Edge [< Rising, Falling >] [↓]

Flow Control 'Break'

Use a Break step to stop the execution of a Paradigm or to interrupt a For Loop.

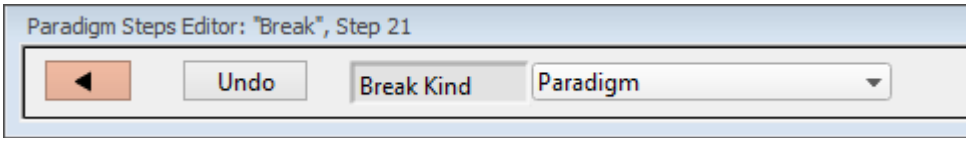


Figure 4-52. Paradigm Step: Break

Default Setting: *Break, Kind=Paradigm*

◀ Close the 'Paradigm Steps Editor'.

[Undo] Remove any unsaved edits to this step.

Break Kind: [< break >] [↓]

Paradigm Immediately stop the Paradigm.

ForLoop — Exit an “Each Sweep” or “Flow Control” For Loop, and execute the following step.

Flow Control ‘Chain’

Use to link step execution to another Paradigm.

Figure 4-53. Paradigm Step: Chain

Default Setting: *Chain, Target=undefined_Paradigm, Return=true*

◄ — Close the ‘Paradigm Steps Editor’.

[Undo] — Remove any unsaved edits to this step.

[ ] Return to calling Paradigm:

Once execution of the target Paradigm has completed, return execution to this Paradigm.

Paradigm to chain to:

[< Paradigm names >] [↓]

Paradigm execution will shift to the selected Paradigm.

For multiple Chains (or recursive calls), you can link a maximum of eight Paradigms.

Edit paradigm < selected Paradigm >

< displays after a Paradigm is selected >

Load the selected Paradigm for editing.

Flow Control 'For Loop'

Use a standard programming "For loop" to repeat a set of steps.

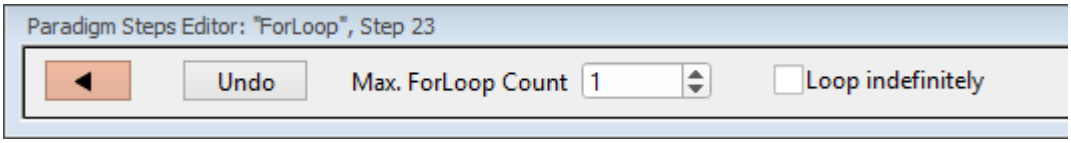


Figure 4-54. Paradigm Step: For Loop

Default Setting: *ForLoop, Max=1*
ForEnd

◄ Close the 'Paradigm Steps Editor'.

[Undo] Remove any unsaved edits to this step.

Max. ForLoop Count
[< 0 – 999 >]

Number of loop cycles to run.

[ ] Loop Indefinitely
Sets 'Max. ForLoop Count' to 'inf'.

Note: A 'For' loop is processed as one step.

Flow Control 'Jump'

Shift the Paradigm sequence to an arbitrary step. When executed, a jump occurs to the step after the target Label.

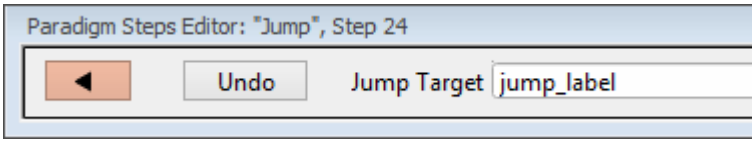


Figure 4-55. Paradigm Step: Jump

Default Setting: *Jump, Target=jump_label*

◄ Close the 'Paradigm Steps Editor'.

[Undo] Remove any unsaved edits to this step.

Jump Target [< label >]

Enter the Label of the step to jump to.

Flow Control 'Label'

Create a Label for a Jump step.

Figure 4-56. Paradigm Step: Label

Default Setting: *Label, Target=jump_label*

◀ Close the 'Paradigm Steps Editor'.

[Undo] Remove any unsaved edits to this step.

Label name [< label >]

Assign a name to the Label.

Condition 'If'

This step allows conditional Paradigm flow control between multiple choices.

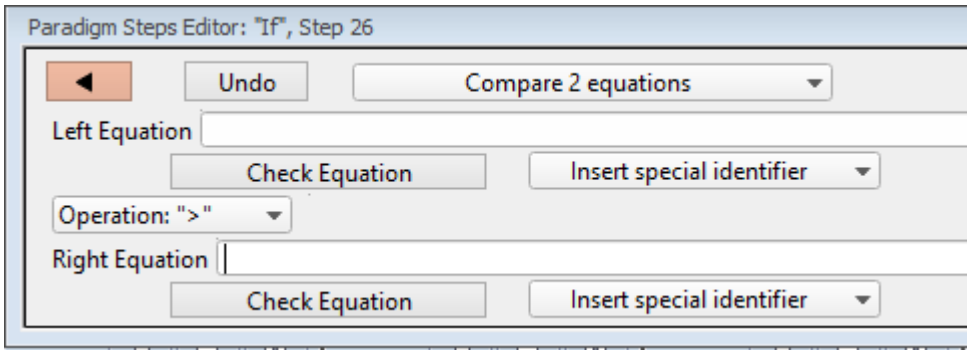


Figure 4-57. Paradigm Step: If

Default Setting: *If, Left=, Operation='>', Right=EndIf*

◀ Close the 'Paradigm Steps Editor'.

[Undo] Remove any unsaved edits to this step.

[< condition >] [↓] Condition selection.

- Compare 2 equations

  Left Equation [< equation >]

  Evaluated to a value.

  [Check Equation] Check the equation syntax. The equation is evaluated for sweep #1, and if valid, it reports "Syntax is ok."

  [Insert special identifier]

  SutterPatch acquisition, amplifier and reference settings are available for use in equations.

  < see list below >

  [Operation: “ “] [↓] Comparison operators.

>	Greater than
>=	Greater than or equal to
=	Equal to
!=	Not equal to
<=	Less than or equal to
<	Less than

  Note: Be careful when comparing two floating-point numbers for equality, as minor variations in resolution can affect the outcome.

  Right Equation [< equation >]

  Evaluated to a value.

  [Check Equation] Check the equation syntax. The equation is evaluated for sweep #1, and if valid, it reports "Syntax is ok."

[Insert special identifier]

SutterPatch acquisition, amplifier and reference settings are available for use in equations.

< see list below >

- String Match

  Control execution of steps based on the Data Navigator tree selection level.

  Source String

  [< source >] [↓]

  - Node Level
  - Node Mark
  - Node Name
  - Paradigm Name
  - Routine Name
  - Signal Name
  - Sweep Name

  Present < source > [Name]

  < read only fields >

  Shows the name of the selected source string.

  Note: When a planned Paradigm is started, the Data Navigator automatically highlights the new Paradigm node.

  When an unplanned Paradigm from a Routine acquisition is started, the Data Navigator automatically highlights the newest Routine node.

  Match String

  [string]

This string may include asterisks as wildcards.

- Check for key pressed

  This is the key last pressed on keyboard since the current Paradigm started, and is displayed in the "Last Key" field.

  Note: The “Last key” field in the Paradigm Editor is cleared at the start of a Paradigm.

  < see “Last Key” button above >

  Key to check for [key]

  Enter a text key, or insert a “special” key.

  [Insert special key] [↓]

  Use a “non-text” key.

  - Space
  - Return
  - Esc

- Check checkbox status

  Select a checkbox to monitor for “on/off” status.

  Checkboxes are displayed at the bottom of the Paradigm Editor window.

  Checkbox [1 – 12]

  Configure the number of available checkboxes in the Paradigm Editor Settings “Edit titles…”.

  1 – 3 These Paradigm-level “local” checkboxes are cleared at the start of a Paradigm.

  4 – 12 These Experiment-level “global” checkboxes states persist across multiple Paradigms for the entire Experiment.

- Answer of yes-no-alert

  [ ] Do Beep — Your computer beeps once when the alert displays.

  Alert Text [< text >]

  Enter your alert question text.

  Run-time dialog

  Elapsed Time [< hh:mm:ss >]

  A time counter for the alert.

  [Yes] 'Yes' button (value = 1)

  [No] 'No' button (value = 0)

  [Stop Paradigm] Manually abort the Paradigm.

Condition 'ElseIf'

Evaluate this step when a prior "If" or "ElseIf" condition fails. This allow conditional Paradigm flow control between multiple choices.

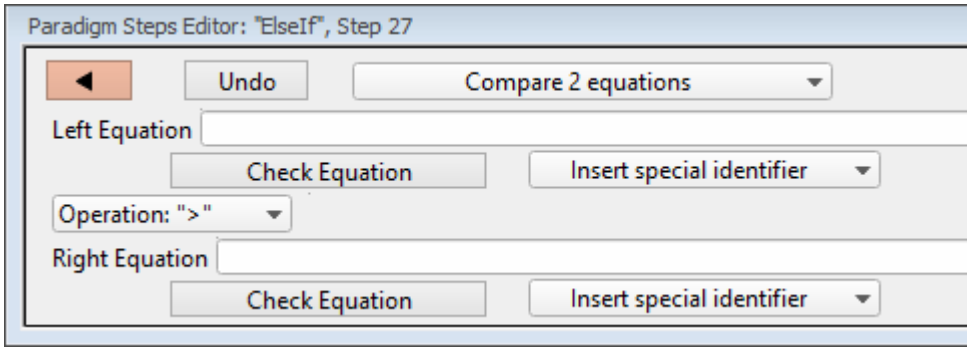


Figure 4-58. Paradigm Step: Else If

Default Setting: *ElseIf, Left=, Operation='>', Right=*

◀ Close the 'Paradigm Steps Editor'.

[Undo] Remove any unsaved edits to this step.

< see “If” step above for conditions >

Condition ‘Else’

This step allows Paradigm flow control to continue to the next step if the previous condition fails.

Default Setting: *Else*

Checkboxes

Checkboxes are useful for quick conditional control of Paradigm steps, and can be manually or automatically enabled/disabled.

Up to 12 checkboxes are visible at the bottom of the Paradigm Editor window, as configured in the Paradigm Editor Settings menu.

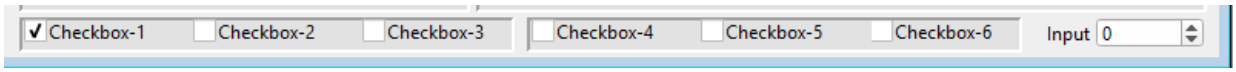


Figure 4-59. Paradigm Checkboxes

[ ] Checkbox1 – 3

These “local” checkboxes are cleared when a Paradigm starts. They provide Paradigm-specific controls that are only valid for the current Paradigm session.

[ ] Checkbox4 – 12

These “global” checkboxes are cleared when an Experiment starts. They can be used across all Paradigm Pools for the entire Experiment.

Input

[#]

Routine and Paradigm variables can be set to this value.

For interactive operation, manually enter a value into the field. For pre-programmed operation, set via the Paradigm step ‘Set Variable / Insert special identifier / Paradigm Parameters / Input’.

Paradigm Variables

The Paradigm Variables table displays at the bottom of the Paradigm Editor.

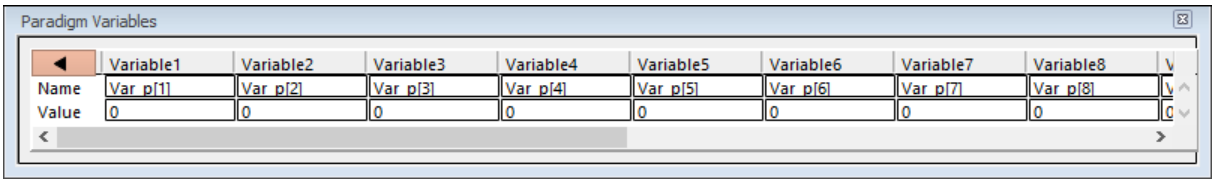


Figure 4-60. Paradigm Variables

These variable can be used in any equation, or in the paradigm step Execute, and persist across experiments. The table can be directly edited during non-acquisition, or set via the paradigm step Set Variable.

◂	'Close' button	Closes the Variables table.
Variable[1 – 16]		16 columns of Paradigm Variables.
Name	Var_p[1 – 16]	Paradigm Variable names can be edited to any text. Note: These names are for display only, and are not supported in equations.
Value	[#]	Numeric values can be manually entered, or programmatically set via the paradigm step 'Set Variable'.

Slider control:Click and drag to change the columns displayed.

Special identifiers list

SutterPatch acquisition, amplifier and reference selections are appended to an equation with a "plus" sign.

Abort selection

Timing

Time	(present date-time, s)
Timer	(timer time, s)
ParadigmTime	(time at start of paradigm, s)
RoutineTime	(time at start of routine, s)

Sweep Time (time relative to routine start, s)

Paradigm Parameters

Loop (active paradigm ForLoop count)

Sweep (active paradigm EachSweep count)

Sweep count of the active sweep in the scope window.

LastSweep (active paradigm sweep count of last sweep)

During acquisition, this is set according to the routine parameters. Once acquisition terminates, this is replaced by the count of the last acquired sweep, i.e., the last sweep in the stored series.

Processing can occur before or after the last sweep of a series.

Example: Use in a 'ForEachSweep' loop Routine, to compare an 'If' step equation to the sweep number.

```
ForEachSweep
   EachSweep, Target=IV
   If, Left=sweep, Operation= '=', Right=LastSweep- 1
     Alert, Text=LAST SWEEP, DoBeep=true
   EndIf
ForEachEnd
```

AqStopped (last acquisition was stopped)

1= the last acquisition was stopped
0 = the last acquisition completed

Stimulant (last applied stimulant concentration)

From the Solution Editor 'Concentration' setting, for a solution configured as a 'Chemical Stimulant'.

Input (Input variable on paradigm window)

Hold[1..4] (holding of n'th output channel)

p[1..16] (n'th paradigm variable)

r[1..16] (n'th routine stimulus variable)

Analysis Results

m[1..16] (n'th analysis measurement value)

gx[1..16] (n'th analysis graph x value)

The X-value of the last data point in the latest version of gaph[#].

gy[1..16] (n'th analysis graph y value)

The Y-value of the last data point in the latest version of graph[#].

Signal Outputs

AuxOUT[1..2] (auxiliary output)

DigOUT[1..8] (digital output bit)

DigOutWord (digital output word) 8 bits

Signal Readings

AuxIN[1..4] (auxiliary input, V)

A single-point reading from an Auxiliary Input channel, such as from a slowly changing temperature probe.

Note: This usage does not require setting up a Routine Input channel.

Imon (amplifier current reading, A)

Vmon (amplifier voltage reading, V)

Mean[name or count,start,width]

(mean of given input signal)

'name' = signal name

'count' = window-signal position

'start' = time of start, s (of measurement range)

'width' = duration, s (of measurement range)

Headstage

ActiveProbe	(active probe) [1 – 4] The “active” probe number is the Sutter headstage presently controlled by the Amplifier Control Panel. For a single headstage system, the active probe is always headstage number "1".
NumProbes	(number of probes) The number of IPA headstages attached to the system.

IPA Settings

CCMode	(amplifier current clamp)
VCMode	(amplifier voltage clamp)
Hold	(IHold in CC-mode, VHold in VC-mode) < in Routines > [±0.000,020 A (±20,000 pA), or ±1.000 V (±1000 mV)]
IHold	(amplifer holding current, A) [± 0.000,020 A (±20 nA)]
IHoldOn	(amplifier holding current On)
VHold	(amplifier holding voltage, V) [±1.000 V (±1000 mV)]
VHoldOn	(amplifier holding voltage On)
IGain	(amplifier current gain, V/A) Read the gain of the active voltage-clamp ‘Current’ input channel.
VGain	(amplifier voltage gain, V/V) V/V evaluates to mV/mV.

	Read the gain of the active current-clamp 'Voltage' input channel.
Filter	(amplifier input filter in VC- and CC-mode, Hz)
	Read the low-pass filter of the input channels.
IFilter	(amplifier input filter in VC-mode, Hz)
	Read the low-pass filter of the 'Current' input channels.
VFilter	(amplifier input filter in CC-mode, Hz)
	Read the low-pass filter of the 'Voltage' input channels.
Offset	(amplifier pipette offset in VC-mode, V)
OffsetLock	(amplifier pipette offset lock On in VC-mode)

IPA Compensation

ECompMag	(amplifier electrode compensation magnitude, F)
ECompTau	(amplifier electrode compensation tau, s)
ECompOn	(amplifier electrode compensation On in CC-mode)
CmComp	(amplifier cell compensation Cm, F)
RsComp	(amplifier cell compensation Rs, Ohm)
RsCompOn	(amplifier cell compensation Rs On)
Bridge	(amplifier bridge balance, Ohm)
BridgeOn	(amplifier bridge balance On)

IPA Correction

RsCorr	(amplifier Rs correction, fraction)
RsPred	(amplifier Rs prediction, fraction)
RsLag	(amplifier Rs correction lag, s)
RsCorrOn	(amplifier Rs correction On)

Dynamic Holding

DynHoldOn (amplifier dynamic holding On)

DynHold (amplifier dynamic holding potential, V)

Membrane Test

Relectr[1..2] (electrode/seal/access resistance, Ohm)

Value from last Membrane Test.

Rmemb[1..2] (membrane resistance (cell mode), Ohm)

Value from last Membrane Test.

Cmemb[1..2] (membrane capacitance (cell mode), F)

Value from last Membrane Test.

RMSNoise[1..2] (membrane test RMS noise, A)

Value from last Membrane Test.

Lock-In

LockInPhaseAdj (Lock-In phase delay adjustment, s)

LockInAttenAdj (Lock-In attenuation adjustment)

Data Navigator

NaviNodeChildren (number of children of selected node)

NaviParadigms (number of paradigms of selected experiment)

NaviRoutines (number of routines of selected paradigm)

NaviSignals (number of signals of selected routine)

NaviSweeps (number of sweeps of selected signal)

NaviNodeNumber (number of selected node)

NaviParadigmNumber

(number of selected paradigm)

NaviRoutineNumber

(number of selected routine)

NaviSignalNumber (number of selected signal)

NaviSweepNumber (number of selected sweep)

4.1.7 Paradigm Overview

'Paradigm Overview' displays data from all Series within the active Paradigm in a modified Reanalysis Scope window. Access this window from the Acquisition Scope window Measurements menu 'Show Paradigm Overview Scope'.

[ ] Auto Width	When enabled, the Paradigm Overview Scope behaves as a "Review" scope, with the Scope X-axis time range being the total Paradigm time. When disabled, the Scope time range uses the Fixed Width time.
Fixed Width (s)	[10 – 3600] The Paradigm Overview Scope X-axis time range displays the last multiple of "Fixed Width". For example, with a Fixed Width of 60 s the Scope time range shows the last minute of the Paradigm time range. The Shift-click Autoscale X-axis button menu includes 'Set the Overview X-range', which forces the Scope time range to the Fixed Width even while Auto Width is enabled. Note: 'The Autoscale All Axes Once' and the 'Initial Autoscale All Axes' (Continuous) button do not apply X-axis scaling in Fixed Width mode.

This view displays all tags in the Paradigm, including those between Series. The tag time is displayed in "Paradigm time".

The state of the continuous Autoscale button applies to all Paradigm Overview, Paradigm Review and Routine Review windows.

To open a Series into a Reanalysis Scope window, right-click on the Series data, and select Analyze <Series Name> from the menu list.

< for more information on the window controls, see the Reanalysis Scope section. >

4.1.8 Routine Editor

SutterPatch: Routine Editor

Routines contain the settings that are in effect during data acquisition. The Routine Editor allows you to define acquisition parameters, set input and output channels, and to create stimulus waveforms and real-time analyses. The Routine Editor is the central place to create and manage saved Routine Pools and data acquisition settings.

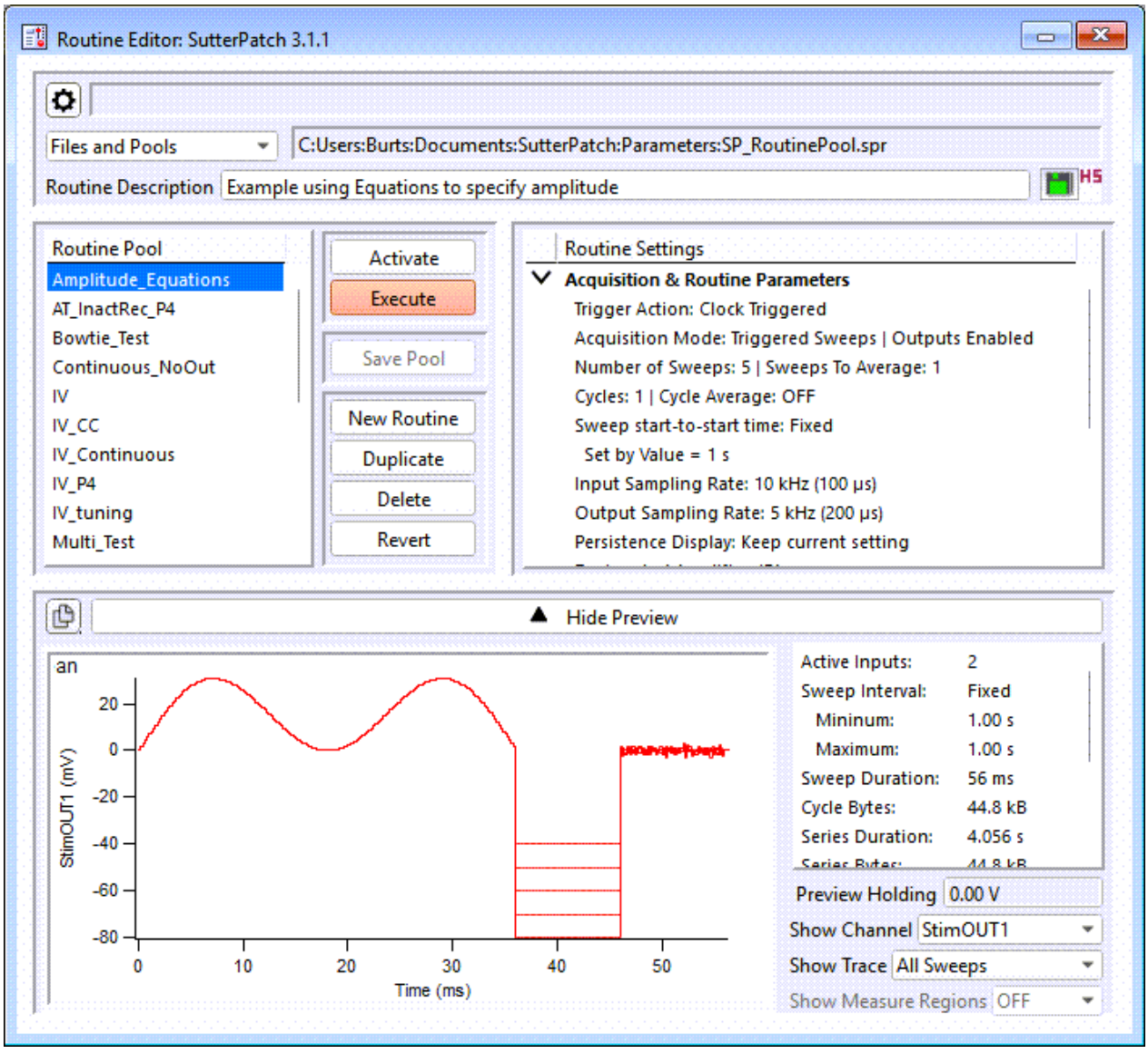


Figure 4-61. Routine Editor

The Routine Editor is structured to hold one or more Routines within its Routine Pool. The Routine Pool thus provides easy access to the set of Routines used in an experiment.

Tip! SutterPatch comes with a sample Routine Pool that contains a collection of frequently used experimental scenarios. Rather than creating a new Routine, it might be easier to Duplicate a sample Routine and modify it until it meets your particular needs.

<table>
<tr><td> 
Routine Editor Settings</td><td>Abort Selection

Show Extended Sampling Rates
Disable Activate Button
Gray out the ‘Activate’ button.
Only Save Real Time Measurement Graph Results
Ungraphed measurements are not saved to the Analysis Editor file.
Limit RTM Regions to Main Pulse When Leak Subtraction is Enabled
Use Specified Holding for Routine Preview</td></tr>
<tr><td>[ ]</td><td>Status field: Notifications on edits and Routine names are displayed.</td></tr>
<tr><td>[Files and Pools] [↓]</td><td>Warning! Microsoft OneDrive is not supported. Do not use to store program files or to acquire data to, or unexpected problems can occur.
Most recently used list of the last 5 Routine Pool file names.
To manually remove a file from the list, Shift-click it.
Note: Path names have a limited number of characters to use. While file names are preserved, paths are shortened by removing excess characters from their ends.
<table><tr><td>Load Routine Pool</td><td>Load the Routine Pool of a previously saved Routine Pool file.</td></tr><tr><td>New Routine Pool</td><td>Create a new Routine Pool with a default Routine, or populated with Routines from the currently loaded Routine Pool.</td></tr></table></td></tr>
</table>

	Get Sample Routine Pool	Load the IPA sample Routine Pool file. Note: There are different sample Routine Pools for one vs. two headstage configurations. 1 HS: SP_RoutinePool.spr 2 HS: SP_RoutinePool_DIPA.spr
	Revert to Last Saved	Undo any unsaved changes to the Routine Pool.
	Save Routine Pool	Save the Routine Pool using its existing file-name and path.
	Save Routine Pool As	Save the Routine Pool to a new filename, and switch to the new file. The default filename has an increment number appended to the original filename.
	Save Routine Pool Copy	Save the Routine Pool to a new filename, but do not switch to the new file. The default filename has 'Copy of" prepended to the original file-name.
	Merge Routine Pools	Insert the Routines from a Routine Pool file into the loaded Routine Pool.
	Merge PatchMaster PGF File	Insert the stimulus templates from a PatchMas-ter *.pgf file (Pulse Generator File) into the loaded Routine Pool. A "Mappings" dialog opens to select the HEKA amplifier type and to set the proper mappings of the analog input and output channels. < this option is not enabled in demo mode >
	Convert Routine Pool	Convert the loaded Routine Pool (designed for other instruments) to be compatible with the at-tached amplifier or emulation mode. All

		conversion changes are written to the Command window. The original file is overwritten, so it is advised to first duplicate a Routine Pool before converting it, to save the original settings. Alert! This action is intended as a "one-time" conversion. Reconverting a converted file can cause corruption.
	Send Last Used List to Command	Copy the path name of the 'Files and Pools' last used Routine Pool to the Command window history.
	Clear Last Used List	Clear the "Last Used" Pool list of all entries.
	Sort Routine Pool – Ascending Order	Sort the 'Routine Pool' list in increasing order.
	Sort Routine Pool – Descending Order	Sort the 'Routine Pool' list in decreasing order.

Table 4-2. Routine Files and Pools

New Routine Pool dialog

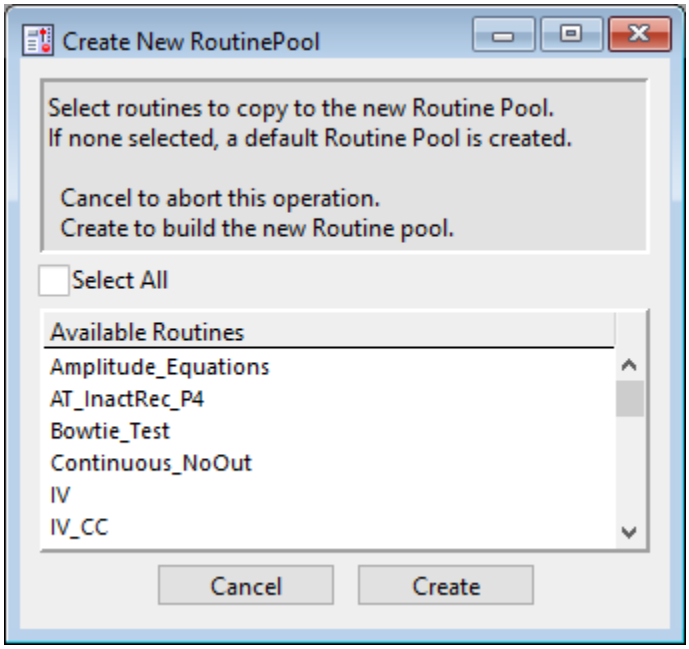


Figure 4-62. New Routine Pool

Create a new Routine Pool populated with a default Routine, or select Routines from the loaded pool to populate the new pool.

[ ] Select All Copy all Routines from the current pool into the new pool.

[< path name >]

Path name of the loaded Routine Pool file.

Routine Description [< text >]

A text comment can be edited and saved with the Routine.

Store data during Routine execution.

This button is green when enabled, and red when disabled. "H5" will also display will also display next to the button if the SutterPatch Preference for HDF5 file saving is enabled.

Routine Pool

The Routine Pool section lists the names of all currently loaded Routines. Selecting a Routine name loads it into the Routine Settings section for editing and activation. As the Routine Pool contents are held in memory, the switching times between Routines are very fast.

To rename a Routine, double-click to select it, then rename or click in it to edit:

- Valid characters are alphabetic and numeric (A-Z, a-z, 0-9), and the underscore "_".

- Names starting with a number are prepended with an 'x' to the name.
- Invalid characters at the start of a name are replaced by an 'x'; invalid characters and spaces within a name are replaced by an underscore.
- The maximum name length is 22 characters; extra characters are truncated.
- The minimum name length is 2 characters; a single character is appended with an 'x'.
- Duplicate names are not allowed in a Routine Pool; an underscore and autoincrement number are appended to the name.

To select multiple Routines, use a Shift-click mouse drag, or individually Shift-click the Routine names. Multiple Routines can thus be deleted or saved to a new Routine Pool.

[Activate]	Open or refresh the Acquisition: Scope window with the latest Routine settings, but do not start acquisition. This button is renamed to "In Progress" during a recording. Note: 'Activate' does not apply any scaling to the Scope window. Therefore, if autoscaling is disabled before acquisition is started, and manual scaling is also not applied, then the signal displays as a flat line at "0.00" without any other Y-axis ticks or units, until scaling is applied which restores the signal.
[Execute] or [Convert]	Open or refresh the Acquisition Scope window and immediately start recording. The latest Routine settings are applied to the Scope window. Routine settings are not updated during acquisition. This button is renamed to "Convert" if the selected routine was designed for a different amplifier type than the current Experiment uses. Routine conversion changes are written to the Command window. The original file is overwritten, so it is advised to first duplicate the Routine before converting it, to save the original settings. Alert! This action is intended as a "one-time" conversion. Reconverting a converted Routine can cause corruption.
[Save Pool]	Save the Routine Pool using its existing file name.
[New Routine]	Add a default Routine to the Routine Pool, and open it for editing. The default Routine name is "untitled" with an increment number

	appended.
[Duplicate]	Add a copy of the selected Routine to the Routine Pool. The Routine name number is appended or incremented.
[Delete]	Remove the selected Routine from the Routine Pool.
[Revert]	Discard any unsaved changes to the selected Routine.

Table 4-3. Routine Editor Buttons

Waveform Preview

The stimulus waveform is graphically displayed at the bottom of the Routine Editor.

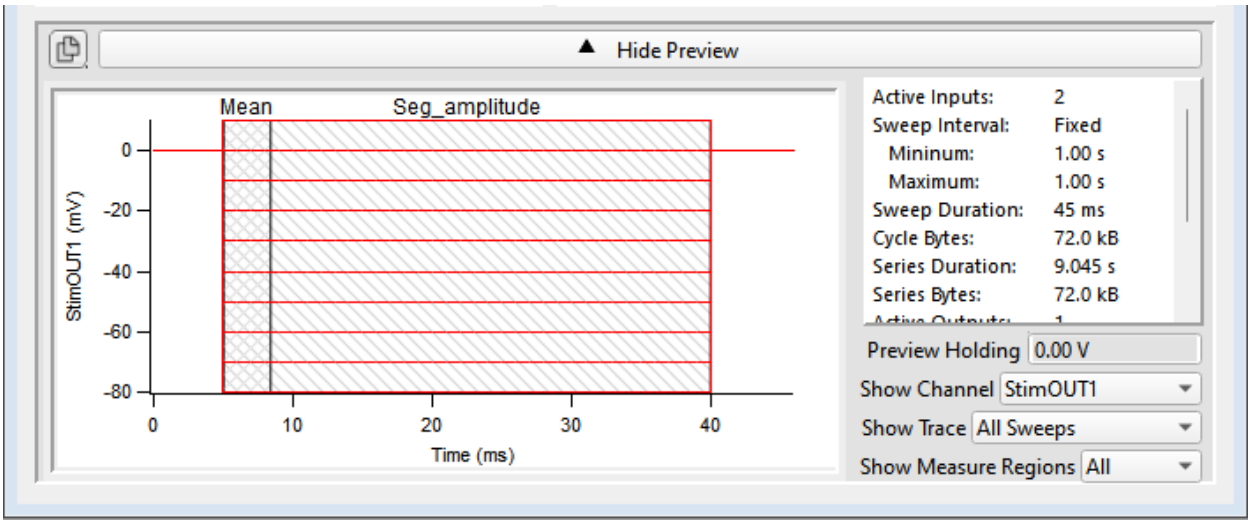


Figure 4-63. Waveform Preview Pane

The waveform preview and its settings are updated live to reflect changes in the Waveform Editor and Amplifier Control Panel.

Measurement regions can be manually repositioned in the Preview pane. Click and hold a measurement region to highlight it in black, then drag it to a new position, and release. This also updates its Measurement Settings / Region Timing 'Start/End Time' settings.

To change the region's duration, click-drag the region's left or right-edge cursor; its Region Timing setting is updated.

The preview for the digital output 'DigOUTWord' sets its Y-axis to ' Digital State (Word)', and displays the decimal value of the selected bits.

Note: A "Cityscape" display mode is used, i.e., plotting with straight horizontal and vertical lines connecting the preview sample points (vs. smooth interpolated transitions).

 Copy Preview — Copy the stimulus graph preview:

To Notebook (as text)	< unavailable >
To Clipboard (as text)	< unavailable >
To Clipboard (as graph)	Copy the waveform to the system clipboard as a graph.
To Layout (as graph)	Copy the waveform as a graph into a new Layout window, or append to an existing Layout page.

[Show/Hide Preview] — Expand or collapse the Preview pane.

X- and Y-axis Control

Hover the mouse cursor over an axis line until the cursor turns into a double-headed arrow, then scroll up or down to contract/expand the axis.

In the preview pane, click and drag the mouse cursor to surround a region of interest with a bounding box (the "marquee"). Right-click in the box and select one of the expand/shrink options.

Some key settings and display controls are listed on the right of the Preview pane.

Time units are in 's', or if < 1 s, then in 'ms'.

Active Inputs:	The number of enabled input channels.
Sweep Interval:	The interval of time between the starts of consecutive triggered sweeps (Sweep Start-to-Start Time) in the active Routine. When set to 'Shortest', this equals the longest Sweep Duration + 200 ms.
Sweep Duration:	The amount of time in a sweep during which signal recording occurs with the active Routine. < for outputs enabled > The sweep duration is based upon the longest stimulus waveform duration set in Output Channels & Waveform / Waveform Editor. < for outputs disabled > The sweep duration is based upon the longest duration set in Input Channels / Edit Signals / Waveform Editor.

Cycle Bytes: The number of bytes of data in a cycle.

Series Duration: The amount of time for the Series.

Series Bytes: The number of bytes of data in the Series.

Active Outputs: The number of enabled output channels.

Stim Duration: The maximum amount of time during which output stimulation occurs in a sweep.

Set in Output Channels & Waveform / Waveform Editor / Duration.

Stim Points: The number of points in the output stimulation.

Cycle Duration: The amount of time for a cycle.

Set in Acquisition & Routine Parameters.

Cycle Points: The number of points in a cycle.

Preview Holding: [#]

The holding level in the Amplifier Control Panel.

User selectable settings

CP Holding [# mV | pA]

< read only field >

The amplifier control panel holding value is used.

or

Preview Hold [<# mV | pA >]

< displays when the Routine Editor Settings 'User Specified Holding for Routine Preview' is enabled >

Show Channel: [< channels >] [↓]

A list of output channels to preview.

- All Channels Preview all analog output channels..
- All Dig Bits Preview all digital output bits.
- [list] Select from the enabled output channels.

Show Trace: [< sweeps >] [↓]

Select how to display autoscaled sweep traces in the preview pane.

- Time Course — Display all traces in continuous linear time.
- All Sweeps — Display all traces overlaid from time zero.

  < not available for 'Show Channel: All Channels' >
- Sweep # — Display a trace from a single sweep.

Show Measure Regions: [< regions >] [↓]

A list of measurement regions to preview.

- None — No regions displayed.
- All — All regions displayed.
- m[#] — Select a single region to display.

If multiple measurement labels overlap and are unreadable, select a single region at a time to display.

Routine Settings

The Routine Settings are split into five main sections, as listed below. Click on a section header or item to open its sub-window.

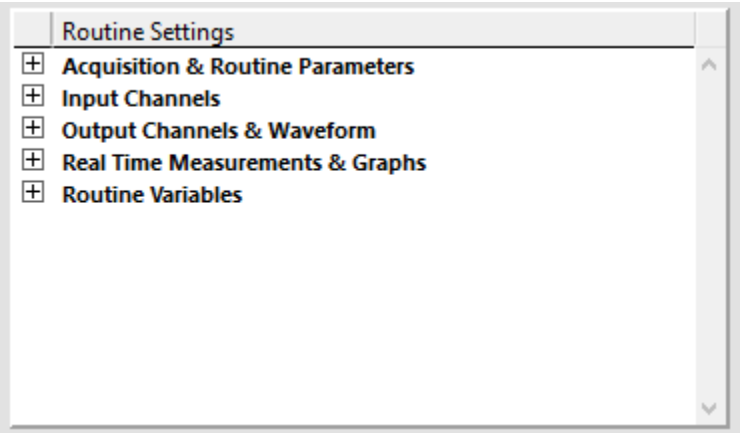


Figure 4-64. Routine Settings

Acquisition & Routine Parameters

Acquisition timing parameters are controlled in this section, such as sweep duration and sampling rates. The settings in this section are shared by all input and output channels.

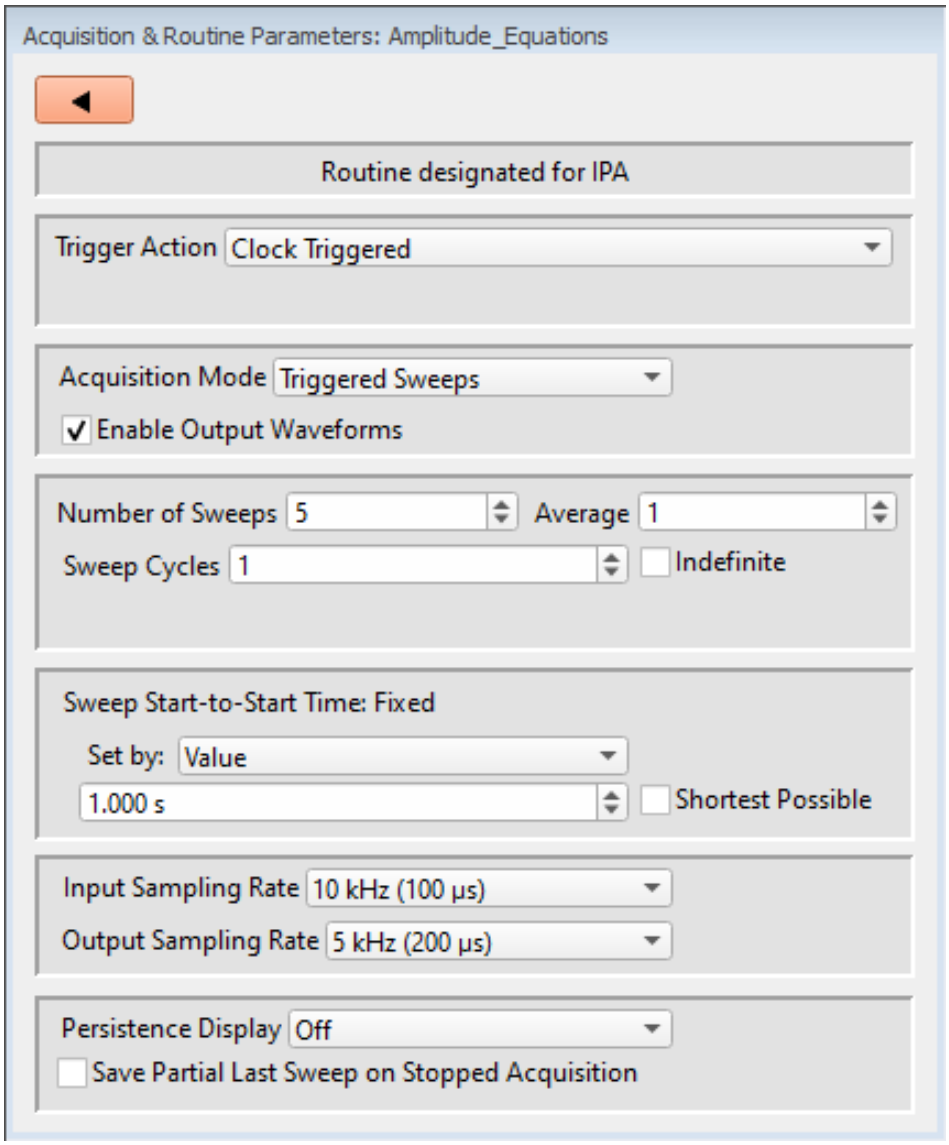


Figure 4-65. Acquisition & Routine Parameters

Trigger Action [↓]

Control how and when recordings occur.

- Clock Triggered: Start a recording timed by the SutterPatch program. Hardware trigger inputs are ignored.

- Externally Triggered Sweep:

  Use an external signal from other laboratory equipment to trigger the recording of each sweep in a Series.

  Connect the external trigger to the 'Trigger In' BNC on the rear panel of the IPA amplifier.

  However, if a Routine is run from within a Paradigm via an 'Each Sweep' step, then the hardware trigger is substituted by a software trigger generated by the Paradigm.

  Once a sweep has been triggered, additional triggers are locked out, until the sweep has been completed. The refractory period, i.e., the time during which another event trigger cannot occur, is the same as the 'Sweep Start-to-Start Time'.

  Note: If this option is grayed out, to ungray the option, first set the Trigger Action to 'Clock Triggered' or 'Externally Triggered Series', then change the Acquisition Mode from 'Continuous Sweeps' to 'Triggered Sweeps'.

  In demo mode, a green 'Do Trigger' button displays below the 'Stop' button, to allow you to manually simulate a hardware trigger.

- Externally Triggered Series:

  < not supported by IPA amplifiers >

  Use an external signal from other laboratory equipment to trigger the start of a Series, then operate like Clock Triggered. A command waveform is only generated for the first cycle.

- Event Triggered: Use an amplitude event in an input signal to trigger data acquisition of a sweep.

  Event triggering is useful to reduce extraneous data when infrequent events occur during long recordings.

  The refractory period, i.e., the time during which another event trigger cannot occur, is the same as the 'Sweep Start-to-Start Time'.

  Note: The Acquisition Mode is reset to 'Continuous Sweeps', to continuously monitor the signal for an event trigger.

Event Triggered Settings

Input Channel To Scan	Trigger on this channel. The unit of the input channel is used for the trigger threshold.
Pre-Trigger Duration	[< 0 – 56.00 ms >] The portion of the sweep duration that is recorded before the event trigger.
Trigger Threshold	[±20.000 nA] current input [±1.000 V] voltage input
Trigger Polarity	Rising ▲ Falling ▼
Minimum Trigger Duration	[< 100 µs – 56.00 ms >]

Acquisition Mode [↓]

- Triggered Sweeps: Each sweep is started by a software trigger from a Routine or Paradigm, or by an external hardware trigger.

  To allow for system delays, there is a short gap (~200 ms) between sweeps. The resolution of the Sweep Start-to-Start time is 1 ms.

- Continuous Sweeps: Uninterrupted data without time gaps between sweeps are recorded when the 'Sweep Start-to-Start Time' is set to the 'Sweep Duration'.

  Data are displayed as successive sweeps, not as a continuous "rolling" display.

  This option does not support:

  - Pausing of sweeps during recording.
  - Paradigm step 'For Each Sweep'.
  - Very short sweeps.

  Note: The IPA demo mode display of continuous sweeps includes artificial gaps between them. Recording with hardware attached does not have any gaps.

Alert! Very high data-processing throughput has the potential to overload system resources and interfere with data processing.

< see theTroubleshooting chapter: Acquisition Q&As >

[ ] Enable Output Waveforms

Output channel waveforms can be optionally disabled.

If outputs are disabled, sweep and segment durations for analysis measurements can be configured in the Input Channels / Edit Signal / Waveform Editor.

If disabled in Continuous Sweeps mode, holding levels can be controlled via the Amplifier Control Panel. And, while metadata settings are only written at the beginning of a Routine, tags are inserted for such additional changes. Also, the amplifier VC/CC mode is set here, as the Output Channels section is unavailable when outputs are disabled.

Restrict To — Ensures that the matching headstage is in the proper VC/CC mode, else the Routine cannot be activated or executed.

- VC Mode — The Amplifier Control Panel matching headstage must be in VC mode to run the routine.

  The default setting for new routines is 'VC Mode'. This prevents CC mode pA (10^{-12} A) current outputs from being accidentally overscaled by VC mode routines using mV (10^{-3} V) voltage outputs.

- CC Mode — The Amplfier Control Panel matching headstage must be in CC mode to run the routine.

Alert! The amplifier can be switched into any mode (VC or CC) while a recording is in progress. However, it is your own responsibility to correctly interpret data with mixed recording modes.

Number of Sweeps [< 1 – 65000 >]

The number of sweeps to record.

Note: a) When allocating large memory blocks, if more than 1 mega-sample of memory is allocated for the Routine, it can take several minutes to load, and a message displays "Allocating acquisition buffers, please wait…"

b) The largest signal size that SutterPatch can record is 2.5 Gsamples, with up to 16 signals (data waves) recorded at a time. This signal limit is independent of the OS file size limit.

c) If a very large amount of memory allocation is needed, and the computer has insufficient RAM memory, an out-of-memory error can occur. In this case, either increase the amount of RAM on the computer, or reduce some of the acquisition settings (such as Number of Sweeps, Number of Cycles, Filter Bandwidth).

Average [< 1 – 1000 >]

< only displays for triggered sweeps >

Repeat the acquisition of a sweep multiple times in a row, and display the averaged sweep before acquiring the next sweep in the sequence.

The raw data is not stored, To retain the raw data, apply averaging with a virtual input signal.

Sweep Cycles [< 1 – 65000 >]

The number of times to automatically repeat the entire set of sweeps recorded by a single Series.

[ ] Maximum

When enabled, the maximum number of sweep cycles for your system's storage is set and displayed in the Sweep Cycles field.

Alert! If an out-of-memory error occurs, see 'Number of Sweeps' Note above.

[ ] Running Cycle Average

< only displays for Sweep Cycles >= 2 >

Acquire sweeps for an entire cycle, and repeat the acquisition of the Series "n" times.

Post Stimulation Cycles < for 'Continuous Sweeps' with Output Waveforms >

< does not display if Sweep Cycles is set to the "Maximum" >

[#]

After the specified number of Sweep Cycles is reached, the Output Waveform is disabled and Post Stimulation Cycles continue to passively record Sweeps until acquisition is stopped.

Alert! If an out-of-memory error occurs, see 'Number of Sweeps' Note above.

Sweep Start-to-Start Time:[Fixed | Variable]

The time from the start of recording a sweep to the start of the next sweep recording.

Fixed: a single time value is used.

Variable: multiple time values are used.

< does not display if # Sweeps = 1 and Average = 1 >

Note: Can use to control the Stop Acquisition button when # Sweeps = 1, if Average >= 2.

Set by: [< value >] [↓]

Value

Use a “fixed” single number for the duration of the sweeps start-to-start time

[< 256 ms – 3600 s (1 hr) >]

When typing in a value, if no unit type is entered, the unit type defaults to seconds (s). If you enter a number followed by an ‘m’ or ‘ms’, the unit type is milliseconds (ms).

Value List

Set an arbitrary duration for each sweep’s start-to-start time.

< for Triggered Sweeps only >

Sweeps | Value

In this table, sweep numbers are associated with a particular value, one row per value.

[< 256 ms – 3600 s (1 hr) >]

Adjust the sweep start-to-start time value by entering a number or by using the increment/decrement controls.

(+)

Add a new row to the table.

This duplicates the last time value, and reassigns the sweep numbers to their values.

If the number of sweeps exceeds the number of values, applies values starting from sweep 1 again, in a

		"round-robin" fashion.
	(-)	Remove the last row in the table. This removes its value, and reassigns the sweep numbers to the remaining values.
	Number of Sweeps	Adjust the total number of sweeps in the Routine.
Value+Increment	Increment the duration for each sweep's start-to-start time.	
	< for Triggered Sweeps only >	
	Base Value	[< 256 ms – 3600 s (1 hr) >]
	Increment Value	[< 1.0 ms – 3600 s (1 hr) >]
	Number of Sweeps	[< # >] Adjust the number of sweeps in the Routine.
Equation	< for Triggered Sweeps only >	
	Specify the sweep start-to-start duration as an equation.	
	[< text >]	A free-form text field for writing equations. The maximum number of characters is 400. Separate multiple equations by a comma. [< 256 ms – 3600 s >] Syntax messages are reported below this field. < see the Equation Editor for more details >
	[Check Equation]	Check the equation syntax. The equation is evaluated for sweep #1, and if valid, it reports "Syntax is ok".

[Insert special identifier]

Acquisition, amplifier and reference settings are available for use in equations.

< see list in Equation Editor >

[Undo] All changes in the equation editing session are discarded.

Alert! Computing an equation for an output wave consumes significant computing power, as every data point needs to be computed by the CPU. For larger acquisitions, this can generate significant delays to the start of acquisition.

Var_r[1 – 16] Variable labels are displayed if a Routine Variable is non-zero.

[#] Settings are reported in this field.

Click in this field to edit the settings.

[ ] Shortest Possible < for Triggered Sweeps set by Value >

Set to the longest waveform duration in the Series + overhead processing time (100 ms).

or

[ ] Sweep Duration < for Continuous Sweeps >

The sweep duration is the longest waveform duration in the Series (as configured in the Waveform Editor.)

< for outputs enabled >

As set in Output Channels & Waveform / Waveform Editor.

< for outputs disabled >

As set in Input Channels / Edit Signals / Waveform Editor.

Note: Demo mode sweep start-to-start times can vary during acquisition, especially on slower computers.

Input Sampling Rate [< # kHz (# µ) >] [↓]

According to the Nyquist sampling theorem, the input sampling rate should oversample the input low-pass filter (set in the Amplifier Control Panel) at a minimum of 2x. However, the Nyquist factor is typically implemented at 5x - 10x for cellular responses, due to their complex shapes.

Also, if the input filter bandwidth is greater than the input sampling rate, the filter is ignored.

This rate applies to all input channels.

Sampling Rate	Sample Interval
100 Hz	(10 ms)
200 Hz	(5 ms)
400 Hz	(2.5 ms)
500 Hz	(2 ms)
1 kHz	(1 ms)
2 kHz	(500 µs)
5 kHz	(200 µs)
10 kHz	(100 µs)
25 kHz	(40 µs)
50 kHz	(20 µs)

Output Sampling Rate [< # kHz (# µ) >] [↓]

This rate applies to all output channels.

Sampling Rate	Sample Interval
100 Hz	(10 ms)
200 Hz	(5 ms)
400 Hz	(2.5 ms)
500 Hz	(2 ms)
1 kHz	(1 ms)

2 kHz	(500 µs)
5 kHz	(200 µs)
10 kHz	(100 µs)

Note: New Routines use a 1 kHz default output channel sampling rate, as command waveforms usually do not require high-resolution time changes. Increase the sampling rate as needed for more complex waveforms.

In general, it is recommended that the Output Sampling Rate be equal to or faster than the Input Filter bandwidth (set in the Amplifier Control Panel).

Channel Timing

IPA amplifiers record both stimulus and response signals via physical analog channels, so the start times of all recorded signals are in sync, with no timing delays between them.

Persistence Display

[< setting >] [↓]

Control which sweeps are displayed in the Scope window

- Off — For each new sweep, all prior sweeps are cleared, and only the newest sweep is displayed.
- On — Overlay each new sweep onto the display of any prior sweeps (per Scope Preferences limits).
- Keep current setting

  Do not change the Scope window's prior settings.

[ ] Save Partial Last Sweep on Stopped Acquisition

Record the data of an interrupted sweep with a Series.

Input Channels

Configure the input channels. Each channel has its own settings.

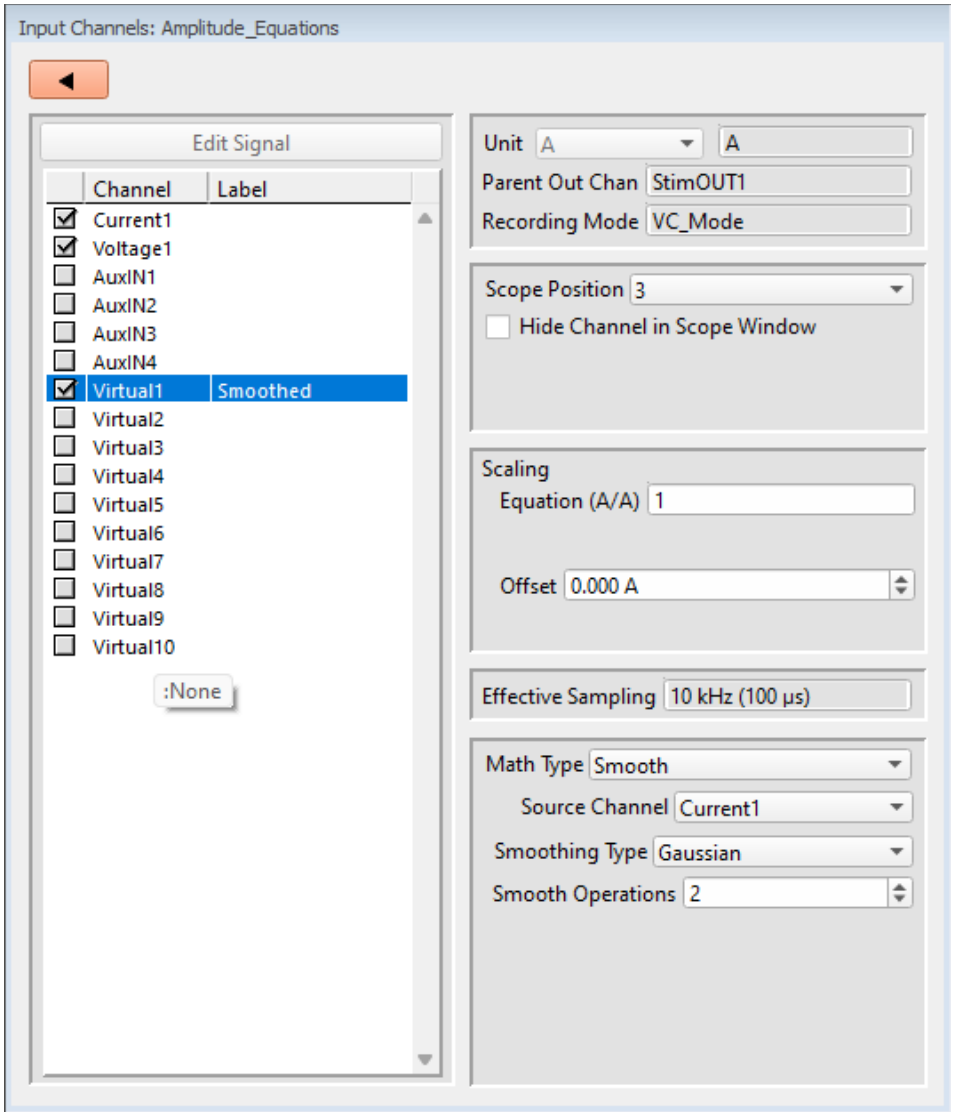


Figure 4-66. Input Channels

Close the 'Input Channels' pane.

[Edit Signal]

< only available when Output Waveforms are disabled in 'Acquisition & Routine Parameters' >

When this button is enabled, double-clicking a channel will open its signal in a special version of the Waveform Editor, which only modifies Segment timing, to allow control of Segment-based measurements.

Channel

Enable up to sixteen Input Channels for recording data:

[ ] Current# — Analog input current channels hardwired from the IPA headstage.

[ ] Voltage# — Analog input voltage channels hardwired from the IPA headstage.

[ ] AuxIN[1 – 4] — Four auxiliary analog input channels allow you to directly digitize and record input signals from connected non-Sutter external equipment.

Note: In Emulation mode, the AuxIN channels display a ±20 mV sine wave.

[ ] Virtual[1 – 10] — Ten virtual channels are available.

Virtual channel data are mathematically transformed data from another input channel, or are entirely computed from an equation.

Label

A user-editable signal name for a channel.

These labels are also used in:

Routine Settings overview for Input and Output Channels

Parent Out Chan'

Virtual channel Math Equations and 'Source' Channels

Scope window signal panes

Data Navigator Preview pane

Metadata Input Signal Name

To rename an Input Channel, first enable it, then double-click its 'Label' field, and enter the new name. If the same label is used by another channel and includes a trailing number, the trailing number will be incremented; otherwise an underscore and increment number are appended to the new label.

When a Virtual input channel is enabled, a default 'Math Type' label is automatically generated for it.

Unit [< unit >] [↓]

[A, V, S, Ohm, °C, °K, °F]

The base unit of measurement.

The signal's unit resolution is automatically adjusted.

- Headstage Channels — < read only >

  Fixed at 'A' for Current channels, and 'V' for Voltage channels.

- AuxIN Channels — Enter the base unit of measurement from a drop-down list.

- Virtual Channels — < only editable for Math Type 'Equation' >

  < read only for all other Math Types, where the unit is the same as its 'Source' channel >

[unit] — The selected unit in an editable field. New unit types are added to the drop-down list.

Parent Out Chan [< channel >] [↓]

This is the output channel associated with the selected input channel.

The ouput channel timing is also used for measurements with 'Cursors Relative to Segments'.

< for headstage input channels > — Displays its associated headstage output channel.

< for Auxiliary input channels > — Select any output channel from the list.

< for Virtual input channels > — Displays its 'Source' channel's Parent Output channel.

Recording Mode [< mode >] [↓]

< only editable for Auxiliary input channels >

Displays the patch-clamp recording mode assigned at the start of acquisition.

- VC_Mode — Voltage Clamp mode
- CC_Mode — Current Clamp mode

Scope Position [< # >] [↓]

The input channel panes can be repositioned in the Scope window.

Position “1” is the top-most pane.

[ ] Hide Channel in Scope Window

The selected input channel is hidden in the Scope window.

[ ] Automatic Baseline Subtraction

< for headstage response input channels without P/N leak subtraction, and for Auxiliary input channels >

Automatically subtract the mean amplitude of the starting region duration from the acquired data. The subtracted data is stored with the Experiment.

Region [< 50 µs – 56 ms >]

Set the duration of the subtraction region (from sweep time ‘0’).

Scaling

< only displays for AuxIN and Virtual input channels >

Equation (‘Unit’/V)

[< equation >]

Enter a Scaling factor as an equation (or a fixed value).

< see the Equation Editor for more details >

Factor (‘Unit’/V)

< only displays for “non-unity” evaluated equations >

[#]

< read only field >

The input channel Scaling factor is evaluated from the equation. Raw values are converted to input units.

Note: The IPA digitizer uses a high-resolution 16-bit ADC with 64-bit data, so data resolution is not an issue when scaling input signals.

Scaled Offset

[< # unit >]

A scaled amplitude offset is applied to the signal.

For ‘mV’ units, append with ‘#m’ or ‘#e-3’.

For ‘pA’ units, append with ‘#p’ or ‘#e-12’

Example:

“5 picoamps” with engineering notation: 5p

or in equivalent scientific E-notation: 5e-12

Offset < only displays for “non-unity” evaluated equations >

[# unit]

< read only field >

The raw amplitude offset of the source signal.

Effective Sampling [# kHz (# μs)]

< read only field >

Displays the sampling rate (and sampling interval) after low-pass filtering is applied.

Virtual Input Channels

Virtual input channels allow you to perform a variety of mathematical transformations on input signals in real time. When a Virtual input channel is enabled and selected, its configuration fields are ungrayed.

Math Type [< math >] [↓]

Apply a data transformation to a Virtual input channel.

List of math types

BaselineSubtract

BesselFilter

CycleAverage

Differentiate

DownSample

Equation

GaussianFilter

Integrate

Leak

LineFreq

LockIn

Smooth

Stimulus

SweepAverage

SweepSubtract

- BaselineSubtract

  Subtract a fixed value from all data points in an input trace.

  This is useful for adjusting an offset or resetting a baseline.

  Post-analysis can be limited to marked sweeps via the Reanalysis Scope Measurements button / Edit Virtual Signals.

Source Channel [< channel >] [↓]

Select an input channel to process.

Baseline From [< channel >] [↓]

Select how to calculate the subtraction value.

- Value — Subtract a fixed value.

  Value [< # >]

  Spinner adjusts in 1 pA or 1 mV increments.

- Trace — Subtract the average of the entire input trace.

- Sweep Time — Subtract the average of the data between the Start Time and End Time.

  Start Time [< # >]

  Set the starting time of the data to be averaged.

  End Time [< # >]

  Set the ending time of the data to be averaged.

- Segment #s — Subtract the average of a Segment.

  Start Ratio [< # >]

  Set the starting time of the data to be averaged, as a ratio relative to the starting time of the Segment duration.

  Start Time [#]

  < read only field >

  End Ratio [< # >]

  Set the ending time of the data to be averaged, as a ratio relative to the

ending time of the Segment duration.

End Time [derived time value]

- BesselFilter A frequency-domain filter with excellent response characteristics for preserving the shape of a biological signal.

  Source Channel [< channel >] [↓]

  Select an input channel to filter.

  [ ] Lowpass Phase Delay Correction

  Correct the signal for estimated digital filtering delays by shifting the signal forwards in time.

  Filter Order [1, 2, 4, 8] [↓]

  Number of "poles" in the filter. A higher number provides a sharper (more accurate) response, but consumes more processing time and system resources.

  Lowpass Bandwidth [< 0.01 Hz to < ½ the sampling rate >]

  Restrict frequencies from this boundary point onwards.

  Allow signal frequencies less than the cutoff frequency, and block all higher frequencies, such as high-frequency noise.

  [ ] Highpass Allow signal frequencies greater than the cutoff frequency, and block all lower frequencies, such as low-frequency drift.

- CycleAverage < only displays if Acquisition 'Sweep Cycles' > 1 >

  Apply averaging across cycles for each numbered sweep.

  Post-analysis can be limited to marked sweeps via the Reanalysis Scope Measurements button / Edit Virtual Signals.

  Source Channel [< channel >] [↓]

  Select an input channel to average.

- Differentiate — Apply differentiation to an input signal. The instantaneous rate of change in the signal is displayed.

  Source Channel [< channel >] [↓]

  Select an input channel to differentiate.

- DownSample — Apply downsampling to an input signal, i.e., reduce the sampling rate of the signal data.

  Source Channel [< channel >] [↓]

  Select an input channel to downsample.

  Source Sampling Rate

  [# Hz]

  < read only field >

  New sampling rate of the reduced signal.

  Reduction Factor [< 2 – 100 >]

  Only whole numbers are used; non-whole numbers are rounded up or down.

- Equation — Specify an equation to process an input signal.

  < for use by Igor Pro power users >

  Source Channel [< channel >] [↓]

  Select an input channel to process.

  Equation [< equation >]

  Click in the field to access the 'Specify math equation' editor.

  Note: The full equation is always visible as a tool tip, by hovering the mouse cursor over the 'Math Equation' field.

  Specify math equation for virtual signal

  [< equation >]

  A free-form text field for valid expressions.

Syntax messages are reported under this field.

[Check Equation] Check the equation syntax. The equation is evaluated for sweep #1, and if valid, it reports “Syntax is ok”.

Note: Not all errors are caught by the syntax checker, such as incompatible sampling rates between waves.

[Insert special identifier]

A limited set of identifiers are available for virtual equation traces. However, special references can also be used within commands.

- Abort selection

- s[SeriesNo,SweepNo, SignalNo]

  (trace of specified series)

  Access an arbitrary input trace (data wave) via counts of Series #, Sweep #, Trace # (scope channel position) in the active Routine.

  The “current” item is the “active” trace in the Scope window, and has a count value of zero.

  If a “count” number is non-zero, it is used as an offset from the current count value of zero. Any fractions in count numbers are truncated to integers.

  Ex: s[0,0,0,]

  The current series, current sweep, current trace, of the current routine.

- t[1..16] (n’th input trace)

Access the input trace (data wave) in Scope channel position “n” for the last sweep of the current Series. This numbering can differ from the Scope Position "n", if signals are re-arranged or hidden.

Tip! You can duplicate a trace by using this.

- a[Name] (name of analysis wave)
- copy[1..16] (n’th trace retrieved via File Control).
- p1..16] (n’th paradigm variable)
- eq[equation] (result of the given equation)
- if[selector ? true-branch : false-branch]

(conditional processing)

The expression is evaluated and returns a value. If the expression in “selector” is true, i.e., non-zero, the result is the content of the “true-branch”, otherwise the result is the content of the “false-branch”.

[Undo] All changes in the equation editing session are discarded.

[Expand to Notebook]

Copy the equation to the Notebook with any Paradigm variables expanded to their values.

< see the Equation Editor for more details >

[ ] Enable User Defined Function

< see Programming chapter SutterPatch Hooks >

Parameters [ ]

< only displays if User Defined Function is enabled >

- GaussianFilter — This filter is useful for reducing ringing and preserving sharp edges.

  Source Channel [< channel >] [↓]

  Select an input channel to filter.

  Lowpass Bandwidth [< 0.10 Hz to ≤ ½ the sampling rate >] [↓]

  [ ] Highpass — Allow signal frequencies greater than the cutoff frequency, and block all lower frequencies, such as low-frequency drift.

  Bandwidth [< " > ½ the sampling rate" >] [↓]

  HighPass Filter Order

  [< 1, 2, 4, 8 >] [↓]

- Integrate — Display the integral of the data signal. This is equivalent to the signed area under a curve.

  Source Channel [< channel >] [↓]

  Select an input channel to integrate.

- Leak — Remove leakage current from the data signal. This is the small passive current when the cell is in a resting state.

  < only available when the Routine includes an output channel with P/N Leak Pulse enabled >

  Source Channel [< channel >] [↓]

  Select an input channel to process.

  Show Leak [< status >] [↓]

  - Off
  - On

  Display the accumulated leak currents after the subtracted data in a sweep.

  Leak Zero Segment [< # >]

Identify a segment with no active cellular response to the command signal.

When set to zero, the field is set to 'OFF'. To re-display the numeric spinners, enter a non-zero number into the field.

Note: The mean of the second half of the specified segment is used to compute an averaged leak current, which is then used to correct the P/N leak average. This option reduces the influence of a constant leak-current, which is otherwise included in the leak current of the main signal.

[ ] Enable — Enable the 'Leak Zero Segment'.

[ ] Baseline Subtraction

The first point of the sweep is used for baseline subtraction of the sweep's main pulse.

- LineFreq — Remove AC line frequency noise (hum) from the data signal.

Alternating current AC) power contains 50 or 60 Hz oscillations that can cause sinusoidal line-frequency noise in recorded signals. This FFT-based filter reduces such noise by > 90% over 6 harmonics. The adjusted signal is displayed in real time.

Source Channel — [< channel >] [↓]

Select an input channel to process.

Line Frequency — [50 | 60 Hz] < read only field >

This parameter is configured in Set Preferences / Hardware.

60 Hz — Canada, (Caribbean), Central America, (Japan), Mexico, (South America), South Korea, Taiwan, USA.

Regions (in parentheses) include both 50 Hz and 60 Hz frequencies.

50 Hz — Most of rest of the world.

Warning! Do not apply to sweeps of 3 minutes or more, or problems will occur. Either apply offline, or reduce the sweep duration.

Notes: When using short sweeps or slow sampling, performance might improve with a larger number of sample points, such as with an increased sweep duration or filter bandwidth.

In demo mode, a sine wave is added to the original input signal, so that the LFR subtraction can be compared to the "added" signal.

In demo mode, when P/N leak subtraction is enabled on an output channel, line frequency reduction is not applied to the input channels.

- LockIn — Measure cell characteristics (such as membrane capacitance) with high signal-to-noise sensitivity, using a dual-phase software lock-in amplifier.

  < only enabled when the Routine includes an output channel with a waveform set to 'Sine / Sine Wave Cycles / For LockIn' >

  Calculations are made using 'conductance' instead of 'resistance'.

  Source Channel [< channel >] [↓]

  Select a (source) input channel with a "current: signal.

  Trace Kind [< kind >] [↓]

  Select the LockIn measurement to display.

  The selected 'Trace Kind' is automatically set as the Virtual Channel label.

  CM Computed membrane capacitance.

  GM Computed membrane conductance.

  GS Computed series conductance.

  DC DC component of measured signal.

  RealY

  Real number part of the lock-in response signal.

ImagY

Imaginary number part of the lock-in response signal.

Cycles to Average [< 1 – 65000 >]

Cycles to Skip [< 1 – 65000 >]

V-reversal [< ±0.75 mV >]

When using a calculated stimulus trace, enter the reversal potential for the ion under study, such as for (Na+) sodium spikes or (K+) potassium tail currents.

< see Appendix F: SutterPatch Algorithms: LockIn computation >

- Smooth — Smooth the data with a "moving average" noise-reduction filter.

Source Channel [< channel >] [↓]

Select an input channel to smooth.

Smoothing Type [< type >] [↓]

- Gausian — A standard filter with excellent 10 – 90% rise-time response.

Smooth Operations [< 1 – 32767 >]

# of smoothing operations to perform.

- Boxcar — A fast time-domain filter with excellent 0 – 100% rise-time response.

Smooth Repetitions [< 1 – 32767 >]

# of smoothing repetitions to perform.

Boxcar Window Points

[< 1 – 101 >]

# of points in boxcar sliding window.

Note: For best performance, only odd values are used.

- Stimulus Replicate the command Waveform.

  Source Channel [< channel >] [↓]

  Select an input channel – the waveform from its 'Parent Out Chan' is used.

- SweepAverage Average the input traces.

  Source Channel [< channel >] [↓]

  Select an input channel to average.

  Average Type [< average >] [↓]

  - Cumulative Average together all designated sweeps from "Start" to "End".

    Start Sweep [< # >]

    Sweep number to start sweep averaging.

    [ ] Set Sweep < Start Sweep To NAN

    Enable so that sweeps prior to the Start sweep are are designated as NaNs (i.e., not displayed).

    End Sweep [< # >]

    Sweep number to end sweep averaging.

    This number must be larger than the Start sweep number.

    [ ] Set Sweep > End Sweep To NAN

    Enable so that sweeps after the End sweep are are designated as NaNs (i.e., not displayed).

  - Run Average Average incrementing sets of "N" sweeps for all designated sweeps from "Start" to "End".

    Number of Sweeps [< # >]

    "N" sweeps to be averaged together.

    Start Sweep [< # >]

Sweep number to start sweep averaging.

[ ] Set Sweep < Start Sweep To NAN

Enable so that sweeps prior to the Start sweep are are designated as NaNs (i.e., not displayed).

End Sweep [< # >]

Sweep number to end sweep averaging.

This number must be larger than the Start sweep number.

[ ] Set Sweep > End Sweep To NAN

Enable so that sweeps after the End sweep are are designated as NaNs (i.e., not displayed).

- GroupAverage

  Average together "N" sweeps per Group, without overlap from the preceeding Group, for all acquired sweeps

  Number of Sweeps [< # >]

  "N" sweeps to be averaged together.

  [ ] Set Intermediate Sweeps To NAN

  Enable so that sweeps that are not the last sweep in a Group are set to NaNs (i.e., not displayed).

- SweepSubtract Subtract a sweep from the input trace.

  Source Channel [< channel >] [↓]

  Select an input channel to process.

  Reference Sweep [< # >]

  Select a sweep to be subtracted from all other sweeps. If the sweep does not yet exist, no subtraction occurs.

Output Channels & Waveform

Configure the output channels and command waveforms.

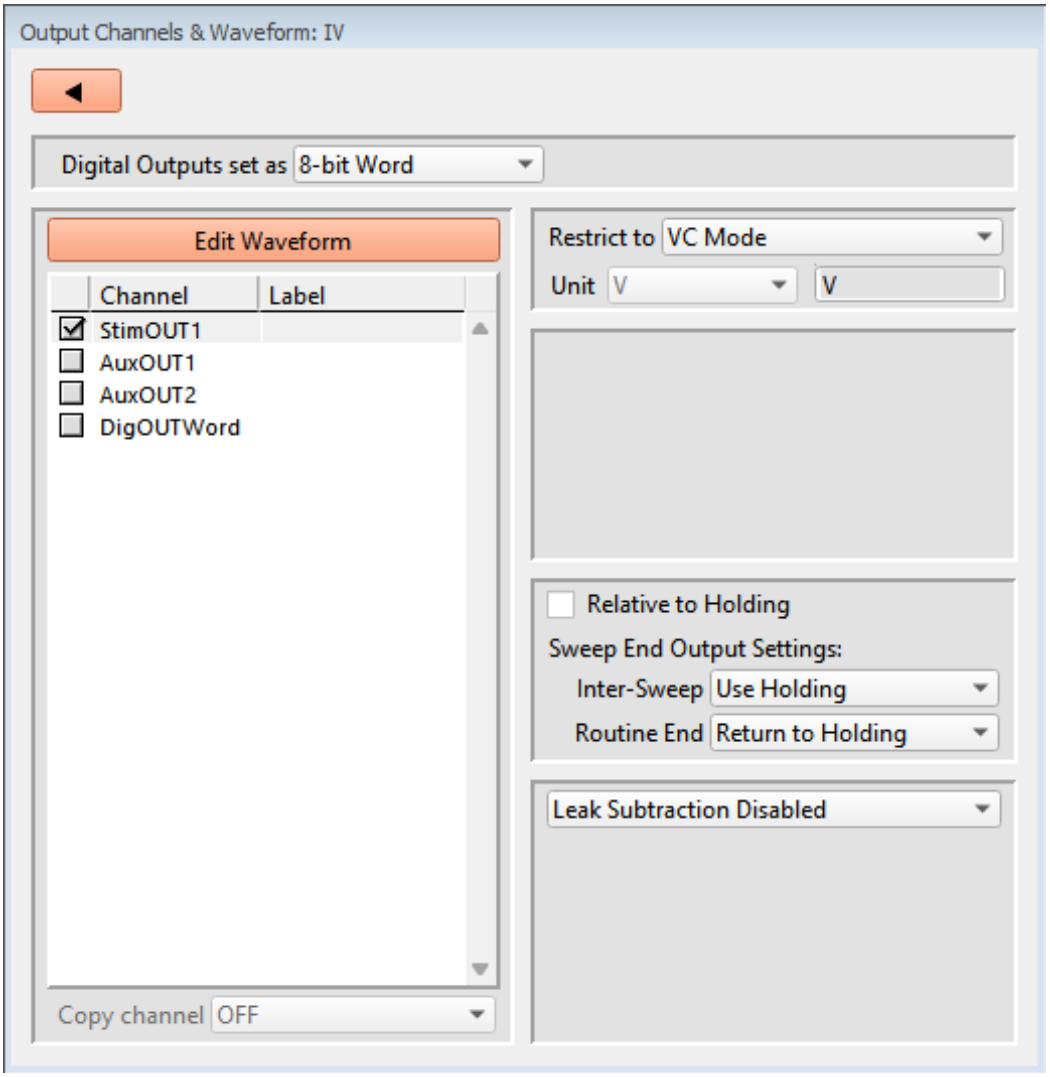


Figure 4-67. Output Channels & Waveform

◀ Close the 'Output Channels & Waveform' pane.

[Status field]

Hardware information displays for the highlighted channel.

Digital Outputs set as [< format >] [↓]

The digital output channels (bits) can be set individually or as a group.

- Individual bits — DigOUT[1 – 8]

  Each bit is individually set in its own Waveform Editor table.

  The waveform preview uses the bit's binary word decimal value for its Y-axis value, i.e. if bit 3 is 'HIGH', it has a "word" value of 4.

- 8-bit Word — [< 0 – 255 >]

  The 8-bit digital output pattern is controlled by a single decimal number, which is also the waveform preview amplitude value.

  The waveform preview uses the binary bit pattern word value for its Y-axis value, i.e., if bits 1 and 3 are 'HIGH', it has a value of 5.

[Edit Waveform]

Click the Edit Waveform button to access the Waveform Editor table and create a stimulus waveform.

< see the Waveform Editor section below >

Channel

Click on the Output Channel checkboxes to enable analog and digital output channels in the Routine. Click on an enabled channel name to highlight and select it – the channel output parameters are displayed for configuration. Double-click an enabled channel name to open its stimulus waveform in the Waveform Editor.

[ ] StimOUT — The default StimOUT channnels are hardwired to the IPA headstage.

For StimOUT channels, the actual DAC output signal is passed through a 20 kHz low-pass filter before entering the headstage.

Tip! If a signal is connected to the front panel 'COMMAND IN' BNC, that signal is summed with the StimOUT waveform that is sent to the headstage.

Note: For experiments that only need a holding level (vs. a stimulus waveform), instead of using StimOUT (which generates a waveform that increases loading time), disable the Acquisition & Routine Parameters 'Enable Output

Waveforms' control, and use an Amplifier Control Panel 'V-holding' or 'I-holding' level.

[ ] AuxOUT — The AuxOUT auxiliary analog output channels can be used to send stimulus or timing waveforms to external instruments.

[ ] DigOUTWord or [ ] DigOUT[1 – 8] — The digital outputs are available as either a single 8-bit "word", as 8 individual 1-bit channels.

Label

A user-defined signal name for the channel.

These are also used in:

- 'Copy Channel'
- Waveform Preview pane 'Show Channel'
- Metadata: Output Signal Name

To rename an Output Channel, first enable it, then double-click its Label field and enter the new name. If the same label is used for another channel and includes a trailing number, the trailing number will be incremented, otherwise an underscore and increment number will be appended to the new label.

Copy channel [< channel >] [↓]

Copies one channel's waveform to another channel, for output channels of the same type (i.e., "StimOUT", "AuxOUT" or DigOUT). If a channel is enabled, then highlighting another or blank channel of the same type ungrays the 'Copy channel' field, and changes it from 'OFF' to 'None', with a drop-down list of available channels to copy from.

Restrict to [< mode >] [↓]

< for headstage channels only >

Ensures that the matching headstage is in the proper VC/CC mode, else the Routine cannot be activated, executed or started.

However, the IPA amplifier can be switched into any mode (VC or CC) while a recording is in progress. Recording Mode tags are inserted into the signal to assist you, but it is your own responsibility to correctly interpret data with mixed recording modes.

- VC Mode — The Amplifier Control Panel matching headstage must be in VC mode to run the Routine.

The default setting for new Routines is 'VC Mode'. This prevents CC mode pA (10^{-12} A) current outputs from being accidentally overscaled by VC mode Routines using mV (10^{-3} V) voltage outputs.

"Tag" Recording Mode: 1

- CC Mode — The Amplfier Control Panel matching headstage must be in CC mode to run the Routine.

  "Tag" Recording Mode: 2

Unit [< mode >] [↓]

< read-only for StimOUT channels >

Fixed at 'V' for voltage-clamp experiments, and 'A' for current-clamp.

< only editable for AuxOUT channels >

[A, V, S, Ohm, °C, °K, °F]

Enter the base unit of measurement from a drop-down list. (Default is 'V'.) The unit resolution is automatically adjusted in the signal.

Or edit the text field to add new nomenclature to the list.

Scaling

< only displays for AuxOUT channels >

Equation (Unit/V)

[< equation >]

Enter a scaling factor as an equation (or a fixed value).

< see the Equation Editor for more details >

Factor ('Unit'/V) < only displays for "non-unity Equation" channels >

[< # >]

Read-only field of the evaluated Scaling equation.

Scaled Offset

[< # >]

Applies an amplitude offset to the output channel.

The offset is set in scaled output units.

Tip! To use 'mV' units, enter: '#m' or '#e-3'
To use 'pA' units, enter: '#p' or '#e-12'

Offset < only displays for "non-zero Offset" channels >

[±10.000 V]

< eead only field of the raw Offset value, before any scaling >

The raw offset can be scaled up to ±10.000 V.

[ ] Relative to Holding

< displays for StimOUT channels >

If 'Relative to Holding' is enabled, the headstage output signal is the command waveform summed with the Holding level in the Amplifier Control Panel. If the holding level is set to '0', this setting has no effect.

[ ] Relative to I/O Setting

< displays for AuxOUT and Digital channels >

AuxOUT For the Auxiliary channels, the command waveform is summed with the Amplifier Control Panel I/O 'Auxiliary Output' settings.

DigOUT For digital channels, the command waveform is relative to the Amplifier Control Panel I/O 'Digital Output' settings.

Note: When enabled, the holding level output is immediately updated by any changes in the Amplifier Control Panel.

Sweep End Output Settings

Control how the amplifier output levels (including I/O Auxiliary and Digital Output levels) are handled when the system is not acquiring data.

Inter-Sweep [< value >] [↓]

This is the time between sweeps, i.e., after a sweep ends, but before the next sweep starts.

- Use Waveform Value Set the output signals to their last values in the

command waveform, at the end of a sweep.

Use to avoid generating a short (potentially disruptive) glitch in your preparation, caused by returning to holding levels at the end of a sweep.

- Use Holding — Set the output signals to the Amplifier Control Panel "holding" levels, at the end of a sweep.

  This ensures that your cells are kept in a resting state as much as possible, and that each output sweep starts from the same holding level.

Routine End [< value >] [↓]

This is the time after the Routine ends, until the next Routine starts.

- Use Waveform Value — Set the output signals to their last values in the command waveform, at the end of a Routine.

  Use to avoid generating a short (potentially disruptive) glitch in your preparation, caused by returning to the holding levels at the end of a Routine.

- Return to Holding — Set the output signals to the Amplifier Control Panel "holding" levels, at the end of a Routine.

  This ensures that your cells are kept in a resting state as much as possible.

Note: In demo mode, holding levels are only updated when a Routine is activated, unless 'Relative to Holding' is enabled - then the 'Return to Holding' levels are updated immediately.

Leak Subtraction [< value >] [↓]

- Leak Subtraction Disabled

  No leak subtraction is configured or performed.

- Leak Subtraction Enabled

  Displays the Leak Pulses section for configuration.

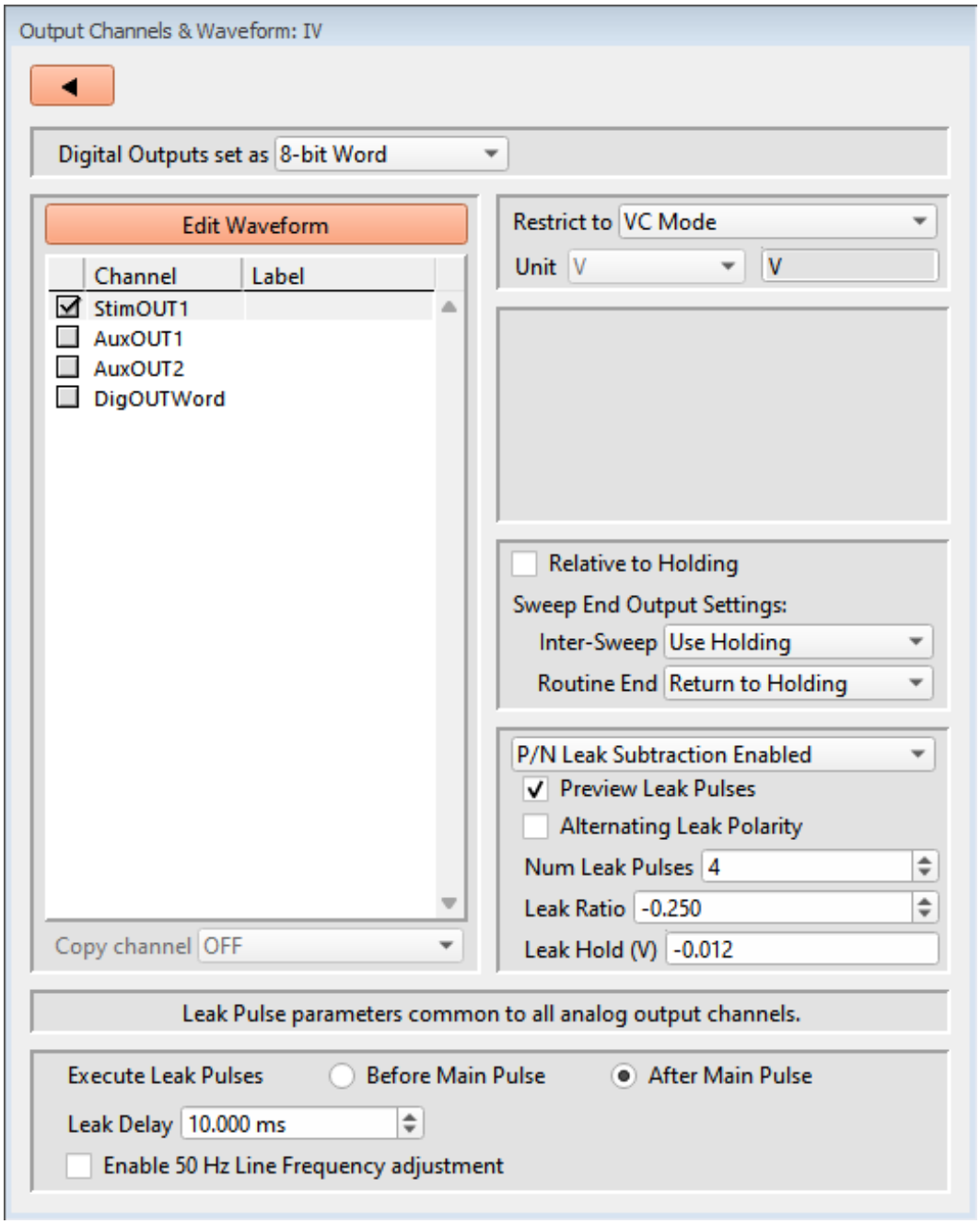


Figure 4-68. Output Channels & Waveform with Leak

Endogenous leak currents can flow, even while a cell is in its resting state, from conditions such as an imperfect or leaky seal, or via existing ion channels, and affect response amplitudes. Real-time P/N leak subtraction automates the removal of such currents from the data.

If endogenous leak conductance is an issue with your cell type, and/or high temporal resolution is required along with a need to reduce capacitive transients (e.g., with voltage-gated sodium currents), click 'Enable P/N Leak Pulses' and configure its settings below.

A “leak pulse” is a replica of the stimulus waveform, and is used to record a fraction of the leakage current. In this technique, leak pulses are generated, and the responses are averaged, scaled, and subtracted from the main response to remove the effects of leakage.

Note: The sub-pulses are stored as part of the sweep. This ensures that if any events occur during the sub-pulses or between the sub- and main pulses and causes unexpected or hard-to-interpret effects, the full original recording condition can be examined.

[ ] Preview Leak Pulses

Display the leak subtraction pulses in the Routine Editor Waveform Preview panel. A leak subtraction pulse is a scaled copy of the main stimulus waveform.

[ ] Alternating Leak Polarity

You can reduce directional bias in the leak conductance by alternating the polarity of the leak subtraction pulses on a sweep-by-sweep basis, as long as no ion channels are activated.

Num Leak Pulses [< # >]

Set the number of leak pulses used to average out noise and leak conductance. Adjust this number in accordance with the amount of noise in the signal. Due to the high precision of modern digitizers, this number can sometimes be reduced to less than 4 leak sub-pulses.

Note: As each leak pulse replicates the stimulus waveform, larger numbers of leak pulses are not recommended, as this can greatly increase the total duration of a sweep during acquisition, and the noise in the sub- and main pulses can add up and actually increase.

The default setting of ‘4’ Leak Pulses, when used with the default Leak Ratio (-0.250) operates equivalently to pCLAMP’s default P/N setting (4 subsweeps for P/4).

Leak Ratio [< # >]

Set the leak subtraction pulse size relative to the main waveform pulse, using a ratio between +1 and -1. The setting should be low enough that no electrically-gated ion channels are activated. For instance, a Leak Ratio setting of 0.25 will generate leak pulses at ¼ the amplitude of the main stimulus waveform, while a Leak Ratio of 0.2 will generate leak pulses at 1/5 the main pulse amplitude.

Note: The program scales the leak subtraction pulses based upon the Leak Ratio setting, not the number of Leak Pulses. This means that the Leak

Ratio can be set independently from Num Leak Pulses, instead of those settings being interdependent.

Tip! As an alternate way to avoid electrical activation of ion channels, use a negative ratio to reverse the polarity of the leak pulses relative to the main pulse.

Leak Hold (V) [< equation >]

The leak pulses holding level can be set differently from the Routine main holding level, for flexibility in finding a suitable leak pulse voltage range. The scaled waveform amplitudes are measured relative to the Leak Hold level, but are subtracted relative to the IPA holding level.

Set to a fixed value, or enter as an equation.

< see the Equation Editor section for more details >

Specify leak holding as an equation.

[Check Equation]	Check the equation syntax. The equation is evaluated for sweep #1, and if valid, it reports "Syntax is ok".
[Insert special identifier]	Acquisition, amplifier and reference settings for use in equations. < see list in Equation Editor >
[Undo]	All changes in the equation editing session are discarded.

Leak Pulse parameters common to all D/A channels

Execute Leak Pulses

Leak pulses can be set to run before or after the main waveform pulse.

- Before Main Pulse — Sub-pulses are output relative to the Leak Hold level. After the sub-pulses complete, the signal goes to the IPA Holding level for the duration of the Leak Delay before the main pulse.
- After Main Pulse — After the main pulse completes, the signal goes to the Leak Hold level for the duration of the Leak Delay setting, and then outputs sub-pulses relative to the Leak Hold level.

Leak Delay [0 – 3.6 ks]

If a settling time is needed between the leak pulses and the main waveform pulse, Leak Delay will insert a time delay between the execution of the leak pulses and the main pulse. Provide enough time to avoid interference of the leak pulses with any active currents or inactivation of ion channels.

When leak pulses occur before the main pulse, Leak Delay uses the amplifier's Holding level; when leak pulses occur after the main pulse, Leak Delay uses the Leak Pulses 'Leak Hold' level.

[ ] Enable 50/60 Hz Line Frequency adjustment

The effect of AC line-frequency noise (hum) can be automatically reduced during P/N leak subtraction recording:

This Line Frequency adjustment automatically calculates the proper inter-pulse interval for the P/N sub-pulses, so that they are counter-phased to the line frequency of the main output signal, which reduces hum without filtering the signal.

- 50 Hz — Enable the reduction of 50 cycle AC line noise.
- 60 Hz — Enable the reduction of 60 cycle AC line noise.

- Background Subtraction Enabled

Background subtraction settings are displayed.

Preview Leak Pulses

Display the background subtraction signal in the Routine Editor Waveform Preview panel.

< read only settings >

Num Leak Pulses [1]

Leak Ratio [0.000]

Leak Hold (V) [Set to Holding]

Waveform Editor

Click the 'Edit Waveform' button to open the Waveform Editor and design a command waveform for the selected output channel.

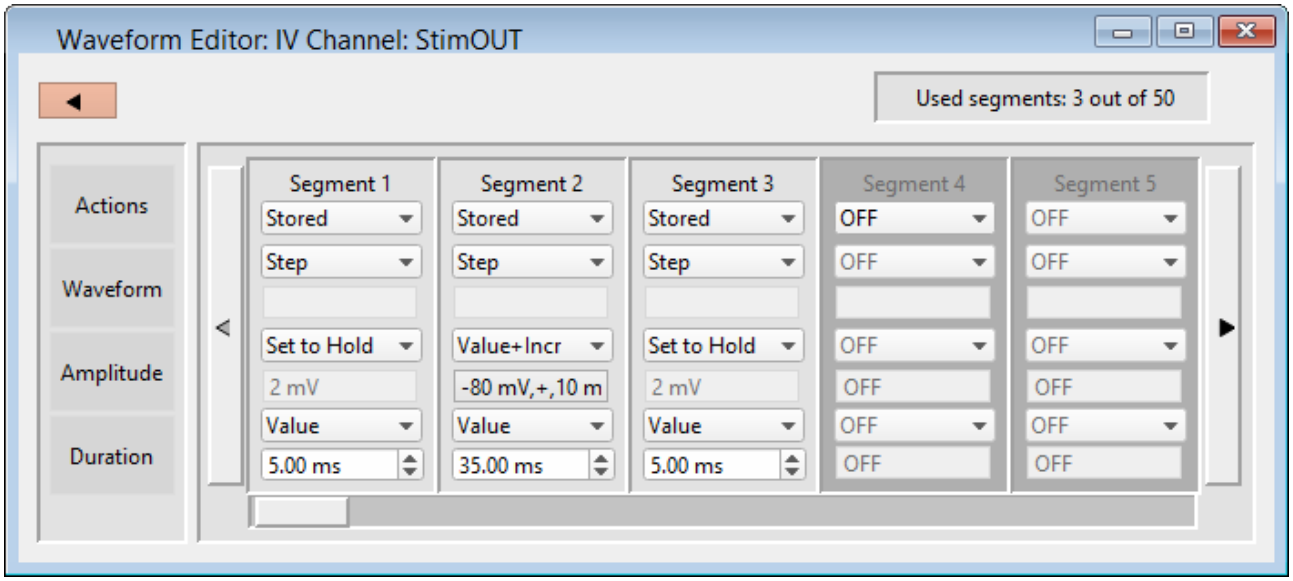


Figure 4-69. Waveform Editor

Close button  Use this button to close the Waveform Editor window.

Bit Pattern Segment # < for digital Words only >

A visual chart of the selected Segment's digital bit pattern. Only displays settings for Bit Word "values" (not for lists, increments, etc.)

Used segments: [< # out of 50 >]

Displays how many of up to 50 contiguous Segments are configured in the waveform.

Actions

[< action >] [↓]

- OFF — Unused Segments are labeled as 'OFF'.

Tip! A Segment with a Duration of '0' ms is equivalent to 'OFF'. This is a convenient way to skip a Segment instead of deleting it.

- Stored — Enable a segment for stimulation and recording.

- Not In Leak — If P/N LeakPulses are enabled, this will optionally exclude the Segment from being generated in the P/N Leak Subtraction output wave.

  This is useful for inactivation or recovery studies, when commands do not change for long periods of time.

- Insert — Insert a default Segment into the current position, and increment the position of the following Segments, i.e., move them to the right.

- Copy — To copy a Segment, click the segment's Actions list and select 'Copy'. A copy is inserted as the next Segment.

  To copy multiple Segments, select the segments to be copied. Then, for the Segment to be inserted before, click its Actions list, select 'Copy', and enter the number of times to copy the Segments - the selected Segments are inserted before the "Copy" Segment.

- Delete — To remove a Segment, select its 'Delete' Action.

  If there is only one Segment, it cannot be deleted - there is always at least one Segment enabled.

  To remove multiple Segments, select the desired Segments. Then, click any Segment's Actions list and select 'Delete'. All selected Segments are deleted.

  To select multiple Segments, in Windows use Ctrl-click, or in macOS use Command ⌘-click, to highlight each segment, or use Shift-click to highlight a range of Segments.

  Any following Segments shift their Segment #'s down by the number of deleted Segments.

Waveform

[< waveform >] [↓]

Select the waveform shape.

[Parameters]

For Waveform types Sine, Chirp, Squarewave, Template and Triangle, a 'Parameters' field displays below their waveform field, to allow quick access to their parameters.

- Step < for analog and digital channels >

  The waveform amplitude rapidly jumps from a pre-existing level to the new level within one sample point, and stays at the new level for the duration of the Segment. The resulting waveform shape looks like a step.

  The first Segment typically consists of a Step waveform set to the holding level amplitude (Set to Hold), to provide a baseline for the recording.

- Ramp < for analog channels >

  A straight line connects the last point of the preceeding Segment (or holding level) to the first point of the current Segment.

- Constant < for analog and digital channels >

  < only available in the last Segment in a waveform >

  For each sweep, output the Holding value for all stimulus points in the last Segment of the output signal. This can help to reduce stimulus loading time.

- Sine < for analog channels >

  The waveform generates a sinusoidal wave.

  [Enter sinusoidal wave parameters for segment #.]

  A status field.

  Sine Wave Cycles [< cycles >] [↓]

  - Multiple

    One or more cycles.

  - Single

    One cycle, where the Cycle Duration is equal to the Segment Duration.

  - For LockIn

    Use a phase-locked loop for

sensitive capacitance measurements.

A corresponding virtual input LockIn channel also needs to be enabled.

LockIn sine waves cannot be mixed with non-LockIn sine waves.

Multiple sine LockIn Segments in a waveform share the same settings (except duration) for each segment.

Sine Frequency [# Hz]

< read only >

The number of cycles per second.

Amplitude [< value >] [↓]

Amplitude of the first peak from the sine wave baseline.

- Value

  Enter a numeric value.

  [< ±1.00 V, ±20.0 nA >]

- Var_r[1 – 16]: #

  Set the amplitude value from a Routine Variable.

Tip! To offset a sine wave from the default baseline (0 units), set the Segment Amplitude value, or enable Routine Editor / Output Channel 'Relative to Holding'.

For LockIn measurements, the larger the sine wave amplitude, the better the signal-to-noise ration for the measurements, just be sure to avoid the activation range of

voltage-gated ion channels.

Cycle Duration [< duration >] [↓]

< for multiple cycles >

Time of one cycle length.

- Value

  Enter a numeric value.

  [< 600 µs – 36 ms >]

- Var_r[1 – 16]: #

  Set the duration value from a Routine Variable.

Ramp Increment [< ±1.00 V, ±20.0 nA >]

< for multiple cycles >

Apply the sine wave onto a ramp "baseline".

Segment Duration [< # s >]

Total duration of the sine wave .

- Square Pulses < for analog and digital channels >

  The waveform generates a train of rectangular pulses.

  [Enter Square Pulses parameters for segment #.]

  A status field.

  Base Amplitude Increment

  < only for analog channels >

  [< ±1.00 V, ±20.0 nA >]

  Increment the baseline amplitude for each succesive pulse.

  Base Increment < for digital Word channels >

  < grayed out for digital Bit channels

>

[< 0 - 255 >]

Increment the baseline amplitude for each succesive pulse in the pulse train.

Step1 Amplitude < for analog channels >

[< value >] [↓]

Starting amplitude of the pulses.

- Value

  Enter a numeric value.

  [< ±1.00 V, ±20.0 nA >]

- Var_r[1 – 16]: #

  Set the amplitude value from a Routine Variable.

Step1 Bit State < for digital Bit channels >

[< value >] [↓]

Starting state of the pulses.

- Value

  Enter a numeric value.

  [< 0, 1 >]

- Var_r[1 – 16]

  Set the Bit state from a Routine Variable.

Step1 Value < for digital Word channels >

[< value >] [↓]

Starting values of the pulses.

- Value

Enter a numeric value.

[< 0 - 255 >]

- Var_r[1 – 16]: #

  Set the Word value from a Routine Variable.

Step1 Width [< value >] [↓]

Duration of the first pulse.

- Value

  Enter a numeric value.

  [< # >]

  Width 1 value.

- Var_r[1 – 16]: #

  Set the duration value from a Routine Variable.

Step2 Amplitude < for analog channels >

[< value >] [↓]

Secondary amplitude of the pulses.

- Value

  Enter a numeric value.

  [< ±1.00 V, ±20.0 nA >]

- Var_r[1 – 16]: #

  Set the amplitude value from a Routine Variable.

Step2 Bit State < for digital Bit channels >

[< value >] [↓]

Secondary amplitude of the pulses.

- Value

Enter a numeric value.

[< 0, 1 >]

- Var_r[1 – 16]: #

  Set the Bit state from a Routine Variable.

Step2 Value < for digital Word channels >

[< value >] [↓]

Secondary amplitude of the pulses.

- Value

  Enter a numeric value.

  [< 0 - 255 >]

- Var_r[1 – 16]: #

  Set the Word value from a Routine Variable.

Step2 Width [< value >] [↓]

Duration of the second pulse.

- Value

  Enter a numeric value.

  [< # s >]

- Var_r[1 – 16]: #

  Set the duration value from a Routine Variable.

Pulse Frequency [# Hz]

< read only >

Number of pulses per second.

Segment Duration [< # s >]

Total duration of the Square wave.

- Chirp < for analog channels >

  This waveform generates a sinusoidal wave that changes its frequency over time.

  [Enter Chirp wave parameters for segment #.]

  Chirp Type [< type >] [↓]

  - Linear

    A linear change in frequency.

  - Geometric

    A geometric change in frequency.

    Note: For a geometric chirp, a minimal frequency spread is enforced: the End Frequency has to be at least double the Start Frequency, or half or less than the Start Frequency.

  Amplitude [< value >] [↓]

  Amplitude of the first chirp.

  - Value

    Enter a numeric value.

    [< ±1.00 V, ±20.0 nA >]

  - Var_r[1 – 16]: #

    Set the amplitude value from a Routine Variable.

  Start Frequency [< 1 – 50000 Hz >]

  End Frequency [< 1 – 50000 Hz >]

  Segment Duration [# s]

  Total duration of the Chirp wave.

- Template < for analog channels >

  Assign an arbitrary predefined waveform to a Segment.

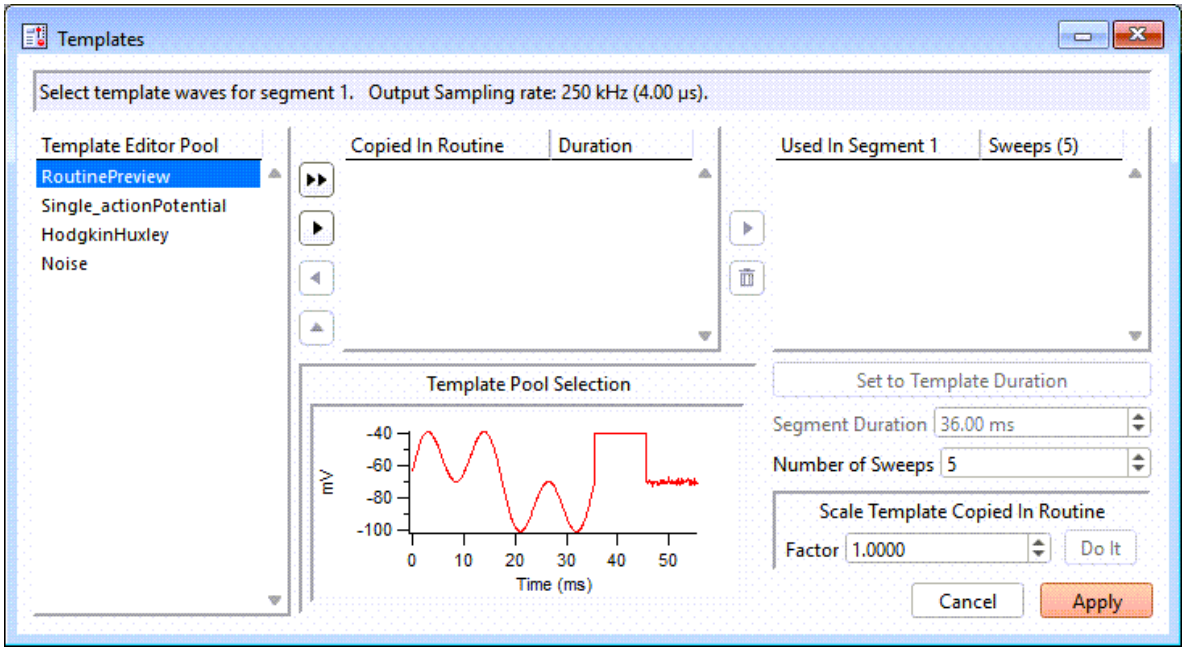


Figure 4-70. Template Waves

[status]

The Routine Segment # and output sampling rate are displayed in the status field.

If the template sampling rate does not match a Routine sampling rate, the template data are interpolated to match the Routine sampling rate.

When used with a digital bit channel, amplitude values below 1.7 V are treated as a LOW, all higher amplitudes are treated as a HIGH.

When used with a digital word channel, decimal amplitudes are converted to binary output patterns.

Note: Changes made in the Template Editor are only applied to Routines when the modified template in the Template Editor Pool list is copied into the Routine.

Template Editor Pool

Lists the templates loaded in the Template Editor, plus any extracted templates.

Copy the selected template wave from the Template Editor Pool into a Routine and Segment.

This button is enabled if the 'Number of Sweeps' allows more Segment templates.

Copy the selected template wave from the Template Pool into a Routine.

Up to 16 template waves can be loaded.

Copy the selected template wave from the Routine into the Template Editor Pool.

Copied In Routine — Lists the templates copied from the Template Editor Pool and loaded into the Routine.

Each output channel can have a maximum of 16 template waves loaded in its routine. Each template can be used in multiple Segments, each Segment can use multiple templates.

While the most used case will probably be a single template paired with a single Segment, the possibilities are endless.

Note: To avoid unnecessary increase in the size of the Routine Pool, only include templates that are actually going to be used in a Segment.

Duration — The duration of the template trace.

Copy the selected template in the Routine into the Segment.

Remove the template from the Segment, or remove an unused Routine template.

Used In Segment — Lists the loaded templates that are actually used in the Routine. Each segment can use multiple templates.

If only one template is listed, then for any number of sweeps, the Segment output wave will be the same for all sweeps.

If multiple templates are copied into the Routine Segment, they will be executed in sequential order, one template per sweep.

Sweeps (#) — Number of sweeps in the Routine.

Sweeps are assigned to templates in sequential order. If the number of sweeps is greater than the number of templates, the sweep number cycles back to the first template and continues incrementing the templates, etc.

In Segment Selection

A preview of the selected template signal.

[Set to Template Duration]

Set the Segment duration to match the template (sweep) duration.

Segment Duration [< # s >]

The Segment duration can be manually adjusted here.

When typing in a value, if no unit type is entered, the unit type defaults to seconds (s). If you enter a number followed by an 'm' or 'ms', the unit type is milliseconds (ms).

Number of Sweeps [< # >]

Scale Template Copied In Routine

Factor [< # >]

Set a scaling factor for the amplitude of the template signal.

- Triangle Pulses < for analog channels >

  The waveform generates a train of triangular pulses.

  [Enter Triangle Pulses parameters for segment #.]

  A status field.

  Base Amplitude Increment

  [< ±1.00 V, ±20.0 nA >]

  Increment the baseline amplitude for each succesive pulse.

  Peak Amplitude [< value >] [↓]

  Amplitude of the peak.

- Value

  Enter a numeric value.

  [±1.00 V, ±20.0 nA]

- Var_r[1 – 16]: #

  Set the amplitude value from a Routine Variable.

Peak amplitude value.

Ramp1 Width [< value >] [↓]

Duration of the initial phase.

- Value

  Enter a numeric value.

  [< # s >]

- Var_r[1 – 16]: #

  Set the duration value from a Routine Variable.

Ramp2 Width [< value >] [↓]

- Value

  Enter a numeric value.

  [< # s >]

- Var_r[1 – 16]: #

  Set the duration value from a Routine Variable.

Frequency [# Hz]

< read only field >

Number of pulses per second.

Segment Duration [< # s >]

The total duration of the triangle

train.

- Membrane Test < for analog channels >

  The Membrane Test is run in 'Cell' mode.

  The waveform applies a predefined negative pulse step (-5 mV) with a 50% duty cycle for Routine-based measurements.

  This enables the Real Time Measurements 'Analysis Functions':

  - MT Series Resistance
  - MT Membrane Capacitance
  - MT Membrane Resistance

  Alert! For valid results, 'Cell Compensation' and Rs Correction should be disabled in the Amplifier Control Panel.

  [Enter Membrane Test Pulse parameters for segment #.]

  A status field.

  Pre-pulse Amplitude

  [# V]

  < read only field >

  Pre-pulse Width [# ms]

  < read only field >

  Test Pulse Amplitude

  [< value >] [↓]

  Starting amplitude of the pulses.

  - Value

    Enter a numeric value.

    [±1.000 V, ±20.0 nA]

  - Var_r[1 – 16]: #

Set the amplitude value from a Routine Variable.

Test Pulse Width [# s]

< read only field >

Segment Duration [< # s >]

Total duration of the Square wave train.

Amplitude

[< value >] [↓]

< for analog output channels >

Set the waveform amplitude for a Segment.

For the Chirp, Sine, Squarewave and Triangle waveforms, this is used as a baseline offset.

For Auxiliary output channels, when the Output Channel / Scaling Factor is not “1”, i.e., when scaling is applied to the signal, then a non-editable scaled output field is also displayed below the amplitude value field.

- Set to Hold — Use the Amplifier Control Panel holding level for the Segment amplitude.

  For voltage-clamp experiments, records the leak current along with the actual holding voltage.

  For current-clamp experiments, records the actual cell potential along with the actual holding current.

  Avoid using the last Segment for this, as post-stimulation data might be recorded, such as from tail currents.

  Tip! To help intepret your data, record an initial baseline in Segment 1, and/or a final baseline in the last segment.

- Value — [< ±1.00 V, ±20.0 nA >]

  Use a single number for the Segment amplitude.

- Value List — Set an arbitrary Segment amplitude for each sweep

number.

For each numbered sweep, enter a value. If the number of sweeps exceeds the number of values, applies values from the starting value again, in a “round-robin” fashion.

[Enter a list of values for segment #.]

A status field.

Sweep | Value — A list of all sweeps and their assigned values.

< read-only >

[< ±1.00 V, ±20.0 nA >]

Type in a value, or use the increment/decrement controls to adjust amplitude values.

Increase the number of values used, and re-assign them to interleaved sweeps.

Decrease the number of values used, and re-assign them to interleaved sweeps.

Segment Duration [< # s >]

Adjust the duration of the Segment.

Number of Sweeps [< # >]

Adjust the number of sweeps in the Routine.

- Value+Increment

Increment the Segment amplitude for each sweep.

[Enter parameters for segment #]

Base Value [< value >] [↓]

Initial amplitude value.

- Holding

- Value

[< ±1.00 V, ± 20.0 nA >]

Increment Value [< ±1.00 V, ± 20.0 A >]

Segment Duration [< # s >]

Adjust the duration of the Segment.

Number of Sweeps [< # >]

Adjust the number of sweeps in the Routine.

- Equation — Specify the segment amplitude as an equation.

[< equation >]

A free-form text field for writing equations. The maximum number of characters is 400. For multiple equations, separate them by a comma.

Syntax messages are reported below this field.

< see the Equation Editor for more details >

[Check Equation] Check the equation syntax. The equation is evaluated for sweep #1, and if valid, it reports “Syntax is ok”.

[Insert special identifier]

Acquisition, amplifier and reference settings are available for use in equations.

< see list in Equation Editor >

[Undo] All changes in the equation editing session are discarded.

Alert! Computing an equation for an output wave consumes significant computing power, as every data point needs to be computed by the CPU. For larger acquisitions, this can generate significant delays to the start of acquisition.

Var_r[1 – 16] Set the amplitude value from a Routine Variable.

or

Bit < for digital output channel amplitudes >

< digital settings are displayed if digital outputs are enabled >

Set the digital level for an individual bit in a Segment.

Set a digital level as:

LOW = 0

HIGH = 1

- Value

  Enter a numeric value.

  [< 0, 1 >]

- Var_r[1 – 16]

  Set the Bit value from a Routine Variable.

or

Bit Word < for digital output channel amplitudes >

< digital settings are displayed if digital outputs are enabled >

Set all digital outputs of a Segment via the decimal number of an 8-bit digital word.

- Value

  Enter a numeric value.

  [< 0 – 255 >]

- Var_r[1 – 16]

  Set the Word value from a Routine Variable.

Duration

[< value >] [↓]

Set the Segment duration.

- Value [0 – 12 ks]

  When typing in a value, if no unit type is entered, the unit type defaults to seconds (s). If you enter a number followed by an 'm' or 'ms', the unit type is milliseconds (ms).

- Value List Set an arbitrary Segment duration for each sweep.

  Sweep | Value — For each numbered sweep, enter a time value. If the number of sweeps exceeds the number of values, applies values from the starting value again, in a "round-robin" fashion.

  [0 – 12 ks] — Type in a time value, or use the increment/decrement controls to adjust the value.

   — Increment the number of values used, and re-assign them to the interleaved sweeps.

   — Decrement the number of values used, and re-assign them to the remaining interleaved sweeps.

  Number of Sweeps [#]

  Adjust the number of sweeps in the Routine.

- Value+Increment

  Increment the Segment duration for each sweep.

  Base Value [# ms]

  Initial duration value.

  Increment Value [# ms]

  Increase duration by a set amount.

Number of Sweeps [#]

Adjust the number of sweeps in the Routine.

- Equation

Specify Segment duration as an equation.

[ ] A free-form text field for writing equations. The maximum number of characters is 400. For multiple equations, separate them by a comma.

Syntax messages are reported below this field.

[< 0 – 12 ks >]

< see the Equation Editor for more details >

[Check Equation] Check the equation syntax. The equation is evaluated for sweep #1, and if valid, it reports “Syntax is ok”.

[Insert special identifier]

Acquisition, amplifier and reference settings are available for use in equations.

< see list in Equation Editor >

[Undo] All changes in the equation editing session are discarded.

Alert! Computing an equation for an output wave consumes significant computing power, as every data point needs to be computed by the CPU. For larger acquisitions, this can generate significant delays to the start of acquisition.

- Var_r[1 – 16] Set the equation value from a Routine Variable.

Segment Controls

To copy or delete multiple Segments, click on the background area of used Segment(s) - the background color turns gold, and enables the Actions items: Copy and Delete.

Standard mouse behaviour is used to select multiple Segments:

- Individual Segments — Windows: Ctrl-click; macOS: Command (⌘)-click
- Range of Segments — Both: Shift-click

To step through the Segments, click on the tall left or right Segment “arrow” buttons.

To scroll through the Segments, use the slider at the bottom of the Waveform Editor.

Real Time Measurements & Graphs

Measurements and analyses are configured in the Real Time Measurements & Graphs dialog. Measurement regions display in the Acquisition: Scope window, and their associated analyses are plotted in an Analysis sub-window during acquisition.

< see 'Analysis window' in the Data Analysis section >

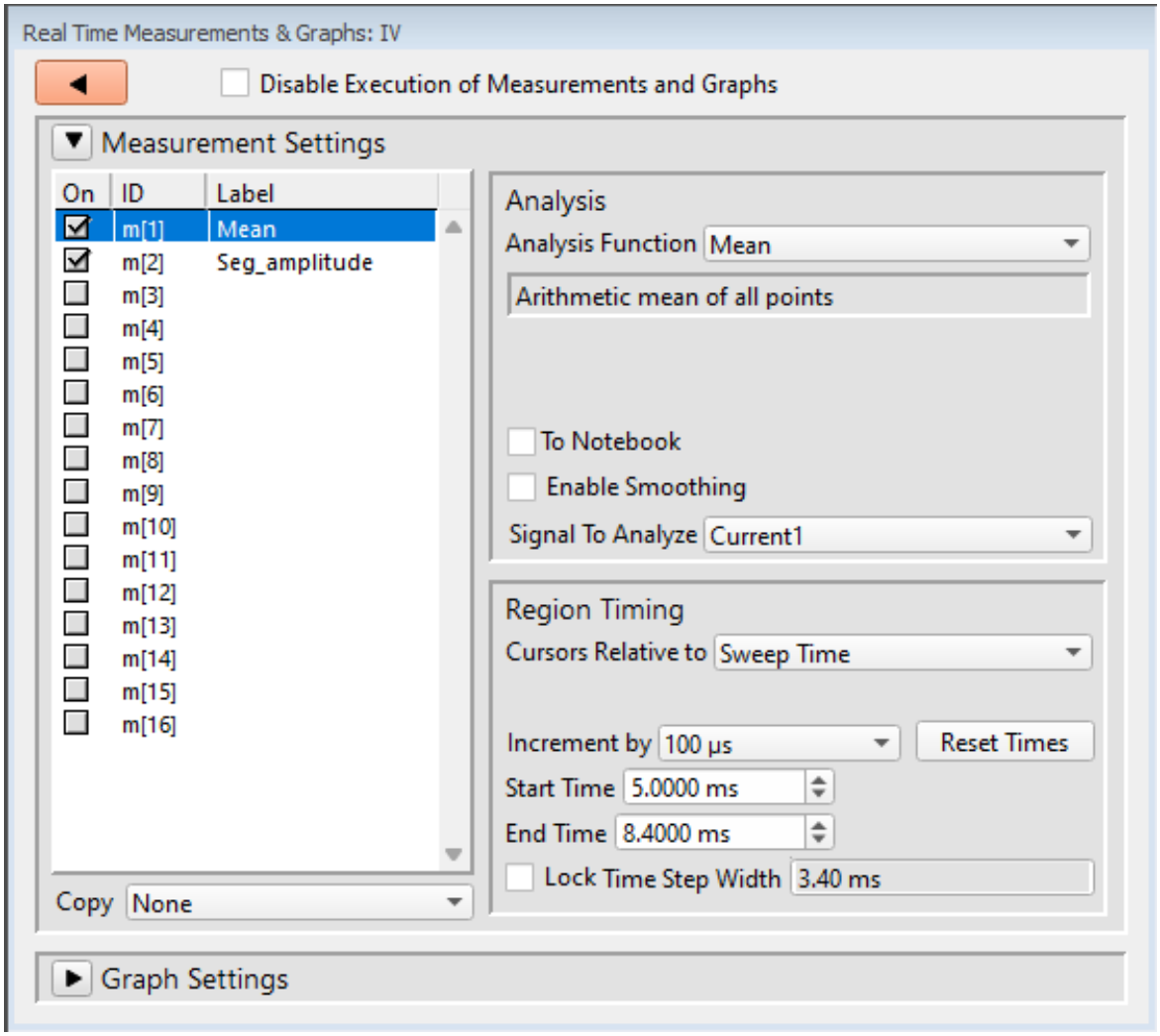


Figure 4-71. Real-Time Measurement Settings

[ ] Disable Execution of Measurements and Graphs

Block all measurements and analyses with one click.

Measurement Settings

On — Enable an analysis to run.

ID [< m[1 – 16] >]

Measurement regions are identified with an ID number: m[#]

Label These measurement labels display in the Waveform Preview and Analysis windows, and can be used in equations. A Label name is automatically generated from the selected Analysis Function; double-click to manually edit.

Copy [< _none_ >] [↓]

[m[1] to m[2], etc.]

Copy the settings from one Measurement to another.

First highlight a target Measurement Settings ID, then click this drop-down list of enabled Measurements to select the source ID. After the copying is done, the field returns to "_none_".

Analysis

Be sure to set appropriate Region Timing (below) for the following analyses.

Analysis Function [< analysis >] [↓]

Select a predefined Analysis statistics for each measurement:

Absolute area	Negative area values are converted to positive and summed with the positive area values.
Absolute peak	Largest absolute value.
AP duration	Action potential duration (by percentiles).
Area	Signed area - negative values negate positive values.
Decay time	10 - 90% decay (fall) time of "peak to end".
Decay tau	Time constant of 'Decay time'.
Equation	Evaluate an equation.
Frequency	Number of threshold crossings per second (Hz).
Max slope	Maximum slope of simple linear regression fit.
Max value	Value of largest (or least negative) sample.
Mean	Arithmetic mean of the samples.

Metadata parameter — Click in its 'Metadata' field for a 'Select Measurement Parameter' list of groups and parameters.

Only metadata parameters with numeric values plot in analysis graphs.

Min value — Value of smallest (or most negative) sample.

< only available when an output channel Segment uses a Membrane Test (MT) waveform >

MT Series Resistance

Membrane test 'Rseries' value of a patch.

MT Membrane Capacitance

Membrane test Cmembrane' value of a whole-cell patch.

MT Membrane Resistance

Membrane test 'Rmembrane' value of a whole-cell patch.

Paradigm time — The absolute date-time of the start of the Paradigm, as set by Igor Pro and the OS, starting from Jan-1-1904, 00:00:00. (Uses pre-2016 Microsoft Excel Macintosh date format.)

Rise tau — Time constant of 'Rise time'.

Rise time — 10 - 90% rise time of "start to peak".

RMS noise — Root-Mean-Square noise.

Routine time — The absolute date-time of the start of the Routine, as set by Igor Pro and the OS, starting from Jan-1-1904, 00:00:00.

< uses pre-2016 Microsoft Excel Macintosh date format >

Segment amplitude — Amplitude of the specified 'Out Channel' Segment.

Segment duration — Duration of the specified 'Out Channel' Segment.

Segment start time — Start time of the specified 'Out Channel' Segment.

Slope — Slope of simple linear regression fit.

Std deviation — Standard deviation of the samples: $\sqrt{(\text{variance})}$

Sweep number — Track the sweep number.

Sweep time — The absolute date-time of the start of the Sweep, as set by Igor Pro and the OS, starting from Jan-1-1904, 00:00:00.

< uses pre-2016 Microsoft Excel Macintosh date format >

Stimulus at absolute peak

Stimulus amplitude at time of the largest absolute sample.

Stimulus at min — Stimulus amplitude at time of the smallest sample.

Stimulus at threshold

Stimulus amplitude at time of the first threshold crossing.

Time of absolute peak

Time from sweep start to largest absolute value.

Time at absolute peak

Time from sweep start to largest absolute value.

Time of max — Time from sweep start to largest sample.

Time of min — Time from sweep start to minimum sample.

Time to threshold — Time from sweep start to first threshold crossing.

Timer time — The Acquisition Control Panel "Timer" time in seconds.

Variance — Variance of the samples.

Weighted tau — Weighted time constant.

Area / Peak - y0 (based on end of measurement).

User measurement — This analysis calls a custom user function.

Two 'User Parameter' fields display to pass information to the function.

< see the Programming chapter SutterPatch Hooks >

The above analyses can be directly plotted, or used in more complex equations.

< see the Equation Editor section for more details >

Many other SutterPatch settings and readings can be plotted, without having to define an Analysis measurement, by using the Graph Settings X- and/or Y-Axis 'Source' equations Special Identifiers.

Note: The first sample point is used for any needed baselines.

The custom function 'UserAnalysis' can also be automatically called after each sweep is collected, before any real time analysis is performed.

< see the Programming chapter: SutterPatch Hooks >

[< status field >]

A short description of the selected Analysis.

Threshold (A) [#]

< only displays for appropriate analyses >

This amplitude level needs to be crossed by the signal to trigger measurements for:

- AP Duration
- Rise/Decay time
- Rise/Decay Tau
- Frequency
- Time to threshold

Polarity [#]

< only displays for appropriate analyses >

The direction of a Threshold crossing.

- Positive — Positive-direction threshold crossing.
- Negative — Negative-direction threshold crossing.
- Largest Change — Use the polarity direction of the largest change for Rise and Decay analyses.

User Parameter 1

[#]

< only displays for 'User Measurement' analysis >

Click on the field to open the 'Specify User Parameter 1 equation' dialog.

Enter a plain numeric value to send to the user function.

Real-time SutterPatch parameter values can be sent to the user function by using Special Identifiers in the equation.

< see Equation Editor for list >

User Parameter 2

[#]

< only displays for 'User Measurement' analysis >

Click on the field to open the 'Specify User Parameter 2 equation' dialog.

Enter a plain numeric value to send to the user function.

Real-time SutterPatch parameter values can be sent to the user function by using Special Identifiers in the equation.

< see Equation Editor for list >

Analysis Index [< # >]

< only displays for 'User measurement' analyses >

Use to activate a corresponding code segment within the UserMeasurement.ipf procedure.

Metadata [< parameter >]

< only displays for 'Metadata Parameter' analysis >

Click in the field to select the metadata parameters that are automatically written into the metadata.

Metadata Signal [< signal >] [↓]

< only displays for 'Metadata Parameter' analyses >

Select which input signal is used for a Metadata Parameter analysis.

[ ] To Notebook

Copy the measurement results to the Notebook window during acquisition:

Experiment File:	< Experiment name >
Paradigm:	< Paradigm name >
Series:	< Series name >
Sweep	#1
m[#]	< analysis function > < analysis value >

[< time >] [↓]

< only displays for “Sweep time” analysis >

- Absolute Sweep Time

  Time = 0 is from 1904, January 1, 12 AM.

- Relative to Timer Time

  From the timer time in the Acquisition Control panel.

- Relative to Routine Time

  From the beginning of the Routine.

- Relative to Paradigm Time

  From the beginning of the Paradigm.

< only displays for “Stimulus” and “Time of” analyses >

- Time Relative to Sweep

  For time measurements, time = 0 is the beginning of the sweep.

- Time Relative to Region

  For time measurements, time = 0 is the beginning of the measurement region.

AP Duration < only displays for ‘AP duration’ analysis >

[< 20, 30, 40, 50, 60, 70, 80, 90, 100 % >] [↓]

The action potential amplitude-percentile setting, to calculate the associated AP Duration width.

[ ] Enable Smoothing

< does not display for analyses with uneditable values >

Equation

Metadata parameter

Paradigm time

Routine time

Segment amplitude

Segment duration

Segment start time

Sweep number

Sweep time

Timer time

User measurement

[< 2 – 200 >] < displays when smoothing is enabled >

Set the number of Gaussian smoothing operations per measurement.

Smoothen noisy data to reduce the effects of high-frequency noise on measurements by averaging the data sample points with an unweighted sliding average.

Signal to Analyze [< signal >] [↓]

For each enabled Analysis measurement, select which signal is to be measured from the list of Input Channels. "Membrane Test" signals are restricted to the headstage “Current” inputs.

A measurement made on one input channel can be used in multiple graphs.

Show Cursors On [< signal >] [↓]

< only displays for “Segment” analyses >

Displays the output channel segment region on the selected input channel.

Region Timing

Cursors Relative to [< time >] [↓]

Set the measurement boundaries with left / right cursors.

Cursor Start times cannot be greater than their End times.

Alert! Beware of boundary issues, where sharp transitions can be unexpectedly included or excluded in measurements. Due to the various input and output sampling rates and time durations of the actual signal, data points might not exactly match up with defined measurement regions.

Consider adjusting the measurement region to be one sample (or more) greater or less, than the target region, depending on whether you want to exclude or include the initial response. Otherwise, for example, a spike at the beginning of a Segment

could skew measurement amplitudes to be larger, or a transition at the beginning of a Segment could be missed in a threshold crossing, thus lowering a Frequency count.

- Sweep Time — Set relative to the start time of a sweep (time zero).

  Increment by: [<# s>] [↓]

  Select the resolution of the Start and End Time spinners.

  [10, 20, 50, 100, 200, 500 µs; 1.00, 2.00, 5.00, 10.00 ms]

  The listed time values depend upon the input filter bandwidth.

  [Reset Times] — Click this button to set the analysis region Start and End Times to the beginning and ending of the sweep.

  Start time [<# s>]

  Set the left cursor start time (s).

  End time [<# s>]

  Set the analysis region end time.

  [ ] Lock — Lock the measurement region width, so that incrementing the Start Time increments the End Time by the same amount.

  Time Step Width [#]

  < read only field >

  The width of the measurement region.

  The minimum width size is 2 sample points.

  The measurement width is maintained at a constant value when the cursor is "locked" and the 'Start Time' is updated.

- Segment Time — Set the time range as a ratio of the Segment duration.

  Uses the Segment timing from the input signal's "Parent Output Channel".

Out Channel [< channel >] [↓]

Select the output channel to use for measurement timing.

StimOUT1

StimOUT2

[< segment # >] [↓]

Select the output segment to use for measurement timing.

Increment by: [< ratio >] [↓]

Increment the Start and End Ratios by a relative amount.

[< 0.001, 0.002, 0.005, 0.01, 0.02, 0.05, 0.1, 0.2, 0.5 >]

[Reset Ratios] Click to reset the Start and End Ratios to span the entire Segment.

Start: 0.0000

End: 1.0000

Tip! If unwanted Segment boundary issues occur, where measurements are affected by data in a neighboring Segment, increase the Start Ratio or decrease the End Ratio until the issue is resolved.

Start Ratio [#]

Set the analysis region left cursor as a ratio of the Segment duration.

(0 = beginning of Segment)

Time [0.0000 s]

Cursor start-time.

< read-only field >

End Ratio [#]

(1 = end of Segment)

Set the analysis region right cursor as a ratio of the Segment duration.

Time [1.0000 s]

Cursor end-time.

< read only field >

Note: If the Start and End Ratios extend past the boundary of a Segment, and the measurement is switched to a beginning or ending Segment, the Start and End Ratios are reset to '0' and '1' respectively.

Cursor Time Width [< # s >]

The width of the measurement region is reported.

Graph Settings

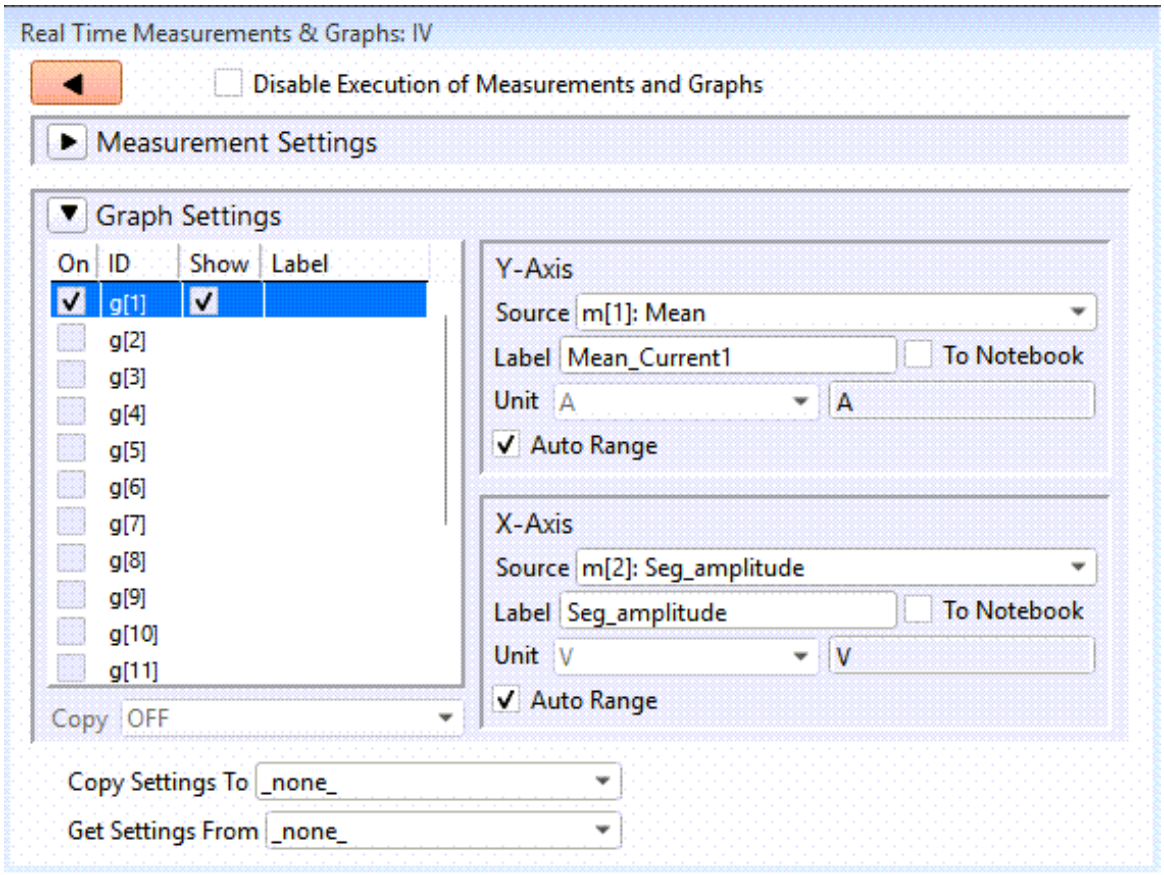


Figure 4-72. Real Time Graph Settings

On	Enable a graph to configure its settings.
ID	Graphs have a default ID (identification): g[1] - g[8]
Show	Display this graph in an Analysis window during acquisition and analysis. Note: If the Y-Axis 'Equation' field is blank, the graph will also be blank.
Label	Double-click to manually enter a graph label for the Analysis sub-window. Spaces and special characters are allowed in the label.
Copy	[< _none_ >] [↓] g[2] to g[1], etc. Copy the settings from one Graph to another. First highlight a target Graph Settings ID, then click this drop-down list of enabled Graphs to select the source ID. After the copying is done, the field returns to "_none_".

Y-Axis

Source [< analysis >] [↓]

Set up the source of the Y-axis numbers

- Equation — Use an equation for a customized Y-axis plot.
  < see the Equation Editor for details >

  Many SutterPatch settings and readings can be plotted, without defining an Analysis measurement, by using Special IDs in the equation.
- <m[#]: *Name*> — Select a Measurement ID for the Y-axis.

Label [< label >]

A Y-axis label is automatically generated from the Measurement label. Directly edit to customize the Y-axis graph label.

[ ] To Notebook

Copy the measurement results to the Notebook window during acquisition:

Experiment File:	< Experiment name >
Paradigm:	< Paradigm name >
Series:	< Series name >
Sweep	#1
m[#]	<analysis function> <analysis value>

Unit [< unit >] [↓]

Select a standard unit from the drop-down list, or enter a custom unit type.

Note: Standard unit solutions, such as 'pA' or 'mV', are automatically calculated and displayed in the graph.

[unit] The selected unit.

[ ] Auto Range

Enable to automatically scale the Y-axis range to the analysis data.

Disable to use a pre-defined Y-axis range:

min [<#>] Lower limit of the Y-axis.

max [<#>] Upper limit of the Y-axis.

X-Axis

Source [< analysis >] [↓]

Set up the source of the X-axis numbers:

- Equation Use an equation for a customized X-axis plot.
  < see the Equation Editor for details >
  Many SutterPatch settings and readings can be plotted, without defining an Analysis measurement, by using Special IDs in the equation.
- Time Use a standard time-base.
- < m[#]: *Name* > Select a Measurement ID for the X-axis.

Label [< label >]

Enter a customized name for the X-Axis.

Unit [< unit >] [↓]

Select a standard unit from the drop-down list, or enter a custom unit type.

Note: Standard unit resolutions, such as 'pA' or 'mV', are automatically calculated and displayed in the graph.

[unit]

The selected unit.

[ ] Auto Range

Enable to automatically scale the X-axis range to the analysis data.

Disable to use a pre-defined X-axis range:

min [<#>] Lower limit of the X-axis.

max [<#>] Upper limit of the X-axis.

Copy/Get Settings

Displaying below the Graph Settings section, Copy/Get functionality applies to both the Measurement Settings and Graph Settings sections.

Copy Settings To [< target >] [↓]

- _none_ Copying settings is not enabled.
- Routine Copy Measurement and Graph Settings to a Routine.

  >> [Routine] [↓]

  Select a Routine to copy the current settings to.
- File Copy the current settings of Measurements and Graphs to a file.

  A 'Save as' file selection dialog displays for copying settings to a *.rtm file.

Get Settings From [< source >] [↓]

- _none_ Getting settings is not enabled.
- Routine Get Measurement and Graph Settings from another Routine.

  >> [< Routine >] [↓]

  Select a Routine to get its active settings.
- Data Copy Original

  Get the last saved settings of the current Routine.
- Data Copy Last Used

  >> [< Series >] [↓]

  A list of Series recorded during the Experiment.

  Select a Series to copy its settings into the current Routine.
- File Get Measurement and Graph Settings from a saved file.

  A 'Select file' dialog displays for getting settings from a *.rtm file.

Metadata 'Select Measurement Parameter'

< from Metadata field above >

Select parameter group

[< group >] [↓] This shows all groups using the "Full" detail level, as set in 'Set Preferences / Metadata'.

All Categories

Frequently Used

Tag

Operator

Preparation – Animal

Preparation – Tissue

Preparation – Cell

Experiment

Amplifier

Instrumentation and Software

Electrode

Recording Solution

Paradigm

Cell Health / Quality Control

Series (= Routine Data)

Data Acquisition Settings

Imaging

Stimulus

Available parameter A list of selected metadata parameters.

This shows all items using the "Full detail level, as set in 'Set Preferences / Metadata'. Additional metadata entries will also display if pre-defined in 'Set Metadata / All Categories'.

All Categories An alphabetical listing of all parameters from all available group categories.

xxx

Frequently Used

xxx

Tag

Tag Comment

Operator

Full Operator Name
Login Name
Operator Identifier
Original Login Name

Preparation – Animal

Animal Age
Animal Circadian Time or Phase
Animal Genotype
Animal Identifier
Animal Preparation Date
Animal Preparation Time
Animal Sex / Gender
Animal Species
Animal Strain
Animal User Parameter 1 Name
Animal User Parameter 2 Name
Animal User Parameter 3 Name
Animal User Parameter 4 Name
Animal User Parameter 5 Name
Animal Weight

Preparation – Tissue

Organ
Organ Region
Preparation Method
Tissue Incubation Duration
Tissue Incubation Solution
Tissue Incubation Temperature
Tissue Preparation Date
Tissue Preparation Identifier
Tissue Preparation Time
Tissue User Parameter 1 Name
Tissue User Parameter 2 Name
Tissue User Parameter 3 Name
Tissue User Parameter 4 Name
Tissue User Parameter 5 Name

Preparation – Cell

Acutely Dissociated Cells

Cell Diameter
Cell Dissociation Solution
Cell Fluorescent Marker
Cell Identifier
Cell Line
Cell Prep. Dissociation Temperature
Cell Prep. Incubation Temperature
Cell Preparation Date
Cell Preparation Identifier
Cell Preparation Incubation Duration
Cell Preparation Incubation Solution
Cell Preparation Time
Cell Type
Cell User Parameter 1 Name
Cell User Parameter 2 Name
Cell User Parameter 3 Name
Cell User Parameter 4 Name
Cell User Parameter 5 Name
In-situ recording
Ion Channel
Slice Preparation
Stem Cell Preparation
User-defined Preparation
Whole-organ Preparation

Experiment

Experiment Category 1 Name
Experiment Category 2 Name
Experiment Category 3 Name
Experiment Category 4 Name
Experiment Category 5 Name
Experiment User Parameter 1 Name
Experiment User Parameter 2 Name
Experiment User Parameter 3 Name
Experiment User Parameter 4 Name
Experiment User Parameter 5 Name

Amplifier

Amplifier Channel
Amplifier Manufacturer
Amplifier Sequence Number
Amplifier Serial Number
Experiment User Parameter 1 Name
Experiment User Parameter 2 Name
Experiment User Parameter 3 Name
Experiment User Parameter 4 Name
Experiment User Parameter 5 Name
Headstage Model
Headstage Preamplifier Model

Headstage Preamplifier Revision
Headstage Revision
Headstage Sequence Number
Headstage Serial Number
Number of Available Headstages

Instrumentation and Software

Computer Name
Data Acquisition Software
Data Acquisition Software SN
Data Acquisition XOP Version
Imported Data (SP or third-party)
Instrumentation User Param. 1 Name
Instrumentation User Param. 2 Name
Instrumentation User Param. 3 Name
Instrumentation User Param. 4 Name
Instrumentation User Param. 5 Name
Interface Input Channel
Interface Manufacturer
Interface Number of Digital Outputs
Interface Out. Ch. (physical or logical)
Interface Sequence Number
Interface Serial Number
Interface Signal Type
Operating System
Operating System Platform
Original Acquisition Software
Original Computer Name
Original Data File Format
Original Data File Name with Path
Original Data File Sub-Format
Original Operating System
Original Wave Name
Physical Computer Memory
Software Environment
Software Environment Kind
Software Environment Serial Number

Electrode

Electrode Beveled
Electrode Coated
Electrode Fire-polished
Electrode Glass Item Inner Diameter
Electrode Glass Item Outer Diameter
Electrode Glass Lot Number
Electrode Glass Manufacturer
Electrode Glass Material
Electrode Glass Ramp Test Value
Electrode Identifier

Electrode Taper Length
Electrode Tip Diameter
Electrode User Parameter 1 Name
Electrode User Parameter 2 Name
Electrode User Parameter 3 Name
Electrode User Parameter 4 Name
Electrode User Parameter 5 Name
Filamented Glass
Pipette Puller Manufacturer
Pipette Puller Serial Number
Pull Heat-on Time
Pull Program Air Mode
Pull Program Air Pressure
Pull Program Number
Pull Program Parameters
Puller Filament Item Number
Puller Filament Type
Puller Preheat Enabled

Recording Solutions

Bath Solution Batch
Bath Solution Composition
Bath Solution Identifier
Bath Solution Name
Bath Solution Osmolarity
Bath Solution pH
Bath Solution Preparation Date
Bath Solution Preparation Time
Bath Solution Preparer
Pipette Solution Batch
Pipette Solution Composition
Pipette Solution Identifier
Pipette Solution Name
Pipette Solution Osmolarity
Pipette Solution pH
Pipette Solution Preparation Date
Pipette Solution Preparation Time
Pipette Solution Preparer
Solution Pair Identifier
Solution Pair Name
Solution User Parameter 1 Name
Solution User Parameter 2 Name
Solution User Parameter 3 Name
Solution User Parameter 4 Name
Solution User Parameter 5 Name

Paradigm

Ambient Temperature
Atmospheric Composition
Atmospheric Humidity
Atmospheric Pressure
Bath Temperature
Key Stimulus for the Cell Preparation
Original Paradigm Data Seq. Number
Paradigm Data Base Name
Paradigm Data Sequence Number
Paradigm Description
Paradigm Name
Paradigm User Comment
Paradigm User Parameter 1 Name
Paradigm User Parameter 2 Name
Paradigm User Parameter 3 Name
Paradigm User Parameter 4 Name
Paradigm User Parameter 5 Name

Cell Health Quality Control

Cell Health User Parameter 1 Name
Cell Health User Parameter 2 Name
Cell Health User Parameter 3 Name
Cell Health User Parameter 4 Name
Cell Health User Parameter 5 Name
Electrode / Pipette Resistance
Electrode Capacitance
Electrode Offset
Membrane Capacitance
Membrane Resistance
Seal Resistance
Series / Access Resistance
Total Capacitance
Total Resistance

Series (= Routine Data)

Number of Input Signals
Number of Sweeps in Series
Original File GUID
Original Series Sequence Number
Routine Acquisition Mode
Routine Description
Routine Name
Routine User Comment
Routn. Completed / Terminated Early
Samples per Sweep
Series Base Name
Series Sequence Number

Data Acquisition Settings

Active Headstage
Auxiliary Input Signal Offset
Auxiliary Output Holding Value [1 – 8]
Auxiliary Output Offset [1 – 8]
Auxiliary Output Sampling Rate [1 – 8]
Auxiliary Output Scaling Factor [1 – 8]
Auxiliary Output Signal Name [1 – 8]
Bridge Balance On/Off
Bridge Balance Resistance
Capacitance Neutralization Magnitude
Capacitance Neutralization On/Off
Capacitance Neutralization Reduction
Capacitance Neutralization Tau
CC Dynamic Hold On For Acquisition
Cell Comp – Membrane Capacitance
Cell Comp – Series Resistance
Command Holding Enabled [1 – 8]
Command Sampling Rate [1 – 8]
Command Scaling Factor [1 – 8]
Command Signal Name [1 – 8]
Command Signal Offset [1 – 8]
Current Clamp Dyn. Hold Potential
Current Clamp Dynamic Hold On/Off
Current Clamp Dynamic Hold Speed
Current Gain
Digital Holding Patter (1→ N)
Dynamic Clamp HS1 Holding 1
Dynamic Clamp HS1 Holding 2
Dynamic Clamp HS2 Holding 1
Dynamic Clamp HS2 Holding 2
Electrode Fast Magnitude
Electrode Fast Time Constant
Electrode Slow Magnitude
Electrode Slow Time Constant
External Command Bandwidth [1 – 8]
External Command Filter Bypass [1 – 8]
External Command Gain [1 – 8]
Filter Cutoff Frequency
Filter Type
Headstage Feedback Mode
Headstage Gain
Input Full-scale Maximum
Input Full-scale Minimum
Input Liquid Junction Potential
Input Offset Lock On/Off
Input Offset Voltage
Input Sampling Rate
Input Scaling Factor
Input Scaling Offset

Input Signal Name
Pretrigger Samples
Recording Mode
Secondary Highp. Filt. Cutoff Freq.
Secondary Highp. Filt. Implementation
Secondary Lowp. Filt. Cutoff Freq.
Secondary Lowp. Filt. Cutoff Implementation
Series Resistance Corr. Lag Time
Series Resistance Correction On/Off
Series Resistance Prediction On/Off
Subtract Pip. Offset in Current Clamp
Trigger Polarity
Trigger Threshold
Virtual Signal Equation
Virtual Signal Integrator Reset Duration
Virtual Signal Integrator Reset Strategy
Virtual Signal Math Type
Virtual Signal Scaling Offset
Virtual Signal Source Channel
Virtual Signal Source Signal Name
Virtual Signal Use Only Marked Sweeps
Voltage Gain
Whole-cell Compensation On/Off

Imaging

Image Camera Name
Image Comment
Image Type

Stimulus

Acoust. Stimulus User Param. 1 Name
Acoust. Stimulus User Param. 2 Name
Acoust. Stimulus User Param. 3 Name
Acoust. Stimulus User Param. 4 Name
Acoust. Stimulus User Param. 5 Name
Acoustic Stimulus Frequency
Acoustic Stimulus Intensity
Application Tip Identifier
Chem,. Stimulus User Param. 1 Name
Chem,. Stimulus User Param. 2 Name
Chem,. Stimulus User Param. 3 Name
Chem,. Stimulus User Param. 4 Name
Chem,. Stimulus User Param. 5 Name
Compd. Vehicle / Solubility Enhancer
Compound Batch
Compound Concentration
Compound Counterion
Compound Description
Compound Group

Compound Identifier
Compound Lot
Compound Name
Compound Plate Column
Compound Plate Identifier
Compound Plate Row
Compound Preparation Date
Compound Preparation Time
Compound Reservoir Identifier
Compound Solution
Compound Source
Compound Vehicle Concentration
Electr. Stimulus User Param. 1 Name
Electr. Stimulus User Param. 2 Name
Electr. Stimulus User Param. 3 Name
Electr. Stimulus User Param. 4 Name
Electr. Stimulus User Param. 5 Name
Electrical Stimulus Frequency
Electrical Stimulus Intensity
Key Stimulus
Light Stimulus Intensity
Light Stimulus User Param.1 Name
Light Stimulus User Param.2 Name
Light Stimulus User Param.3 Name
Light Stimulus User Param.4 Name
Light Stimulus User Param.5 Name
Light Stimulus Wavelength
Mech. Stimulus User Param. 1 Name
Mech. Stimulus User Param. 2 Name
Mech. Stimulus User Param. 3 Name
Mech. Stimulus User Param. 4 Name
Mech. Stimulus User Param. 5 Name
Mechanical Stimulus Intensity
Other Stimulus User Param. 1 Name
Other Stimulus User Param. 2 Name
Other Stimulus User Param. 3 Name
Other Stimulus User Param. 4 Name
Other Stimulus User Param. 5 Name
Stimulus Control Signal
Stimulus Duration
Therm. Stimulus User Param. 1 Name
Therm. Stimulus User Param. 2 Name
Therm. Stimulus User Param. 3 Name
Therm.. Stimulus User Param. 4 Name
Therm. Stimulus User Param. 5 Name
Thermal Stimulus Temperature

Routine Variables

Up to 16 Routine Variables can be configured for use in Routines. These variables allow manual or automatic control of certain Routine settings.

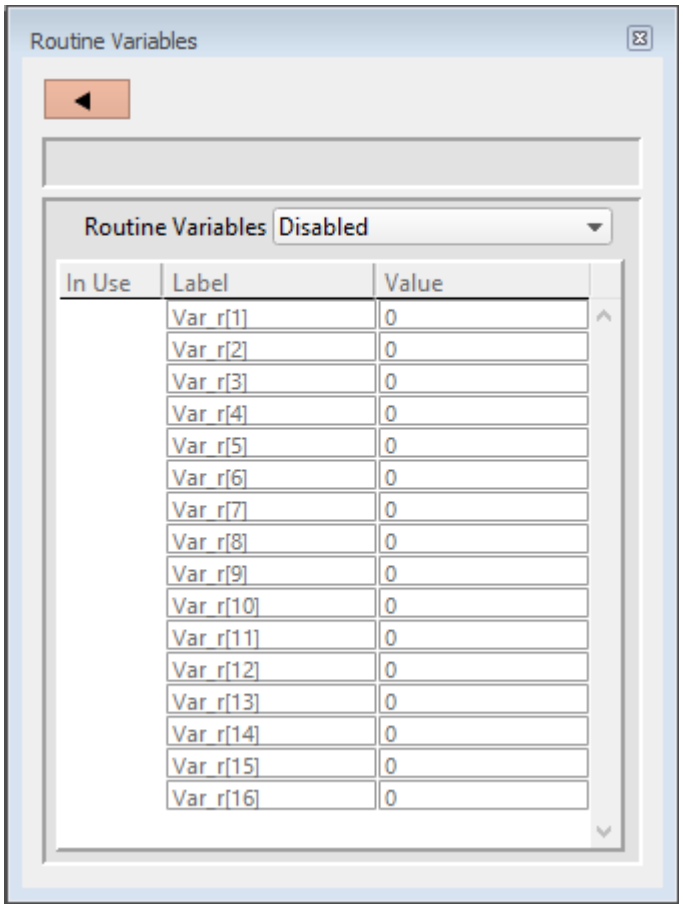


Figure 4-73. Routine Variables

Routine Variables [< status >] [↓]

- Disabled
- Enabled — Once Routine Variables are enabled, they become visible in the Waveform Editor Amplitude and Duration lists.

In Use — A checkmark means the Routine Variable is "active", i.e., set to a non-zero value, or is being used in a Routine setting or equation field.

Label — Var_r[1 – 16] — Edit the default Routine Variable name if desired.

Value [#]

Numeric values can be manually entered here, or automatically set by the Paradigm step ‘Set Variable’.

Routine Variables can be used in:

Input Channels / AuxIN / Scaling

Input Channels / Virtual Channel / Equation

Output Channels / Enable P/N Leak Pulses / Leak Hold

Output Channels / Waveform Editor / Amplitude

Output Channels / Waveform Editor / Duration

Measurements / AP Duration / Threshold

Measurements / Frequency / Threshold

Measurements / Time to Threshold / Threshold

If a Waveform Editor / ‘Amplitude’ or ‘Duration’ is set to a Routine Variable, and then changed to a value, the Waveform Editor converts its ‘Var_r[#]’ settings to ‘Value’ settings, using the last enabled value.

4.1.9 Solution Editor

SutterPatch: Solution Editor

Create a named list of solutions to control physical valves in solution changers and perfusion systems.

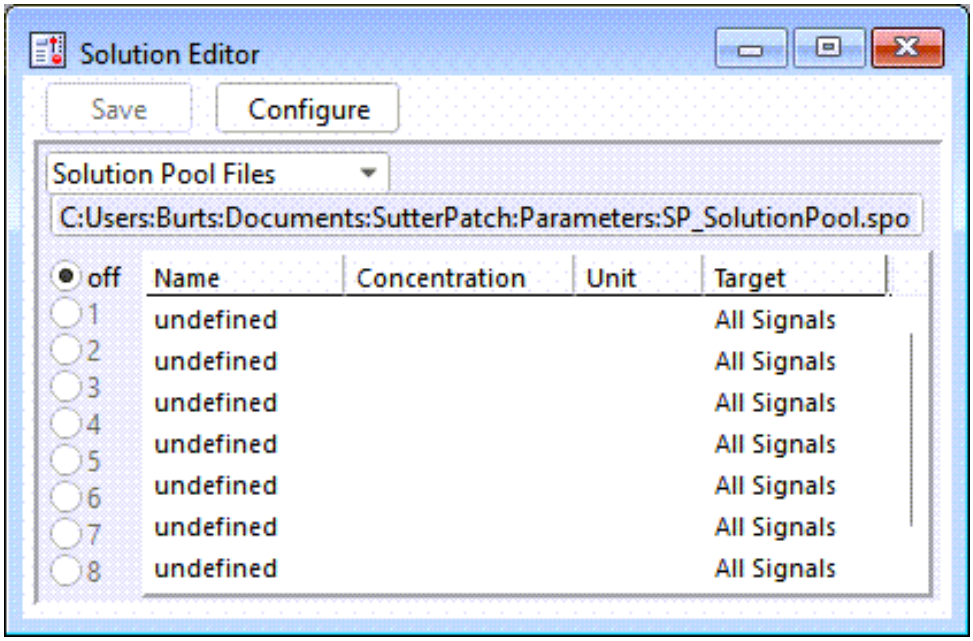


Figure 4-74. Solution Editor

[Save] Save changes to the current Solution Pool file. This button becomes active once any changes are made in the Solution Editor.

[Configure] Open the Configure Solutions Hardware dialog to categorize solution types and configure output channels.

[Solution Pool Files] [↓]

A Solution Pool file (*.spo) can contain multiple defined solutions.

New Solution Pool	Create a new Solution Pool, either blank or populated with selected Solutions.
Load Solution Pool	Load the Solutions of a previously saved Solution Pool file into the Solution Pool.
Revert to Last Saved	Undo any unsaved changes to the Solution Pool.
Save Solution Pool	Save the Solution Pool using its existing file path.
Save Solution Pool As	Save the Solution Pool to a new file, and switch to the new file.

Save Solution Pool Copy — Save the Solution Pool to a new file, but do not switch to the new file.

Note: Default file names are auto-incremented from the previously loaded Solution Pool name.

[< path name >]

The path name of the loaded Solution Pool file is displayed.

[off, 1 – #] — Select a radio button to open a valve using its corresponding solution configuration. A tag named "STIM_CHANGE" is inserted into the data when a valve is opened.

A "valve" radio button becomes available (ungrayed) when its name is changed from 'undefined'.

Only one "valve" can be active at a time. The number of radio buttons is set in the Configure Solutions sub-window.

When set to 'off', all configured solution outputs are set to a zero amplitude.

Name — Double-click on a field to edit it; click-and-drag to move it up or down in the table.

Concentration — The concentration value for the solution.

Tip! You can access the concentration value from the last-used 'Test Compound' or 'Control' solution valve in any fields that accept the Special Identifier 'Paradigm Parameters: Stimulant'.

Unit — The unit type of the concentration.

Target — Displays the associated signals from the Configure Solutions Hardware dialog.

Configure Solutions

◄ — Close Dialog button.

[# solutions] [↓]

Set the maximum number of solutions to configure. When this number is changed, a new Solution Pool is created.

[4, 8, 12, 16, 20, 24]

Loading other Solution Pool files allows an unlimited number of solutions to be accessed in an Experiment.

Description A text note for each solution.

[< signals >] [↓]

A drop-down list of headstage and signal selections.

- All Signals
- Headstage 1
- Headstage 2

[< solution >] [↓]

A list of predefined solution types.

- Initial Condition
- Washout
- Control

  Index [1 – 4] Distinguish between different Control solutions.

- Test Compound
- Not a Solution

[< channel >] [↓]

Select a physical output channel.

- No Output
- AuxOUT[1 – 4] Use an auxiliary output channel.
- DigOUT Word Set multiple digital bits to “high”.
- DigOUT[1 – 8] Set a single digital bit to “high”.

Output

[±10.000 V] Set the value of an analog output voltage signal.

[< 0 – 255 >] Set the decimal value of an 8-bit digital word.

4.1.10 Template Editor

SutterPatch: Template Editor

Templates allow any data waveform or portion of an existing data wave to be incorporated into a command waveform. The Template Editor can manage and manipulate such templates. A Template Pool file (*.spt) can contain multiple defined Templates.

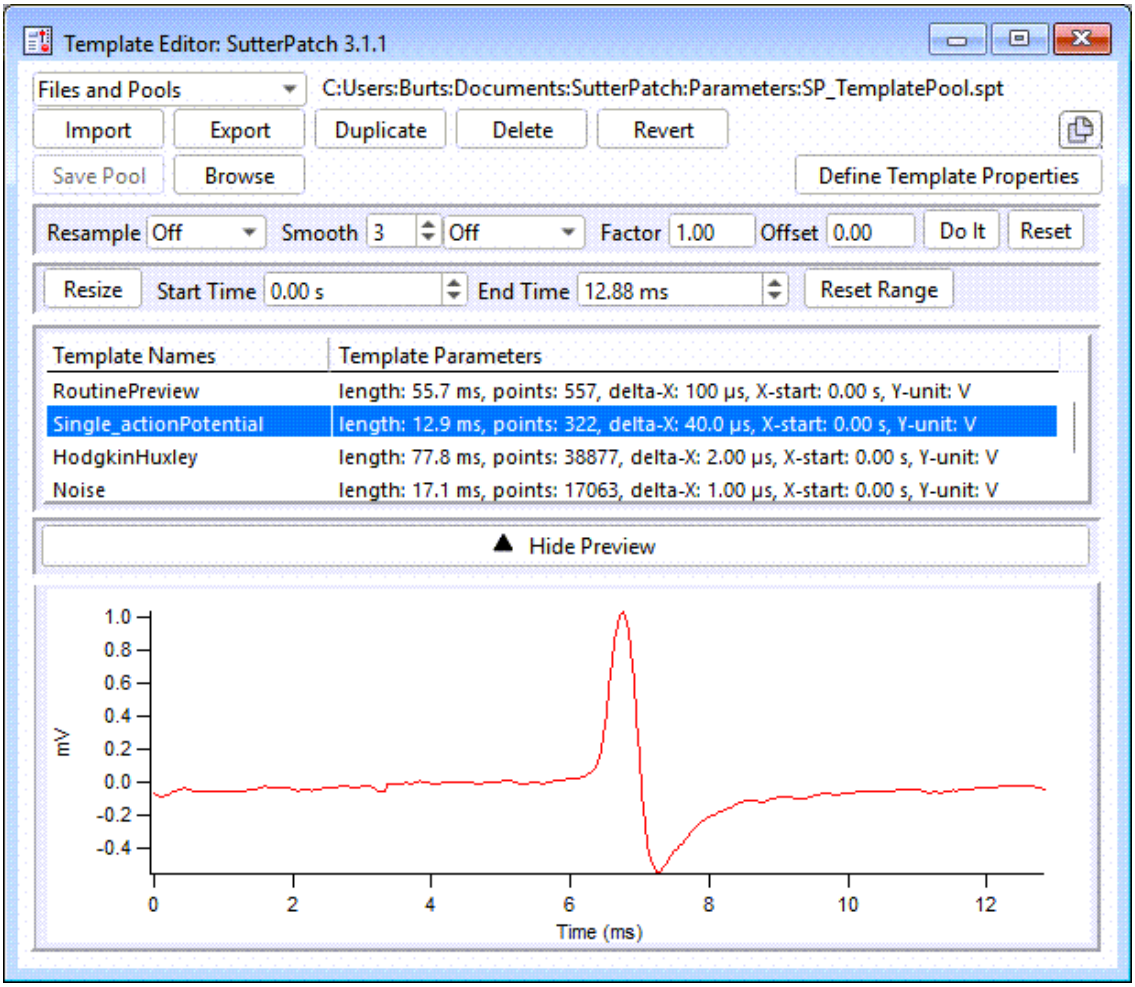


Figure 4-75. Template Editor

Note: Changes made in the Template Editor are only applied to Routines when the Routine Editor > Output Channels > Waveform Editor > Waveform > Template dialog is used to copy the modified template wave from its 'Template Editor Pool' list to the Routine.

[Files and Pools] [↓]

[	< names >	] Most recently used list of the last 5 Template Pool file names.

To manually remove a file from the list, Shift-click it.

Note: Path names have a limited number of characters to use. While file names are preserved, paths are shortened by removing excess characters from their ends.

Load Template Pool — Load the Templates of a previously saved Template Pool.

Multiple templates can be selected for loading at the same time.

New Template Pool — Create a blank Template Pool.

Get Sample Template Pool — Load the factory default Template Pool file.

Revert to Last Saved — Undo any unsaved changes to the Template Pool.

Save Template Pool — Save the Template Pool using its existing file name and path.

Save Template Pool As — Save the Template Pool to a new file, and switch to the new file. The default file name is the same as the original file name.

Save Template Pool Copy — Save the Template Pool to a new file, but do not switch to the new file. The default file name increments.

Merge Template Pools — Insert the Template from a previously saved Template Pool file into the loaded Template Pool.

Send Last Used List to Command

Copy the path name of the 'Files and Pools' last used Template Pool into the Command window history.

Clear Last Used List — Clear the "Last Used" Pool list of all entries.

Sort Template Pool – Ascending Order

Sort the 'Template Names' list in increasing order.

Sort Template Pool – Descending Order

Sort the 'Template Names' list in decreasing order.

[< file path >] The file path and file name of the loaded Template Pool file is displayed.

[Import] Click to create and add a template file directly from data.

Import Binary Wave

Select an Igor Pro wave (*.ibw) as the template file.

Import Text File

Select a text file (such as .*.ATF or .*.CSV) as the template file..

Select column block to load

Select from a drop-down list of numbered sweeps. If 'All' sweeps are selected, the following dialog will display for each sweep.

Sweep configuration dialog

Enter X-increment	[1]	(s).
Enter X-start	[0]	(s)
Enter Y-unit	[" "]	Enter a unit label between the quote marks.

Alternatively, you can create and add a template directly from displayed data. In a Scope window or preview pane, click and drag the mouse to surround a region of interest with a bounding box (the "marquee"). Right-click in the box and select 'Extract Template'. A template with the signal name is added to the template list.

An extracted template is composed of a single sweep:

Acquisition Scope window:	Last sweep.
Reanalysis Scope window:	Selected sweep.
Preview pane:	Last or selected sweep.
Analysis Editor:	Selected wave.

The Y-axis values are copied to the template; the X-axis values are reset in the template to start at zero.

Note: 'Extract Template' is not implemented for the Data Navigator preview pane. Also, it is only valid with monotonically increasing or decreasing X-axes.

[Export] Export the selected template to an Igor Pro 1-D wave file (*.ibw).

To export a portion of a sweep, select the region of interest with the mouse, and use the marquee 'Extract Template' right-click command. The new wave can now be exported.

[Duplicate] Add a copy of the selected template to the list. The new template name's number is appended or incremented.

[Revert] Discard any unsaved changes to the selected template.

[Save Pool] Save the template pool using its existing file name.

[Browse] Create a template from the Experiment data in the Data Browser.

Copy Template Copy the selected template graph:.

To Notebook (as text) Copy the template to the SutterPatch Notebook as text.

To Clipboard (as text)

Copy the template to the system clipboard as text.

To Clipboard (as graph)

Copy the template to the system clipboard as a graph.

To Layout (as graph) Copy the template as a graph into a new Layout window or append to an existing Layout page.

[Define Template Properties]

Update a data wave's X- and Y-axis parameters to be compatible with SutterPatch templates.

Enter X-increment [<#>]

The data point time interval is changed, which also adjusts the length of the trace.

Enter X-start [<#>]

The X-axis starting time for the data.

Enter Y-unit [<" unit ">]

The Y-axis base unit (enclose in double quotes.)

Resample [< Off, (ms: 10, 5, 2.5, 2.0, 1.25, 1), (µs: 500, 250, 200, 125, 100, 50, 25, 20, 10, 5, 4, 2, 1), Other >] [↓]

The data is interpolated to match the new sampling rate. While the number of samples is updated, the length of the trace is unchanged.

Smooth [< 1 – 1000 >]

Apply smoothing to the template.

[< filter >] [↓]

- Off
- Boxcar — A fast time-domain filter with excellent 0 – 100% rise-time response.
- Gaussian — A standard filter with excellent 10 – 90% rise-time response.

Factor [#]

Adjust the template scaling factor.

Offset [#]

Enter a template offset.

[Do It] Apply the adjustments to the template parameters.

[Reset] Revert all settings to the last saved state.

[Resize] Set the template sweep duration to match the Start/End Times.

Start Time [# ms]

Set the beginning time of the signal to use.

End Time [# ms]

Set the ending time of the signal to use.

[Reset Range] Reset the Start/End Times to match the template sweep.

Template Names A list of the loaded templates.

Click on a Template entry to make it the active one.

Double-click on a Template Name to rename it.

Click-and-drag a Template entry to reposition it in the list.

Click-and-drag the bottom window frame to adjust the list height.

Shift-click to select multiple entries.

Template Parameters

Values are displayed with SI unit prefixes.

Parameter settings description:

length: # ms

points: #

delta-X: # µs

X-start: # ms

Y-unit: # ms

[Show/Hide] Preview

Display or hide a preview pane for the selected template.

The preview pane X- and Y-axes can be controlled in two ways:

- Hover the mouse over an axis line until the cursor turns into a double-headed arrow, then scroll up or down to contract / expand the axis.
- In the preview, click and drag the mouse to surround the region of interest with a bounding box (the "marquee"). Right-click in the box and select one of the expand / shrink options.

4.2 Data Analysis

Data analyses for both during and after data acquisition can be configured in these main SutterPatch Editors:

- Routine Editor — Real Time Measurements section
- Paradigm Editor — Note: For extra flexibility in performing data analysis, you can also execute SutterPatch commands, Igor Pro analyses, or user-defined functions.

Additional measurement plots can be set up through the Scope window 'Measurements' button:

- Amplitude Histogram Plot
- Color Plot
- Parametric Plot
- Power Spectrum

Fitting can be applied to most displayed data.

The Analysis Editor can be used for additional processing of analyses results:

- Average
- Concatenate
- Normalize

Specialized analysis modules are available in the Data Navigator 'Available actions':

- Action Potential Analysis
- Single-Channel Analysis
- Synaptic Analysis

Igor Pro also offers its own additional analyses via the Analysis main menu.

4.2.1 Action Potential Analysis

SutterPatch: Available Analysis Modules: Action Potential Analysis

Action potentials (APs) are analyzed offline with this window. Access via the Reanalysis Scope window 'Measurements' button, or the Data Navigator (signal) 'Available actions' menu.

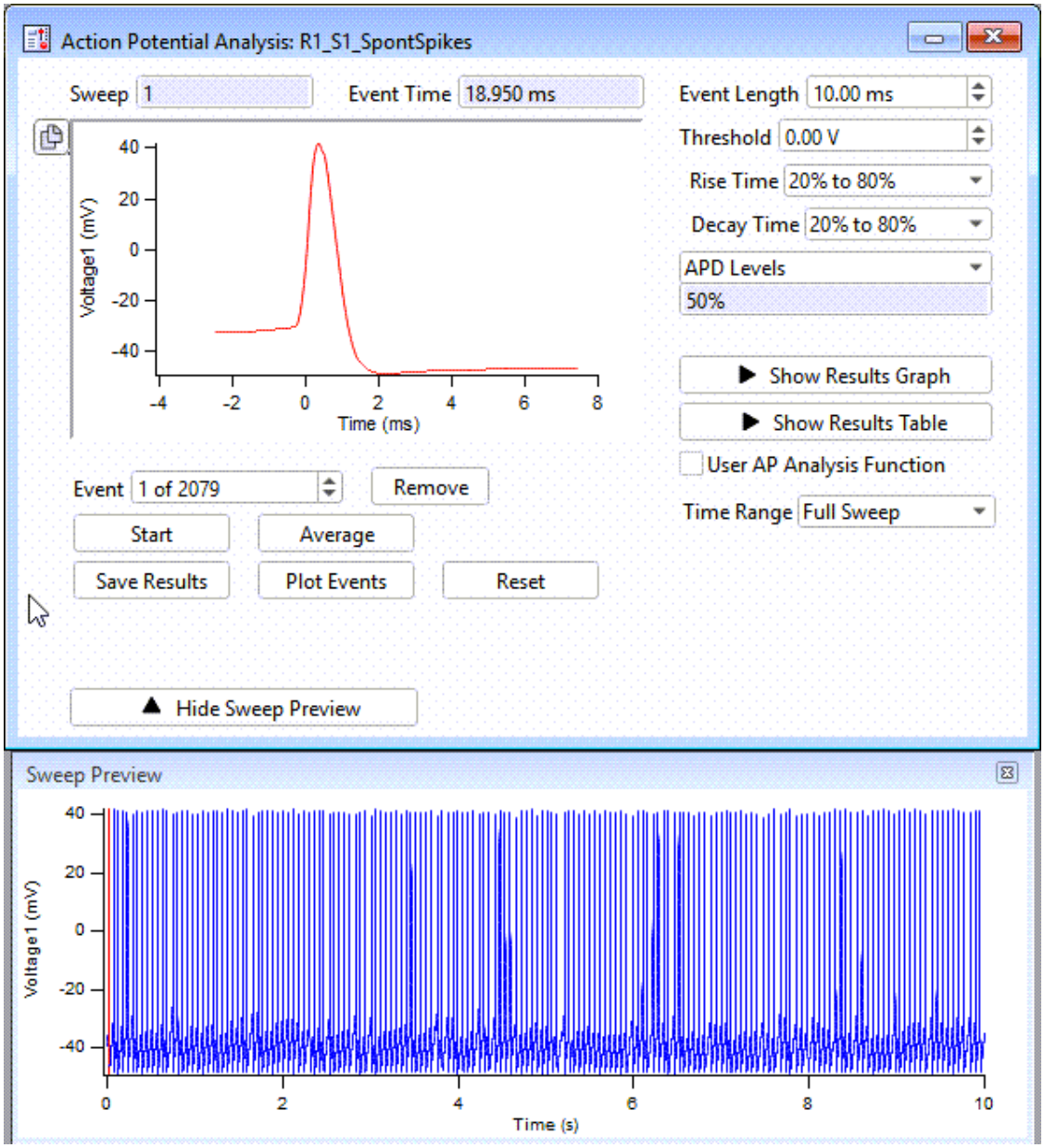


Figure 4-76. Action Potential Analysis

Sweep [#]

The sweep number of the selected action potential event.

The Sweep # is set to 'Average' when the averaged Event is displayed in the Event pane.

The Sweep # is set to '0' when cycling through unanalyzed data.

or

Marked Sweep [#]

Pre-select sweeps for processing by "marking" them in a Scope window during acquisition or reanalysis, or in the Data Navigator tree. If the Data Navigator "Enable Marks" checkbox is enabled, this field is renamed to 'Marked Sweep #', and only marked sweeps are displayed and analyzed.

Event Time [# s]

Time-point when the potential of the selected Event crosses the threshold.

Export Event Export the selected Event:

To Notebook (as text) Copy the Event as text to the Notebook.

To Notebook (as graph)
Copy the Event as a graphic to the Notebook.

To Clipboard (as text)
Copy the Event as text to the system clipboard.

To Clipboard (as graph)
Copy the Event as a graphic to the system clipboard.

To Printer (as text) Print the Event as text directly to the default printer as raw output.

To Printer (as graph) Print the Event as a graphic directly to the default printer as raw output.

To Layout (as graph) Copy the Event as a graphic into a new Layout window or append to an existing Layout page.

[Event pane] A plot of the selected Event or Event Average, with the X-axis zero point reset to the Threshold point.

Sweep [#]

Cycle through the unanalyzed sweeps in the 'Sweep' pane.

or

Event [# of #]

Event number vs. total number of Events.

Cycle through the analyzed Events in the Event pane. The current Event is also displayed in the 'Sweep Preview' pane and highlighted in the Results Table. If there are multiple Events in a sweep, the current Event is highlighted in red in the 'Sweep Preview' pane.

[Remove] Remove the displayed Event from the list of Events to be analyzed by 'Start'.

[Start] Click to find and analyze action potentials, and to display the Results pane.

Also, the special function 'UserAP' can be automatically called to custom analyze each event as it is found.

< see the Programming chapter: SutterPatch Hooks >

or

[Calculating] After pressing the 'Start' button, this button changes to 'Calculating' while the analysis is being calculated.

[Average] Click to display the average of all Events in the Event pane.

The Event pane is labeled with "AVERAGE", and the Event number is replaced with "Average".

Click the 'Remove' button to display the last viewed Event, or click the Event increment/decrement button to display Event 1.

< the AVERAGE Event does not display in the Sweep Preview >

or

[Abort] After pressing the 'Start' button, this button changes to 'Abort' while the analysis is being calculated, so if the calculation is taking too long, you can press this button to abort the process and reset your parameters.

[Save Results] The latest results are displayed in the SP_Layout window and the Analysis Editor.

The Layout window displays:

Results Table Summary Info

Average Event plot

Results Graph phase plot

The Analysis Editor contains data waves for:

R#_S#_#_ap_avg	Averaged Event vs. Time
R#_S#_#_ap_df	Differentiated Event vs. Time
R#_S#_#_ap_results	Results Table

Separate 'Average AP' and 'Phase plot' graphs are also created, and can be accessed via the menu item Windows / Graphs.

[Plot Events] The 'Plot Events dialog displays to list Event to be plotted as overlapping sweeps in a floating graph window.

Enter a list of Events separated by a comma "," and/or a range of Events separated by a dash "-".

[Reset] Reset the analysis list to all sweeps, and clear the Results Graph and Results Table.

[Show / Hide Sweep Preview]

Show or hide the Sweep Preview pane below.

Displays a sweep of data colored in blue, with the selected Event highlighted in red.

Event Length [# s]

The Event duration in the Event pane; the selected Event is highlighted in red in the Sweep pane.

Threshold (V) [±0.1000]

This voltage level needs to be reached or exceeded for analysis of an Event to be triggered.

Rise Time [< % >] [↓]

Measure the rise time of the action potential.

0% to 100%

10% to 90%

20% to 80%

30% to 70%

Decay Time [< % >] [↓]

Measure the decay time of the action potential.

0% to 100%

10% to 90%

20% to 80%

30% to 70%

APD Levels: [< % >] [↓]

[20, 30, 40, 50, 60, 70, 80, 90, 100 %, Set to Default, Select All Odd, Select All Even]

Set the Action Potential Duration percentage levels.

Measures the duration of an Event at percentages of the Event's repolarization amplitude.

[%]

Selected APD level percentages.

[Show/Hide Results Graph]

Display or hide the Results Graph of the analyzed data. A phase plot of the measurement results is displayed for the selected Event.

< see below >

[Show / Hide Results Table]

Display or hide the Results Table of the analyzed data.

< see below >

[ ] User AP Analysis Function

Enable to execute this custom function, if it exists, for each Event.

< see Programming: SutterPatch Hooks UserAP >

Time Range [< range >]] [↓]

- Full Sweep
- Sweep Time

  Analysis Start [# s]

  Set the start-time of the Sweep data to be analyzed.

Analysis End [# s]

Set the end-time of the Sweep data to be analyzed.

- Segment Time

  Segment [#]

  Select an available segment number.

  Start Ratio [0 – 1.00]

  End Ratio [0 – 1.00]

  Analysis Start [# s]

  Based on Start Ratio.

  Analysis End [# s]

  Based on End Ratio.

Results Graph A resizable results pane displays for the event selected in the main window.

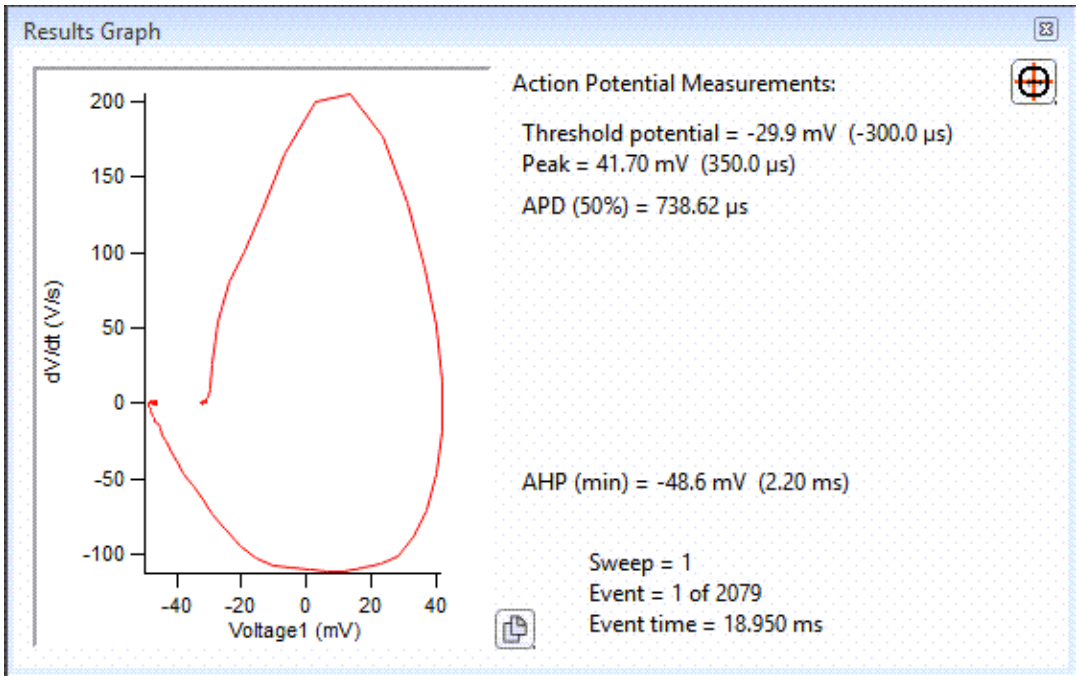


Figure 4-77. Action Potential Measurements

[Phase Plot pane] A resizable graph of the phase plot, for visual inspection of the derivatives.

X-axis: V

Y-axis: dV/dt (V/s)

Threshold potential = [# V (# s)]

Amplitude of the beginning of the measured Event.

Time of the beginning of the measured Event compared to the time point of the user-defined “trigger” Threshold amplitude.

This is essentially the baseline of the Event.

< see Appendix F: SutterPatch Algorithms: Action Potential Threshold Algorithm >

Peak = [# V (# s)]

Amplitude of the event peak.

followed by:

Time point of the peak compared to the beginning of the measured Event.

APD (%) = [# % = # s]

The user-defined APD (Action Potential Duration) Level percentile of repolarization from the peak amplitude and its duration measurement.

AHP (min) = [# V (# s)]

Peak (negative) amplitude of the After Hyper-Polarization phase.

followed by:

Time point of the After Hyper-Polarization peak compared to the beginning of the measured Event.

AHP is the hyperpolarized refractory period of the cell, when the action potential repolarization phase drops below the resting membrane potential before eventual recovery back to the resting membrane potential.

< displays after 'Start' or when reviewing individual Events >

Sweep = [#]

The sweep number of the analyzed Event.

Event = [# of #]

The analyzed Event (of the total number of Events) found in the analyzed data.

Event time = [# ms]

The sweep time of the start of the analyzed Event.

< displays after 'Average' and 'Save Results' >

Events found = The number of averaged Events.

Event frequency = The average frequency of the found Events.

Export Phase Plot	Export button with options:
To Notebook (as text)	Copy the plot as text to the Notebook.
To Notebook (as graph)	Copy the plot as a graphic to the Notebook.
To Clipboard (as text)	Copy the plot as text to the system clipboard.
To Clipboard (as graph)	Copy the plot as a graphic to the system clipboard.
To Printer (as text)	Print the plot as text directly to the default printer as raw output.
To Printer (as graph)	Print the plot as a graphic directly to the default printer as raw output.
To Layout (as graph)	Copy the plot as a graphic into a new Layout window or append to an existing Layout page.

Scan or extract data

- Scan data

  Open a floating window to manually measure phase plot X-Y data points.

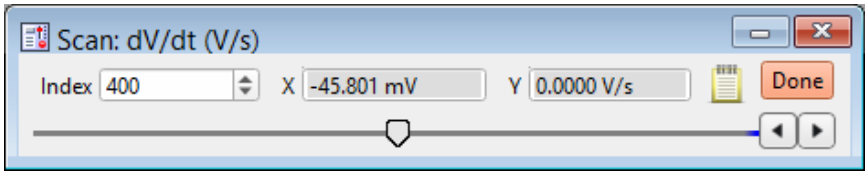


Figure 4-78. Scan Data

Index [< 0 to (n-1) >]

The selected data point number in the plot.

A data point number can be entered, or use the increment/decrement controls to increase/decrease the selected data point by one point.

X [#]

The X-axis value of the selected data point.

Y [#]

The Y-axis value of the selected data point.

Write to Notebook

Click to write to the Notebook:

Scan: dV/dt (V/s)	Label.
index=#	Point number.
x=#	X data value.
y=#	Y data value.

Close the “Scanner” floating window.

This window also automatically closes when you click outside of it.

X-slider bar

Click and drag the slider for the data-point cursor.

The data cursor display mode is set in 'Set Preferences / Graphs and Layouts'.

Click to decrement/increment the data cursor by one point at a time, or with the Shift-key, by 10 data points.

Or, the keyboard left/right-arrow keys decrease/increase the data selection by one point; with the Shift key, they decrease/increase the selection by 10 points.

Or, the keyboard Up/Down arrow keys increase/decrease/ the data selection by 10 points.

- Extract data

  Open a floating window with data extraction controls.

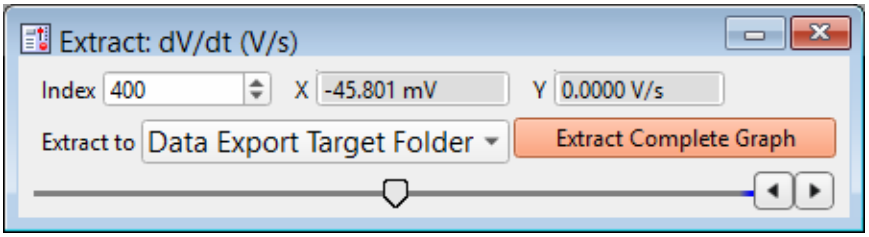


Figure 4-79. Extract Data

Extract: dV/dt (V/s)

Index [< 0 to (n-1) >]

The selected data point number in the plot.

A data point number can be entered, or use the increment/decrement controls to increase/decrease the selected data point by one point.

X [#]

The X-axis value of the selected data point.

Y [#]

The Y-axis value of the selected data point.

Extract to [< target >] [↓]

Select the data extraction target:

Analysis Pool	< unavailable >
Template Pool	< unavailable >
Data Export Target Folder	< unavailable >
To Standalone Graph	Extract the plot to a separate graph window; if a fit has been performed, only the fitted line is extracted.
To Notebook	Extract the graph as a graphic to the Notebook.
To Clipboard	Extract the graph as a graphic to the system clipboard.
To Printer	Print the graph as a graphic directly to the default printer as raw output.

[Extract complete graph]

Click to extract the entire graph.

X-slider bar

Click and drag the slider for the data point cursor.

The data cursor display mode is set in 'Set Preferences / Graphs and Layouts'.

Click to decrement/increment the data cursor by one point at a time, or with the Shift-key, by 10 data points.

Or, the keyboard left/right-arrow keys decrease/increase the data selection by one point; with the Shift key, they decrease/increase the selection by 10 points.

Or, the keyboard Up/Down/Up-arrow keys increase/decrease/ the data selection by 10 points.

This floating window automatically closes when you click outside of it.

Results Table

[< view >] [↓]

- Show as table — Display the results as numbers in a resizable table.

  The table view displays the selected Event and highlights it.

  Table view

  Summary Info

  Signal Name: — The signal name of the analyzed signal.

  Analysis Prefix: — [Routine#_Signal#_#]

  The prefix for the signal's analysis objects in the Igor Pro 'Data:Analysis' folder.

  Total time analyzed = — [s]

  Includes the Start / End times for all analyzed sweeps.

  Number of events detected = — Total number of Events found.

  Event Frequency = — [Hz]

  The average frequency of the found Events.

  Note: In a sweep, the time before the first Event, and after the last Event, are not included in this calculation.

  All Sweeps analyzed — Every sweep was analyzed.

  or

  Sweeps analyzed: — [list of analyzed sweep #s]

   Export Summary — Export button with options:

  To Notebook (as text) — Copy the summary as text to the Notebook.

To Notebook (as graph)	Copy the summary as a graphic to the Notebook.
To Clipboard (as text)	Copy the summary as text to the system clipboard.
To Clipboard (as graph)	< unavailable >
To Printer (as text)	Print the summary as text directly to the default printer as raw output.
To Printer (as graph)	Print the summary as a graphic directly to the default printer as raw output.

Column Headers

[ ]	Row number, one row per Event.
Sweep Number	Sweep number the Event is in.
Event Time (s)	Time point of the start of the measured Event from the start of the sweep data.
Threshold (V)	Amplitude of the beginning of the measured Event.
Threshold Time (s)	(negative) Time of the beginning of the measured Event compared to the time point of the user-defined "trigger" Threshold amplitude.
Peak (V)	Amplitude of the Event peak.
Peak Time (s)	Time point of the peak compared to the beginning of the measured Event.
AHP (V)	Peak (negative) amplitude of the After Hyper-Polarization phase. AHP is the hyperpolarized refractory period of the cell, when the action potential repolarization phase drops below the resting membrane potential before eventual recovery back to the resting membrane potential.
AHP Time (s)	Time point of the After Hyper-Polarization peak compared to the beginning of the measured Event.
Absolute Event Time	The time point of the start of the measured Event from the start of the data recording.

Peak to Peak Time	The time between the peaks of the current and previous Events.
Max Slope (V/s)	The maximum (positive) slope of the rising phase of the Event.
Min Slope (V.s)	The minimum (most negative) slope of the falling phase of the Event.
Rise Time (s)	The rise time at the user-defined event amplitude percentile range.
Decay Time (s)	The fall time at the user-defined Event amplitude percentile range.
APD area (V * s)	Area of the action potential at the user-defined APD (Action Potential Duration) Level percentile of repolarization from the peak amplitude.
AP Duration @ n% (s)	The action potential duration at the user-defined ("n") APD Level percentile of repolarization from the peak amplitude. Multiple columns display if multiple APD levels are set.
User	User analysis equation results from the UserAP function, if present. < see the Programming chapter: SutterPatch Hooks >

Export Table	Export button with options:
To Notebook (as text)	Copy the table as text to the Notebook.
To Notebook (as graph)	< unavailable >
To Clipboard (as text)	Copy the table as text to the system clipboard.
To Clipboard (as graph)	< unavailable >
To Printer (as text)	Print the table as text directly to the default printer as raw output.
To Printer (as graph)	< unavailable >
To Layout (as graph)	< unavailable >

- Show as scatter plot Display the results plotted in a resizable graph.

  Plot view

  X [< view >] [↓]

  Select the X-axis from its drop-down list:

  Y [< view >] [↓]

  Select the Y-axis from its drop-down list:

  Sweep Number

  Event Time (s)

  Threshold (V)

  Threshold Time (s)

  Peak (V)

  Peak Time (s)

  AHP (V)

  AHP Time (s)

  Absolute Event Time (s)

  Interevent Interval (s)

  Max Slope (V/s)

  AP Duration @ XX% (s)

   Set marker size and kind

Marker Size	[1 – 9]
Marker Type	Select a symbol from the panel.

   Export Table Export button with options:

To Notebook (as text)	Copy the table as text to the Notebook.
To Notebook (as graph)	Copy the table as a graphic to the Notebook.

To Clipboard (as text)	Copy the table as text to the system clipboard.
To Clipboard (as graph)	Copy the table as a graphic to the system clipboard
To Printer (as text)	Print the table as text directly to the default printer as raw output.
To Printer (as graph)	Print the table as a graphic directly to the default printer as raw output.
To Layout (as graph)	Copy the table as a graphic into a new Layout window, or append to an existing Layout page.

'Save Results' Layout window

Note: If objects are overlayed, click and drag to reposition them in the Layout page.

[summary info]

Signal Name:	The Igor Pro experiment name for the analyzed signal.
Analysis Prefix:	[Routine#_Signal#_#] The prefix for the signal's analysis objects in the Igor Pro 'Data: Analysis' folder.
Total time analyzed =	[s] Includes the Start / End times for all analyzed sweeps.
Number of events detected =	Total number of Events found.
Event Frequency =	[Hz] The average frequency of the found Events. Note: In a sweep, the time before the first Event, and after the last Event, are not included in this calculation.
All Sweeps analyzed or	Every sweep was analyzed.
Sweeps analyzed:	[list of analyzed sweep #s]
[event graph]	[V vs. s] A graph of the averaged Event.

[phase plot] [dV/dt (V/s) vs. V]

A graph of the phase plot for visual inspection of the derivatives.

4.2.2 Analysis Editor

SutterPatch: Analysis Editor

View and manipulate the data in your Experiment's various analyses and graphs.

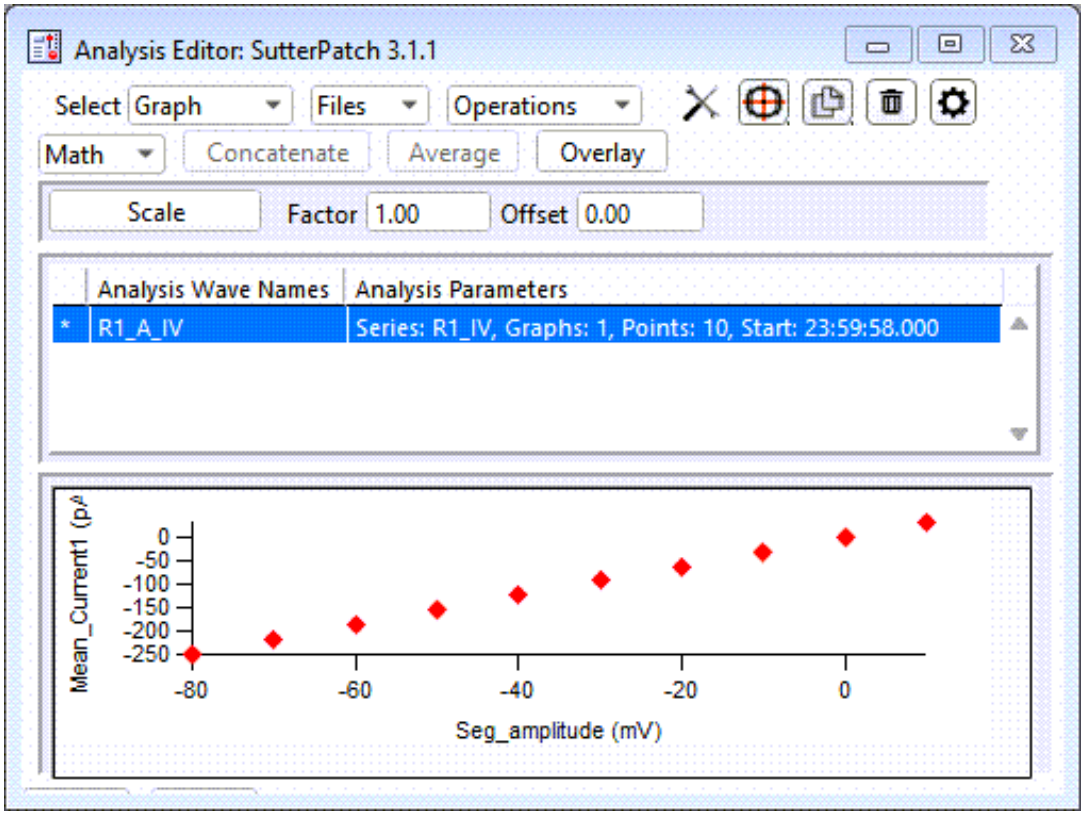


Figure 4-80. Analysis Editor

Select [< view >] [↓]

Choose how to view the data:

- Graph- [1 – 8] Select an Analysis wave to be graphed, and its data points are plotted. The graph number refers to its original Analysis window position.

  < see Graph pane below >

- Table — View a spreadsheet of the Analysis data

  < see Table pane below >

Files [< action >] [↓]

Import or export an analysis graph file.

Export Table to text file

The table data are written to a tab-delimited plain text file. Any column header information is lost. To preserve such metadata, export to the binary format.

Export Graphs as binary wave

Save the entire graph as a multi-dimensional Igor Binary Wave file (*.ibw).

Export Graph X-column

Save the X-column data, including labels, as a one-dimensional Igor Binary Wave file (*.ibw).

Export Graph Y-column

Save the Y-column data, including labels, as a one-dimensional Igor Binary Wave file (*.ibw).

Import Table from text file

Import numeric text data from comma- or tab-delimited columns.

Import Graphs from binary wave

Open and display a saved graph.

Note: Import of one-dimensional Igor Binary Wave files (*.ibw) is not supported.

Operations [< action >] [↓]

Duplicate — Insert a copy below the highlighted item.

Delete Analysis or Table

Delete the entire analysis wave.

Delete Single Graph — Delete the selected graph.

Note: If an analysis cannot be deleted, it likely exists in another Graph window or Layout page - first close the other analysis instance via menu items Windows / Graphs, or Windows / Layouts, or Windows / Layout

Macros.

Open Text Formatting preferences

Open the Set Preferences 'Data Export' pane to configure export and table format preferences.

Scan, fit or extract analysis data

- Scan data

Open a floating window to manually measure analysis X-Y data points in graphs.

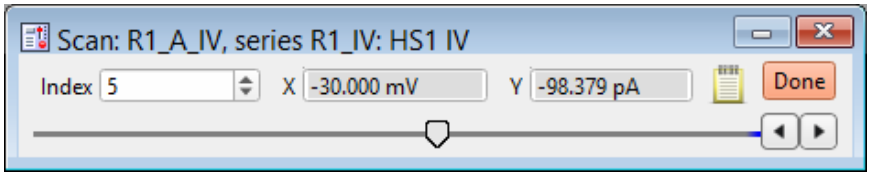


Figure 4-81. Scan Analysis Data

Scan: Wave Name

Index [< 0 to (n-1) >]

The selected data point number in the plot.

A data point number can be entered, or use the increment/decrement controls to increase/decrease the selected data-point by one point.

X [#]

The X-axis value of the selected data point.

Y [#]

The Y-axis value of the selected data point.

Write to Notebook

Click to write to the Notebook:

Scan: wave name Label.

series Routine#_Routine_name

Name.

index=#	Point number
x=#	X data value.
y =#	Y data value.

Close the “Scanner” floating window.

This window also automatically closes when you click outside of it.

X-slider bar

Click and drag the slider for the data-point cursor.

The data cursor display mode is set in ‘Set Preferences / Graphs and Layouts’.

Click to decrement/increment the data cursor by one point at a time, or with the Shift-key, by 10 data points.

Or, the keyboard left/right-arrow keys decrease/increase the data selection by one point; with the Shift key, they decrease/increase the selection by 10 points.

Or, the keyboard Up/Down arrow keys increase/decrease the data selection by 10 points.

- Fit data

  Open a floating window to fit the analysis data.

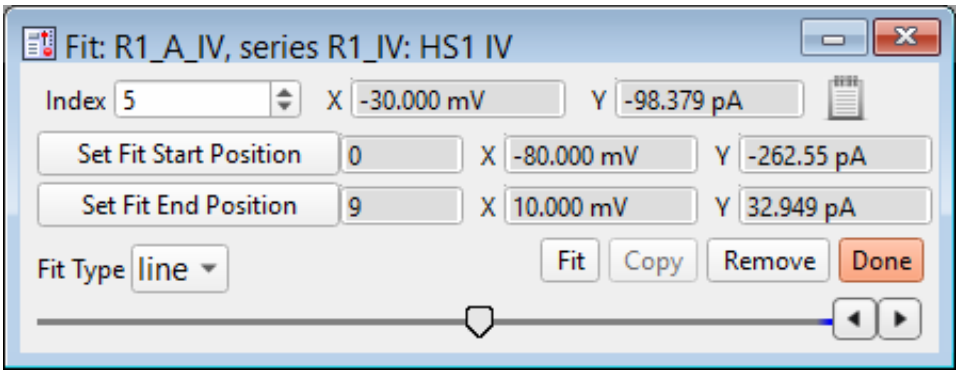


Figure 4-82. Fit Analysis Data Control

Fit: Wave Name

Index [< 0 to (n-1) >]

The selected data point number in the plot.

A data point number can be entered, or use the increment/decrement controls to increase/decrease the selected data point by one point.

X [#]

The X-axis value of the selected data point.

Y [#]

The Y-axis value of the selected data point.

Click to write the last fit results to the Notebook.

[Set Fit Start Position]

Click to set the starting point of the fit.

Shift-click to set it to the array minimum.

[< 0 to (n-1) >]

Index number of the fit start.

X [#]

The X-axis value of the fit start.

Y [#]

The Y-axis value of the fit start.

[Set Fit End Position]

Click to set the ending point of the fit.

Shift-click to set it to the array maximum.

[< 0 to (n-1) >]

Index number of the fit end.

X [#]

The X-axis value of the fit end.

Y [#]

The Y-axis value of the fit end.

Fit Type [< fit >] [↓]

Select from a drop-down list:

line

poly

poly_XOffset

gauss

Ior

Voigt

exp_XOffset

dbexp_XOffset

exp

dblexp

dblexp_peak

sin

HillEquation

Sigmoid

Power

LogNormal

Log

[Fit] Click to perform the fit, and replace any previous fit.

[Copy] Copy the fit trace to the Analysis Editor.

[Remove] Remove the fit line from the graph.

Done Close the “Fitter” floating window.

This window also automatically closes when you click outside of it.

 X-slider bar

Click and drag the slider for the data-point cursor.

The data cursor display mode is set in ‘Set Preferences / Graphs and Layouts’.

 Click to decrement/increment the data cursor by one point at a time, or with the Shift-key, by 10 data points.

Or, the keyboard left/right-arrow keys decrease/increase the data selection by one point; with the Shift key, they decrease/increase the selection by 10 points.

Or, the keyboard Up/Down arrow keys increase/decrease the data selection by 10 points.

- Extract data

Open a floating window with data extraction controls.

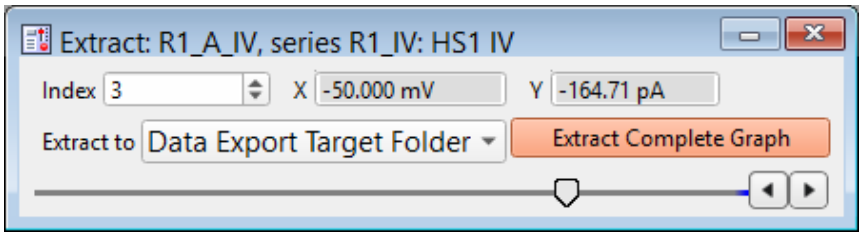


Figure 4-83. Extract Data

Extract: Wave Name

Index [< 0 to (n-1) >]

The selected data point number in the plot.

A data point number can be entered, or use the increment/decrement controls to increase/decrease the selected data point by one point.

X [#]

The X-axis value of the selected data point.

Y [#]

The Y-axis value of the selected data point.

Extract to [< target >] [↓]

Select the data extraction target:

Analysis Pool < unavailable >

Template Pool < unavailable >

Data Export Target Folder

< unavailable >

To Standalone Graph

Extract the plot to a separate graph window; if a fit has been performed, only the fitted line is extracted.

To Notebook Extract the graph as a graphic to the Notebook.

To Clipboard Extract the graph as a graphic to the system clipboard.

To Printer	Print the graph as a graphic directly to the default printer as raw output.

[Extract complete graph]

Click to extract the entire graph.

X-slider bar

Click and drag the slider for the data-point cursor.

The data cursor display mode is set in 'Set Preferences / Graphs and Layouts'.

Click to decrement/increment the data cursor by one point at a time, or with the Shift-key, by 10 data points.

Or, the keyboard left/right-arrow keys decrease/increase the data selection by one point; with the Shift key, they decrease/increase the selection by 10 points.

Or, the keyboard Up/Down arrow keys increase/decrease the data selection by 10 points.

This floating window automatically closes when you click outside of it.

Copy Analysis — Copy the selected analysis graph or table:

Graph

To Notebook (as text)	< unavailable >
To Notebook (as graph)	Copy the analysis graphs as graphics to the Notebook.
To Clipboard (as text)	< unavailable >
To Clipboard (as graph)	Copy the analysis graphs as graphics to the system clipboard.
To Printer (as text)	< unavailable >
To Printer (as graph)	Print the graphs directly to the default printer as raw output.

To Layout (as graph)	Copy the analysis graphs as graphics into a new Layout window, or append to an existing Layout page.

Table

To Notebook (as text)	Copy the table as text to the Notebook.
To Notebook (as graph)	Copy the table as a graphic to the Notebook.
To Clipboard (as text)	Copy the table as text to the system clipboard.
To Clipboard (as graph)	Copy the table as a graphic to the system clipboard.
To Printer (as text)	Print the table as text directly to the default printer as raw output.
To Printer (as graph)	Print the table as a graphic directly to the default printer as raw output.
To Layout (as graph)	Copy the graph or table as a graphic into a new Layout window, or append to an existing Layout page.

Delete Analysis or Table

Click to delete the selected analyses or tables. Hold <Shift> to delete without verification.

Options

Show Fits	Display fit lines on the graph data.
Show Error Bars	Display SEM error bars for averaged data.
Show Axes Color	Display a background color for the axes.
Show Grid	Display X & Y grid lines in a graph.
Show Markers	Display data points with marker symbols.
Show Lines	Display a line between data points.

Math [< target >] [↓]

< for Tables >

Table selection average

Table selection sum

< for Graphs >

Normalize: zero to maximum

Rescale the data, so the zero point is maintained in, or relative to the data, and the most positive point is set to “1”.

Normalize: minimum to maximum

Subtract the minimum value from all data points, so the smallest point is at the zero point, and rescale the data so the largest point is set to “1”.

Tip! Use normalization to compare % of solution block.

Invert Reverse the Y-axis sign of the data points.

Average of respective sweeps in a cycle

More than one full cycle of sweeps is required.

Average of all sweeps in a cycle

Power Spectrum Compute the power spectrum of a signal data wave, i.e., a “Sweep”.

To obtain a suitable data wave, use the Data Navigator sweep Action “Extract Sweep to Analysis Pool” and select the sweep or an average of sweeps.

Power Spectrum window

[Source: Sweep R# S# Routine name]

Source name field.

FFT output mode [< mode >] [↓]

Real output

Magnitude

Magnitude squared

Scaled magnitude

Scaled magnitude scaled

[ ] Use all data When disabled, the “limit” fields ungray.

Left limit [#]

Set in seconds.

Right limit [#]

Set in seconds.

Equation Dock an Equation Editor pane to the bottom of the Analysis Editor.

Equation Editor pane

◀ Close the Equation Editor pane.

[Undo] Remove all edits to the equation.

[Execute] Apply the equation to the analysis.

[< equation >]

Enter an equation to be executed.

[Check] Check the equation syntax. The equation is evaluated, and if valid, it reports "Syntax is ok.”

[Append] Append an “Eq[ ]” equation or an analysis wave name to the equation.

[Expand to Command Line]

Copy the equation to the Command window command line.

[Concatenate]

To enable this button, select additional analysis waves using Shift-click. The newly concatenated wave is inserted below the last selected analysis wave; if the last selected wave is also a concatenated wave, the additional data is instead concatenated with the last selected wave.

Time-course data are plotted relative to the loaded analysis wave’s “time zero”.

[Average] Select an analysis wave (Shift-click in Windows) to be averaged with the loaded wave. A weighted average is performed, i.e., the number of data sets is accounted

for when averaging in new data.

Two new entries are inserted into the wave list after the loaded wave:

1. The averaged wave.
2. The SEM (Standard Error of Means) data points wave.

If 'Options / Show Error Bars' is enabled, the SEM data are used to display error bars in the corresponding averaged data graph.

< see Appendix F: SutterPatch Algorithms: Standard Error of the Mean (SEM) Algorithm >

[Overlay] Select multiple analysis waves (Shift-click in Windows) and plot them in the same graph.

To plot both signals and their analyses, use the Data Navigator sweep Actions to "Extract sweep to Analysis pool". Then, in the Analysis Editor, select both the analysis and signal waves and click the 'Overlay' button.

Note: The X-axis of the first selected wave will be used as the X-axis of the overlay graph.

Scale (and add)

Click this button to apply optional scaling and offset to the selected analysis wave. When the Factor is '1.00' and the Offset is '0.00', this operation simply adds the selected waves to the displayed wave.

When multiple waves are selected, then this changes to the 'Scale and add' button, which adds their scaled values to the last selected (displayed) wave.

Factor [#]

Set a scaling factor for a data wave that will be added to the displayed data.

Values are displayed with SI unit prefixes.

To subtract a data wave, change the Factor to a negative number.

Offset [#]

Set an offset for a data wave that will be added to the displayed data.

Values are displayed with SI unit prefixes.

Analysis Wave Names

A column of loaded analyses available for manipulation.

Analysis Parameters

A column of the loaded waves parameters.

- Series: R#_ Series name of the wave.
- Graphs: # Number of graphs in the wave.
- Points: # Number of data points in the graph.
- Start: # Start time of the analysis wave,

  or
- SEM Standard Error of the Mean wave.

  < for averaged waves >
- Average: # Number of graphs averaged or appended.

Tip! If the Analysis Parameters text is not fully visible, increase the width of the Analysis Editor window.

[Graph pane]

Data point markers are plotted in a graph.

X- and Y-axes can be magnified to be larger or smaller. Place the mouse cursor in the axis ticks region, then scroll the mouse wheel up or down. The axis ticks region does not include the tick label (numbers) area.

The marquee tool is also supported in the Graph pane. Click and drag a bounding box around the region of interest, then right-click in it for magnification options.

To measure X-Y data points or set a fitting range, select the ”Scan, fit” button  .

[Table pane]

View a spreadsheet of the Analysis data

The first set of numbers corresponds to the graph(s) values (if any), and separated by blank columns, the second set of numbers corresponds to all measurements made on the data, whether graphed or not.

The default text table format (in ‘Set Preferences / Data Export: Table Formatting) is Engineering prefix’, otherwise for the ‘Exponential notation’ and ‘Igor general number’ table formats, it is a native Igor Pro table.

If no measurements were performed on the data, the only columns that are populated are the Row number, Routine Name_Sweep Number, and Time (of sweep start).

Warning! Editing the table will permanently alter its data.

Tip! As there is no “Undo”, before making any changes, use Operations / Duplicate to make a working copy of the data that can be later deleted.

First Row

[#R x #C] The number of data rows times the number of data columns in the selection. Displays when column headers, or ‘Row’ column numbers, or multiple data cells are selected.

or

[R# Label] The row number plus “Label” designation for the selected sweep name (R#_Rtn_name_Swp#).

or

[R# C#] The Row and Column number of the selected cell.

[# unit] Editable contents of the selected cell. If multiple cells are selected, the first cell’s value displays.

 Text Editor

Click to edit the selected data cell in a text editor.

 Modify Columns

Click to modify the selected columns.

Shift-click to modify all columns.

Alt-Shift-click (Windows) or Option-Shift-click (macOS) to modify all columns except the Point column.

 Wave Dimension Orientation

Specify which wave dimensions are displayed vertically and horizontally in the table.

Second Row

Row First column header. The first column contains noneditable row numbers for the data rows in the table.

AnalysisEditTable.1

Second column header.

The second column contains the Routine number_ Routine name_Sweep number label of a row.

AnalysisEditTable[ ][column #].d

Third column header wave name.

The third column (# 0) and subsequent columns contain data cells.

Third Row

[ ] The first column header is blank.

The remaining column headers are editable by double-clicking them.

[x \ y] The second column header shows either horizontal indices or dimension labels.

[Time (s)] The third column (# 0) header displays the X-axis label,

[Measurement (unit)]

The fourth and subsequent column headers display measurements Y-axis labels,

Data Rows

[0 – n] < these rows contain noneditable row numbers >

The first sweep is in row 0, while the last sweep is in row [n – 1].

Row 'n', the last row in the table, is a blank row that contains grayed-out cells. It is used to manually add extra rows of data to the table. Once a number is entered into one of these grayed cells, the row ungrays and a new row is automatically created below it.

Columns for time-series measurements

Column 0 [#.#####]

"Time (s)" column with the start times of the

measured sweeps, used as the time-data for an X-axis.

Column 1 [#.#####]

Measurements data.

Columns m – n

[#.#####, #.#####, …]

Another pair of X- and Y-data columns displays for each additional time-based graph. However, the X-data columns are blank, as the Column 0 (Time) values apply instead.

Columns for X-Y graphs

Column 0 [#.#####]

"Time (s)" column with start times of the measured sweeps.

Column 1 [#.#####]

Y-data measurements from the first graph, for the Y-axis amplitudes.

Column 2 [#.#####]

X-data measurements from the first graph, for the X-axis data points.

Columns m – n

[#.#####, #.#####]

For each additional X-Y graph, a pair of Y- and X-data columns repeat.

4.2.3 Analysis Window

Scope measurements are plotted in an Analysis window, usually docked on the right side of the Scope window.

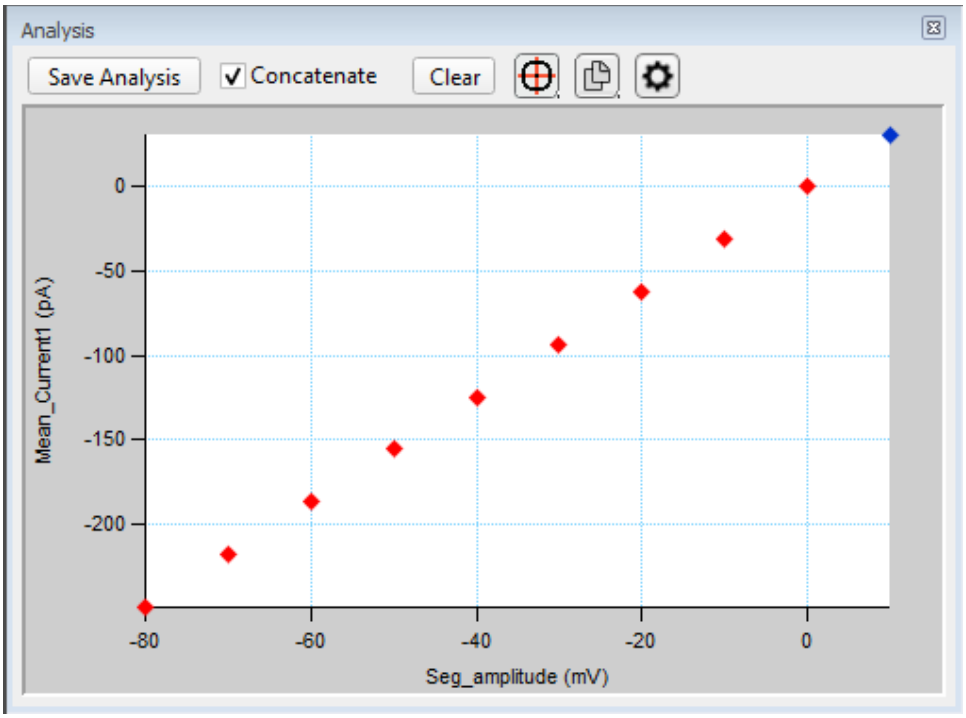


Figure 4-84. Analysis Window

Measurements can be plotted during data acquisition in real-time as configured in the Routine Editor 'Real Time Measurements & Graphs' section. A separate pane is created in the Analysis window for each enabled Measurement graph.

Data can be opened for later review or analysis via the Dashboard 'View Last' button or the Data Navigator. When stored data are rerun for analysis, the data displays in a Reanalysis Scope window, and the measurements are graphed in the accompanying Analysis window. The last measurements applied to the data are automatically used to reanalyze the data.

An Analysis window can be resized, closed, or undocked from the Scope window.

[Save Analysis] This button saves the displayed analyses with the Experiment.

Saved analyses are viewable in the Analysis Editor (or also the Data / Data Browser 'Data: Analysis' folder). Unmarked sweeps measurements are not visible in Analysis Editor tables.

[ ] Concatenate Append new measurements to the existing measurements in the graph.

[Clear] Erase all measurements from the graph display.

 Scan, fit or extract analysis data

- Scan analysis data

Open a floating window to manually measure analysis X-Y data points in graphs.

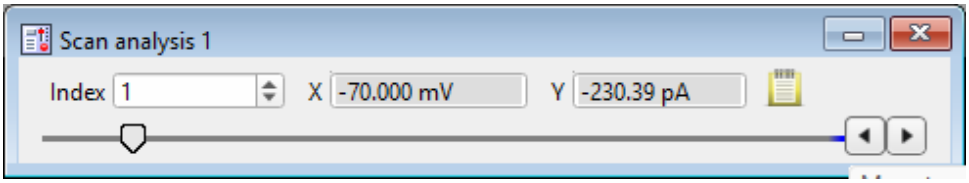


Figure 4-85. Scan Analysis Data

Scan analysis #

Index [< 0 to (n-1) >]

The selected data point number in the plot.

A data point number can be entered, or use the increment/decrement controls to increase/decrease the selected data point by one point.

X [#]

The X-axis value of the selected data point.

Y [#]

The Y-axis value of the selected data point.

Write to Notebook

Click to write to the Notebook:

Scan: analysis #	Label.
index=#	Point.
x=#	X data value.
y=#	Y data value.

Done Close the “Scanner” floating window.

This window also automatically closes when you click outside of it.

X-slider bar

Click and drag the slider for the data-point cursor.

The data cursor display mode is set in 'Set Preferences / Graphs and Layouts'.

Click to decrement/increment the data cursor by one point at a time to update the Index number

Or, the keyboard left/right-arrow keys decrease/increase the selection by one data point, with the Shift key, they decrease/increase by 10 data points.

Or, the keyboard Down/Up-arrow keys decreases/increases the selection by 10 data points.

- Fit analysis data

  Open a floating window to fit the analysis data.

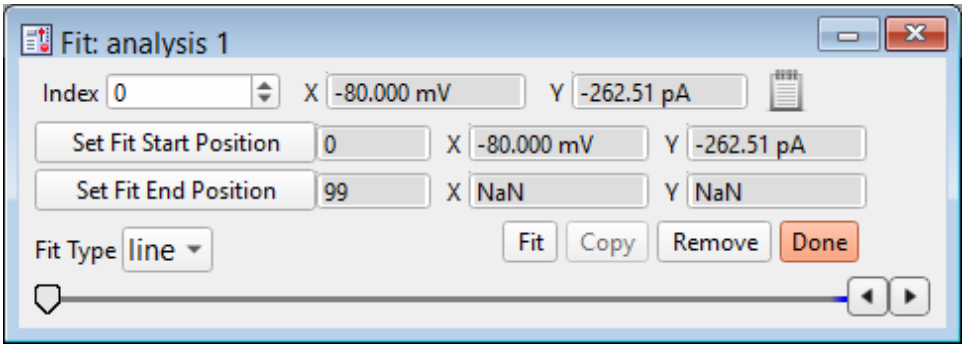


Figure 4-86. Fit Analysis Data

Fit: analysis #

Index [< 0 to (n-1) >]

The selected data point number in the plot.

A data point number can be entered, or use the increment/decrement controls to increase/decrease the selected data point by one point.

X The X-axis value of the selected data point.

Y The Y-axis value of the selected data point.

Write to Notebook

Write the last fit results to the Notebook.

[Set Fit Start Position]

Click to set the starting point of the fit.

Shift-click to set it to the array minimum.

[< 0 to (n-1) >]

Index number of the fit start.

X [#]

The X-axis value of the fit start.

Y [#]

The Y-axis value of the fit start.

[Set Fit End Position]

Click to set the ending point of the fit.

Shift-click to set it to the array maximum.

[< 0 to (n-1) >]

Index number of the fit end.

X [#]

The X-axis value of the fit end.

Y [#]

The Y-axis value of the fit end.

Fit Type [< target >] [↓]

Select from a drop-down list:

line

poly

poly_XOffset

gauss

Ior

Voigt

exp_XOffset

dbexp_XOffset

exp

dblexp

dblexp_peak

sin

HillEquation

Sigmoid

Power

LogNormal

Log

[Fit] Click to perform the fit, and replace any previous fit.

[Copy] Copy the fit trace to the Analysis Editor pool.

[Remove] Remove the fit line from the graph.

Done Close the “Fitter” floating window.

This window also automatically closes when you click outside of it.

X-slider bar

Click and drag the slider for the data-point cursor.

The data cursor display mode is set in ‘Set Preferences / Graphs and Layouts’.

Click to decrement/increment the data cursor by one point at a time, or with the Shift-key, by 10 data points.

Or, the keyboard left/right-arrow keys decrease/increase the selection by one data point, with the Shift key, they decrease/increase by 10 data points.

Or, the keyboard Down/Up-arrow keys decrease/increase the selection by 10 data points.

- Extract analysis data

Open a floating window with data extraction controls.

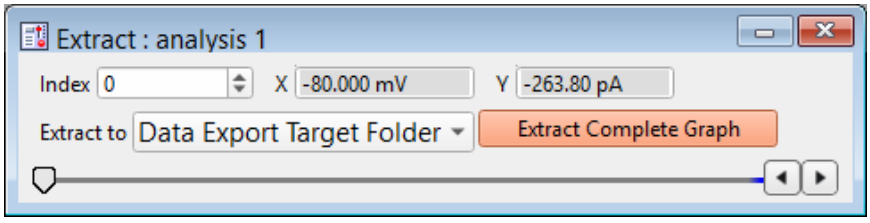


Figure 4-87. Extract Analysis Data

Extract: analysis #

Index [< 0 to (n-1) >]

The selected data-point number in the plot.

A data-point number can be entered, or use the increment/decrement controls to increase/decrease the selected data-point by one point.

X [#]

The X-axis value of the selected data point.

Y [#]

The Y-axis value of the selected data point.

Extract to [< target >] [↓]

Select the data extraction target:

Analysis Pool < unavailable >

Template Pool < unavailable >

Data Export Target Folder

< unavailable >

To Standalone Graph

Extract the plot to a separate graph window; if a fit has been performed, only the fitted line is extracted.

To Notebook Extract the graph as a graphic to the Notebook.

To Clipboard Extract the graph as a graphic to the system clipboard.

To Printer Print the graph as a graphic directly to the default printer as raw output.

[Extract complete graph]

Click to extract the entire graph.

X-slider bar

Click and drag the slider for the data-point cursor.

The data cursor display mode is set in 'Set Preferences / Graphs and Layouts'.

Click to decrement/increment the data cursor by one point at a time, or with the Shift-key, by 10 data points.

Or, the keyboard left/right-arrow keys decrease/increase the data selection by one point; with the Shift key, they decrease/increase the selection by 10 points.

Or, the keyboard Up/Down arrow keys increase/decrease the data selection by 10 points.

This floating window automatically closes when you click outside of it.

 Copy Graphs Copy the Analysis graphs:

To Notebook (as text)	Copy the Analysis graphs as text to the Notebook.
To Notebook (as graph)	Copy the Analysis graphs as a graphic to the Notebook.
To Clipboard (as text)	Copy the Analysis graphs as text to the system clipboard.
To Clipboard (as graph)	Copy the Analysis graphs as a graphic to the system clipboard.
To Printer (as text)	< unavailable >
To Printer (as graph)	Print the Analysis graphs directly to the default printer as raw output.
To Layout (as graph)	Copy the Analysis graphs as a graphic into a new Layout window or append to an existing Layout page.

 Settings

Marker Size	Select the marker symbol size.
[Auto, 1, 2, 3, 5, 7, 9]	
Marker Type	Select a marker symbol from a palette of symbols.
[63 symbols]	
Standalone Window	Undock the Analysis window from the Scope window, so that it is a free-floating window. Closing the Scope window will still close the Analysis window.

[Graph panes] The Graph pane X and Y-axes can be magnified to be larger or smaller. Place the mouse cursor in the axis ticks region (do not include the tick labels or numbers), then scroll the mouse wheel up or down.

The marquee tool is also supported in the Graph pane. Click and drag a bounding box around the region of interest, then right-click in it for magnification options.

And, selecting an Analysis marker during reanalysis will also make its corresponding data sweep active in the Reanalysis Scope window.

4.2.4 Data Browser

Data: Data Browser

The Data Browser can be used to access and display all of the Experiment's data objects, such as data waves, analysis graphs, layouts, images, metadata, Paradigms and Routines. Access it from the Data menu.

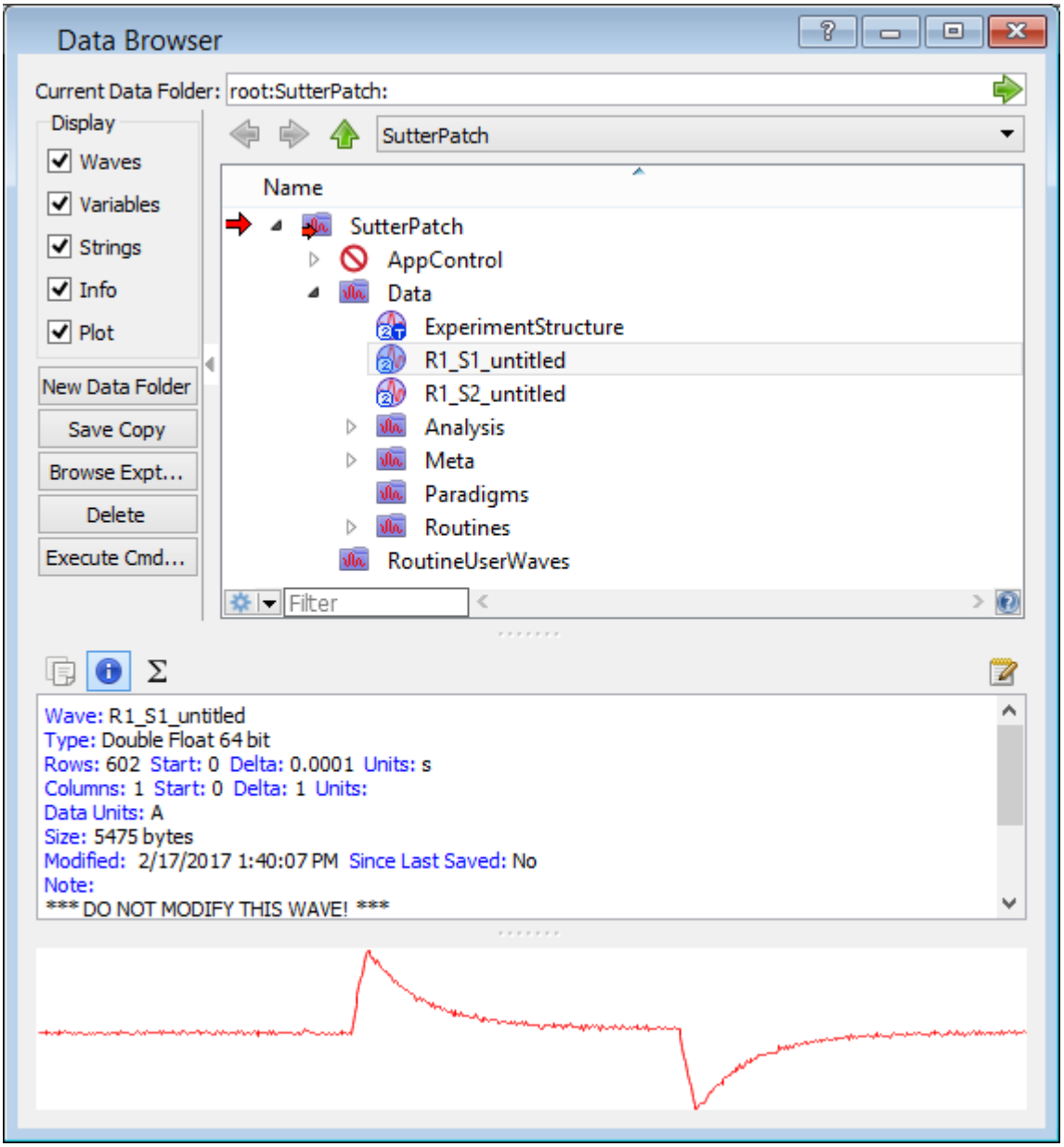


Figure 4-88. Data Browser

Warning! If this window is kept open during data acquisition, the Experiment can

unexpectedly terminate!

Alert! On the macOS, opening and closing windows can take a long time.

The 'Data' subfolder contains additional subfolders, followed by recorded data waves, arranged per Signal. Objects are displayed in a tree structure, using a path "root" of 'SutterPatch'.

ExperimentStructure — The sequence of Paradigms and Routines.

< names of data Series…>

Analysis — This folder contains data measurements, including results from fits, and Event tables.

Wave names that include "_M_" contain the status of sweep marks. A marked sweep has a value of '1', while an unmarked sweep has a value of '0'.

Wave names that include "_A_" contain analysis measurements.

Wave names that include "_df_" contain the differentiated average action potential (phase plot) waveform.

Images — This folder contains stored images that display in the preview pane.

Meta — This folder contains a table of general system metadata parameters (unformatted).

Routines — This folder contains limited information on the used Routines.

Right-click Menu

< right-click on a data wave >

Display — Display the first sweep of the data in a visual graph.

Edit — Display the Analysis data in a numerical table.

SutterPatch signal data are stored in two-dimensional data waves, with one column per trace, and one row per sample point.

Warning! Editing data here permanently alters the raw data. Modify at your own risk!

Copy Full Path — Copy the object's path name to the clipboard. This is in relation to an internal (hidden) Igor Pro data folder, not the computer's file system. This path name can be used by advanced Igor Pro users in user functions and executable commands.

4.2.5 Data Navigator

SutterPatch: Data Navigator

The Data Navigator window organizes and displays all levels of data for the active Experiment.

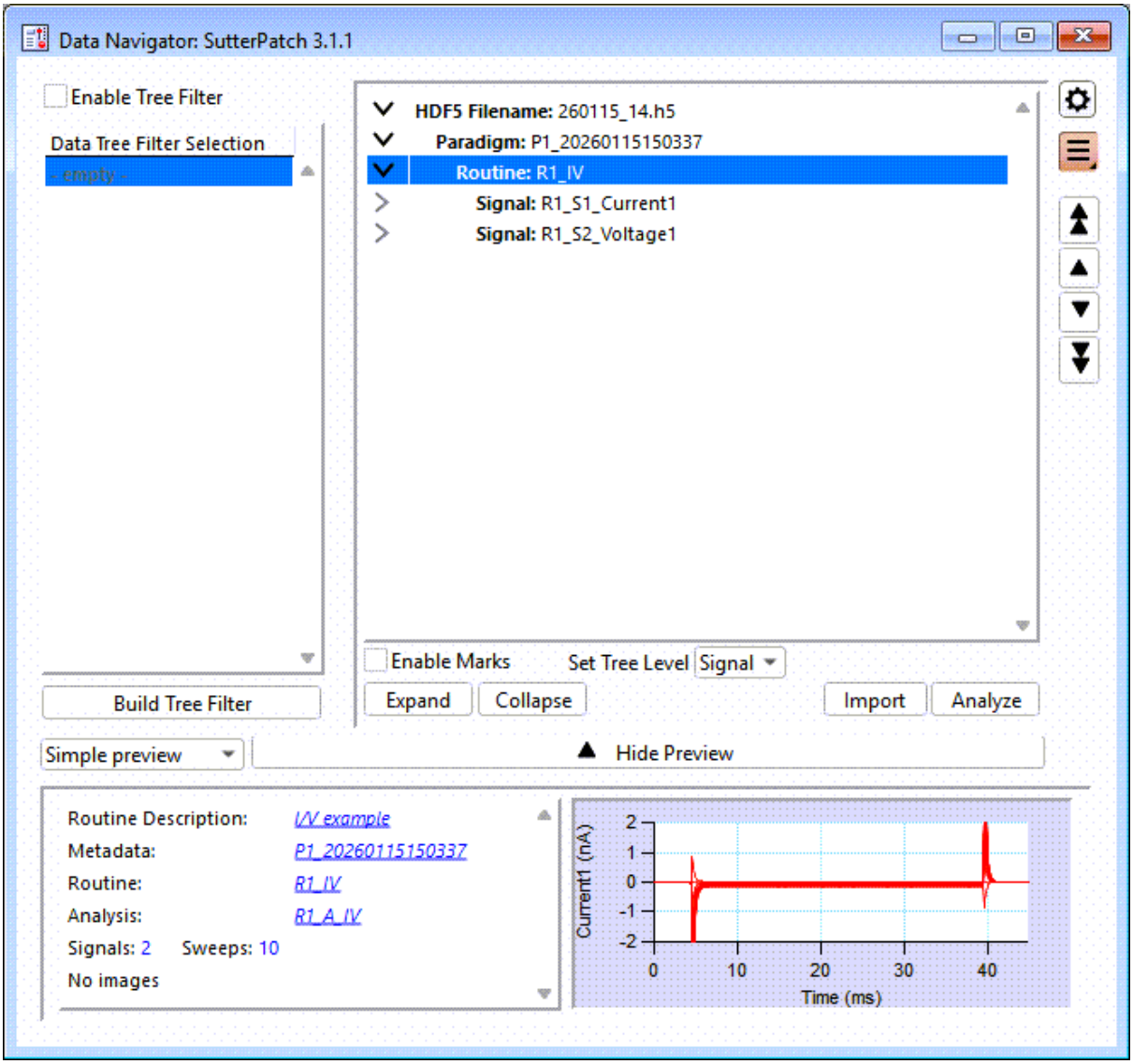


Figure 4-89. Data Navigator

[ ] Enable Tree Filter — Filter and sort data according to the Data Tree Filter.

Data Tree Filter Selection — The hierarchy of filter levels and their settings are displayed in this pane.

[Build Tree Filter] — Click this button to create or organize the data tree filter.

Define Data Tree Filtering window

Data Filter Pool Files [< action >] [↓]

New Data Tree Filter Pool	Create a blank Data Tree Filter Pool.
Load Data Tree Filter Pool	Load a previously saved Data Tree Filter Pool.
Revert to Last Saved	Undo any unsaved changes to the Data Tree Filter Pool.
Save Data Tree Filter Pool	Save the Data Tree Filter Pool using its existing file name and path.
Save Data Tree Filter Pool As	Save the Data Tree Filter Pool to a new file, and switch to the new file. The default file name is the same as the original file name.
Save Data Tree Filter Pool Copy	Save the Data Tree Filter Pool to a new file, but do not switch to the new file. The default file name increments to the first available number.
Merge Template Pools	Insert the filters from a previously saved Data Tree Filter Pool file into the loaded Data Tree Filter Pool.

[< file path >]	The file path and file name of the loaded Data Tree Filter Pool file is displayed.
[New Entry]	Append a blank entry to the filter list.
[Duplicate Entry]	Add a duplicate of the selected filter to the list.
[Delete Entry]	Remove the selected filter from the list.

Select and order parameters for data tree filtering

Select parameter group	Select a Group of metadata parameters to select a filter from. Group availability depends on the selected 'Set Preferences / Metadata' detail level.
[< groups >] [↓]	< this Group list is for the 'Full' level >
All Categories	< includes **bolded** Categories not found in a

defined ‘Set Metadata’ Group >

Frequently Used

Tag

Operator

Preparation - Animal

Preparation - Tissue

Preparation - Cell

Experiment

Amplifier

Instrumentation and Software

Electrode

Recording Solutions

Paradigm

Cell Health / Quality Control

Series (= Routine Data)

Data Acquisition Settings

Imaging

Stimulus

Available parameter — Select from a list of parameters in the selected Group.

< parameter 1 >

< parameter 2 >

< parameter … >

 — Click on the “copy” button to insert the selected parameter below the highlighted level in the Data Filter pane.

Tree filtering parameters window

Maintain a list of filtering parameters for inclusion in a Data Filter.

Selection is numeric / text.

Parameters have metadata tags which are either numeric or text based.

Table columns

Selected Parameter	A hierarchical list of selected filter parameters .
Operation	Click in this field to select a comparison operation to use when filtering with the selected parameter. The “Operation” uses standard math when both the “Value” and the metadata tag are numeric, otherwise “cmpstr” is used for the operators “<” and “>”, and “StringMatch” for “=” and “!=”.

Select the Operation window

[< operation >] [↓]

< see the Igor Pro manual for a comprehensive description of these operators >

<	Less than
=	Equal
>	Greater than
!=	Not equal

Value	This is the value that is compared against when performing Data Tree filtering. Both numeric and text values can be directly edited by clicking on them.
Signal	While most of the metadata parameters apply to all signals in a Routine, certain parameters (such as Cell Health / Quality Control) can be tailored to a specific signal.

Select the signal window

Select Signal

[all, 1 – 16]

Remove the selected filter from the list.

The sorting levels operate from top down. They can be re-organized by selecting a parameter and clicking on the Up/Down keys to reposition it.

[Do It] Click to copy changes to the selected entry in the Data Filter Pool and close the filtering dialog.

[Remove All] Remove all parameters from the Tree filtering table.

[Copy to Pool] Update the selected entry in the Data Filter Pool with the new filtering parameters.

Data Tree Pane

The Experiment's filtered data are arranged in the data tree in five default levels:

Experiment: < name >

Paradigm: < name >

Routine: < name >

Signal: < name >

Sweep_< n >

Selecting a level or node in the Data Tree highlights it in blue.

[ ] Enable Marks Select the checkbox to display nodes that allow levels to be manually "marked" in the Data Tree for Action processing. Marks are stored with the data, if changes are saved to the Experiment.

Marks enabled:

- Node highlighted and marked:

  All levels and nodes below it are included for Action processing.

- Node highlighted and unmarked:

  Only marked levels and nodes below it are included for Action processing.

Marks disabled:

- Level is highlighted:

  All levels below it are included for Action processing.

  Note: Even when the 'Enable Marks' checkbox is disabled, the levels still retain their underlying "mark" state; they just aren't visible in the Data Navigator data tree.

  Non-visible "marks" can be used by the Paradigm "If" step "String Match" option.

Sweeps "marked" during acquisition are loaded into the Data Navigator as "marked".

"Marking/unmarking" sweeps in a signal "marks/unmarks" those sweeps in all signals in the same Series.

Mark a range: Highlight a marked starting sweep, and shift-click on the ending sweep.

Clear a range: Highlight an unmarked starting sweep, and shift-click on the ending sweep.

Set Tree Level [< level >] [↓]

Expand or collapse all levels of the Data Tree to the desired level:

- Experiment
- Paradigm
- Routine
- Signal
- Sweep

[Expand] Expand all levels of the Data Tree down to the Signal level.

Or, to expand a level to the next lower level with a mouse, double-click the level name. With a keyboard, use the up/down arrow keys to select a level and press the space key.

[Collapse] Collapse all levels of the data tree up to the Paradigm level.

Or, to collapse the lower levels of a level with a mouse, double-click the level name; or with a keyboard, use the up/down arrow keys to select a level and press the space key.

[Import] Select a previously saved Experiment, data or image file to add into the current SutterPatch Experiment.

Importing is not allowed during acquisition. The same data set cannot be re-imported into the same Experiment session. Import information is written to the Log window.

- Import SutterPatch Example File(s)

  ActionPotentials.pxp

  LargeAPs.pxp

  MiniExample.pxp

- Import SutterPatch Experiment File

  Only data are imported, i.e., no graphs or layouts.

  Supported file types:

  *.pxp
  *.uxp
  *.h5xp

- Import SutterPatch HDF5 Data File

  This is the data portion of a SutterPatch Experiment when HDF5 file saving is enabled.

  Supported file type:

  *.h5

- Import PatchMaster Data File

  < only available if Sutter Amplifier Systems hardware has been attached and detected by the SutterPatch software at any previous point in time for the current OS user >

  Also supports PATCHMASTER NEXT data files.

  Mappings

Select the leak-subtraction mode when importing PatchMaster traces in SutterPatch.

Main Pulse Traces:

- Keep traces P/N-leak subtracted
- Make P/N-leak unsubtracted traces

- Don’t subtract zero-current from traces
- Subtract zero-current from traces

Set Defaults

- Import ABF Data File

< only available if Sutter Amplifier Systems hardware has been attached and detected by the SutterPatch software at any previous point in time for the current OS user >

Supported file type:

*.abf

for pCLAMP ABF versions 1.6+ and 2.0 – 2.07 data files.

Supported pCLAMP acquisition modes:

Episodic Stimulation

Equivalent to SutterPatch Clock Triggered mode ‘Triggered Sweeps’.

Gap-free

Equivalent to SutterPatch Clock Triggered mode ‘Continuous Sweeps’.

ABF: Map Channel Connections

This panel provides SutterPatch with channel and headstage mappings from the ABF file header, plus pre-determined initial settings for non-ABF fields, which should be verified or updated.

Number of Waveform Output Channels [#]

DA Channel [#: ( )]

Analog Output Channel number and name.

Channel Type
- CMD Voltage
- CMD Current
- Auxiliary

Headstage [_none_, 1, 2, 3, 4]

Recording Mode
- VC_Mode
- CC_Mode

YUnit
- V
- A

[ABF: aB] The native unit (mV, pA, etc.)

Number of Signal Input Channels [#]

AD Channel [#: ( )]

Analog Input Channel number and name.

Channel Type
- Voltage IN
- Current IN
- Auxiliary IN
- Virtual IN

Headstage [_none_, 1, 2, 3, 4]

Parent Out Chan [# ( )]

Parent Output Channel number and name. This associates the input channel to an output “source” channel for various parameters, such

as measurements and timing.

Recording Mode
- VC_Mode
- CC_Mode

YUnit
- V
- A

[ABF: aB] The native unit (mV, pA, etc.)

- Import Image File
- Import Multiple Files

Use the Shift-click to select a range of files with the mouse, or the Ctrl-click to select individual files.

Note: Imported Routine names are truncated to a maximum length of 28 characters, and special characters are replaced by an underscore.

When a Series name already exists in the Data Navigator, imported Series are renamed to avoid conflicts.

[Review] < only displays for Paradigms >

Signals are displayed in a Scope window as continuous data.

< this button changes to the Analyze button when a Routine, signal or sweep is selected >

[Analyze] < only displays for Routines, Signals, Sweeps >

The Routine's signals are displayed in the Reanalysis Scope window and Measurements analysis is run. If a marked sweep is highlighted, that sweep is also selected in the Scope window.

< this button changes to the Review button when a Paradigm is selected or marked >

[Simple preview / Full preview]

Summary information and limited or full graphed data are displayed in a sub-pane and/or docked window, depending upon the data tree level.

Experiment

Experiment Name:	The experiment file name.
HDF5 File Name:	For optional HDF5 files.
Paradigms:	Total number of Paradigms in the Experiment.
Routines:	Total number of Routines in the Experiment.
Total bytes in data waves:	Combined size of all data waves in the Experiment.

Paradigm

Paradigm Description:	Displays the Paradigm description text.
	Click to edit.
Metadata:	Click to display the Paradigm's metadata in a docked sub-window.
Paradigm:	"AutoTriggered", or name link to the "planned" Paradigm.
Routines:	Number of Routines in the Paradigm.
Images:	Open the saved image in a docked window.
Note	An editable text field for notes.
Invert Vertically	Reverse the image vertical orientation.
Invert Horizontally	Reverse the image horizontal orientation
Export Image	Export the image:
To Notebook (as text)	< unavailable >
To Clipboard (as text)	< unavailable >
To Clipboard (as graph)	

		Copy the image to the system clipboard.
	To Layout (as graph)	Copy the image into a new Layout window, or append to an existing Layout page.
	<u>Simple preview</u>	
	Paradigm Preview window	Displays a thumbnail image of the first signal of the first Routine.
	<u>Full preview</u>	
	Paradigm Preview window	Displays all signals and all Routines in continuous mode in a docked Paradigm Preview window.
<u>Routine</u>		
	Routine Description:	Displays the Routine description text.
		Click to edit.
	Metadata:	Click to display the Routine's metadata in a docked sub-window.
	Images:	Open any saved images.
	Metadata:	Click to display the Routine metadata.
	Routine:	Click to display the named Routine parameters.
	Analysis:	Click an analysis name to open it into the Analysis Editor.
	Signals:	Number of signals in the Routine.
	Sweeps:	Number of sweeps in the Routine.
	Images:	Open the saved image in a

docked window.

Note — An editable text field for notes.

Invert Vertically — Reverse the image vertical orientation.

Invert Horizontally — Reverse the image horizontal orientation

Export Image — Export the image:

To Notebook (as text) < unavailable >

To Clipboard (as text) < unavailable >

To Clipboard (as graph) — Copy the image to the system clipboard.

To Layout (as graph) — Copy the image into a new Layout window, or append to an existing Layout page.

Simple preview

Preview sub-pane — Displays a thumbnail image of the first signal of the selected Routine.

Full preview

Routine Preview window — Displays all signals in the Routine in continuous mode in a docked window.

Signal

Preview pane — Displays a thumbnail image of the selected Signal.

Sweep

Preview pane — Displays a thumbnail image of the selected Sweep.

[Show Preview / Hide Preview]

The Preview information is displayed in a subpane at the bottom of the Data Navigator window and/or a docked window on its right side. The

items displayed depend upon the selected data tree level and the “full vs. simple” preview setting.

 Settings menu

Single Review Window Re-use the same window for all Reviews.

Multiple Review Windows Create a new window for each Review.

Review is Sweeps Display Mode

Sweeps are displayed overlaid on each other.

Review in Concatenated Display Mode

Sweeps are displayed in a timeline contiguous to each other, i.e., inter-sweep spacing is removed.

Review in Time Course Display Mode

Sweeps are displayed in a full and complete timeline.

Create New Nodes with All Nodes Set

Create New Nodes with All Nodes Cleared

Bring All Review Windows to Front

Close All Review Windows

 Available Actions button

Access various actions for the marked and/or highlighted data levels.

These actions are also available via a right-click on the selected data level.

When Marks are enabled, the items in < brackets] display in the menus.

Experiment Level

Abort selection

< Apply to Selection >

Copy Experiment to external HDF5 file

Copy data from the entire Experiment to an HDF5 file, whether data is marked or unmarked.

SutterPatch HDF5 data files can be imported into an Experiment's existing data, or be reopened via the File menu to replace an Experiment's data.

Copy Experiment Name to Clipboard

Copy the name of the Experiment to the system clipboard.

Copy HDF5 Filename to Clipboard

Copy the name of the HDF5 file to the system clipboard.

< Apply to Marked Children of Marked Parents >

Copy < Marked > Signal Data Paths

Copy the internal Igor Pro data paths for all Signals to the system folder.

Export < Marked > Data (See Preferences)

Export the < marked > data in the highlighted < or marked > Paradigms to files.

Uses the 'Set Preferences / Data Export' options.

When saving an export file, and the new filename is the same as an existing filename in the target folder:

- Choose a different folder, or
- First delete the pre-existing file via the OS file browser.

Modify < Marked > Signals

Modifying hardware input signals or digitally filtered (Bessel or Gaussian) virtual input signals creates (or updates) the associated virtual signals of type "Filter" or "Modified" with the selected properties.

Modify Signals window

Select the signals to modify:

[ ] Modify Current Signals

[ ] Modify Voltage Signals

[ ] Modify AuxIN Signals

[ ] Modify Bessel and Gaussian Virtual Signals

[< modify >] [↓]

- Don’t modify ‘Filter’ Signals
- Re-use ‘Filter’ Signals

Select a bandwidth and modify it:

[ ] Low-Pass Bandwidth

[# kHz]

[ ] High-Pass Bandwidth

[# kHz]

Subtraction Mode [< mode >] [↓]

- None
- Fixed value
- Measured value

  Time Range [< time >] [↓]

  - Sweep Time

    Start Time

    [#]

    End Time

    [#]

    Units automatically convert to engineering units.

  - Segment Time

Segment [#]

Start Ratio

[#]

End Ratio

[#]

- Ohmic leak value

  Measure the currents of 2 segments with different voltages.

  Using these values, we compute R and the ohmic current for each segment, and subtract the respective zero current from each individual segment.

  Segment 1 [#]

  Segment 2 [#]

  Start Ratio [#]

  End Ratio [#]

- Reference Signal

  Subtract the reference signal sweeps from the selected signals.

  Reference Series [ ]

  < read only field >

- Reference Sweep

  Subtract the reference sweep from the selected sweeps.

  Reference Sweep [ ]

  < read only field >

- Analysis Wave

Subtract the analysis wave from the selected waves.

Analysis Name [↓]

[ ] Messages to Notebook

Write signal modify information to the Notebook.

[ ] Enable 'User Modify Signal'

Run a custom function to automatically modify the signal.

< see the Programming chapter SutterPatch Hooks section >

[Modify]

Apply the changes.

Discard < Marked > Deletable Signals

Deletable signals are virtual signals not followed by non-virtual signals in their Scope positions.

Discard Deletable Signals window

- Discard all virtual signals

  < in the Experiment >

- Discard only <virtual Signal_Name> signals.

  < of the first valid virtual signal type >

< Discard Marked Paradigms >

Remove the marked Paradigms and their data from the Experiment.

Terminate Current Paradigm Group

For an auto-triggered Paradigm created by starting a recording, this closes the Paradigm so the next recording initiates a new Paradigm.

Analyze All < Marked > Routines

Run the reanalysis on all < marked > Routines in the

Experiment.

Store Analysis Waves

Append results to the Analysis Editor pool.

Copy Analysis Results to Clipboard

Copy analysis results to the system clipboard.

Copy Analysis Graphs to Layout Page

< these only display if Marks are enabled >

< Apply to Marked Children of Marked Parents >

< Mark Paradigms >

All Paradigms in the Experiment are marked.

< Unmark Paradigms >

All Paradigms in the Experiment are unmarked.

< Mark Routines >

All Routines in the Experiment are marked.

< Unmark Routines >

All Routines in the Experiment are unmarked.

< Mark Signals >

All signals in the Experiment are marked.

< Unmark Signals >

All signals in the Experiment are unmarked.

< Mark Sweeps >

All sweeps in the Experiment are marked.

< Unmark Sweeps >

All sweeps in the Experiment are unmarked.

< these only display if Marks are enabled >

< Apply to All Nodes >

< Mark All Paradigms, Routines and Signals >

All Paradigms, Routines and Signals in the Experiment are marked.

< Unmark All Paradigms, Routines and Signals >

All Paradigms, Routines and Signals in the Experiment are unmarked.

< Mark All Routines and Signals >

All Routines and Signals in the Experiment are marked.

< Unmark All Routines and Signals >

All Routines and Signals in the Experiment are unmarked.

< Set Paradigm Marks by Name Match >

Enter the Paradigm name to mark.

Paradigm Mark: Name Match Editor

Match Name [ ]

< Set Routine Marks by Name Match >

Enter the Routine name to mark.

Routine Mark: Name Match Editor

Match Name [ ]

< Set Signal Marks by Name Match >

Opens the ‘’ to enter the Signal names to mark.

Signal Mark: Name Match Editor

Match Name [ ]

< Set Sweep Marks by Equation >

Enter an equation to mark/unmark all sweeps in the

Experiment.

Sweep Mark: Equation Editor

Equation

[ ]

[Undo]

Remove all edits to the equation.

[Check Equation]

Check the equation syntax. The equation is evaluated, and if valid, it reports "Syntax is ok."

[Insert special identifier]

sweep

Enumerate the sweeps in the equation when applying marks.

Odd(sweep)

Set all odd sweeps to “1”, and all even sweeps to “0”.

Even(sweep)

Set all even sweeps to “1”, and all odd sweeps to “0”.

[Do Mark]

Evaluate the equation and update the sweep marking.

[Status message]

Value ≥ 0.1 = 1 (marked)

Value < 0.1 = 0 (unmarked)

< Set Sweep Marks by Value List >

Enter a list of sweeps to mark.

Sweep Mark: Value List Editor

Value List

[ ]

[Undo]

Remove all edits to the list.

[Check Value List]

Check the list syntax. The list is evaluated, and if valid, it reports "Syntax is ok."

[Do Mark]

Apply changes.

Paradigm Level

Abort selection

< Apply to Selection >

Review < Marked Signals of > Paradigm

Display the < marked > signals with their < marked > sweeps of the < marked > Series (with all signals and sweeps) from the highlighted Paradigm.

If a signal is marked in any of the marked Series, it will display for all marked Series.

Note: This action is not supported with the HDF5 file preference “Keep only one Sweep in Memory”.

View Metadata

Display the Paradigm metadata in the Metadata Review sub-window, docked to the right of the Data Navigator window.

View Paradigm Steps

< only available for “planned” Paradigms >

Paradigm Steps Review

Paradigm description

< read only field >

Copy selected Paradigm to clipboard. Hold the Shift key to remove line counts and step formatting.

Paradigm to Review

Display the steps from the selected Paradigm in a 'Paradigm Steps Review' window.

Paradigm Steps

The Paradigm steps can be copied to the system clipboard. Hold the Shift key when clicking, to remove the line counts and step formatting.

Copy to Pool

The Paradigm can also be copied to the Paradigm Pool,

Edit Paradigm Description

Add or alter Paradigm Description text in the Preview window. Changes are appended to the metadata as tags.

Copy Paradigm Name to Clipboard

Copy the Paradigm name to the system clipboard.

< Apply to Marked Children of Marked Parents >

Copy< Marked > Signal Data Paths

Copy the Signals internal Igor Pro data paths to the system clipboard.

Export < Marked > Data (See Preferences)

Export the < marked > data in its highlighted < or marked > Routines to files.

Uses the 'Set Preferences / Data Export' options.

When saving files, and the new filename is the same as an existing filename in the target folder:

- Choose a different folder, or
- First delete the pre-existing file via the OS file browser.

< Average Marked Sweeps >

The average sweep of all marked sweeps is copied to the Analysis Editor.

Modify < Marked > Signals

Modifying hardware input signals or digitally filtered (Bessel or Gaussian) virtual input signals creates (or updates) the associated virtual signals of type “Filter” or “Modified” with the selected properties.

Modify Signals window

Select the signals to modify:

[ ] Modify Current Signals

[ ] Modify Voltage Signals

[ ] Modify AuxIN Signals

[ ] Modify Bessel and Gaussian Virtual Signals

Select a bandwidth and modify it:

[ ] Low-Pass Bandwidth

[# kHz]

When not defined, use:

Low-pass Filter [< filter >] [↓]

- Bessel

  Order [< 2, 4, 8 >] [↓]

  Phase Delay Adjust [< Off, On >] [↓]

- Gaussian

  Phase Delay Adjust [< Off, On >] [↓]

- DownSample

[ ] High-Pass Bandwidth

[# kHz]

Subtraction Mode [< mode >] [↓]

- None
- Fixed value
- Measured value

  Time Range [< time >] [↓]

  - Sweep Time

    Start Time

    [#]

    End Time

    [#]

    Units automatically convert to engineering units.

  - Segment Time

    Segment [#]

    Start Ratio

    [#]

    End Ratio

    [#]

- Ohmic leak value

  Measure the currents of 2 segments with different voltages.

  Using these values, we compute R and the ohmic current for each segment, and subtract the respective zero current from each individual segment.

  Segment 1 [#]

  Segment 2 [#]

  Start Ratio [#]

End Ratio [#]

- Reference Signal

  Subtract the reference signal sweeps from the selected signals.

  Reference Series [series]

  < read only field >

- Reference Sweep

  Subtract the reference sweep from the selected sweeps.

  Reference Sweep [sweep]

  < read only field >

- Analysis Wave

  Subtract the analysis wave from the selected waves.

  Analysis Name [↓]

[ ] Messages to Notebook

Write signal modify information to the Notebook.

[ ] Enable 'User Modify Signal'

Run a custom function to automatically modify the signal.

< see the Programming chapter SutterPatch Hooks section >

[Modify]

Apply the changes.

Discard < Marked > Deletable Signals

Deletable signals are virtual signals not followed by non-virtual signals in their Scope positions.

Discard Deletable Signals window

- Discard all virtual signals

  < in the Paradigm >

- Discard only <virtual Signal_Name> signals

  < of the first valid virtual signal type >

Baseline Subtraction < of Marked Signals >

- Revert baseline subtraction

  Restore the data to their original values.

- Apply baseline subtraction

  Automatically subtract the mean amplitude of the starting region duration from the acquired data.

  Baseline duration [1 - 999 ms]

  Set the duration of the subtraction region (from sweep time '0').

Discard < Marked Routines of > Paradigm

Remove the highlighted Paradigm and its data from the Experiment.

For "Marks Enabled":

- All Routines marked:

  The Paradigm is removed.

- Selected Routines marked:

  Selected Routines removed.

- No Routines marked:

  No action.

If the last Paradigm is discarded, then when acquiring another Paradigm in the same Experiment, the new Paradigm name will be incremented past the discarded Paradigm name.

Note: If any associated graphs are still open when trying

to discard the Paradigm, an error message will display. To fix, close any associated Graph windows found in the main menu Windows / Graphs.

Analyze All < Marked > Routines

Run Reanalysis on all < marked > Routines in the Paradigm.

.

Store Analysis Waves

Append results to the Analysis Editor pool.

Copy Analysis Results to Clipboard

Copy analysis results to the system clipboard.

Copy Analysis Graphs to Layout Page

< these only display if Marks are enabled >

< Apply to Marked Children of Marked Parents >

< Mark Routines >

All Routines in the Paradigm are marked.

< [Unmark Routines >

All Routines in the Paradigm are unmarked.

< Mark Signals >

All signals in the Paradigm are marked.

< Unmark Signals >

All signals in the Paradigm are unmarked.

< Mark Sweeps >

All sweeps in the Paradigm are marked.

< Unmark Sweeps >

All sweeps in the Paradigm are unmarked.

< these only display if Marks are enabled >

< Apply to All Nodes >

< Mark All Routines and Signals >

All Routines and Signals in the Paradigm are marked.

< Unmark All Routines and Signals >

All Routines and Signals in the Paradigm are unmarked.

< Set Routine Marks by Name Match >

Enter the Routine name to mark.

Routine Mark: Name Match Editor

Match Name [ ]

< Set Signal Marks by Name Match >

Enter the Signal names to mark.

Signal Mark: Name Match Editor

Match Name [ ]

< Set Sweep Marks by Equation >

Enter an equation to mark/unmark all sweeps in the Paradigm.

Sweep Mark: Equation Editor

Equation

[ ]

[Undo]

Remove all edits to the equation.

[Check Equation]

Check the equation syntax. The equation is evaluated, and if valid, it reports "Syntax is ok."

[Insert special identifier]

sweep

Enumerate the sweeps in the equation when applying marks.

Odd(sweep)

Set all odd sweeps to “1”, and all even sweeps to “0”.

Even(sweep)

Set all even sweeps to “1”, and all odd sweeps to “0”.

[Do Mark]

Evaluate the equation and update the sweep marking.

[Status message]

Value ≥ 0.1 = 1 (marked)

Value < 0.1 = 0 (unmarked)

< Set Sweep Marks by Value List >

Enter a list of sweeps to mark.

Sweep Mark: Value List Editor

Value List [ ]

Routine Level

Abort selection

< Apply to Selection >

Analyze < Marked Signals of > Routine

Display the < marked > signals with their < marked > sweeps from the highlighted Series in a Reanalysis Scope window.

Review < Marked Signals of > Routine

Display the < marked > signals with their < marked > sweeps from the highlighted Series in a Routine Review

Scope window.

All Routines in the Experiment can be cycled through here.

Note: This Action is not supported with the HDF5 file preference “Keep only one Sweep in Memory”.

View Metadata

Display the highlighted Series’ metadata in the Metadata Review sub-window docked to the right of the Data Navigator window.

View Routine Settings

Display the highlighted Series’ settings and preview in the Routine Settings window.

Edit Routine Description

Add or alter Routine Description text in the Preview window. Changes are appended to the metadata as tags.

Copy Routine Name to Clipboard

Copy the Routine name to the system clipboard.

Show in Data Browser

Open Igor Pro’s Data Browser window to examine the Experiment’s data waves – the first Signal in the Series is highlighted.

Concatenate Sweeps

Combine all sweeps into one sweep.

Restore Concatenated Sweeps

Convert the concatenated sweep back to the original sweeps.

Change Sweep Duration

Modify the sweep duration of oscilloscope-style data, such as stored Free Run data.

Enter new sweep duration in seconds: [ ]

< or, only for Free Run data >

Select new sweep duration from list:

[100, 200, 500 ms; 1.00, 2.00, 5.00. 10.0, 20.0, 50.0, 100 s]

The sweep duration list dynamically updates depending upon how many Free Run sweeps were acquired, so the final list entry will be the acquired number of Free Run sweeps, even if not in the "1, 2, 5" progression.

< also modify Series data with >

Output Waveforms: disabled

Sweep Cycles: 1

< and either >

Number of Sweeps: 1

< or >

Trigger Action:

'Clock Triggered' or
'Externally Triggered Series'

Acquisition Mode:

Continuous Sweeps

Start-to-Start Time:

Sweep Duration: enabled

Note: Any open Scope window is closed by this action.

Also, the Data Navigator Simple Preview summary information is replaced by an enlarged thumbnail image.

Restore Sweep Duration

Revert the sweep length to its original duration.

Discard Routine

Remove the highlighted Series and their data from the Experiment.

If the last Series is discarded, when acquiring another Series in the same Experiment, the new Series name will be incremented past the discarded Series name.

Note: If any associated graphs are still open when trying to discard the Routine, an error message will display. To fix, close any associated Graph windows found in the main menu Windows / Graphs.

< Apply to Marked Children of Marked Parents >

Copy < Marked > Signal Data Paths

Copy the Signals internal Igor Pro data paths to the system clipboard.

Export < Marked > Data (See Preferences)

Export the data in the highlighted < or marked > Series to files.

Uses the 'Set Preferences / Data Export' options.

When saving files, and the new filename is the same as an existing filename in the target folder:

- Choose a different folder, or
- First delete the pre-existing file via the OS file browser.

< Average Marked Sweeps >

The average sweep of all marked sweeps is copied to the Analysis Editor.

Modify < Marked > Signals

Modifying hardware input signals or digitally filtered (Bessel or Gaussian) virtual input signals creates (or updates) the associated virtual signals of type "Filter" or "Modified" with the selected properties.

Modify Signals window

Select the signals to modify:

[ ] Modify Current Signals

[ ] Modify Voltage Signals

[ ] Modify AuxIN Signals

[ ] Modify Bessel and Gaussian Virtual Signals

Select a bandwidth and modify it:

[ ] Low-Pass Bandwidth

[# kHz]

When not defined, use:

Low-pass Filter [< filter >] [↓]

- Bessel

  Order [< 2, 4, 8 >] [↓]

  Phase Delay Adjust [< Off, On >] [↓]

- Gaussian

  Phase Delay Adjust [< Off, On >] [↓]

- DownSample

[ ] High-Pass Bandwidth

[# kHz]

Subtraction Mode [< mode >] [↓]

- None
- Fixed value
- Measured value

Time Range [< time >] [↓]

- Sweep Time

  Start Time

  [#]

End Time

[#]

Units automatically convert to engineering units.

- Segment Time

  Segment [#]

  Start Ratio

  [#]

  End Ratio

  [#]

- Ohmic leak value

  Measure the currents of 2 segments with different voltages.

  Using these values, we compute R and the ohmic current for each segment, and subtract the respective zero current from each individual segment.

  Segment 1 [#]

  Segment 2 [#]

  Start Ratio [#]

  End Ratio [#]

- Reference Signal

  Subtract the reference signal sweeps from the selected signals.

  Reference Series [series]

  < read only field >

- Reference Sweep

  Subtract the reference sweep from the selected sweeps.

Reference Sweep [sweep]

< read only field >

- Analysis Wave

  Subtract the analysis wave from the selected waves.

  Analysis Name [↓]

[ ] Messages to Notebook

Write signal modify information to the Notebook.

[ ] Enable 'User Modify Signal'

Run a custom function to automatically modify the signal.

< see the Programming chapter SutterPatch Hooks section >

[Modify]

Apply the changes.

Discard < Marked > Deletable Signals

Deletable signals are virtual signals not followed by non-virtual signals in their Scope positions.

Discard Deletable Signals window

- Discard all virtual signals

  < in the Routine >

- Discard only <virtual Signal_Name> signals.

  < of the first valid virtual signal type >

Baseline Subtraction < of Marked Signals >

- Revert baseline subtraction

  Restore the data to their original values.

- Apply baseline subtraction

Automatically subtract the mean amplitude of the starting region duration from the acquired data.

[1 – 999 ms]

Set the duration of the subtraction region (from sweep time ‘0’).

< these only display if Marks are enabled >

< Apply to Marked Children of Marked Parents >

< Mark Signals >

All signals in the Series are marked.

< Unmark Signals >

All signals in the Series are unmarked.

< Mark Sweeps >

All sweeps in the Series are marked.

< Unmark Sweeps >

All sweeps in the Series are unmarked.

< these only display if Marks are enabled >

< Apply to All Nodes >

< Set Signal Marks by Name Match >

Enter the Signal names to mark.

Signal Mark: Name Match Editor

Match Name [ ]

< Set Sweep Marks by Equation >

Enter an equation to mark/unmark all sweeps in the Routine.

Sweep Mark: Equation Editor

Equation

[ ]

[Undo]

Remove all edits to the equation.

[Check Equation]

Check the equation syntax. The equation is evaluated, and if valid, it reports "Syntax is ok."

[Insert special identifier]

sweep

Enumerate the sweeps in the equation when applying marks.

Odd(sweep)

Set all odd sweeps to “1”, and all even sweeps to “0”.

Even(sweep)

Set all even sweeps to “1”, and all odd sweeps to “0”.

[Do Mark]

Evaluate the equation and update the sweep marking.

[Status message]

Value ≥ 0.1 = 1 (marked)

Value < 0.1 = 0 (unmarked)

< Set Sweep Marks by Value List >

Opens the ‘’ to enter a list of sweeps to mark.

Sweep Mark: Value List Editor

Value List [ ]

[Check Value List]

Check the list syntax. The list is evaluated, and if

valid, it reports "Syntax is ok."

[Do Mark]

Update the sweep marking.

Signal Level

Abort selection

< Apply to Selection >

Analyze Routine

Display the < marked > sweeps of all signals in the highlighted Series in a Reanalysis Scope window.

View Metadata

Display the highlighted signal's metadata in a Metadata Review sub-window docked to the right of the Data Navigator window.

View Routine Settings

Display the Series parameters in the Routine Settings window.

Copy Signal Name to Clipboard

Copy the Signal name to the system clipboard.

Copy Signal Data Path

Copy the Signal's internal Igor Pro data path to the system clipboard.

Show in Data Browser

Open Igor Pro's Data Browser window to examine the Experiment's data waves – the first selected Signal is highlighted.

Display Signal

Highlighted signal:

Display the marked sweeps in the signal in a graph window.

Marked signal:

Display all sweeps in the signal in a graph window.

Edit Signal

Display all sweeps of the highlighted signal as numeric columns in an editable table.

Export < Marked > Data (See Preferences)

Export the data in the highlighted < or marked > Signals to files.

Uses the 'Set Preferences / Data Export' options.

When saving files, and the new filename is the same as an existing filename in the target folder:

- Choose a different folder, or
- First delete the pre-existing file via the OS file browser.

Average All / < Marked > Sweeps

Average all < or marked > sweeps in the highlighted signal and display in the Analysis Editor.

Baseline Subtraction

- Revert baseline subtraction

  Restore the signal's data to their original values.

- Apply baseline subtraction

  Automatically subtract the mean amplitude of the starting region duration from the signal's acquired data.

  [1 – 999 ms]

  Set the duration of the subtraction region (from sweep time '0').

Set Reference Signal

Select a signal to be used for equivalent sweep

subtractions in Actions 'Modify < Marked > Signal(s)'.

The selected signal is highlighted in blue.

Set Reference Sweep

Select a sweep to be used for sweep subtraction in Actions 'Modify < Marked > Signal(s)'.

The selected sweep is highlighted in blue.

Modify Signal

Modifying a hardware input signal or digitally filtered (Bessel or Gaussian) virtual input signal creates (or updates) the associated virtual signal of type "Filter" or "Modified" with the selected properties.

Modify Signal window

[< modify >] [↓]

- Don't modify 'Filter' Signals
- Re-use 'Filter' Signals

Select a bandwidth and modify it:

[ ] Low-Pass Bandwidth

[# kHz]

When not defined, use:

Low-pass Filter [< filter >] [↓]

- Bessel

  Order [< 2, 4, 8 >] [↓]

  Phase Delay Adjust [< Off, On >] [↓]

- Gaussian

  Phase Delay Adjust [< Off, On >] [↓]

- DownSample

[ ] High-Pass Bandwidth

[# kHz]

Subtraction Mode [< mode >] [↓]

- None
- Fixed value

  Fixed baseline [#]
- Measured value

  Time Range [< time >] [↓]

  - Sweep Time

    Start Time

    [#]

    End Time

    [#]

    Units automatically convert to engineering units.
  - Segment Time

    Segment [< # >]

    Start Ratio

    [< # >]

    End Ratio

    [< # >]
- Ohmic leak value

  Measure the currents of 2 segments with different voltages.

  Using these values, we compute R and the ohmic current for each segment, and subtract the respective zero current from each individual segment.

  Segment 1 [< # >]

Segment 2 [< # >]

Start Ratio [< # >]

End Ratio [< # >]

- Reference Signal

  < available after a “Set Reference Signal” action >

  < read only field >

  Reference Series [signal]

  Subtract the reference signal sweeps from the selected signal.

- Reference Sweep

  < available after a “Set Reference Sweep” action >

  < read only field >

  Reference Sweep [sweep]

- Analysis Wave

  Subtract the analysis wave from the selected waves.

  Analysis Name [< name >] [↓]

[ ] Messages to Notebook

Write signal modify information to the Notebook.

[ ] Enable ‘User Modify Signal’

Run a custom function to automatically modify the signal.

< see the Programming chapter SutterPatch Hooks section >

Discard Deletable Signal

A deletable signal is a virtual signal not followed by non-virtual signals in their Scope positions.

Action Potential Analysis

Analyze action potentials from the marked sweeps of the highlighted signal.

Single Channel Analysis

Analyze single-channel Events in the highlighted signal.

Synaptic Event Analysis

Analyze synaptic events (EPSPs, minis, etc.) from the marked sweeps of the highlighted signal

---

< these only display if Marks are enabled >

< Apply to Node >

< Mark Sweeps >

All sweeps in the Series are marked.

< Unmark Sweeps >

All sweeps in the Series are unmarked.

< these only display if Marks enabled >

< Apply to All Nodes >

< Set Sweep Marks by Equation >

Enter an equation for the sweeps to mark.

Sweep Mark: Equation Editor

Equation [ ]

[Undo]

Remove all edits to the equation.

[Check Equation]

Check the equation syntax. The equation is evaluated, and if valid, it reports "Syntax is ok."

[Insert special identifier]

sweep

Enumerate the sweeps in the equation when applying marks.

Odd(sweep)

Set all odd sweeps to “1”, and all even sweeps to “0”.

Even(sweep)

Set all even sweeps to “1”, and all odd sweeps to “0”.

[Do Mark]

Evaluate the equation and update the sweep marking.

[Status message]

Value ≥ 0.1 = 1 (marked)

Value < 0.1 = 0 (unmarked)

< Set Sweep Marks by Value List >

Enter a comma separated list of sweep numbers to mark.

Sweep Mark: Value List Editor

Value List [ ]

[Undo]

Remove all edits to the list.

[Check Value List]

Check the list syntax. The list is evaluated, and if valid, it reports "Syntax is ok.”

[Do Mark]

Update the sweep marking.

Sweep Level

Abort selection

< Apply to Selection >

Single Channel Analysis

Launch the Single Channel Analysis module for the highlighted sweep.

Extract Sweep to Analysis Pool

Create a graph of the highlighted sweep in the Analysis Editor.

Extract Sweep to Template Pool

Create a graph of the highlighted sweep in the Template Editor.

Display Sweep

Display the highlighted sweep in a graph window.

Set Reference Sweep

Select a sweep to be used for sweep subtraction in Actions 'Modify < Marked > Signal(s)'.

The selected sweep is highlighted in blue.

Export < Marked > Data (See Preferences)

Export the data in the highlighted < or marked > sweeps to a file

Uses the 'Set Preferences / Data Export' options.

To export a portion of a sweep, extract the data with the marquee tool, and then export from the Template Editor.

When saving files, and the new filename is the same as an existing filename in the target folder:

- Choose a different folder, or
- First delete the older file via the OS file browser.

< these only display if Marks are enabled >

< Apply to Node >

< Mark Sweep >

The sweep in the Series is marked.

< Unmark Sweep >

The sweep in the Series is unmarked.

Level navigation controls

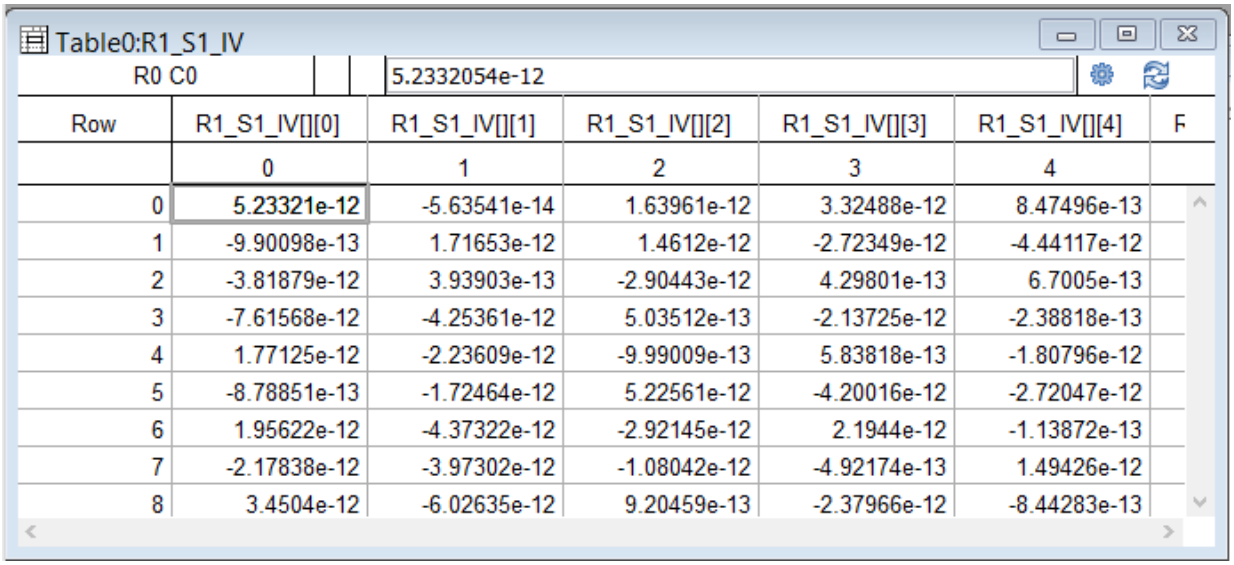
Move the selection highlight to the first visible Routine node.

Move the selection highlight to the Previous / Next Routine.

Move the selection highlight to the last visible Routine node.

4.2.6 Data Table

The Data Table provides direct access to the sample points in a data Series, using a spreadsheet-style presentation.



Row	R1_S1_IV[][0]	R1_S1_IV[][1]	R1_S1_IV[][2]	R1_S1_IV[][3]	R1_S1_IV[][4]	F
	0	1	2	3	4	
0	5.23321e-12	-5.63541e-14	1.63961e-12	3.32488e-12	8.47496e-13	
1	-9.90098e-13	1.71653e-12	1.4612e-12	-2.72349e-12	-4.44117e-12	
2	-3.81879e-12	3.93903e-13	-2.90443e-12	4.29801e-13	6.7005e-13	
3	-7.61568e-12	-4.25361e-12	5.03512e-13	-2.13725e-12	-2.38818e-13	
4	1.77125e-12	-2.23609e-12	-9.99009e-13	5.83818e-13	-1.80796e-12	
5	-8.78851e-13	-1.72464e-12	5.22561e-12	-4.20016e-12	-2.72047e-12	
6	1.95622e-12	-4.37322e-12	-2.92145e-12	2.1944e-12	-1.13872e-13	
7	-2.17838e-12	-3.97302e-12	-1.08042e-12	-4.92174e-13	1.49426e-12	
8	3.4504e-12	-6.02635e-12	9.20459e-13	-2.37966e-12	-8.44283e-13	

Figure 4-90. Data Table

Warning! Editing data permanently alters the raw data. Modify at your own risk!

Data Tables are accessed from the Data / Data Browser. Select a Series from the Data folder, then right-click the menu item ‘Display’.

To allow adding data to the table, the last row of data in the table is followed by a final row of blank (gray) cells. Manually entering data into the final blank row causes a new last row of data to be created in the table, followed by a new final blank row.

4.2.7 Edit Virtual Signals

The Reanalysis Scope window Measurements button provides access to the ‘Edit Virtual Signals’ dialog. Use it when applying different analysis scenarios to recorded data with “pseudo” input signals, in conjunction with the 'Reanalysis Measurements & Graphs' dialogs.

Virtual input channels allow you to perform a variety of mathematical transformations on input signals. To enable a virtual signal, highlight a signal name. When a virtual input channel is enabled, its configuration fields are ungrayed. Changes to the highlighted signal are saved when you click the ‘Do It’ button, and changes in unhighlighted signals are discarded.

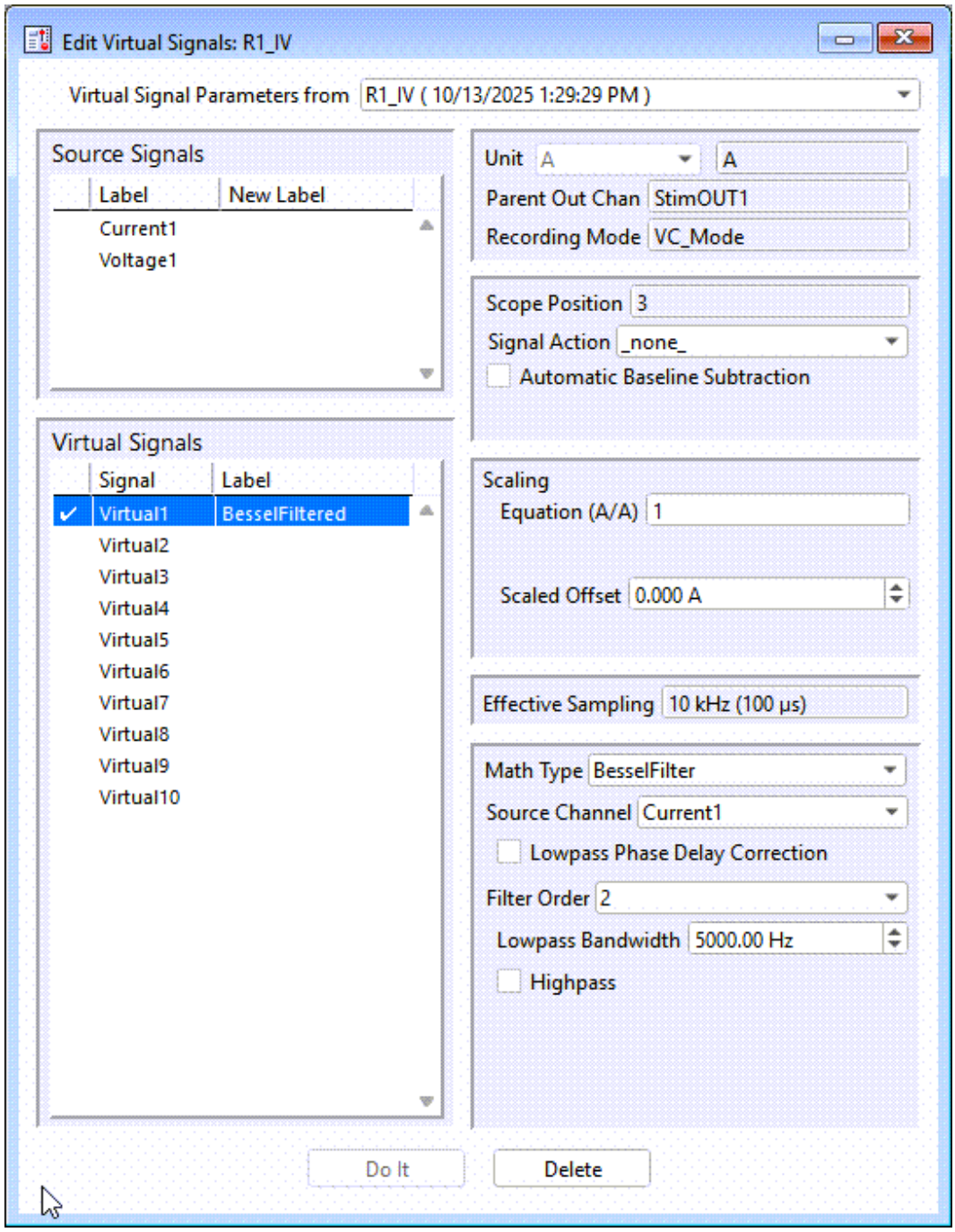


Figure 4-91. Edit Virtual Signals

Virtual Signal Parameters from [< source >] [↓]

- Series name > (date/time stamp)
- Overwrite with Original Routine

Source Signals

Label	The input signal name.
New Label	Double-click this field to edit the signal name, then click the 'Do It' button. Legal characters are A-Z, a-z, 0-9, and underscore "_". The label must start with a letter, be at least two characters long, and not be a duplicate of another label. Otherwise, the label will be automatically updated to a legal format. To see if automatic updates will be applied to the label, after making edits, first click the 'Enter' key, before clicking the ungrayed 'Do It' button.

Virtual Signals

Virtual signals can be added, edited, or removed from the Scope window.

To enable a virtual signal, highlight it and click the 'Do It' button. A check mark is displayed in the first column, and the signal is added to the Scope window.

To disable a virtual signal, highlight it and click the 'Delete' button. The check mark is removed from the first column, and the signal is removed from the Scope window.

Signal	The virtual signal name.
Label	Double-click this field to edit the signal name, then click the 'Do It' button. Legal characters are A-Z, a-z, 0-9, and underscore "_". The label must start with a letter and be at least two characters long, and not be a duplicate of another label. Otherwise, the label will be automatically updated to a legal format. To see if automatic updates will be applied to the label, after making edits, first click the 'Enter' key, before clicking the ungrayed 'Do It' button.

Unit [< unit >] [↓]

< read-only field >

The base unit of measurement from its Source signal. The resolution of the unit is automatically adjusted in the signal.

Parent Out Chan

[< channel >]

< read-only field >

This shows which output channel is associated with the selected input channel.

The ouput channel timing is also used for measurements with 'Cursors Relative to Segments'.

Recording Mode

[< mode >]

< read-only field >

Displays the patch-clamp recording mode assigned at the start of acquisition.

- VC_Mode Voltage-Clamp mode
- CC_Mode Current-Clamp mode

Scope Position

[1 – n]

From a numbered sequence starting with the topmost Scope signal pane as position # "1".

Signal Action

[< action >] [↓]

- None No action taken.
- Show Show the signal in the Scope.
- Hide Hide the signal in the Scope.
- Move to [signal name] Scope Pane

  Move the selected Virtual Signal to the Scope position of the listed signal.

Scaling

Equation (unit/unit)

[< equation >]

< only displays for virtual signals >

Apply scaling to interpret the virtual input signal data. Specify as a numeric value or an equation for the scaling ratio.

Factor < only displays for AuxIN source signals >

< read only field of Equation result >

Note: The dPatch system acquires data with a high-resolution 16-bit ADC into 64-bit data words, so data resolution is not an issue when scaling input signals.

Scaled Offset [< # >]

< displays for virtual signals and AuxIN source signals >

< read only for AuxIN signals >

A scaled offset is applied to the signal.

For “mV” units, append with ‘m’ or ‘e-3’.

For “pA” units, append with ‘p’ or ‘e-12’.

Example: “5 picoamps” with engineering notation: 5p

or in equivalent scientific E-notation: 5e-12

Offset < only displays for AuxIN source signals >.

< read only field >

The raw amplitude offset of the source signal.

Effective Sampling

[# kHz (# μs)]

< read-only field >

Displays the sampling rate (and sampling interval) after low-pass filtering is applied.

.

Math Type [< math >] [↓]

Apply a data transformation to a virtual input signal:

- BaselineSubtract

  Subtract a fixed value from all data points in an input trace.

  This is useful for adjusting for an offset, or resetting a baseline.

  Source Channel [< channel >] [↓]

  Select an input channel to process.

  Baseline From [< channel >] [↓]

  Select how to calculate the subtraction value.

  - Value Subtract a fixed value.

    Value [#]

    Spinner adjusts in 1 pA or 1 mV increments.

  - Trace Subtract the average of the entire input trace.

  - Sweep Time Subtract the average of the data between the Start Time and End Time.

    Start Time [#]

    Set the starting time of the data to be averaged.

    End Time [#]

    Set the ending time of the data to be averaged.

  - Segment #s [#]

    Subtract the average of a Segment from the input trace.

Start Ratio [#]

Set the starting time of the data to be averaged, as a ratio relative to the starting time of the Segment duration.

Start Time [derived value]

End Ratio [#]

Set the ending time of the data to be averaged, as a ratio relative to the ending time of the Segment duration.

End Time [derived value]

[ ] Limit to Marked Sweeps

Enable to limit this analysis to marked sweeps.

- BesselFilter A frequency-domain filter with excellent response characteristics for preserving the shape of a biological signal.

Source Channel [< channel >] [↓]

Select an input channel to filter.

[ ] Lowpass Phase Delay Correction

Correct the signal for estimated digital filtering delays by shifting the signal forwards in time.

Filter Order [1, 2, 4, 8]

Number of “poles” in the filter.

A higher number provides a sharper (more accurate) response, but consumes more processing time and system resources.

Lowpass Bandwidth [0.01 Hz to < ½ the sampling rate]

Restrict frequencies from this boundary point onwards.

Allow signal frequencies less than the

cutoff frequency, and block all higher frequencies, such as high-frequency noise.

Integrator Reset < for amplifier Capacitive Mode >

[< channel >] [↓]

- Ignore — Capacitive-mode transients are displayed in the data.
- Blank [< # µs >]

  The data during capacitive transients are made invisible by replacing those data points with NaNs (Not a Number).

  Blank Duration [10 µs – 1 s]
- Mask [< # µs >]

  The data during capacitive transients are replaced by the last data value before the transient discharge, simulating a sample-and-hold operation.

  Mask Duration [10 µs – 1 s]

  Note: The default value of 500 µs should be sufficient to encompass the reset transient duration.

- CycleAverage — Apply averaging across cycles for each numbered sweep.

  Source Channel — Select an input channel to average.

  Limit to Marked Sweeps

  Enable to limit this analysis to marked sweeps.

- Differentiate — Apply differentiation to an input signal. The instantaneous rate of change in the signal is displayed.

  Source Channel — Select an input channel to differentiate

- Equation — Specify an equation to process an input signal.

  < for use by Igor Pro power users >

  Source Channel [< channel >] [↓]

Select an input channel to process.

Equation [< equation >]

Click field to access the 'Specify math equation' editor.

Note: The full equation is always visible as a tool tip, by hovering the mouse cursor over the 'Math Equation' field.

Specify math equation for virtual signal

[< equation >]

A free-form text field.

< syntax status message >

Syntax errors are reported under the equation field.

[Check Equation] Check the equation syntax. The equation is evaluated for sweep #1, and if valid, it reports "Syntax is ok".

[Insert special identifier]

A limited set of identifiers are available for virtual equation traces.

- s[SeriesNo, SweepNo,SignalNo]

  Access an arbitrary input trace (data wave) via counts of Series #, Sweep #, Trace # (Scope Position in the active Routine.

  The "current" item is the "active" trace in the Scope window, and has a count value of zero.

  If a "count" number is non-zero, it is used as an offset from the current count value of zero. Any fractions in count numbers are truncated to integers.

  Ex: s[0,0,0,]

The current series, current sweep, current trace, of the current routine.

- t[1..16] (nth input trace)

  Access the input trace (data wave) in Scope Position “n” for the last sweep of the current Series.

  This numbering can differ from the Scope Position "n" if signals are re-arranged or hidden

- a[Name] (name of analysis wave)
- copy[1..16] (n’th trace retrieved via File Control).
- p[1..16] (n’th Paradigm variable)
- eq[equation] (result of the given equation)
- if[selector ? true-branch : false-branch]

  (conditional processing)

  The expression is evaluated and returns a value. If the expression in “selector” is true, i.e., non-zero, the result is the content of the “true-branch”, otherwise the result is the content of the “false-branch”.

[Undo] All changes in the equation editing session are discarded.

[ ] Limit to Marked Sweeps

Enable to limit this analysis to marked sweeps.

< see the Equation Editor for more details >

- GaussianFilter

  This filter is useful for reducing ringing and preserving sharp edges.

  Source Channel [< channel >] [↓]

  Select an input channel to filter.

  Lowpass Bandwidth [0.01 Hz – 5.000 kHz]

  Cutoff frequency must be <= ½ sampling frequency.

  [ ] Highpass Allow signal frequencies greater than the cutoff frequency, and block all lower frequencies, such as low-frequency drift.

- Integrate Display the integral of the data signal. This is equivalent to the signed area under a curve.

  Source Channel [< channel >] [↓]

  Select an input channel to integrate.

- Leak Remove leakage current from the data signal. This is the small passive current when the cell is in a resting state.

  < only available when the Routine includes an output channel with P/N Leak Pulse enabled >

  Source Channel [< channel >] [↓]

  Select an input signal to process.

  Show Leak [< status >] [↓]

  - Off
  - On

  Display the accumulated leak currents after the subtracted data in a sweep.

  Leak Zero Segment [#]

  Identify a Segment with no active cellular response to the command signal.

When set to zero, the field is set to 'OFF'. To re-display the numeric spinners, enter a non-zero number into the field.

Note: The mean of the second half of the specified Segment is used to compute an averaged leak current, which is then used to correct the P/N leak average. This option reduces the influence of a constant leak-current, which is otherwise added to the leak current of the main signal.

[ ] Enable — Enable the 'Leak Zero Segment'.

[ ] Baseline Subtraction

The first point of the sweep is used for baseline subtraction of the sweep's main pulse.

- LineFreq — Remove AC line frequency noise (hum) from the data signal.

  Alternating current (AC) power contains 50 or 60 Hz oscillations that can cause sinusoidal line-frequency noise in recorded signals. This FFT-based filter reduces such noise by > 90% over 6 harmonics. The adjusted signal is displayed in real time.

  Source Channel — [< channel >] [↓]

  Select an input channel for noise reduction.

  Line Frequency — [50/60 Hz]

  < read-only field >

  This parameter is configured in Set Preferences / Hardware.

  60 Hz — Canada, (Caribbean), Central America, (Japan), Mexico, (South America), South Korea, Taiwan, USA.

  Regions in (parentheses) include both 50 Hz and 60 Hz frequencies.

50 Hz Most of rest of world.

- LockIn — Measure cell characteristics (such as membrane capacitance) with high signal-to-noise sensitivity, using a dual-phase software lock-in amplifier.

  < requires an output channel with a waveform Segment set to 'Sine / Sine Wave Cycles / For LockIn' >

  Calculations are made using 'conductance' (1 / resistance) insead of 'resistance'.

  Source Channel [< channel >] [↓]

  Select a (source) input channel with a "current" signal.

  Trace Kind [< kind >] [↓]

  Select the LockIn measurement to display.

  The selected 'Trace Kind' is automatically set as the Virtual Channel label.

  CM Computed membrane capacitance.

  GM Computed membrane conductance.

  GS Computed series conductance.

  DC DC component of measured signal.

  RealY
  Real number part of the lock-in response signal.

  ImagY
  Imaginary number part of the lock-in response signal.

  Cycles to Average [1 – 1000]

  Cycles to Skip [1 – 1000]

  V-reversal [±1000 mV]

  When using a calculated stimulus trace, enter the reversal potential for the ion under study, such as for (Na^+) sodium spikes or (K^+) potassium tail currents.

< see Appendix F: SutterPatch Algorithms >

- Smooth — Smooth the data with a “moving average” noise-reduction filter.

  Source Channel [< channel >] [↓]

  Select an input channel to smooth.

  Smoothing Type [< type >] [↓]

  - Gausian — A standard filter with excellent 10 – 90% rise-time response

    Smooth Operations [1 – 32767]

    # of smoothing operations to perform.

  - Boxcar — A fast time-domain filter with excellent 0 – 100% rise-time response

    Smooth Repetitions [1 – 32767]

    # of smoothing repetitions to perform.

    Boxcar Window Points [1 – 101]

    # of points in boxcar sliding window.

    Note: For best performance, only odd values are used.

  Integrator Reset < for dPatch capacitive mode >

- Stimulus — Replicate the command waveform.

  Source Channel [< channel >] [↓]

  Select an input channel – the waveform from its Parent Out Chan is used.

- SweepAverage Average the input traces.

  Source Channel [< channel >] [↓]

  Select an input channel to average.

  Average Type [< average >] [↓]

  - Cumulative

    Average all processed sweeps together.

  - RunAverage

    Average the last “N” sweeps.

  Number of Sweeps [#]

  < for RunAverage >

  Start Sweep [#]

  Sweep number to start sweep averaging.

  [ ] Set Sweep < Start Sweep To NAN

  Sweeps prior to the Start Sweep are set by default to the initial source sweep. Enable to set these pre-sweeps to NaNs.

  End Sweep [#]

  Sweep number to end sweep averaging.

  This number must be larger than the Start Sweep number.

  [ ] Set Sweep > End Sweep To NAN

  Sweeps after the End Sweep are set by default to the initial source sweep. Enable to set these post-sweeps to NaNs.

  [ ] Limit to Marked Sweeps

  Enable to limit this analysis to marked sweeps.

- SweepSubtract Subtract a sweep from the input trace.

  Source Channel [< channel >] [↓]

  Select an input channel to process.

  Reference Sweep [#]

  Select a sweep to be subtracted from all other sweeps. If the sweep does not yet exist, no subtraction occurs.

  [ ] Limit to Marked Sweeps

  Enable to limit this analysis to marked sweeps.

4.2.8 Equation Editor

SutterPatch: Equation Editor

The Equation Editor manages simple or complex expressions that evaluate to a value. Such math equations can be used to create stimulus waveforms, or for data analysis. Multiple Equations can be created and saved to an Equation Pool file.

Access the Equation Editor from the SutterPatch menu.

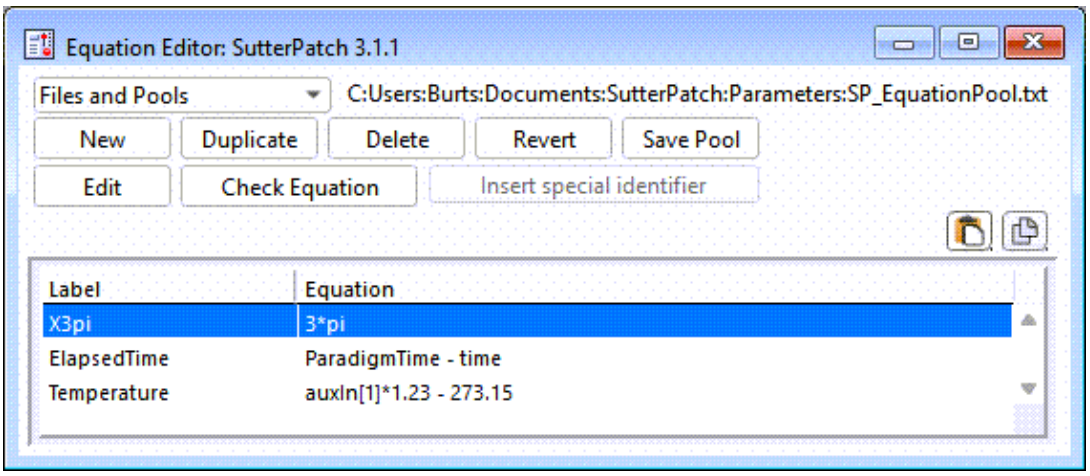


Figure 4-92. Equation Editor

[Files and Pools] [↓]

[ ] Most recently used list of the last 5 Equation Pool file path names

To manually remove a file from the list, Shift-click it.

Note: Path names have a limited number of characters to use. While file names are preserved, path names are shortened by removing excess characters from their ends.

Load Equation Pool	Load the Equations of a previously saved Equation Pool file into the Equation Pool.
New Equation Pool	Create a blank Equation Pool file.
Get Sample Equation Pool	Load the factory default Equation Pool file.
Revert to Last Saved	Undo any unsaved changes to the Equation Pool.
Save Equation Pool	Save the Equation Pool using its existing file name and path.
Save Equation Pool As	Save the Equation Pool to a new file, and switch to the new file. The default file name is the original file name.
Save Equation Pool Copy	Save the Equation Pool to a new file, but do not switch to the new file. The default file name has 'Copy of' prepended to it.
Merge Equation Pools	Insert the Equations from a previously saved Equation Pool file into the loaded Equation Pool.
Send Last Used List to Command	Copy the path name of the 'Files and Pools' last used Equation Pool into the Command window history.
Clear Last Used List	Clear the "Last Used" Pool list of all entries.
Sort Equation Pool – Ascending Order	Sort the 'Files and Pools' list in increasing order.
Sort Equation Pool – Descending Order	Sort the 'Files and Pools' list in decreasing order.

Note: Equation Pool files are simple text files (*.txt) that can be directly edited.

Multiple Equations can be created and saved to an Equation Pool file.

[New] Create a blank Equation.

[Duplicate] Add a copy of the selected Equation to the Equation Pool.

[Delete] Remove the selected Equation from the Equation Pool.

[Revert] Select an Equation and click the Revert button. All editable steps are reset to their last saved settings.

[Save Pool] Save the Equation Pool using its existing file name.

[Edit] Make edits to the 'Equation' field.

[Check Equation] Check the equation syntax. The equation is evaluated for sweep #1, and if valid, it reports "Syntax is ok".

[Insert special identifier]

SutterPatch acquisition, analysis and reference settings are available for use in equations.

< see list below >

Equations Table

Label — A column of editable equation names, for easy usage in equations in place of the actual equation.

< see 'Syntax' below >

Equation — A column of associated equations in free-form text fields, that evaluate as math expressions.

Equations are limited to a maximum of 80 characters, including white space.

 Paste equations from clipboard

Append

Replace

 Copy equations

To Notebook (as text) — Copy the equations as text to the Notebook.

To Notebook (as graph) — Copy the equations as a graphic to the Notebook.

To Clipboard (as text) — Copy the equations as text to the system clipboard.

To Clipboard (as graph) — Copy the equations as a graphic to the system clipboard.

To Printer (as text)	Print the equations as text directly to the default printer as raw output.
To Printer (as graph)	Print the equations graphic directly to the default printer as raw output.
To Layout (as graph)	< unavailable >

Paste equations from clipboard

Append

Replace

 Copy equations

To Notebook (as text)	Copy the equations as text to the Notebook.
To Notebook (as graph)	Copy the equations as a graphic to the Notebook.
To Clipboard (as text)	Copy the equations as text to the system clipboard.
To Clipboard (as graph)	Copy the equations as a graphic to the system clipboard.
To Printer (as text)	Print the equations as text directly to the default printer as raw output.
To Printer (as graph)	Print the equations graphic directly to the default printer as raw output.
To Layout (as graph)	< unavailable >

[Special Identifiers]

SutterPatch acquisition, analysis and reference selections are appended to the equation with a “plus” sign.

Abort selection

Timing

Time	(present date-time, s)
Timer	(timer time, s)
ParadigmTime	(time at start of paradigm, s)
RoutineTime	(time at start of routine, s)

Sweep Time (time relative to routine start, s)

Paradigm Parameters

Loop (active paradigm ForLoop count)

Sweep (active paradigm EachSweep count)

LastSweep (active paradigm sweep count of last sweep)

Processing can occur before or after the last sweep of a series.

Example: In a Paradigm 'If' step, compare 'sweep' numbers in a ForEachSweep loop.

```
ForEachSweep
  EachSweep, Target=IV
  If, Left=sweep, Operation= '=', Right=LastSweep-1
    Alert, Text=LastSweep, DoBeep=true
  EndIf
ForEachEnd
```

AqStopped (last acquisition was stopped)

The last Routine-Series did not complete by itself.

Stimulant (last applied stimulant concentration)

From the Solution Editor 'Concentration' setting, for solutions configured as a 'Chemical Stimulant'.

Input (Input variable on paradigm window)

Hold[1..4] (holding of n'th output channel)

p[1..16] (n'th paradigm variable)

r[1..16] (n'th routine stimulus variable)

Analysis Results

m[1..16] (n'th analysis measurement value)

gx[1..16] (n'th analysis graph x value)

gy[1..16] (n'th analysis graph y value)

Signal Readings

AuxIN[1..4] (reading of auxiliary input, V)

A single-point voltage reading from an Auxiliary Input channel, such as from a slowly changing temperature probe.

Note: This usage does not require setting up a Routine Input Channel.

Imon (amplifier current reading, A)

Value from the Amplifier Control Panel.

Vmon (amplifier voltage reading, V)

Value from the Amplifier Control Panel.

Smean[name or count,start,width]

(mean of given input signal)

'name' = signal name

'count' = window-signal position

'start' = time of start, s (of measurement range)

'width' = duration, s (of measurement range)

Signal Outputs

AuxOUT[1..2] (auxiliary output)

DigOUT[1..8](digital output bit)

DigOutWord (digital output word) 8 bits

Headstage

ActiveProbe (active probe)

[1 – 4]

The "active" probe number is the Sutter headstage presently controlled by the Amplifier Control Panel.

For a single headstage system, the active probe is always headstage number "1".

NumProbes (number of probes)

[1 – 4]

The number of IPA headstages attached to the system.

IPA Settings

CCMode (amplifier current clamp)

VCMode (amplifier voltage clamp)

Hold (IHold in CC-mode, VHold in VC-mode)

[±0.000,000,020 A (±20,000 pA), or ±1.000 V (±1000 mV)]

IHold (amplifer holding current, A)

[± 0.000,000,020 (±20,000 pA)]

IHoldOn (amplifier holding current On)

VHold (amplifier holding voltage, V)

[±1.000 V (±1000 mV)]

VHoldOn (amplifier holding voltage On)

IGain (amplifier current gain, V/A)

The gain of the active voltage-clamp 'Current' input channel.

VGain (amplifier voltage gain, V/V)

The gain of the active current-clamp 'Voltage' input channel.

Filter (amplifier input filter in VC- and CC-mode, Hz)

Read the low-pass filter of the input channels.

IFilter (amplifier input filter in VC-mode, Hz)

Read the low-pass filter of the 'Current' input channel in

VC-mode.

VFilter (amplifier input filter in CC-mode, Hz)

Read the low-pass filter of the 'Voltage' input channel in CC-mode.

Offset (amplifier pipette offset in VC-mode, V)

OffsetLock (amplifier pipette offset lock On in VC-mode)

IPA Compensation

ECompMag (amplifier electrode compensation magnitude, F)

ECompTau (amplifier electrode compensation tau, s)

ECompOn (amplifier electrode compensation On in CC-mode)

CmComp (amplifier cell compensation Cm, F)

RsComp (amplifier cell compensation Rs, Ohm)

RsCompOn (amplifier cell compensation Rs On)

Bridge (amplifier bridge balance, Ohm)

BridgeOn (amplifier bridge balance On)

IPA Correction

RsCorr (amplifier Rs correction, fraction)

RsPred (amplifier Rs prediction, fraction)

RsLag (amplifier Rs correction lag, s)

RsCorrOn (amplifier Rs correction On)

Dynamic Holding

DynHoldOn (amplifier dynamic holding On)

DynHold (amplifier dynamic holding potential, V)

Membrane Test

Cmemb[1..2] (membrane capacitance (cell mode), F)

Value from last Membrane Test.

Rseries[1..2] (series resistance (cell mode), Ohm)

Value from last Membrane Test.

Relectr[1..2] (electrode resistance, Ohm)

Value from last Membrane Test.

< for Seal mode >

Rmemb[1..2] (membrane resistance (cell mode), Ohm)

Value from last Membrane Test.

RMSNoise[1..2] (membrane test RMS noise, A)

Value from last Membrane Test.

Lock-In

LockInPhaseAdj (Lock-In phase delay adjustment, s)

LockInAttenAdj (Lock-In attenuation adjustment)

Data Navigator

NaviNodeChildren (number of children of selected node)

NaviParadigms (number of paradigms of selected experiment)

NaviRoutines (number of routines of selected paradigm)

NaviSignals (number of signals of selected routine)

NaviSweeps (number of sweeps of selected signal)

NaviNodeNumber (number of selected node)

NaviParadigmNumber

(number of selected paradigm)

NaviRoutineNumber

(number of selected routine)

NaviSignalNumber (number of selected signal)

NaviSweepNumber (number of selected sweep)

Other identifiers are forwarded to Igor Pro's 'Execute' command.

Paste from clipboard	Paste equations from the system clipboard.
Paste Equations	Select the paste action.
Append	
Replace	
Copy to clipboard	Copy the selected equations to the system clipboard.

Equation Usage

Arguments

X

The "X" (or "x") specifier allows an argument to be passed to an equation. Insert "X" as the placeholder(s) in numeric expressions.

To call such an equation in other parts of the program, prepend a "#" to the equation label, and append the argument in parentheses.

Example 1

Pass the value "1.7" to the named equation label "My_Equation":

```
#My_Equation(1.7)
```

Example 2

Send an AuxOUT voltage command to a piezo-drive controller in distance units, using the sample conversion formula:

```
volts = ( ( micrometers + 0.08 ) / 4.04 )
        ^ 1.3
```

Instead of retyping this equation every time it is used, use an argument 'X' in the equation:

```
volts = ( ( X + 0.08 ) / 4.04 ) ^ 1.3
```

Label the equation as:

```
um2volt
```

Pass a distance of 10 micrometers to the labeled equation in a Routine (Routine Editor / Output Channels / Waveform Editor /

Amplitude Segment), or in a Paradigm (Paradigm Editor / Amplifier step / Auxiliary Output target) as:

#um2volt(10)

Constants

true	1
false	0
ON	1
OFF	0

The following constants have 27-digit precision:

e	2.71...	(Euler's number)
pi	3.14...	(π)

Lists

Anywhere equations can be used, a list of comma-separated equations can also be used, to generate a sequence of values. If the sequence extends beyond the end of the list, the sequence wraps around and continues from the beginning of the list again, and so on.

Places used:

Paradigm Steps

Amplifier

Checkbox

Set Variable

Sound

Write Log

If

Else If

Routine Editor

Virtual Input Channel: Equation

Waveform Editor: Amplitude, Duration

Measurements: Time to Threshold

Graphs: X-Axis, Y-Axis

Example: Create a sequence of increasing values with a 1 / 2 / 5 progression, such as might be used to increase a Routine's waveform amplitude or duration, on a per sweep basis:

1m*10^ceil(sweep/3),2m*10^ceil(sweep/3),5m*10^ceil(sweep/3)

This will generate a sequence of values of: 10m, 20m, 50m, 100m, 200m, 500m, 1000m…

The 'ceil' function rounds up any fraction to the next higher whole number, and "sweep" is a special identifier that reports the active sweep number. So, for the first 3 sweeps (1, 2, 3), "ceil(sweep/3)" generates a '1'. As '10' raised to '1' is '10', the initial number (1, 2, 5) is multiplied by '10', resulting in values of "10m, 20m, 50m".

For the next 3 sweeps (4, 5, 6), the sequence wraps around the list, and now "ceil(sweep/3)" generates a '2'. As '10' raised to '2' is '100', the initial number (1, 2, 5) is now multiplied by '100', resulting in values of "100m, 200m, 500m".

Parsing and Operators

Equation parsing is executed from left to right, processing the highest precedence level operators first, except for comparison and bitwise operators, which associate from right to left.

Precedence	Operation Type	Operator
8	Comment	;
7	Exponentiation, Arithmetic operations: Left Shift, Right Shift	^, <<, >>
6	Negation (logical) operations: Unary Negation, Logical Negation	-, !

5	Multiplication, Division, Remainder	*, /, %
4	Addition, Subtraction	+, -
3	Bitwise operations: And, Or, Nor, Xor	&, |, nor, %^
2	Comparison operations: Greater Than, Greater Than or Equal, Less Than, Less Than or Equal, Equal To, Not Equal To	>, >=, <, <=, !=
1	Logical operations: And, Or, Conditional	&&, ||, ? :
0	Other functions	abs, acos, asin, atan, ceil, cos, deg, exp, floor, ln, log, mlast, noise, odd, rad, random, round, sin, sqrt, tan, trunc

Table 4-4. Equation Parser

Comments are also processed differently between the SutterPatch equation parser and the Igor Pro command parser:

SutterPatch	All characters to the right of a semicolon are ignored
Igor Pro:	All characters to the right of a double slash "//" are ignored. A semicolon separates multiple commands on the same command line.

An arithmetic left shift (<<) is the same as a bitwise left shift, whereby the least significant bit is padded with a zero. However, while an arithmetic right shift (>>) fills the most significant bit with its original value, thus preserving the sign, a bitwise right shift pads the most significant bit with a zero. A bitwise right shift can be constructed from existing operators.

Example: Shift # right by “n” bits

/ 2^n

The Conditional operator “? : ” is a shortcut for an if-else-endif expression. It evaluates as:

expression ? True : False

If the expression operand evaluates as non-zero, the ‘True’ numeric operand is evaluated.

If the expression evaluates as zero, the ‘False’ numeric operand is evaluated.

For complex expressions, only the real portion is evaluated.

Note: The " : " is a colon with 2 blank spaces around it.

The function “mlast[count]” returns the measurement result of the previous sweep.

The function “Odd” returns a “1” when its argument is odd, and a “0” when it is even.

For expressions using Comparison and Logical operators, it is recommended to use parentheses to explicitly define the order of execution.

Syntax

All equations use the same syntax as Igor Pro, with a few additions:

- Three kinds of brackets [ ], { }, ( ), can be used equivalently to improve the clarity of nested expressions.
- Numeric values can be written in scientific E-notation using exponents:

  5e-12 (5 picoamps)

  or in equivalent engineering notation using unit prefixes:

  5p (5 picoamps)

Prefix	Exponent	Prefix Name		Prefix	Exponent	Prefix Name
k	10^{3}	Kilo		**m**	10^{-3}	milli
M	10^{6}	Mega		**µ (or u)**	10^{-6}	micro
G	10^{9}	Giga		**n**	10^{-9}	nano
T	10^{12}	Tera		**p**	10^{-12}	pico

P	10^{15}	Peta		**f**	10^{-15}	femto
E	10^{18}	Exa		**a**	10^{-18}	atto
Z	10^{21}	Zetta		**z**	10^{-21}	zepto
Y	10^{24}	Yotta		**y**	10^{-24}	yokto

Table 4-5. Engineering Notation

- Insert an equation from the Equation Editor Pool into an Equation field by entering "#" followed by the label of the equation, e.g., "#MyLabel". For variable inputs, "#MyLabel(5)"passes the argument "5" to the equation labeled "MyLabel" for evaluation.

Example: Using an LED light source

To stimulate in increments of light intensity, use an equation to transform light intensity values in Routine variables into actual stimulus values with amplitudes in volts.

Build an equation in the equation pool as follows:

equation = ln(r[1]) * 2.55 + 3

The natural log of the Routine Variable r[1] is multiplied by 2.55 and added to 3.

label = power_to_volts

In the Waveform Editor, set a Segment Amplitude field to 'Equation', and enter the equation as "#power_to_volts".

Two of the SutterPatch "Editors" use a simplified version of the Equation Editor which allows equations and equation Labels to be used:

Paradigm Editor

Steps: Amplifier, Checkbox, Set Variable, Sound, Write Log, If, Else If

Routine Editor

Input Channels: Virtual Channels: Math Type: Equation

Output Channels: P/N Leak Pulses: Leak Hold, Waveform Editor: Amplitude, Duration

Measurements: Time to Threshold, X-Axis, Y-Axis

Note: For acquisition, computing an equation within a command waveform consumes significant computing power, as every data point needs to be computed by the CPU. While a slight update delay in such operations is expected, for computers with marginal computing power, the "beach ball" icon displays while the computer is unresponsive and busy processing.

4.2.9 Igor Pro Analyses

Analysis

Numerous mathematical operations are found in the Analysis main menu. and are documented in the Igor Pro Help.

These built-in Igor Pro fitting analyses are also accessible via the "Scope" right-click menus:

- Curve Fitting — Create your own fitting equation
- Quick Fit — Use a pre-defined equation:

  line

  poly [3 – 10]

  poly_XOffset [3 – 10]

  gauss

  Ior

  Voight

  exp_XOffset

  dblexp_XOffset

  exp

  dblexp

  dblexp_peak

  sin

  HillEquation

  Sigmoid — < use for Boltzmann function >

Power

LogNormal

poly2D [1 – 10]

Gauss2D

FitBetweenCursors

Weight from Error Bar Wave

Textbox Preferences

Example: Perform a fit on a section of a sweep:

1. Open the data into a Reanalysis Scope window.
2. In the Scope window, right-click 'Toggle Cursor Info' to display the cursor pane.
3. Drag cursors 'A' and 'B' from the cursor pane onto the data to set the fitting range.
4. Right-click on the data, and select Quick Fit and the fit of your choice.
5. Fitting results are written to the Command window.

Other built-in Igor Pro analyses include:

- Transforms
    - Fourier Transforms
    - Periodogram
    - Lomb Periodogram
    - MultiTaperPSD
    - Discrete Wavelet Transform
    - Continuous Wavelet Transform
    - Wagner Transform
    - Short-Time Fourier Transform

- Convolve
- Correlate
- Differentiate
- Integrate
- Smooth
- Interpolate
- Filter
- Resample
- Sort
- Histogram
- Compose Expression
- Packages
    - Average Waves
    - Batch Curve Fitting
    - Function Grapher
    - Global Fit
    - Igor Filter Design Laboratory
    - Median XY Smoothing
    - MultiPeak Fitting
    - Percentiles and Box Plot
    - Wave Arithmetic

4.2.10 Metadata Review

"Metadata" parameters describe the system environment, the attached Sutter instrumentation, the Paradigm and Routine acquisition settings, and tag information.

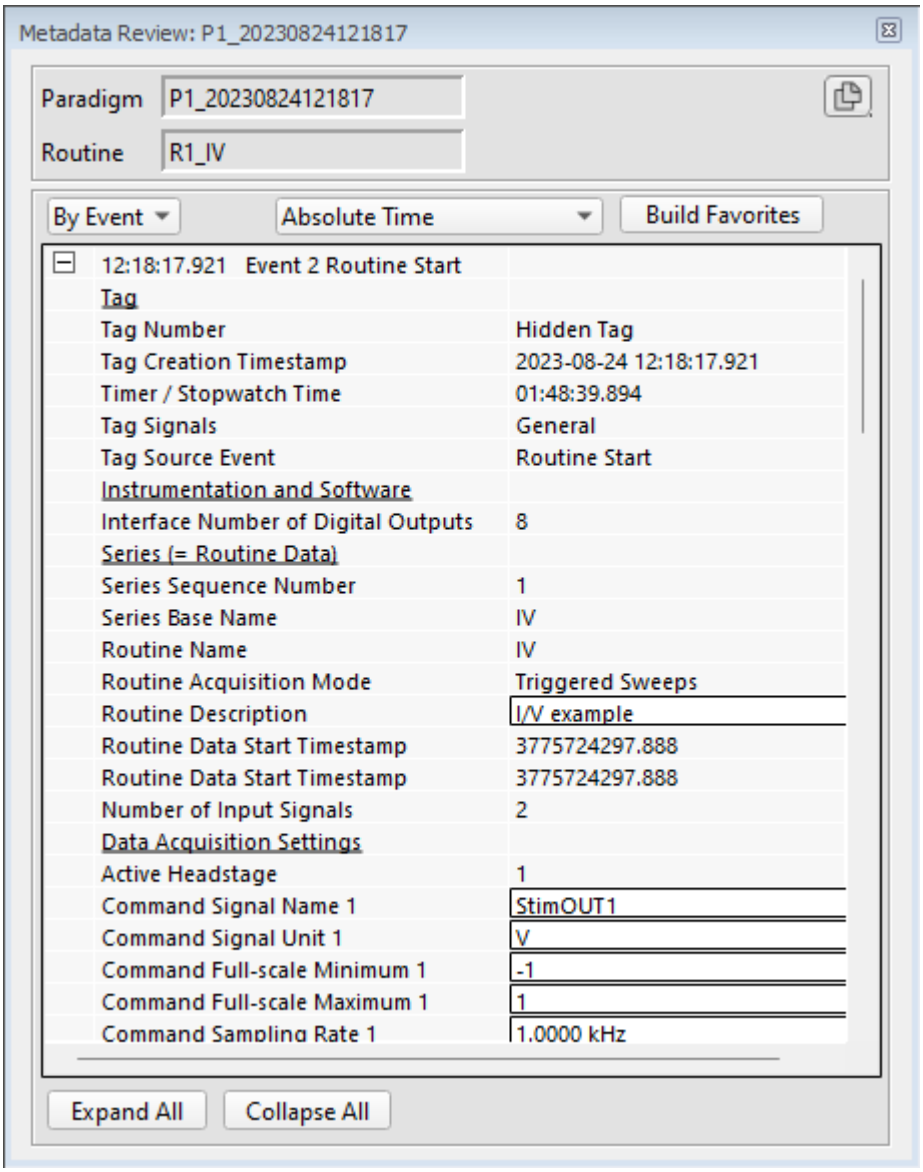


Figure 4-93. Metadata Review

Metadata parameters can be retrieved several different ways:

Reanalysis Scope window:

Open a Metadata Review floating sub-window.

Open a Series into a Reanalysis Scope window (from the Data Navigator

'Analyze' button or Action 'Analyze Routine'), and use the 'View Metadata' button to open a Metadata Review floating sub-window.

Data Navigator

Open a Metadata Review docked sub-window.

- Select a Paradigm or Series and click on its metadata wave in the Preview pane.
- Select a Paradigm or Series, then click the 'Available actions' button and select 'View Metadata'.
- Right-click a Paradigm or Series and select 'View Metadata'.

When this docked window is open, it is linked to the Data Navigator window, where changing the Paradigm or Series node selection also updates the docked Metadata Review parameters.

Simultaneously display metadata from two different Paradigms using floating and docked windows:

> Select the first Paradigm and the Action 'Review Paradigm'. Then, in the Paradigm Review window, click the 'View Metadata' button to open a Metadata Review floating sub-window. Next, select the second Paradigm, and select the Action 'View Metadata' to open a Metadata Review docked sub-window.

Simultaneously display metadata from two different Series using floating and docked windows:

> Select the first Series and the Action 'Analyze Routine' (or 'Review Routine'). Then, click the 'View Metadata' button to open a Metadata Review floating sub-window. Next, select the second Series, and the Action 'View Metadata' to open a Metadata Review docked sub-window.

Data Browser < for advanced Igor Pro users >

A metadata wave is stored for each Paradigm.

This is a 3D wave holding the metadata for all signals in a Paradigm.

First dimension:

> Parameter per parameter matrix. The row label corresponds to root:SutterPatch:'AppControl':MetaData:MetaStructure.

Second dimension:

> The column index represents the Signal number N (1-based). Column 0

contains parameter values that either are not related to a signal, or apply to all signals.

Third dimension:

Tag ID (zero-based)

A metadata wave contains only a relatively small set of mandatory parameters at creation. Additional parameters are added on demand. See root:SutterPatch:'AppControl':MetaData:MetaStructure for the full set of supported parameters.

Metadata Review window

Paradigm [ ]	Displays the name of the Paradigm.
Routine [ ]	Displays the name of the Series.
Signal [ ]	Displays the name of the Signal. < only if selected in the Data Navigator >
[< metadata >] [↓]	Choose how to display the metadata parameters:.
• By Event	Events are grouped by [time-stamp] [Event #] [Event type]. Highlighted values are editable.
• By Parameter	Parameters are grouped into major categories, and include extra system and Paradigm parameters automatically written before a Routine starts. Additional metadata entries display if pre-defined in 'Set Metadata'. If available, parameters also display their "Prior" values. This allows you to look at a parameter and how it changes over time. < see Metadata Parameters list below >
• By Favorites	View your favorite metadata parameters, as selected in 'Build Favorites'. < see Favorites Parameters list below > < the Data Navigator 'Enable Tree Filter' checkbox needs to be enabled for display of the Favorites here >
[< time >] [↓]	Choose how to display the time:
• Absolute Time	Use time values relative to the computer's operating system date-time.

- Relative to Routine Time

  Use time values relative to the start of the Routine.

- Relative to Timer Time

  Use time values relative to the Timer time in the Acquisition Control Panel.

[Build Favorites]

Define Metadata Favorites

Select and order parameters for metadata favorites

Select parameter group [< group >] [↓]

This lists all groups from the Set Preferences / Metadata / Full detail level.

All Categories

Frequently Used

Tag

Operator

Preparation – Animal

Preparation – Tissue

Preparation – Cell

Experiment

Amplifier

Instrumentation and Software

Electrode

Recording Solutions

Paradigm

Cell Health / Quality Control

Series (= Routine Data)

Data Acquisition Settings

Imaging

Stimulus

Available parameter

An alphabetical listing of all “By Parameter” metadata parameters by group.

This shows all items using the Set Preferences / Metadata / Full detail level, and includes automatic acquisition-related metadata entries.

< see below for list of Favorites parameters >

▸ Copy the selected ‘Available parameter’ on the left, to the ‘Parameter’ list on the right.

Metadata favorites

Selected Parameter
The names list of the favorite parameters.

Signal The signal number associated with the parameter.

To change it, click on the Signal number to bring up a channel selection dialog.

 Remove the highlighted parameter from the favorites list

 Move selected parameter Up / Down in the favorites list.

[Clear Frequently Used]

Clear the ‘Available parameter’ list.

[Remove All]

Clear the ‘Selected Parameter’ list.

[Expand All] All settings entries are displayed.

Two columns of information are presented (parameter name and value). If the first column’s text does not fully display, either increase the width of the window, or adjust the indentation of the second column – drag it when the mouse cursor turns into a double-headed arrow

[Collapse All] All settings entries are hidden and collapsed up to the Event or Parameter level.

 Copy Metadata

Copy the metadata parameters:

To Notebook (as text)	Copy the metadata to the SutterPatch Notebook as text.
To Clipboard (as text)	Copy the metadata to the system clipboard as text.
To Clipboard (as graph)	Copy the metadata to the system clipboard as a graph.
To Layout (as graph)	< unavailable >

Metadata Parameters

This shows all items using the Full detail level, as set in 'Set Preferences / Metadata'.

Tag

Tag Number
Tag Creation Timestamp
Timer / Stopwatch Time
Tag Signals
Tag Source Event

Operator

Login Name

Experiment

Experiment Timestamp

Amplifier

Amplifier Sequence Number
Amplifier Manufacturer
Amplifier Model
Amplifier Firmware Version
Amplifier Serial Number
Amplifier Channel
Number of Available Headstages
Headstage Sequence Number

Headstage Model

Instrumentation and Software

Interface Sequence Number
Interface Manufacturer
Interface Model
Interface Firmware Version
Interface Serial Number
Interface Input Channel (physical)
Interface Signal Type
Interface Number of Digital Outputs
Computer Name
Physical Computer Memory
Operating System Platform
Operating System
Software Environment
Software Environment Version
Software Environment Build
Software Environment Kind
Software Environment Serial Number
Data Acquisition Software
Data Acquisition Software Version
Data Acquisition Software Build
Data Acquisition XOP Version

Paradigm

Paradigm Data Sequence Number
Paradigm Data Base Name
Paradigm Name
Paradigm Description
Paradigm Data Start Timestamp
Paradigm Data Start Timezone

Series (= Routine Data)

Series Sequence Number
Series Base Name
Routine Name
Routine Acquisition Mode
Routine Description
Routine Data Start Timestamp
Routn. Completed / Terminated Early
Number of Input Signals
Sweep Number

Data Acquisition Settings

Active Headstage	
Recording Mode	
Current Gain	
Voltage Gain	
Headstage Gain	
Headstage Feedback Mode	< for dPatch only >
Filter Cutoff Frequency	
Filter Type	
Input Offset Voltage	< VC mode, headstage channels >
Input Offset Lock On/Off	< for headstage channels >
Input Liquid Junction Potential	
Input Signal Name	
Input Signal Unit	
Input Scaling Factor	< for AuxIN channels >
Input Scaling Offset	< for headstage channels >
Input Full-scale Minimum	
Input Full-scale Maximum	
Input Sampling Rate	
Auxiliary Input Signal Offset	< for AuxIN channels >
Virtual Signal Scaling Offset	< for Virtual Input channels >
Virtual Signal Math Type	< for Virtual Input channels >
Virtual Signal Equation	< for Virtual Input channels >
Virtual Signal Source Channel	< for Virtual Input channels >
Virtual Signal Source Signal Name	< for Virtual Input channels >
Virtual Signal Stim Source Sampling Rate	< for Virtual Stimulus >
Virtual Signal Subtract Baseline Type	< for Virtual BaselineSubtract >
Virtual Signal Subtract Baseline Start	< for Virtual BaselineSubtract >
Virtual Signal Subtract Baseline End	< for Virtual BaselineSubtract >
Virtual Signal Filter Type	< for Virtual BesselFilter >
Virtual Signal Filter Order	< for Virtual BesselFilter >
Virtual Signal Filter Cutoff Frequency	< for Virtual BesselFilter >
Virtual Signal Integrator Reset Strategy	< for Virtual BesselFilter and Smoothing, Capacitive mode >
Virtual Signal Integrator Reset Duration	< for Virtual BesselFilter and Smoothing, Capacitive mode >
Virtual Signal Leak Display On/Off	< for Virtual Leak >
Virtual Signal Leak Zero Segment	< for Virtual Leak >
Virtual Signal Line Frequency Base	< for Virtual LineFreq >
Virtual Signal LockIn Trace Kind	< for Virtual LockIn >
Virtual Signal LockIn Cycles to Average	< for Virtual LockIn >

Virtual Signal LockIn Cycles to Skip	< for Virtual LockIn >
Virtual Signal LockIn Reversal Potential	< for Virtual LockIn >
Virtual Signal Smoothing Algorithm	< for Virtual Smoothing >
Virtual Signal Smoothing Factor	< for Virtual Smoothing >
Virtual Signal Sweeps Processed	< for Virtual SweepAverage >
Virtual Signal Reference Sweep	< for Virtual SweepSubtract >
Electrode Fast Magnitude	< VC mode >
Electrode Fast Time Constant	< VC mode >
Whole-cell Compensation On/Off	< VC mode >
Cell Comp – Series Resistance	< VC mode, if WC Comp On >
Cell Comp – Membrane Capacitance	< VC mode, if WC Comp On >
Series Resistance Correction On/Off	< VC mode >
Series Resistance Prediction Value	< VC mode, if Rs Correction On >
Series Resistance Correction Value	< VC mode, if Rs Correction On >
Series Resistance Corr. Lag Time	< VC mode, if Rs Correction On >
Capacitance Neutralization On/Off	< CC mode >
Capacitance Neutralization Mag.	< CC mode, if Cap Neut On >
Capacitance Neutralization Tau	< CC mode, if Cap Neut On >
Bridge Balance On/Off	< CC mode >
Bridge Balance Resistance	< CC mode, if Bridge Balance On >
Current Clamp Dynamic Hold On/Off	< CC mode >
Current Clamp Dyn. Hold Potential	< CC mode, if Dynamic Hold On >
Current Clamp Dynamic Hold Speed	< CC mode, if Dynamic Hold On >
CC Dynamic Hold On for Acquisition	< CC mode, if Dynamic Hold On >
Command Signal Name 1	
Command Signal Unit 1	
Command Full-scale Minimum 1	
Command Full-scale Maximum 1	
Command Sampling Rate 1	
Command Holding Enabled 1	
Command Holding Value 1	< ‘0’ if Holding disabled >
Auxiliary Output Signal Name 1	< if AuxOUT1 enabled >
Auxiliary Output Scaling Factor 1	< if AuxOUT1 enabled >
Auxiliary Output Offset 1	< if AuxOUT1 enabled >
Auxiliary Output Holding Value 1	< ‘0’ in demo mode >
Command Signal Name 2	< if StimOUT 1 & 2 enabled >
Command Signal Unit 2	< if StimOUT 1 & 2 enabled >
Command Full-scale Minimum 2	< if StimOUT 1 & 2 enabled >
Command Full-scale Maximum 2	< if StimOUT 1 & 2 enabled >
Command Sampling Rate 2	< if StimOUT 1 & 2 enabled >
Command Holding Enabled 2	< if StimOUT 1 & 2 enabled >
Command Holding Value 2	< ‘0’ if Holding disabled >
Auxiliary Output Signal Name 2	< if AuxOUT2 enabled >
Auxiliary Output Scaling Factor 2	< if AuxOUT2 enabled >

Auxiliary Output Offset 2	< if AuxOUT2 enabled >
Auxiliary Output Holding Value 2	< '0' in demo mode >
Digital Holding Pattern (1 → N)	< 1 – 8 > bits

Stimulus

Compound Group	
Compound Name	
Compound Description	< for 'Control' or 'Test Compound' Solutions >
Compound Concentration	< for 'Control' or 'Test Compound' Solutions >
Compound Concentration Unit	< for 'Control' or 'Test Compound' Solutions >

Favorites Parameters

All Categories

An alphabetical listing of all parameters from all available group categories.

Frequently Used

A listing of recent or often used parameters.

Tag

Tag Number	
Tag Creation Timestamp	
Timer / Stopwatch Time	
Tag Signals	
Tag Source Event	
Tag Comment	< for user tags >

Operator

Login Name

Preparation – Animal

Animal Age
Animal Circadian Time or Phase
Animal Genotype
Animal Identifier
Animal Preparation Date
Animal Preparation Time
Animal Sex / Gender
Animal Species
Animal Strain
Animal User Parameter 1 Name
Animal User Parameter 2 Name

Animal User Parameter 3 Name
Animal User Parameter 4 Name
Animal User Parameter 5 Name
Animal Weight

Preparation – Tissue

Organ
Organ Region
Preparation Method
Tissue Incubation Duration
Tissue Incubation Solution
Tissue Incubation Temperature
Tissue Preparation Date
Tissue Preparation Identifier
Tissue Preparation Time
Tissue User Parameter 1 Name
Tissue User Parameter 2 Name
Tissue User Parameter 3 Name
Tissue User Parameter 4 Name
Tissue User Parameter 5 Name

Preparation – Cell

Acutely Dissociated Cells
Cell Diameter
Cell Dissociation Solution
Cell Fluorescent Marker
Cell Identifier
Cell Line
Cell Prep. Dissociation Temperature
Cell Prep. Incubation Temperature
Cell Preparation Date
Cell Preparation Identifier
Cell Preparation Incubation Duration
Cell Preparation Incubation Solution
Cell Preparation Time
Cell Type
Cell User Parameter 1 Name
Cell User Parameter 2 Name
Cell User Parameter 3 Name
Cell User Parameter 4 Name
Cell User Parameter 5 Name
In-situ Recording
Ion Channel
Slice Preparation
Stem Cell Preparation
User-defined Preparation
Whole-organ Preparation

Experiment

All Events During Routine
Date Time
Experiment Category 1 Name
Experiment Category 2 Name
Experiment Category 3 Name
Experiment Category 4 Name
Experiment Category 5 Name
Experiment User Parameter 1 Name
Experiment User Parameter 2 Name
Experiment User Parameter 3 Name
Experiment User Parameter 4 Name
Experiment User Parameter 5 Name
Paradigm Step Instruction
Sweep Start Time

Amplifier

Amplifier Channel
Amplifier Manufacturer
Amplifier Sequence Number
Amplifier Serial Number
Amplifier User Parameter 1 Name
Amplifier User Parameter 2 Name
Amplifier User Parameter 3 Name
Amplifier User Parameter 4 Name
Amplifier User Parameter 5 Name
Headstage Model
Headstage Preamplifier Model
Headstage Preamplifier Revision
Headstage Revision
Headstage Sequence Number
Headstage Serial Number
Number of Available Headstages

Instrumentation and Software

Computer Name
Data Acquisition Software
Data Acquisition Software S/N
Data Acquisition XOP Version
Imported Data (SP or third-party)
Instrumentation User Param. 1 Name
Instrumentation User Param. 2 Name
Instrumentation User Param. 3 Name
Instrumentation User Param. 4 Name
Instrumentation User Param. 5 Name
Interface Input Channel (physical)
Interface Manufacturer
Interface Number of Digital Outputs
Interface Out. Ch. (physical or logical)
Interface Sequence Number

Interface Serial Number
Interface Signal Type
Operating System
Operating System Platform
Original Acquisition Software
Original Computer Name
Original Data File Format
Original Data File Name with Path
Original Data File Sub-Format
Original Operating System
Original Wave Name
Physical Computer Memory
Software Environment
Software Environment Kind
Software Environment Serial Number

Electrode

Electrode Beveled
Electrode Coated
Electrode Fire-polished
Electrode Glass Item Inner Diameter
Electrode Glass Item Outer Diameter
Electrode Glass Lot Number
Electrode Glass Manufacturer
Electrode Glass Material
Electrode Glass Ramp Test Value
Electrode Identifier
Electrode Taper Length
Electrode Tip Diameter
Electrode User Parameter 1 Name
Electrode User Parameter 2 Name
Electrode User Parameter 3 Name
Electrode User Parameter 4 Name
Electrode User Parameter 5 Name
Filamented Glass
Pipette Puller Manufacturer
Pipette Puller Serial Number
Pull Heat-on Time
Pull Program Air Mode
Pull Program Air Pressure
Pull Program Number
Pull Program Parameters
Puller Filament Item Number
Puller Filament Type
Puller Preheat Enabled

Recording Solutions

Bath Solution Batch
Bath Solution Composition

Bath Solution Identifier
Bath Solution Name
Bath Solution Osmolarity
Bath Solution pH
Bath Solution Preparation Date
Bath Solution Preparation Time
Bath Solution Preparer
Liquid Junction Potential, computed
Liquid Junction Potential, measured
Pipette Solution Batch
Pipette Solution Composition
Pipette Solution Identifier
Pipette Solution Name
Pipette Solution Osmolarity
Pipette Solution pH
Pipette Solution Preparation Date
Pipette Solution Preparation Time
Pipette Solution Preparer
Solution Pair Identifier
Solution Pair Name
Solution User Parameter 1 Name
Solution User Parameter 2 Name
Solution User Parameter 3 Name
Solution User Parameter 4 Name
Solution User Parameter 5 Name

Paradigm

Ambient Temperature
Atmospheric Composition
Atmospheric Humidity
Atmospheric Pressure
Bath Temperature
Key Stimulus for the Cell Paradigm
Original Paradigm Data Seq. Number
Paradigm Data Base Name
Paradigm Data Sequence Number
Paradigm Description
Paradigm Name
Paradigm User Comment
Paradigm User Parameter 1 Name
Paradigm User Parameter 2 Name
Paradigm User Parameter 3 Name
Paradigm User Parameter 4 Name
Paradigm User Parameter 5 Name

Cell Health / Quality Control

Cell Health User Parameter 1 Name
Cell Health User Parameter 2 Name
Cell Health User Parameter 3 Name

Cell Health User Parameter 4 Name
Cell Health User Parameter 5 Name
Electrode / Pipette Resistance
Electrode Capacitance
Electrode Offset
Membrane Capacitance
Membrane Resistance
Seal Resistance
Series / Access Resistance
Total Capacitance
Total Resistance

Series (= Routine Data)

Number of Input Signals
Number of Sweeps in Series
Original File GUID
Original Series Sequence Number
Routine Acquisition Mode
Routine Description
Routine Name
Routine User Comment
Routn. Completed / Terminated Early
Samples per Sweep
Series Base Name
Series Sequence Number

Data Acquisition Settings

Active Headstage
Auxiliary Input Signal Offset
Auxiliary Output Holding Value [1 – 8]
Auxiliary Output Offset [1 – 8]
Auxiliary Output Sampling Rate [1 – 8]
Auxiliary Output Scaling Factor [1 – 8]
Auxiliary Output Signal Name [1 – 8]
Bridge Balance On/Off
Bridge Balance Resistance
Capacitance Neutralization Magnitude
Capacitance Neutralization On/Off
Capacitance Neutralization Reduction
Capacitance Neutralization Tau
CC Dynamic Hold On For Acquisition
Cell Comp – Membrane Capacitance
Cell Comp – Series Resistance
Command Holding Enabled [1 – 8]
Command Sampling Rate [1 – 8]
Command Scaling Factor [1 – 8]
Command Signal Name [1 – 8]
Command Signal Offset [1 – 8]
Current Clamp Dyn. Hold Potential

Current Clamp Dynamic Hold On/Off
Current Clamp Dynamic Hold Speed
Current Gain
Digital Holding Pattern (1 --> N)
Dynamic Clamp HS1 Holding 1
Dynamic Clamp HS1 Holding 2
Dynamic Clamp HS2 Holding 1
Dynamic Clamp HS2 Holding 2
Electrode Fast Magnitude
Electrode Fast Time Constant
Electrode Slow Magnitude
Electrode Slow Time Constant
External Command Bandwidth [1 – 8]
External Command Filter Bypass [1 – 8]
External Command Gain [1 – 8]
Filter Cutoff Frequency
Filter Type
Headstage Feedback Mode
Headstage Gain
Input Full-scale Maximum
Input Full-scale Minimum
Input Liquid Junction Potential
Input Offset Lock On/Off
Input Offset Voltage
Input Sampling Rate
Input Scaling Factor
Input Scaling Offset
Input Signal Name
Pretrigger Samples
Recording Mode
Secondary Highp. Filt. Cutoff Freq.
Secondary Highp. Filt. Implementation
Secondary Highp. Filter Type
Secondary Lowp. Filt. Cutoff Freq.
Secondary Lowp. Filt. Implementation
Secondary Lowp. Filter Type
Series Resistance Corr. Lag Time
Series Resistance Correction On/Off
Series Resistance Prediction On/Off
Subtract Pip. Offset in Current Clamp
Trigger Polarity
Trigger Threshold
Virtual Signal Equation
Virtual Signal Integrator Reset Duration
Virtual Signal Integrator Reset Strategy
Virtual Signal Math Type
Virtual Signal Scaling Offset
Virtual Signal Source Channel
Virtual Signal Source Signal Name
Virtual Signal Use Only Marked Sweeps

Voltage Gain
Whole-cell Compensation On/Off

Imaging

Image Camera Name
Image Comment
Image Type

Stimulus

Acoust. Stimulus User Param. 1 Name
Acoust. Stimulus User Param. 2 Name
Acoust. Stimulus User Param. 3 Name
Acoust. Stimulus User Param. 4 Name
Acoust. Stimulus User Param. 5 Name
Acoustic Stimulus Frequency
Acoustic Stimulus Intensity
Application Tip Identifier
Chem. Stimulus User Param. 1 Name
Chem. Stimulus User Param. 2 Name
Chem. Stimulus User Param. 3 Name
Chem. Stimulus User Param. 4 Name
Chem. Stimulus User Param. 5 Name
Compd. Vehicle / Solubility Enhancer
Compound Batch
Compound Concentration
Compound Counterion
Compound Description
Compound Group
Compound Identifier
Compound Lot
Compound Name
Compound Plate Column
Compound Plate Identifier
Compound Plate Row
Compound Preparation Date
Compound Preparation Time
Compound Reservoir Identifier
Compound Solution
Compound Source
Compound Vehicle Concentration
Electr. Stimulus User Param. 1 Name
Electr. Stimulus User Param. 2 Name
Electr. Stimulus User Param. 3 Name
Electr. Stimulus User Param. 4 Name
Electr. Stimulus User Param. 5 Name
Electrical Stimulus Frequency
Electrical Stimulus Intensity
Key Stimulus
Light Stimulus Intensity
Light Stimulus User Param. 1 Name
Light Stimulus User Param. 2 Name
Light Stimulus User Param. 3 Name

Light Stimulus User Param. 4 Name
Light Stimulus User Param. 5 Name
Light Stimulus Wavelength
Mech. Stimulus User Param. 1 Name
Mech. Stimulus User Param. 2 Name
Mech. Stimulus User Param. 3 Name
Mech. Stimulus User Param. 4 Name
Mech. Stimulus User Param. 5 Name
Mechanical Stimulus Intensity
Other Stimulus User Param. 1 Name
Other Stimulus User Param. 2 Name
Other Stimulus User Param. 3 Name
Other Stimulus User Param. 4 Name
Other Stimulus User Param. 5 Name
Stimulus Control Signal
Stimulus Duration
Therm. Stimulus User Param. 1 Name
Therm. Stimulus User Param. 2 Name
Therm. Stimulus User Param. 3 Name
Therm. Stimulus User Param. 4 Name
Therm. Stimulus User Param. 5 Name
Thermal Stimulus Temperature

4.2.11 Paradigm Review

'Paradigm Review' displays data from all Series within the selected Paradigm in a modified Reanalysis Scope window. Access this window from the Data Navigator 'Available actions' menu 'Review Paradigm'.

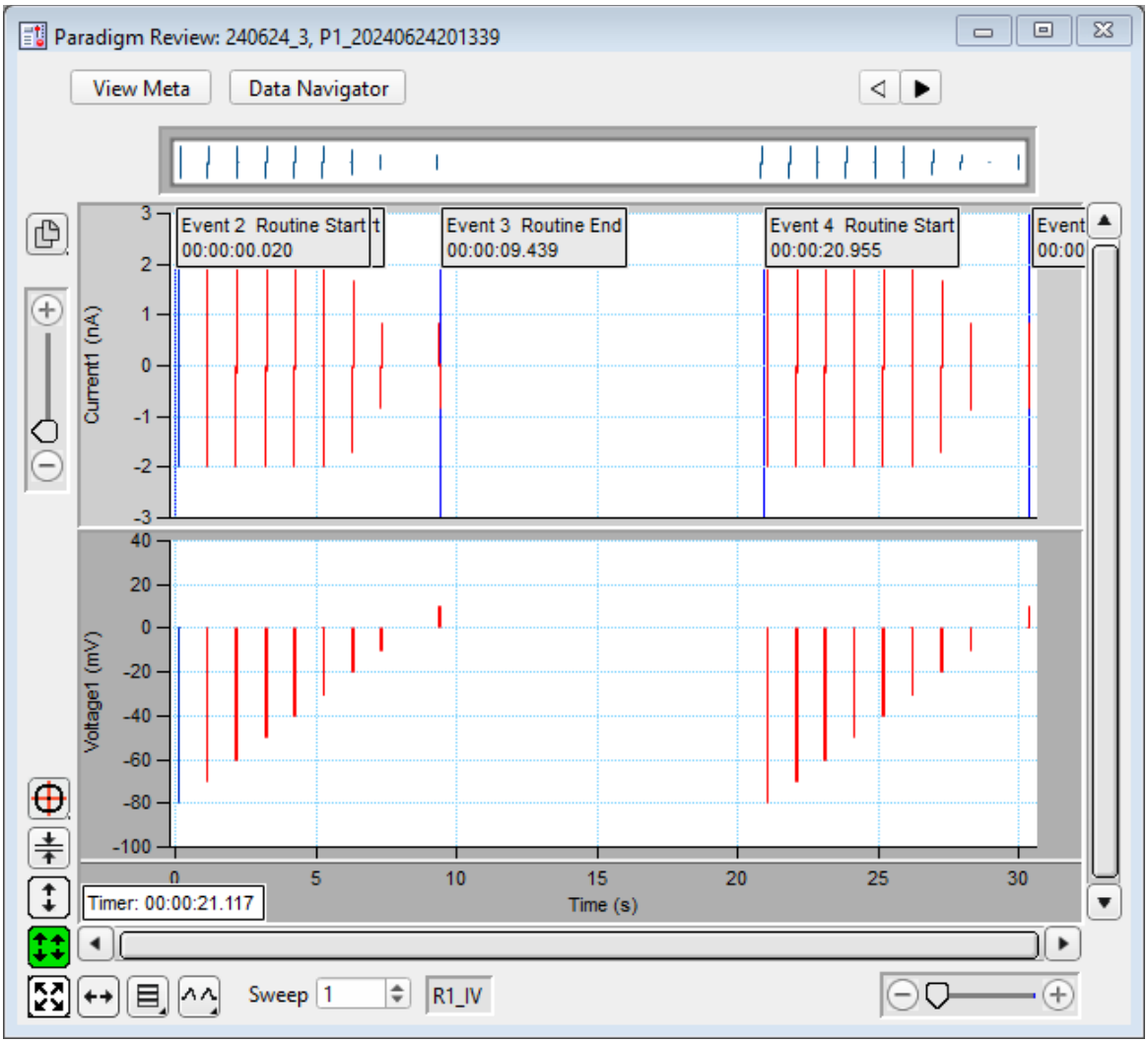


Figure 4-94. Paradigm Review Window

The selected sweep number and the Series_Routine name display at the bottom of the window.

Use the 'Show previous/next routine' buttons to jump to the first sweep of the previous/next Routine in the Experiment. The first sweep in the Routine is set to the active sweep color in all signals, as well as in the Scope Navigator above the signals. If the Routine is out of view, drag the Scope Navigator region to the desired data.

In Continuous display mode, all tags in the Paradigm display, including those between Series. The tag time is displayed in "Paradigm time". To see the tag time in "Routine time", display the Routine in a 'Routine Review' window.

In Concatenated display mode, only the first Routine's Start and End tags display.

Note: In the default 'Time Course' display mode, the first data point starts at ~100 ms, due to system overhead.

Also, the state of the continuous Autoscale button applies to all Paradigm Review, Routine Review and Paradigm Overview Scope windows.

To reopen a Series into a Reanalysis Scope window, right-click on the Series data, and select Analyze <Series Name> from the bottom of the menu list.

For more information on the Review window controls, see the Reanalysis Scope section below.

4.2.12 Reanalysis Measurements & Graphs

The Reanalysis Scope window Measurements button 'Edit Measurements' provides access to the 'Reanalysis Measurements & Graphs' dialog. Use it to apply different analysis scenarios to recorded data. Settings changes for input channel measurements and analysis graphs can override the loaded Routine for quick interactive control.

Note: This window will automatically close if the Reanalysis Scope window is closed,.

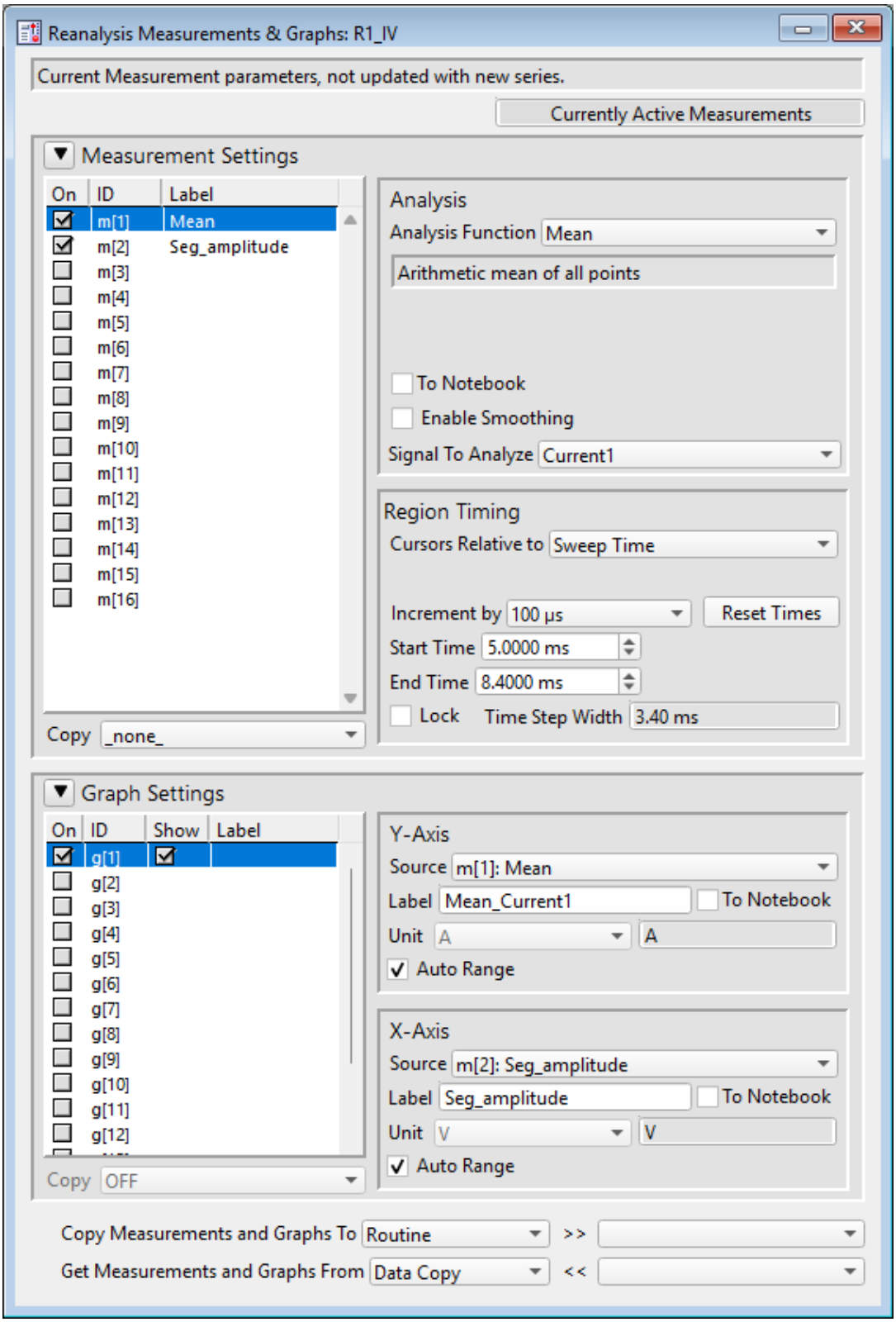


Figure 4-95. Reanalysis Measurements & Graphs

This dialog is similar to the Routine Editor: Real Time Measurements & Graphs dialog, with the

addition new fields at bottom of dialog:

Copy Settings To

none

Routine — Copy any changes to a Routine in the loaded Routine Pool. After copying, the field returns to "_none_"

File — Save the parameters to a "*.rtm" Measurement File.

Get Settings From

none — No entry.

Routine — Update the parameters from a Routine in the loaded Routine Pool. After copying, the field returns to "_none_"

Data Copy — Update the parameters from…

File — Update the parameters from a "*.rtm" Measurement File.

The current parameters can also be optionally overwritten (updated) from these sources, via these Reanalysis Scope 'Measurements' button selections:

- Analyze with Active Values
- Analyze with Original Routine Measurements
- Analyze with Routine Last Executed Measurements

Analysis Examples

Example 1: Plot the mean of the data (using sample routine IV).

1. Set measurement m[5] to the 'Mean' analysis and select signal Current1.
2. Enable graph g[5].
3. From the graph's Y-Axis list, select m[5]. The Equation field displays:
   m[5]
4. Set 'X-Axis' to 'time' .
5. Run the analysis.
6. An Analysis window displays a graph of the mean vs. time.

Example 2: Plot the difference between two measurements

1. Set measurement m[5] to the 'Mean' analysis and select signal Current1.
2. Set measurement m[6] to the 'Mean' analysis, using the same signal.
3. Adjust the m[6] cursors Start/End times so they do not overlap with the m[5] cursors.
4. Enable graph g[6].
5. For the graph's Y-Axis, select 'Y-Equation' and enter the equation as:

   m[5] – m[6].
6. Set the X-Axis to 'time'.
7. Run the analysis.
8. An Analysis window displays a graph of the difference vs. time.

4.2.13 Reanalysis Scope

This analysis version of the Scope window is used to display and reanalyze stored data.

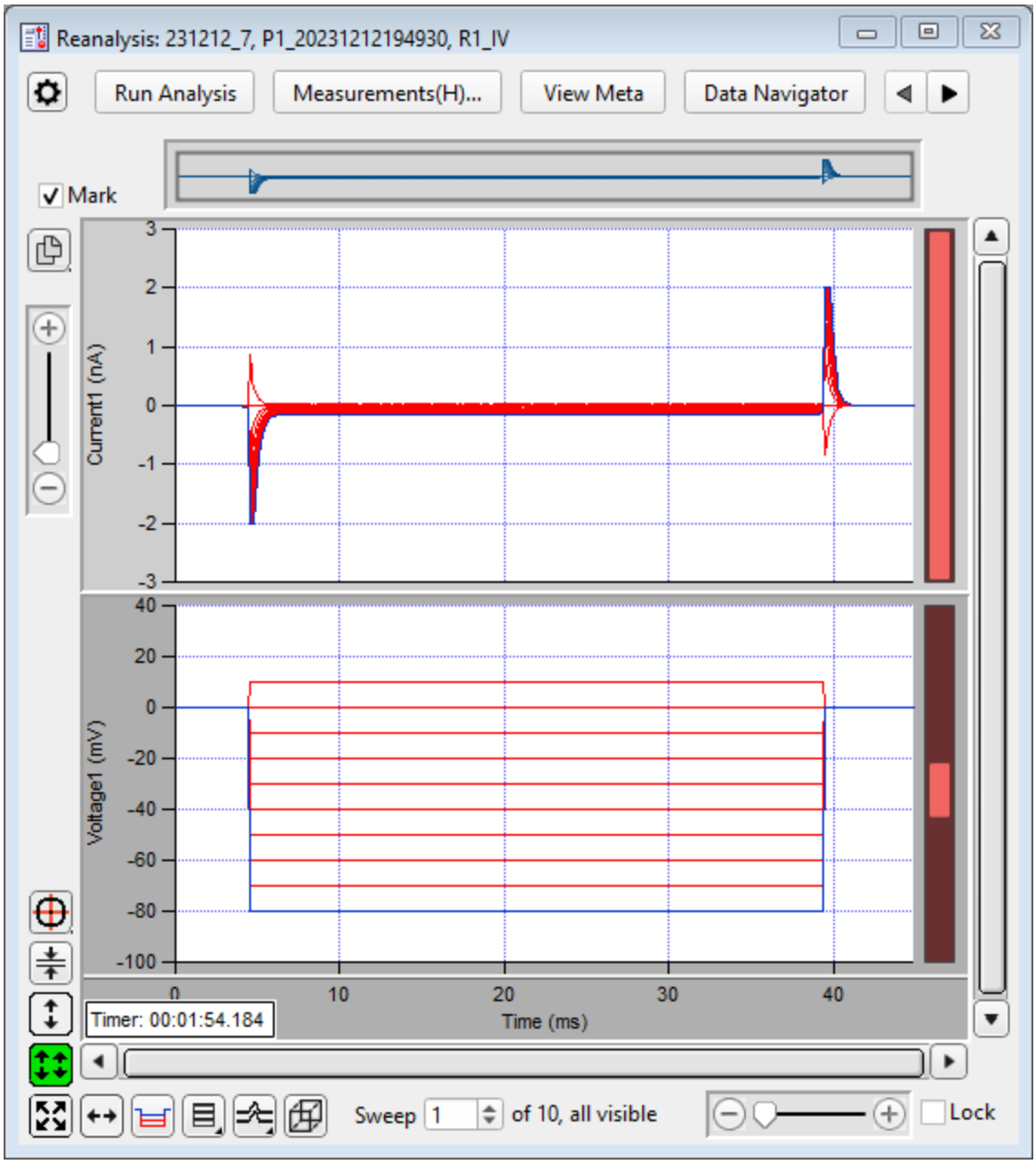


Figure 4-96. Reanalysis Scope Window

Both physical and virtual channels can be displayed and analyzed here.

Many window controls are the same as in the Acquisition Scope window, and are documented there. However, others have slight changes, and new controls were also added, as documented below.

Navigation pane

The Navigation pane appears at the top of the Reanalysis Scope window. It displays an overview of the active signal's full-scale data, with a gray box surrounding the magnification area.

Figure 4-97. Navigation Pane

The Navigation pane "magnification" box can be used to scroll through the active signal's data. Place the mouse cursor over the magnification box and it changes into a 'hand' icon; click and drag the magnification box to scroll through the data.

Buttons

Settings 	Scope Settings: Show all sweeps All sweeps are visible. Show marked sweeps Only marked sweeps are visible. The text "Showing Marked" displays above the Scope window 'Mark' check-box. --- Set all marks in sweeps of active series Clear all marks in sweeps of active series Set all marks in sweeps of active series by equation < see below > Note: Analysis is only run on visible sweeps.
Run Analysis	Run the defined analysis for the displayed sweeps of the active data series, and graph the results in the Analysis window. To stop a long-running analysis, click on the 'Abort' button in the bottom right corner of the main screen. Note: To stop a long-running analysis, click on the 'Abort' button in the bottom right corner of the main screen.
Measurements	Show Cursors: Display measurement cursors in the Scope window. Each measurement region is bounded by a start-time cursor (the left edge) and an end-time cursor (the right edge).

	To move a measurement region, click and drag it with the mouse - the region briefly turns dark when selected. To resize a measurement region, click and drag an end-time cursor (the right edge of a region.) Hide Cursors: Do not display cursors in the Scope window. Button displays as “Measurements(H)”. Lock Cursors: Prevent cursors from being adjusted or moved. Button displays as “Measurements(L)”.
	Clear Measurements and Graphs Analyze with Active Measurements Analyze with Original Routine Measurements Analyze with Routine Last Executed Measurements
	Edit Measurements: Open a special Reanalysis Measurements & Graphs dialog, where all changes apply instantly to the measurements and the graphs, even during acquisition. These edits override the loaded routine for quick interactive control. < see the Routine Editor Routine Settings for ‘Real-Time Measurements & Graphs’ > Edit Virtual Signals: Open the virtual input signals panel for editing. < see the Routine Editor Routine Settings for ‘Input Channels’ with a virtual input enabled >
	Action Potential Analysis Analyze action potentials. < see section above > Single Channel Analysis Analyze individual ion channels.

	< see section below > Synaptic Event Analysis Analyze synaptic events (EPSPs, mEPSPs, etc.) < see section below > Parametric Plot Plot the relationship between two signals. < see section below > Amplitude Histogram Plot Plot an amplitude histogram. < see section below > Color Plot Map the data to a color table. < see section below > Power Spectrum Plot a power spectrum graph. < see section below >
View Meta	Display any extra information (metadata) associated with the displayed data Series, such as the operator, preparation details, solution information, etc., in a floating window.
Data Navigator	Open a Data Navigator window with all of your Experiment data and metadata available in a tree structure.
	Show and analyze [Previous / Next] Routine. Any associated Measurements are displayed in a docked Analysis window.
[ ] Mark	Enable/disable to “mark/unmark” the active sweep for display and/or analysis. The Data Navigator ‘Available Actions’ can process marked sweeps as a group.

	When the Scope Settings 'Show marked sweeps' is enabled, the text "Showing Marked" displays above the Scope window 'Mark' checkbox.
Copy 	Copy graphs To Notebook (as text) < unavailable > To Notebook (as graph) Copy the active signal as a graphic to the Notebook; to copy all visible signals, press with "Shift" key. To Clipboard (as text) < unavailable > To Clipboard (as graph) Copy the active signal as a graphic to the system clipboard; to copy all visible signals, press with "Shift" key. To Printer (as text) < unavailable > To Printer (as graph) Print the active signal directly to the default printer as raw output; to print all visible signals, press with "Shift" key. To Layout (as graph) Copy all visible signals and analysis graphs as a graphic into a new Layout window, or append to an existing Layout page.
 Y-Mag Combo	Click on the "+" and "-" buttons to magnify / unmagnify by steps, or click and drag the slider to smoothly zoom / unzoom the active signal. The Y-axis magnification only controls the active pane.
 Show Cursors	Use to manually measure X-Y data points or to fit the data. < see the 'Signal data' section below >

 Center Signal.	Center the Y-range of the X-axis data in the active signal pane. The Y-axis offset is automatically adjusted, while the X-axis scaling is unchanged. To center all signals, shift-click the button.
 Y-Autoscale	Click to autoscale the Y-axis of the selected signal to its visible sweeps data limits. To autoscale the Y-axes of all visible signals, in Windows Shift-click the button, or in macOS Control-click the button. To include the zero amplitude in the Y-ranges, enable "Include zero when autoscaling" in Set Preferences / Scope Window / General. Tip! To invert the Y-axis of the selected signal, such as for data with reversed polarity from an outside-out patch, right-click in the Y-axis of the signal and select Axis Properties / Axis Range. Either reverse the Manual Range Settings / Minimum and Maximum values, or disable the Manual Range and enable the Autoscale Settings / Reverse axis.
 Continuous Autoscale Y-axes	Click to continuously autoscale the Y-axes of all signals to their visible sweeps data limits during reanalysis. The Continuous Autoscale button remains enabled (green) in this state. However, continuous autoscaling is disabled by any changes to the Scope window Y-axis scaling or offset. To include the zero amplitude in the Y-ranges, enable "Include zero when autoscaling" in Set Preferences / Scope Window / General.
 Autoscale All Axes	Click to one-time autoscale the Y-axes of all signals to their visible sweeps data limits and to set the X-axis range to the maximum defined sweep duration for all signals. To include the zero amplitude in the Y-ranges, enable "Include zero when autoscaling" in Set Preferences / Scope Window / General.
 X-Autoscale	Click to set the X-axis range to the maximum defined sweep duration for all signals. Shift-click the button to access additional X-axis scaling options: Autoscale the X-axis Maximize the X-axis range.

	Set X-Axis Scale — Manually set the X-axis range. X-min — Enter the minimum time point. X-max — Enter the maximum time point. Note: The X-min and X-max values can use different time units. < only for Series with Trigger Action: Clock Triggered or Externally Triggered Series, no Output Waveforms, Acquisition Mode: Continuous, Sweep Cycles: 1 > Change Scope duration to — Enter new sweep duration in seconds Restore — Restore the prior X-axis range.
 Persistence Display	Enable: Display all sweeps (per Marks and Scope Preferences limits). Disable: Only the active sweep is displayed. Also applies to the Scope window Measurements graphs: Parametric Plot Amplitude Histogram Plot Color Plot Power Spectrum
 Signal Layout	Graphically arrange the input signals. Stack: A vertical column of signals. Single: Only the active signal. m x n: A tiled array of signals with 'm' rows and 'n' columns.
Display Mode	This button has 3 display modes:

	Sweeps 	Each data trace starts the first data point from time zero to the duration of the wave-form . To view tags, switch to a 'Time Course' or 'Concatenated' display.
	Time Course 	Display sweeps in time sequence on a single time axis. Portions without data are left blank (such as the time between triggered sweeps.) Note: a) The first data point is delayed by 10's of ms after "time zero" due to Routine startup overhead time. b) Emulation mode has a minimum 0.5 s interval between sweeps, both triggered and continuous. If the sweep duration is less than 0.5 s, the time between sweeps will be padded with "blank" time. c) Routine Start" & "Routine End" tags occur outside of the actual Routine time, and may or may not display, depending upon end-range effects.
	Concatenated 	Display sweeps in time sequence on a single time axis. Portions without data, are re-placed by a vertical line. Display sweeps in time sequence on a single time axis. Portions without data, are re-placed by a vertical line. Note: a) The first data point is delayed by 10's of ms after "time zero" due to Routine startup overhead time. b) Emulation mode has a minimum 0.5 s interval between sweeps, both triggered and continuous. c) All tags display.

 3D View	The 'Show 3D view of current signal' button brings up a separate 3D display window attached to the right of the Analysis window. The Sweep data are color-coded for amplitude, and their 3D graph can be rotated in any direction. < see below >
Sweep #:	The 'Sweep #' display at the bottom of the Scope window indicates the 'active sweep' number, the total number of sweeps in the Series, and either "all" or the total number of visible sweeps (per Preferences).
 X Mag Combo	Click on the "+" and "-" buttons to magnify/unmagnify by steps, or click and drag the slider to smoothly zoom/unzoom the active signal. The X-axis magnification controls all signals time axes.
[ ] Lock	Lock the X-axis range Enable this checkbox to retain the X-axis scaling and position for the next activated or created scope window (Acquisition, Analysis, Free Run, Membrane Test). However, any changes to the X-axis duration (rescaling or autoscaling) or position (scrolling) disables the 'Lock' option.

Table 4-6. Reanalysis Scope Window Buttons

Tags are only shown in the Time Course and Concatenated display modes. They display as vertical blue lines at the tag time points in the data. Their associated text boxes are positioned in the top-most signal pane:

Event < # > Tag Comment

< Time stamp >

Comment: < text >

Settings

"Set all marks in sweeps of active series by equation"

This new option in the Settings menu opens an Equation Editor:

Sweep Mark: Equation Editor

Equation [ ]

value >= 0.1 = 1 < marked >

value < 0.1 = 0 < unmarked >

[Undo] Remove all edits to the equation.

[Check Equation] Check the equation syntax. The equation is evaluated, and if valid, it reports "Syntax is ok."

[Insert special identifier]

sweep

Odd(sweep)

Even(sweep)

[Do Mark] Evaluate the equation and update the sweep marking.

[Status message]

Measurements and Plots

< continued from above >

Parametric Plot Display a graph of X vs. Y input signals in a separate window.

Note: If this window is left open when the Scope window is closed, it will also close; and re-opening the Scope window will also re-open the Parametric Plot window.

Y-signal [< signal >] [↓]

Available signals.

Select an input signal for the Y-axis.

X-signal [< signal >] [↓]

Available signals.

Select an input signal for the X-axis.

Time Range [< time >] [↓]

The time range of the data to be plotted.

- Full Sweep Use the entire sweep for the time range.

- Sweep Time — Set relative to the start time of a sweep (as time zero).

  Start Time [<# s>]

  Set the starting time.

  Once the Start Time is within 2 sample points of the End Time, further Start Time increments will increase the End Time by the same amount.

  End Time [<# s>]

  Set the ending time.

  Once the End Time is within 2 ms of the Start Time, the End Time cannot be decremented.

- Segment Time — Set the time range as a ratio of the Segment duration.

  Segment — Select the Segment number.

  Start Ratio [<# s>]

  Set the starting time ratio.

  0 = beginning of Segment

  End Ratio [<# s>]

  Set the ending time ratio.

  1 = end of Segment

[ ] Autoscale Y Range

Enable to keep the data visible by automatically scaling the vertical axis.

Disable to manually scale the Y-axis.

Y-min [<#>]

Manually set the Y-axis minimum.

Y-max [<#>]

Manually set the Y-axis maximum.

Copy the parametric plot

To Notebook (as text)	Copy the Parametric Plot sweeps value pairs as text to the Notebook.
To Notebook (as graph)	Copy the Parametric plot as a graphic to the Notebook.
To Clipboard (as text)	Copy the Parametric Plot sweeps value pairs as text to the system clipboard.
To Clipboard (as graph)	Copy the Parametric plot as a graphic to the system clipboard.
To Printer (as text)	Print the Parametric Plot sweeps value pairs as text to the default printer.
To Printer (as graph)	Print the Parametric plot directly to the default printer as raw output.
To Layout (as graph)	Copy the Parametric plot as a graphic into a new Layout window, or append to an existing Layout page.

Scan or extract data

• Scan data	Open a floating window to manually measure X-Y data points in the active sweep. < see 'Signal Data/Scan signal data' below >
• Fit data	Open a floating window to fit the data. < see 'Signal Data/Fit signal data' below >
• Extract data	Open a floating window with data extraction controls. < see the Analysis Window 'Extract analysis data' above >

Alert! If magnifying the plot X-range, it is recommended to use the Time range control in the plot vs. using the marquee

"Expand" controls, which can result in non-optimal axis settings or out-of-bounds points in the graph.

[ ] Plot — Update the plot using the new parameters.

[graph pane] — Displays the plotted data.

Amplitude Histogram Plot

Open a histogram plot window. The amplitude data are binned and plotted. The window is cleared at the start of a new Series.

Note: If this window is left open when the Scope window is closed, it will also close; and re-opening the Scope window will also re-open the Amplitude Histogram Plot window.

Y-signal — [< signal >] [↓]

Available signals.

Select the input signal to be analyzed.

Time Range — [< time >] [↓]

The time range of the data to be plotted.

- Full Sweep — Use the entire sweep for the time range.
- Sweep Time — Set relative to the start time of a sweep (as time zero).

  Start Time — [<#>]

  Set the starting time.

  End Time — [<#>]

  Set the ending time.

- Segment Time — Set the time range as a ratio relative to the Segment duration.

  Segment — Select the Segment number.

  Start Ratio — [<#>]

  Set the starting time ratio.

  0 = beginning of Segment

End Ratio [<#>]

Set the ending time ratio.

1 = end of Segment

[ ] Autoscale X Range

Enable to keep the data visible by automatically scaling the horizontal axis.

Disable to manually scale the X-axis.

X-min [<#>]

Manually set the X-axis minimum.

X-max [<#>]

Manually set the X-axis maximum.

Histogram Bins [50, 100, 200, 500, 1000, 2000, 4000] [↓]

Select the number of bins for the amplitude range (X-axis). Changes instantly update the plot.

[ ] Cityscape Display the plot line using steps, no interpolation.

 Copy to Clipboard

To Notebook (as text) Copy the Amplitude histogram amplitude/bin count values as text to the Notebook.

To Notebook (as graph) Copy the Amplitude histogram as a graphic to the Notebook.

To Clipboard (as text) Copy the Amplitude histogram amplitude/bin count values as text to the system clipboard.

To Clipboard (as graph) Copy the Amplitude histogram as a graphic to the system clipboard.

To Printer (as text) Copy the Amplitude histogram amplitude/bin count values as text to the default printer.

To Printer (as graph) — Print the Amplitude histogram directly to the default printer as raw output.

To Layout (as graph) — Copy the Amplitude histogram as a graphic into a new Layout window, or append to an existing Layout page.

Scan or extract data

- Scan data — Open a floating window to manually measure X-Y data points in the active sweep.
  < see 'Signal Data/Scan signal data' below >
- Fit data — Open a floating window to fit the histogram data.
  < see 'Signal Data/Fit signal data' below >
- Extract data — Open a floating window with data extraction controls.
  < see 'Signal Data/Extract signal data' below >

Alert! If magnifying the plot X-range, it is recommended to use the Time Range control in the plot vs. using the marquee "Expand" controls, which can result in non-optimal axis settings or out-of-bounds points in the graph.

[Plot] — Update the plot using the new parameters.

[graph pane] — Displays the plotted data.

Color Plot — Plot amplitude data in a false-color graph of Sweep vs. Time.

Tip! This "heat map" display mode is commonly used in fast-scan cyclic voltammetry.

The data display for a sweep is centered on its Y-axis whole number tick mark (±0.5).

Note: If this window is left open when the Scope window is closed, it will also close; and re-opening the Scope window will also re-open the Color Plot window.

Signal [< signal >] [↓]

Available signals.

The color graph is based on the selected input signal name.

If no such signal name exists in the current Series, the color graph is blank.

[< range >] [↓] Select the Y-range to be used for a Plot.

- Auto Range Use an autoscaled Y-axis range for the data.
- Use Scope Y Axis min and max

  Use the existing Y-range for the data.
- Given min and max

  Manually set the Y-axis data limits for the color mapping.

  Min [<#>]

  Manually set the Y-axis minimum.

  Max [<#>]

  Manually set the Y-axis maximum.

Color Table [< table >] [↓]

Color lookup tables.

[ ] Reverse Reverse the color lookup table.

 Copy the false color graph

To Notebook (as text)	< unavailable >
To Notebook (as graph)	Copy the Color graph as a graphic to the Notebook.
To Clipboard (as text)	< unavailable >
To Clipboard (as graph)	Copy the Color graph as a graphic to the system clipboard.
To Printer (as text)	< unavailable >

To Printer (as graph) — Print the Color plot directly to the default printer as raw output.

To Layout (as graph) — Copy the Color graph as a graphic into a new Layout window, or append to an existing Layout page.

Scan data or extract plot

- Scan data — Open a floating window to manually measure X-Y data points in the active sweep.

  < see 'Signal Data/Scan signal data' below >

- Extract plot — Open a floating window with data extraction controls.

  < see 'the Analysis Window 'Extract analysis data' above >

Note: If a plot region is magnified with the marquee "Expand" controls, the entire graph is still extracted.

[Plot] — Update the false-color graph using the new parameters.

[graph pane] — Displays the color graph.

Power Spectrum — Plot power spectrum data in a graph of Magnitude vs. Frequency.

Note: If this window is left open when the Scope window is closed, it will also close, but then re-opening the Scope window will also re-open the Power Spectrum window.

FFT output mode — [< mode >] [↓]

Available modes :

Real output

Magnitude

Magnitude squared

Scaled magnitude

Scaled magnitude squared

Signal [< signal >] [↓]

Available signals.

The Power Spectrum is based on the selected input signal.

If no such signal name exists in the current Series, the Power Spectrum graph is blank.

Copy Power Spectrum

To Notebook (as text)	Copy the Power Spectrum frequency/magnitude values as text to the Notebook.
To Notebook (as graph)	Copy the Power Spectrum as a graphic to the Notebook.
To Clipboard (as text)	Copy the Power Spectrum frequency/magnitude values as text to the system clipboard.
To Clipboard (as graph)	Copy the Power Spectrum as a graphic to the system clipboard.
To Printer (as text)	Print the Power Spectrum frequency/magnitude values as text to the default printer.
To Printer (as graph)	Print the Power Spectrum directly to the default printer as raw output.
To Layout (as graph)	Copy the Power Spectrum as a graphic into a new Layout window, or append to an existing Layout page.

Scan or extract data

• Scan data	Open a floating window to manually measure X-Y data points in the active sweep. < see 'Signal Data/Scan signal data' below >
• Fit spectra	Open a floating window to fit the power spectrum data.

< see 'Signal Data/Fit signal data" below >

- Extract data — Open a floating window with data extraction controls.

  < see 'Signal Data/Extract signal data' below >

[graph pane] — Displays the power spectrum graph.

Right-click Menus

X Axis

Autoscale All Axes — Scale all signals Y-axes to their data, and set the X-axis range for all signals to the maximum defined sweep duration.

Autoscale X Axis — Set the X-axis range for all signals to the maximum defined sweep duration.

Set X Scale — Manually set the X-axis range.

X-min — [<#>]

Minimum X-axis value.

X-max — [<#>]

Maximum X-axis value.

Axis Properties — Modify the axes style and components.

Y Axis

Autoscale All Axes — Autoscale all signals Y-axes to their data, and set the X-axis range for all signals to the maximum defined sweep duration.

Initial Autoscale Y Axis — Autoscale the signal's Y-axis based on the first 1% of the data.

Autoscale Y Axis — Autoscale the signal's Y-axis to its data.

Full scale Y Axis — Set the signal's Y-axis to its full-scale range.

Use Last Y Scale — Maintain the Y-axis scaling at its existing range, overriding any prior Y-axis scaling settings.

Set Y Scale — Manually set the Y-axis range.

Y-min [<#>]

Minimum Y-axis value.

Y-max [<#>]

Maximum Y-axis value.

Copy Y scale of signal [< signal >] [↓]

Apply the Y scaling from another signal.

Axis Properties — Modify the axis style and components.

Use to reverse the Y-axis polarity (such as for inside-out or cell-attached patches).

Axis Range tab

Manual Range Settings

[ ] Minimum: [<#>]

Enable and enter a positive number.

[ ] Maximum: [<#>]

Enable and enter a negative number.

or, if Y-axis autoscaling will be used:

Click the 'Uncheck Both' button, and…

Autoscale Settings

[ ] Reverse axis:

Enable to reverse.

Hide Signal < name > — Hide the selected signal in the Scope window.

Show Signal < name > Only — Show the selected signal in the Scope window, hide all other signals.

or

Show Single Signal — When only a single channel is visible, this selection displays as grayed out.

Stack All Signals	Display all signals stacked in a single column layout.

Main Window

Limited data modification menu

Right-click in the blank area in a signal pane.

Tip! If you click too close to the signal data, the full data modification menu displays instead; if this occurs, click near to a horizontal or vertical edge of the signal pane.

This context menu is the same as in the Acquisition: Scope window (plus a couple additional items):

- Show All Sweeps < with triggered sweeps >
- Show Marked Sweeps < with triggered sweeps >

Autoscale All Axes	Scale all signals Y-axes to their data, and set the X-axis range for all signals to the maximum defined sweep duration.
Add Annotation	Add a floating text-box label to the signal pane. To edit or delete an annotation, double-click on it.
Export Graphics	Export the signal graphics.
Colors	Adjust the colors used by the active signal pane:
graph background	The background of the pane.
all axes	The X- and Y-axis areas.
all grids	The grid lines in the pane.
all tick labels	The tick labels in the X- and Y-axis areas.
all axis labels	The axis labels in the X- and Y-axis areas.
Hide Signal < name >	Hide the selected signal in the Scope window.
Show Signal < name > Only	Show the selected signal in the Scope window, and hide all other signals.
or	
Show Single Signal	When only a single channel is visible, this selection displays as grayed out.
Stack All Signals	Display all signals stacked in a single column layout.
Show All Sweeps	

Show Marked Sweeps

Move Tags to Default Position

If tags are visible in a signal, such as in 'Time Course' display mode, and their text boxes are dragged to new locations, this feature will return the text boxes to their original default locations..

Marquee

Click and drag the mouse to surround a region of interest, and right-click for a context menu:

Expand	Set the signal's Y-axis range from the marquee vertical data limits, and set all signals X-axes ranges from the marquee horizontal data limits.
Horiz Expand	Set all signals X-axes ranges from the marquee horizontal data limits.
Vert Expand	Set the signal's Y-axis range from the marquee vertical data limits.
Shrink	Move the signal's Y-axis current limits to the position of the marquee vertical data limits, and move all signals X-axes current limits to the position of the marquee horizontal data limits.
Horiz Shrink	Move all signals X-axes current limits to the position of the marquee horizontal data limits.
Vert Shrink	Move the signal's Y-axis current limits to the position of the marquee vertical data limits.
Extract Template	Copy the last sweep to the Template Editor.
Extract To Graph	Display the active trace in a floating window, using all data within the X- range.

Set Time Range of Amplitude Histogram

< displays if an Amplitude Histogram is open >

Set Time Range of Analysis < displays if Single Channel Analysis is open >

Set Time Range of Parametric Plot

< displays if a Parametric Plot is open >

Signal Data

Full data modification menu

Right-click on or near the data to display this context menu, which includes options to modify sweeps and data points, such as marker symbols and lines.

This context menu is the same as in the Acquisition: Scope window.

For the display modes 'Time Course' and 'Concatenated', Igor Pro measurements are only correct within a single sweep. For measurements across multiple sweeps, use the 'Sweeps' display mode.

Scan, fit or extract < signal > data

- Scan < signal > data

  Open a floating window to manually measure X-Y data points in the active sweep.

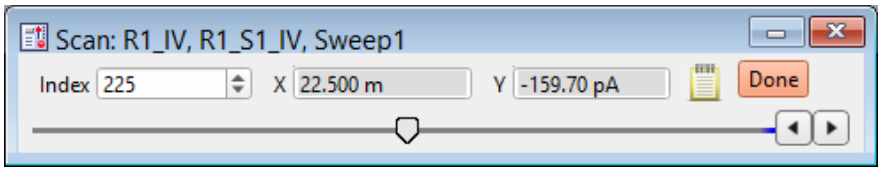


Figure 4-98. Scan Signal Data

Scan: Routine#_Routine name, Routine#_Signal_#_Routine name, Sweep #

Index	[< # >]	< for Scope data >
	[< 0 to (n-1) >]	< for Measurements plots >

The selected data point number.

A data point number can be entered, or use the increment/decrement controls to increase/decrease the selected data point by one point.

X [#]

The X-axis value of the selected data point.

Y [#]

The Y-axis value of the selected data point.

Write to Notebook

Click to write to the Notebook:

Routine#_Routine_name	Name.
sweep=#	Sweep.
< for Scope data >	
index=#	Point.
x= #	X data value.
y= #	Y data value.
< for Measurements plots >	
index[signal name]=#	Point.
x[signal name]= #	X data value.
y[signal name]= #	Y data value.

If the Shift key is pressed, write the information for all signals to the Notebook.

Close the “Scanner” floating window.

This window also automatically closes when you click outside of it.

X-slider bar

Click and drag the slider for the data-point cursor.

The data cursor display mode is set in ‘Set Preferences / Graphs and Layouts’.

Click to decrement/increment the data cursor by one point at a time, or with the Shift-key, by 10 data points.

Or, the keyboard left/right-arrow keys decrease/increase the selection by one data point; with the Shift key, they decrease/increase the selection by 10 data points.

Or, the keyboard Up/Down arrow keys decrease/increase the selection by 10 data points.

Additional Scope Window Controls

Additional controls are also added to the top of the Scope window, until its 'Done' button closes Scope mode.

Done — Close the Scope mode.

↔ — Click to display the "Scanner" floating window.

[< signal >] [↓]

Signal selector drop-down list.

Sweep [#]

The active sweep selection.

Index [<#>] < for Scope data >

[< 0 to (n-1) >] < for Measurements plots >

The selected data-point number in the sweep.

A data-point number can be entered, or use the increment/decrement controls to increase/decrease the selected data-point by one point.

X [#]

The X-axis value of the selected data point.

Y [#]

The Y-axis value of the selected data point.

 Write to Notebook

Click to write to the Notebook:

Routine#_Routine_name	Name.
sweep=#	Sweep.
< for Scope data >	
index=#	Point.
x= #	X data value.

y= #	Y data value.
< for Measurements plots >	
index[signal name]=#	Point.
x[signal name]=#	X data value.
y[signal name]=#	Y data value.

If the Shift key is pressed, write the info for all signals to the Notebook.

- Fit < signal > data

  Open a floating window to fit the < signal > data.

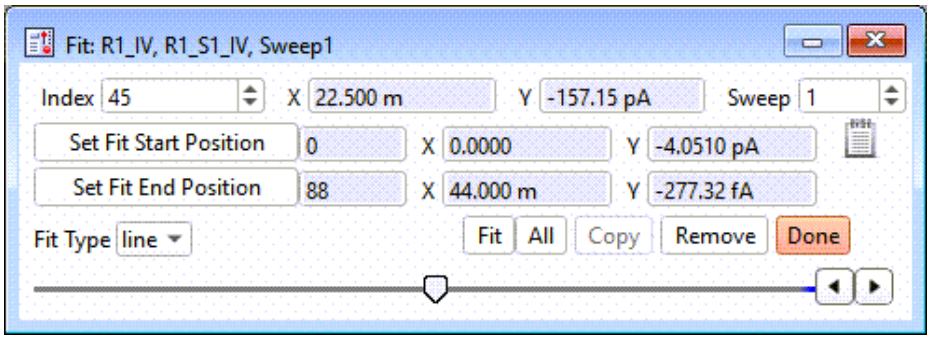


Figure 4-99. Fit Signal Data

Fit: Routine#_Routine name, Routine#_Signal_#_Routine name, Sweep #

Index	[<#>]	< for Scope data >
	[0 to (n-1)]	< for Measurements plots >

The selected data point number in the active sweep.

A data point number can be entered, or use the increment/decrement controls to increase/decrease the selected data point by one point.

X	[#]

The X-axis value of the selected data point.

Y	[#]

The Y-axis value of the selected data point.

Write to Notebook.

Click to write the last fit results to the Notebook.

[Set Fit Start Position]

Click to set the starting point of the fit.

Shift-click to set it to the array minimum.

[<#>] Index number of the fit start.

X [#]

The X-axis value of the fit start.

Y [#]

The Y-axis value of the fit start.

[Set Fit End Position]

Click to set the ending point of the fit.

Shift-click to set it to the array maximum.

[<#>] Index number of the fit end.

X [#]

The X-axis value of the fit end.

Y [#]

The Y-axis value of the fit end.

Fit Type [<fit>] [↓]

Select the fitting function:

line
poly
poly_XOffset
gauss
Ior
Voigt
exp_XOffset
dbexp_XOffset
exp

dblexp

dblexp_peak

sin

HillEquation

Sigmoid

Power

LogNormal

Log

[Fit] Click to perform the fit, and replace any previous fit.

[All] Click to perform the fit on all sweeps.

[Copy] Copy the fit line to the Analysis Editor.

[Remove] Remove the fit line and cursors from the Scope.

Close the “Fitter” floating window.

This window also automatically closes when you click outside of it.

X-slider bar

Click and drag the slider for the data-point cursor.

The data cursor display mode is set in ‘Set Preferences / Graphs and Layouts’.

Click to decrement/increment the data cursor by one point at a time, or with the Shift-key, by 10 data points.

Or, the keyboard left/right-arrow keys decrease/increase the selection by one data point; with the Shift key, they decrease/increase the selection by 10 data points.

Or, the keyboard Up/Down arrow keys decrease/increase the selection by 10 data points.

- Extract < signal > data

  Open a floating window with data extraction controls.

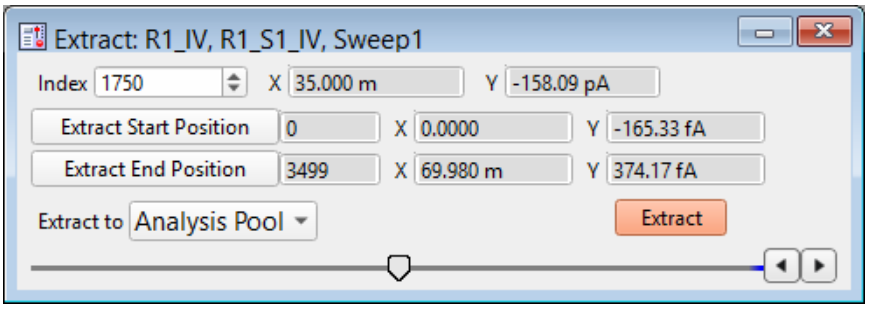


Figure 4-100. Extract Signal Data

Extract: Routine# Routine name, Routine# Signal # Routine name, Sweep #

Index [<#>] < for Scope data >

[0 to (n-1)] < for Measurements plots >

The selected data point number in the sweep.

A data point number can be entered, or use the increment/decrement controls to increase/decrease the selected data point by one point.

X [#]

The X-axis value of the selected data point.

Y [#]

The Y-axis value of the selected data point.

[Extract Start Position]

Click to set the starting point of the data extraction.

[<#>] Index number of the extraction start.

X [#]

The X-axis value of the extraction start.

Y [#]

The Y-axis value of the extraction start.

[Extract End Position]

Click to set the ending point of the data extraction.

[< # >] Index number of the extraction end.

X [#]

The X-axis value of the extraction end.

Y [#]

The Y-axis value of the extraction end.

Extract to [< target >] [↓]

Select the data extraction target:

Analysis Pool — Extract the data to a Data / Data Browser wave, as configured in Set Preferences / Data Export / Copy Data Waves to Igor Folder.

Template Pool — Extract the signal to a Template Editor template wave.

Data Export Target Folder

Extract the data to a Data / Data Browser wave, as configured in Set Preferences / Data Export / Copy Data Waves to Igor Folder.

To Standalone Graph

Extract the signal to a separate graph window; if a fit has been performed, only the fitted line is extracted.

To Notebook — Extract the graph as a graphic to the Notebook.

To Clipboard — Extract the graph as a graphic to the system clipboard.

To Printer	Print the graph as a graphic directly to the default printer as raw output.
[Extract]	Click to extract the selected data.
	X-slider bar Click and drag the slider for the data-point cursor. The data cursor display mode is set in 'Set Preferences / Graphs and Layouts'.
	Click to decrement/increment/ the data cursor by one point at a time, or with the Shift-key, by 10 data points. Or, the keyboard left/right-arrow keys decrease/increase the selection by one data point; with the Shift key, they decrease/increase the selection by 10 data points. Or, the keyboard Up/Down arrow keys increase/decrease the selection by 10 data points.

This floating window automatically closes when you click outside of it.

Channel Timing

IPA amplifiers record both headstage stimulus and response signals via physical analog channels, so all recorded signals are precisely in sync, with no timing delays between them.

4.2.14 3D View Window

 Show 3D View

The Reanalysis Scope 3D View window creates a three dimensional representation of your data., where a surface plot is color-coded to show amplitude variations. This 3D view can be especially helpful during assay development.

The axis definition in 3D View is based on the change of a waveform over the course of successive sweeps.

In the default orientation of the 3D View, the Z axis, on which the Sweep Number is plotted, points backwards to the right.

In a two-dimensional display, the X-axis represents the Sweep Time, while the Amplitude is plotted on the vertical Y-axis. For consistency, the vertical axis in the SutterPatch 3D view is also defined as the Y-axis.

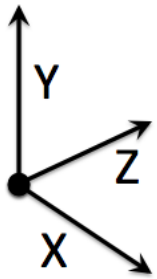


Figure 4-101. 3D Axes Definition

Note: 1) If the Igor Pro/SutterPatch main window frame is smaller than the Reanalysis Scope window plus its Analysis sub-window, clicking the 3D button will generate an error message, but the operation will still execute.

2) The performance of the 3D View is dependent upon the power of the computer system's graphics card.

3) For Apple iMac users, 3D View requires a computer based on the M1 chip.

4) Using Rosetta 2 on a Mac can take a long time to load the 3D "gizmo". However, this does not affect performance once loading is completed.

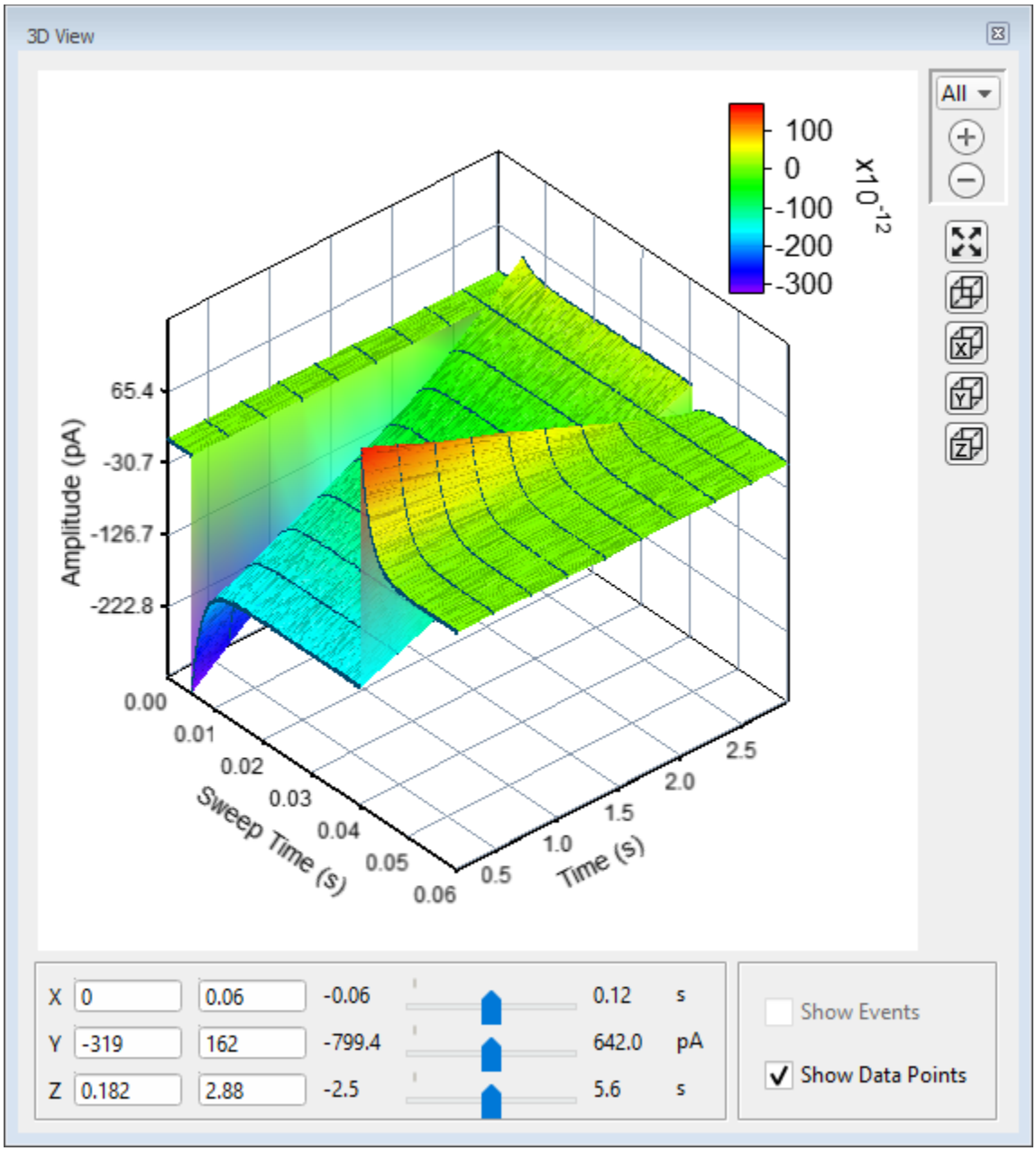


Figure 4-102. 3D View

A “heat map” bar illustrates the color measurement units.

Magnification buttons are located in the upper right corner of the window for the selected axis:

[< axis >] [↓]

- All All 3 axes
- X Sweep Time axis

- Y Amplitude axis
- Z Time axis

 Zoom in Magnify

 Zoom out Unmagnify

 Autoscale Set to the data limits.

X, Y and Z axis limits can be set in the bottom section of the 3D View window. Their delta value is preserved when using the scroll bars to update the visual graph (and the numeric axes limits.)

The 3D graph viewing angle can be changed with a set of 3D buttons:

 = Default View X, Y & Z axes display as autoscaled.

 X = Right View Y & Z axes display.

 Y = Top View Z & X axes display.

 Z = Front View X & Y axes display.

Alternatively, you can rotate the display in any direction by simply clicking and dragging the 3D graph. If you release the mouse button while dragging, the 3D display will rotate in the direction of the mouse drag.

[ ] Show Events Enable to display a translucent "tag plane" in the 3D graph for each tag event.

< grayed out if no tags in the data >

[ ] Show Data Points Display data points as surface dots in the 3D graph.

4.2.15 Routine Review

'Routine Review' displays data from the selected Series in a modified Reanalysis Scope window.

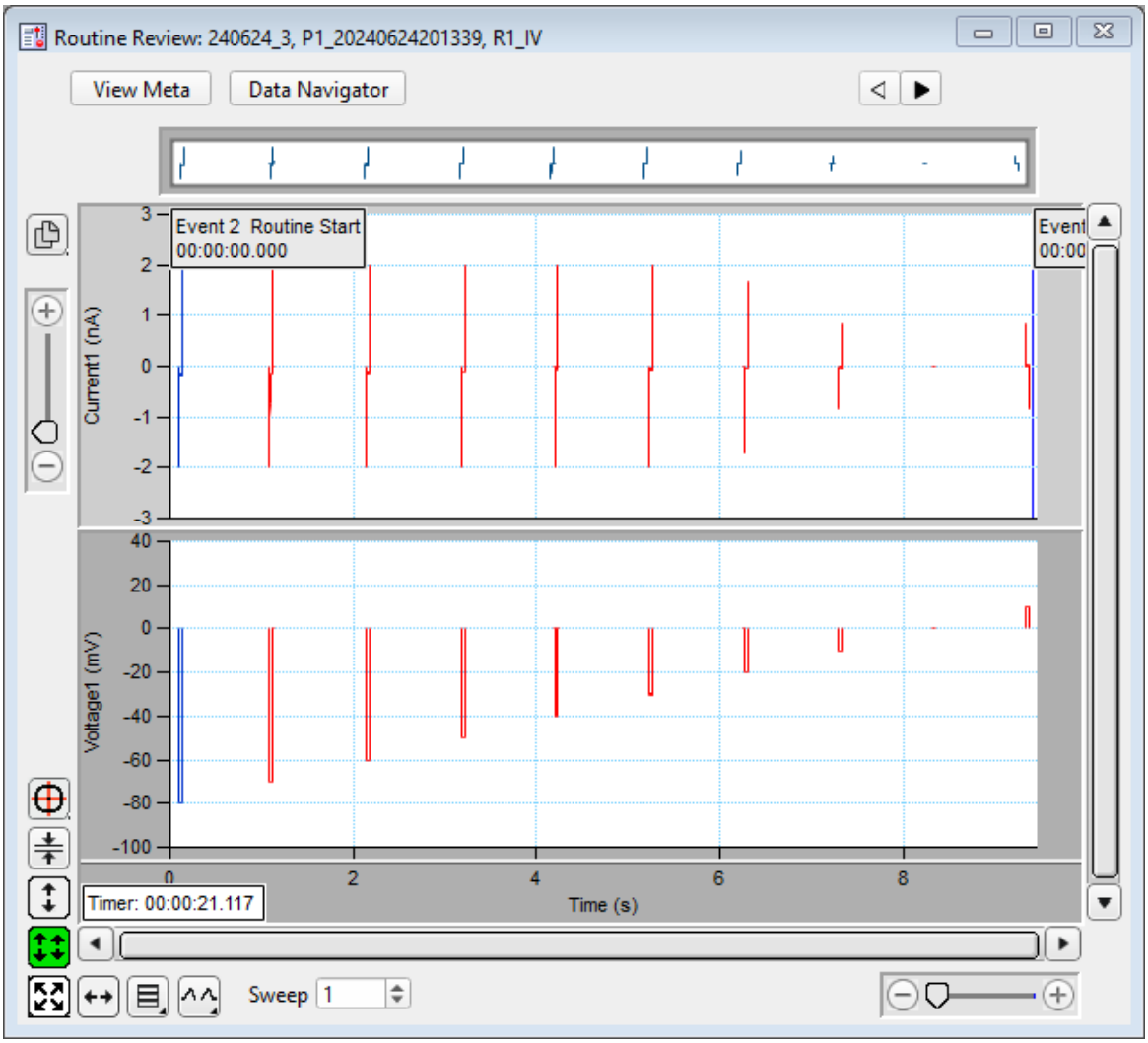


Figure 4-103. Routine Review Window

Access this window from the Data Navigator 'Available actions' menu 'Review Routine'.

The selected sweep number displays at the bottom of the window.

Use the 'Show previous/next routine' buttons to jump to the first sweep of the previous/next Routine in the Experiment. The first sweep in the Routine is set to the active sweep color in all signals, as well as in the Scope Navigator above the signals.

To reopen a Series into a Reanalysis Scope window, right-click on the Series data, and select 'Analyze <Series Name>' at the bottom of the menu list.

This review also displays all tags in the Series. The tag time is displayed in “Routine time”. To see the tag time in “Paradigm time”, display the Routine in a 'Paradigm Review' window.

Note: In the default ‘Time Course’ display mode, the first data point does not start at time = 0, due to system overhead.

Also, the state of the continuous Autoscale button applies to all Routine Review, Paradigm Review and Paradigm Overview Scope windows.

For more information on the Review window controls, see the Reanalysis Scope section.

4.2.16 Routine Settings

The Routine Settings window reports the same settings as would be seen in the Routine Editor / Routine Settings, however the preview pane does not support interactive dragging of measurement regions.

Open this window from the Data Navigator by highlighting a Series, and selecting the ‘View Routine Settings’ command from a right-click menu or the ‘Available actions’ button, or by selecting the ‘Routine’ name in the Data Navigator preview pane.

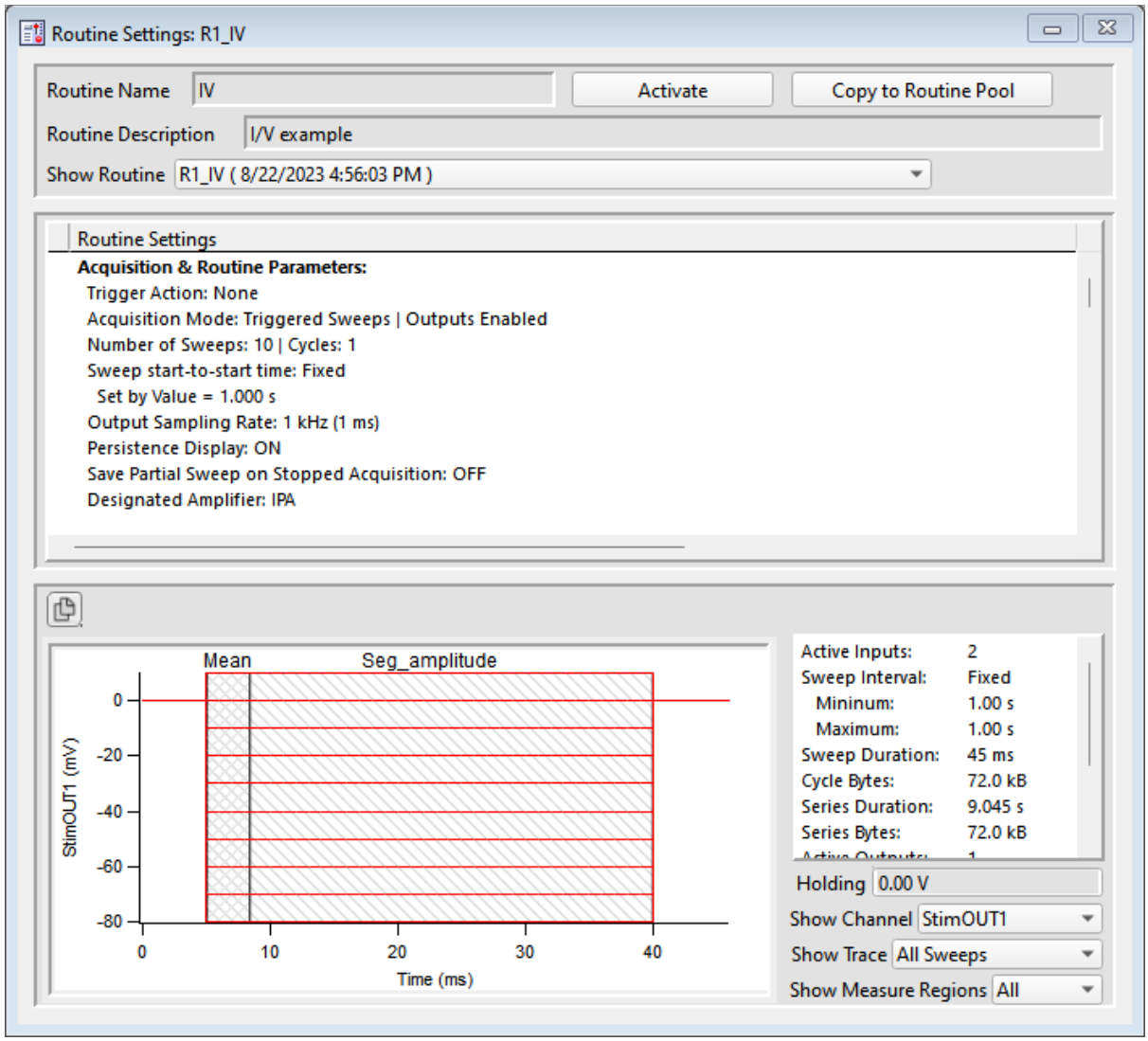


Figure 4-104. Routine Settings

Routine Name [< name >]

Displays the Routine name.

[Activate] Click to open the Acquisition: Scope window loaded with these settings.

[Copy to Routine Pool] Click to add this Routine to the active Routine Pool.

Routine Description [< text >]

Displays the Routine description.

Show Routine [< Routine >] [↓]

Select a named Routine.

Routine Settings — Listing of all settings of the Routine.

Sections

Acquisition & Routine Parameters

Input Channels

Output Channels & Waveform

Real Time Measurements & Graphs

Preview panel — Display of the stimulus waveforms.

Copy Preview — Copy the visible stimulus waveforms.

To Notebook (as text)	< unavailable >
To Notebook (as graph)	Copy the Preview graph as a graphic to the Notebook.
To Clipboard (as text)	< unavailable >
To Clipboard (as graph)	Copy the Preview graph to the system clipboard as a graphic.
To Printer (as text)	< unavailable >
To Printer (as graph)	Print the Preview graph as a graphic directly to the default printer as raw output.
To Layout (as graph)	Copy the Preview graph as a graphic into a new Layout window, or append to an existing Layout page.

Some key acquisition settings and display controls are listed on the right of the Preview pane:

Acquisition Settings

Active Inputs:

Sweep Interval:

Minimum:

Maximum:

Sweep Duration:

Cycle Bytes:

Series Duration:

Series Bytes:

Active Outputs:

Stim Duration:

Stim Points:

Cycle Duration:

Cycle Points:

Display Controls

Holding	[#]
Show Channel	[< channels >] [↓]
	Select the output signals to display.
Show Trace	[< traces >] [↓]
	Select the output traces to display.
Show Measure Regions	[< regions >] [↓]
	Select the measurement regions to display.

4.2.17 Single Channel Analysis

SutterPatch: Available Analysis Modules: Single Channel Analysis

Perform analysis of low-noise currents from single ion channels.

Access single-channel analysis via:

- the Reanalysis Scope window 'Measurements' button, or
- the Data Navigator (signal) 'Available actions' menu, or
- the main menu SutterPatch > Available Analysis Modules > Single Channel Analysis.

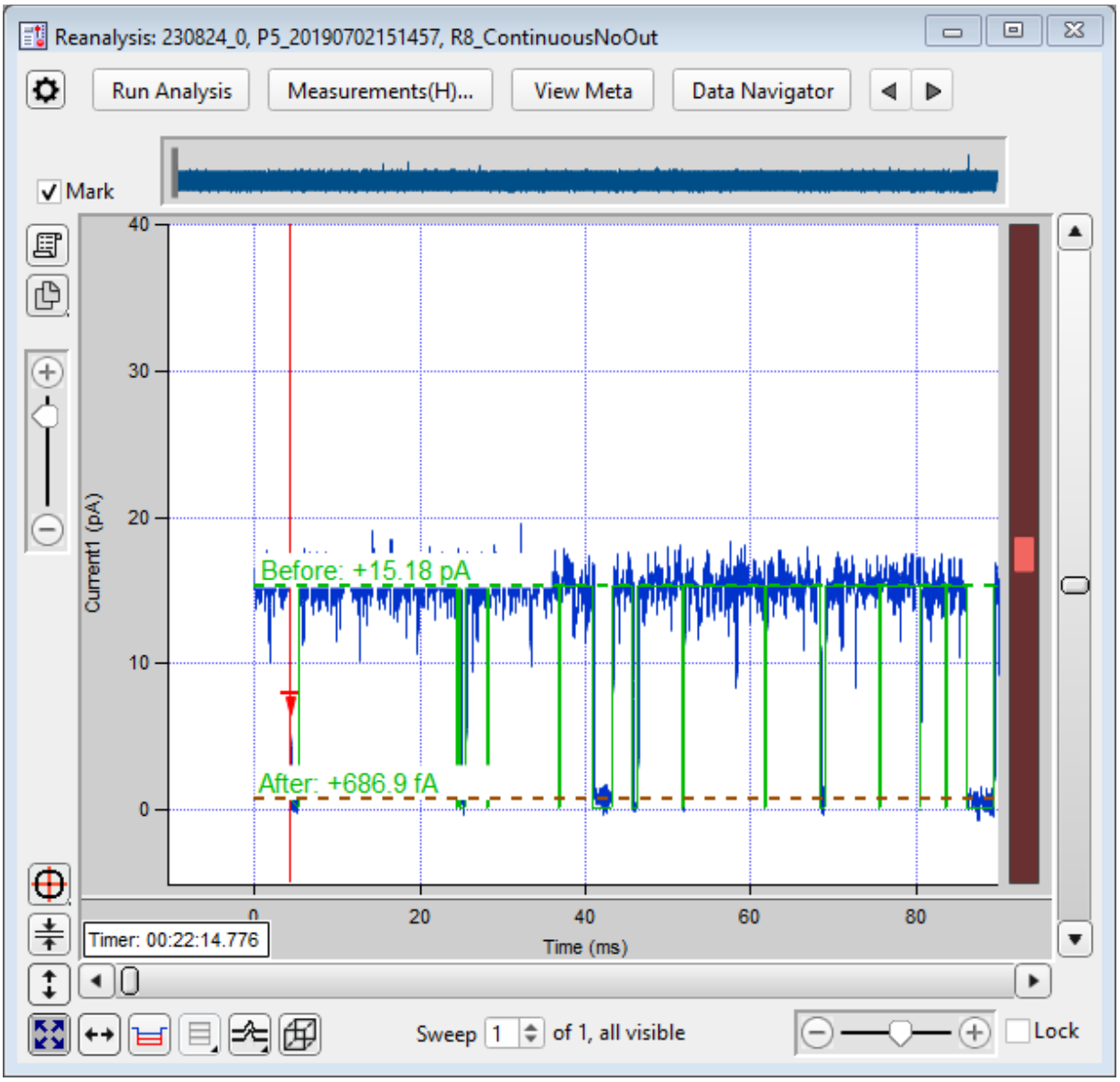


Figure 4-105. Single-Channel Scope

When single channel analysis is activated, the Reanalysis Scope window active signal is overlaid with the transition levels of the first single-channel opening or closing, and a Single Channel Analysis control panel is opened.

Note: Single-channel analysis only operates in the Scope 'Sweeps' display mode; the Concatenated and Time Course display modes are not supported.
Single Channel Analysis uses a special Scope window, where amplitude levels and transitions and are overlaid onto the raw data. When you click-and-drag in the Scope window, the closest amplitude level is repositioned to the new amplitude. Because of this, to access the marquee tool in the Scope window, hold down the shift key when you click-and-drag the mouse.

Marquee Right-click Menu

Expand	Set the graph's Y-axis range from the marquee vertical data limits, and set the graph's X-axis range from the marquee horizontal data limits.
Horiz Expand	Set the graph's X-axis range from the marquee horizontal data limits.
Vert Expand	Set the graph's Y-axis range from the marquee vertical data limits.
Shrink	Set the graph's Y-axis range to the positions of the marquee vertical data limits, and set the graph's X-axis range to the positions of the marquee horizontal data limits.
Horiz Shrink	Set the graph's X-axis range to the positions of the marquee horizontal data limits.
Vert Shrink	Set the graph's Y-axis range to the positions of the marquee vertical data limits.
Extract Template	Copy the last sweep to the Template Editor.
Extract To Graph	Display the active trace in a floating window, using all data within the X- range.
Set Time Range of Analysis	Sets the Single Channel Analysis 'Time Range' to 'Sweep Time', and the 'Start Time' and 'End Time' are set from the marquee range.

Scope window levels

- A dashed **green** "Before" line displays the amplitude of the previous transition/event, i.e., the level before the transition point. Manually adjust by dragging with the mouse.
- A dashed **brown** "After" line displays the amplitude of the selected transition/event, i.e., the level after the transition point. Manually adjust by dragging with the mouse.
- A solid **green** line displays the idealized trace of the found transitions/events.

  At times, the dashed amplitude lines might superimpose onto the idealized trace.
- A vertical **red** line displays at the transition point between the two levels, with a red arrow indicating the direction of the transition.

If the initial levels are incorrect, a couple of basic settings need to be adjusted:

1. Determine the starting amplitude of the data before the first transition.

   Zoom in on the Scope data, so that the open and closed state amplitudes are well visualized. Or run the 'Plots and Tables' 'Current Amplitude Histogram' to find the amplitude peaks in the binned data.

2. Set the 'Current Transition Controls' estimated 'Amplitude' signed value for the first level in the data. (Use negative numbers for negative-going openings.)

3. Set the Start Level number for the initial data (0 = baseline state, 1+ = open states).

4. Click on the 'Find target transition' section 'Clear All' button.

5. The Scope window resets the "Before" and "After" transition levels to proper values.

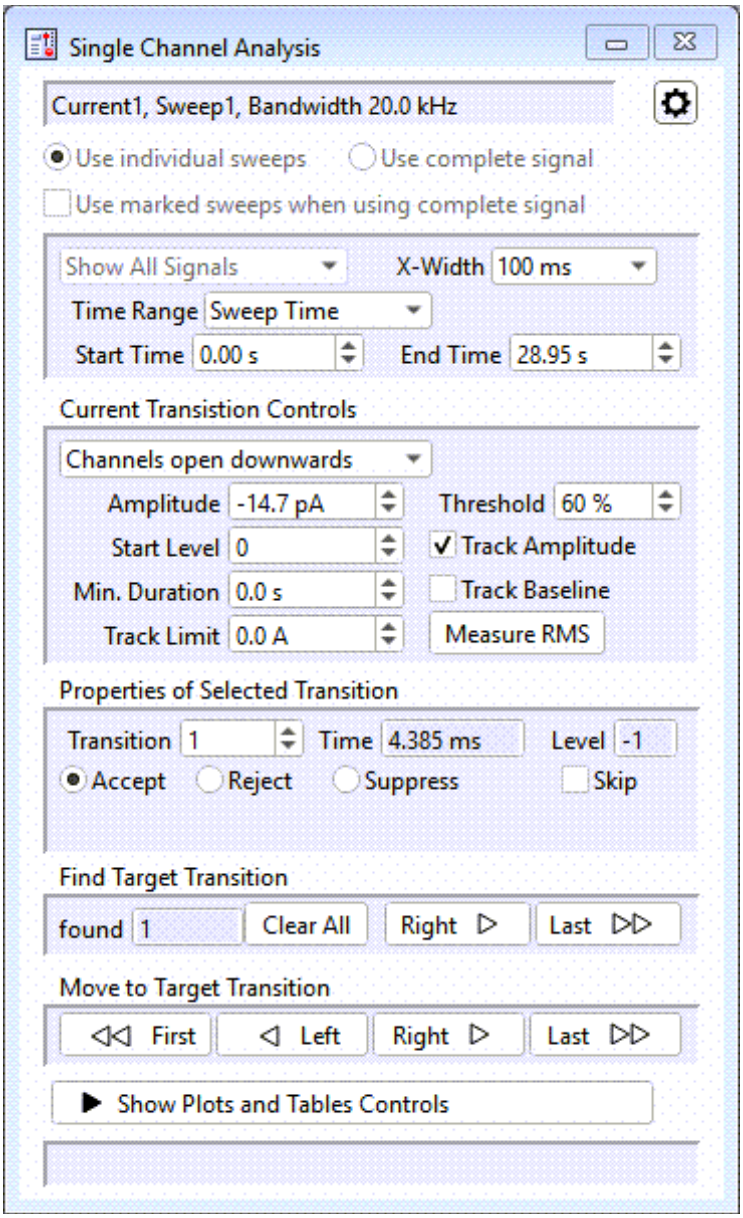


Figure 4-106. Single Channel Analysis

[< Channel name, Sweep#, Bandwidth # Hz >]

< read only field >

Single Channel Analysis Preferences

Dock to scope Position the single channel control panel by the Scope.

Baseline Average Duration = x.x ms

Set the duration of the (closed state) baseline before the next transition, used to compute the baseline average.

Enter Baseline Average Duration

Duration [# s]

Mean Amplitude Duration = x.x ms

Set the minimum duration that an open state must be valid, when computing the mean of its amplitude.

Enter Mean Amplitude

Duration [# s]

Show Results in Graphs — Display the fit equation and key results in the fitted graph window.

Print Fit Results to History — When a fit is performed, extensive fitting results are written to the Command window history section.

Allow display compression — Enable for automatic compression of the data display.

Fill Baseline Wave — Display the baselines as a separate signal in the Scope window, to examine fluctuation of the base signal in relation to the recorded currents.

Note: This is not the idealized line, it only displays the baselines before a transition. Also, maximum limits are ignored, rejected events are included, and transition timing is not precisely accurate.

Before using this feature, a virtual input signal named "Baseline" needs to be included in the Series:

1. In the Scope window, click the 'Measurements' button, then select 'Edit Virtual Signals'.
2. Enter a label of "Baseline" for an unused virtual signal.
3. Then set the 'Math Tupe' to "Equation" and set the equation content to "NaN".
4. Set the 'Source Channel' to the single channel input signal.

5. Click the 'Do It' button to create the empty baseline signal.

6. In the Single Channel Analysis Preferences, click on the 'Fill Baseline Wave' option.

7. In the Single Channel Analysis 'Current Transition Controls', enter a reasonable value for the 'Track Limit' and enable 'Track Limit' and 'Track Baseline'.

8. In 'Find Target Transitions', click 'Clear All' and then 'Last' to find and update all transitions.

9. The idealized baseline is now displayed in the last Scope window signal.

Idealized Line Properties Set the idealized line thickness and color.

Enter Idealized Line Properties

Line Thickness [< # >] [↓]

[0.25, 0.50, 0.75, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10]

Color [< color >] [↓]

Open a color palette and select a color.

Signal Controls

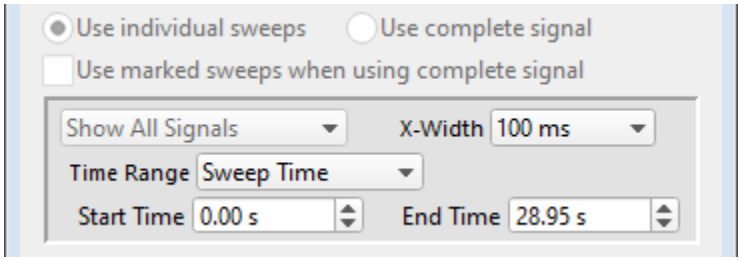


Figure 4-107. Signal Controls

Control the display of single channel data in the Scope window:

- Use individual sweeps Perform analysis on a single sweep at a time.
- Use complete signal For plotting - use found transitions from all sweeps in the active signal.

[ ] Use marked sweeps when using complete signal

Include transitions only from the marked sweeps in the active signal.

[< signal >] [↓]

X-Width: [< # >] [↓]

[Sweep; 1 s; 500, 200, 100, 50, 20, 10, 5, 2, 1 ms]

The Scope window X-axis duration is reset to this value whenever a 'Find' or 'Move' transition operation is performed.

Time Range [< range >] [↓]

Set the time range of the data to be analyzed.

- Full Trace — The entire sweep is analyzed.
- Sweep Time — Start Time (s) [< # >]

  The beginning of analysis.

  End Time (s) [< # >]

  The end of analysis.
- Segment Time — Start Ratio [< # >]

  Relative to the start of a Segment.

  End Ratio [< # >]

  Relative to the end of a Segment.

Note: If this setting is changed, all found transitions are cleared.

Current Transition Controls

Set up the basic level-detection parameters.

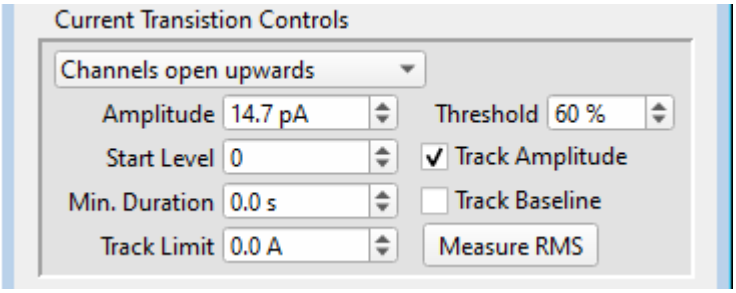


Figure 4-108. Current Transition Controls

[< direction >]

- Channels open upwards

  Upwards opening channels only accept positive amplitudes.

- Channels open downwards

  Downwards opening channels only accept negative amplitudes.

Amplitude [#]

Set to the expected transition size of the initial ion-channel level in the data.

For downwards-opening channels, use a negatively-signed value.

Start Level [#]

Set the starting state of the ion-channel data:

Level 0 = Closed state
Level 1 = First open state
Level 2 = Second open state
etc.

If there are multiple levels in the data, the program will try to automatically detect them. However, overlapping channel openings are treated as a single combined level.

Min. Duration [< 0.0 – ∞ s >]

Set the minimum duration for a “found” transition.

The increment/decrement spinners use a step size of 100 µs.

Note: Displayed values are rounded up or down to one decimal point for the scaled unit of display. For example, for values greater than 1.0 s, the increment spinner does not update the displayed value until a rounding threshold is reached for the last digit, i.e., '1.5499' converts to '1.5', while '1.5500' converts to '1.6'.

Track Limit [< 0 – 1.0 nA>]

Set the maximum (absolute) amount that the Baseline level can change while being automatically tracked.

For baseline tracking, the value must be > 0. Set manually, or set to 3 * RMS via the 'Measure RMS' button.

Threshold [< 20 – 80% >]

Set the percentile of the Amplitude value (open state) that needs to be reached by the raw data to "find" a transition.

[ ] Track Amplitude Enable to store the amplitude of the measured event, instead of the theoretical (short) event, in the event transition table.

[ ] Track Baseline Enable to automatically adjust the baseline amplitude (Level 0) based on the prior data.

To use, the 'Track Limit' value must be > 0.

[Measure RMS] To measure the RMS (Root-Mean-Square) noise in the signal, adjust the signal trace in the Scope window, such that it shows a stretch of current without any channel activity (i.e., all channels are closed), then click on the 'Measure RMS' button.

The mean and RMS values are displayed at the bottom of the dialog and written to the Notebook.

Properties of Selected Transition

View or alter how a transition is processed by the analysis.

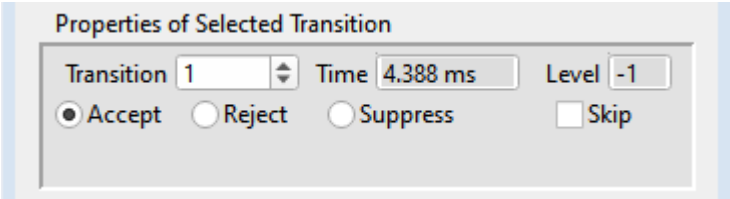


Figure 4-109. Properties of Selected Transition

Transition [#]

The count number of the selected (active) transition.

Time [# s]

< read only field >

The start time of the selected transition.

Level [#]

< read only field >

The level number of the selected transition.

Note: If other unexpected levels are detected "below the baseline", they are assigned a negative number. Negative levels might be detected from noise, biological artifacts, or an incorrect initial 'Start Level' setting.

Select the operational status of the selected transition.

- Accept — Terminate the preceding event and start a new open/close time. The selected transition is included in the idealized trace and all Plots.
- Reject — Terminate the preceding event and start a new open/close time. However, the selected transition is considered inappropriate for analysis, and is excluded from the idealized trace and all Plots.

  Events that border a rejected transition are also excluded from histograms.
- Suppress — Do not terminate the preceding event or start a new open/close time. A suppressed event is considered as "not having happened". The selected transition is excluded from the idealized trace and all Plots.

[ ] Skip — Enable to define a region of time to skip over when processing the data for transitions.

< only displays when 'Skip' is enabled >

Start Skip [# s]

Enter the start time of the Skip region.

If the start time overlaps any preceding transitions, you can optionally clear them from the record, or reset the start time to after them.

End Skip [# s]

Enter the end time of the Skip region.

Any transitions after the skip region are cleared from the record.

Find Target Transition

Find a transition based on the 'Current Transition Controls', and process the transition based on the 'Properties of selected transition'.

An "event" is a valid transition that is followed by another valid transition.

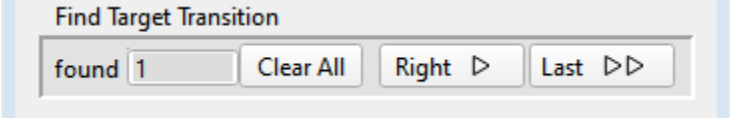


Figure 4-110. Find Target Transition

found [#]

< read only field >

Displays the total number of found transitions (including rejected and suppressed transitions).

[Clear All] Click to reanalyze the data – resets the number of found transitions to zero, and moves to the first found transition.

[Right >] Click to find, move to, and process the next transition.

[Last >>] Click to find and process all subsequent transitions, and move to the last transition.

[Abort] After pressing the 'Last >>' button, this 'Abort' button temporarily displays above the 'Last >>' button while the analysis is being calculated, so if the calculation is taking too long, you can press this button to abort the process and reset your parameters.

Note: Multiple overlapping open levels are not supported. For each detected Event, it is assumed that there is only one channel open.

Example:

Level 1 openings:	The Event duration is from the transition to the Level 1 amplitude, to the next transition to a different Level amplitude.
Level 2 openings:	The Event duration is from the transition to the Level 2 amplitude, to the next transition to a different Level amplitude.
etc.	

Move to Target Transition

Among the 'found' (processed) transitions, move to an adjacent transition, or jump to the beginning or ending transition.

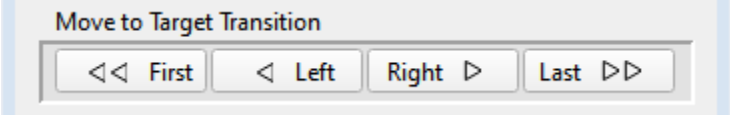


Figure 4-111. Move to Target Transition

[<< First]	Click to move to the first found event.
[< Left]	Click to move to the prior found event.
[Right >]	Click to move to the next found event.
[Last >>]	Click to move to the last found event.

 [Show/Hide Plots and Tables Controls]

This button opens/closes the 'Tables and Plots' dialog, which is docked on the right of this dialog.

[< total events >]

Status bar for the number of events in a particular Plot.

Single Channels: Plots and Tables

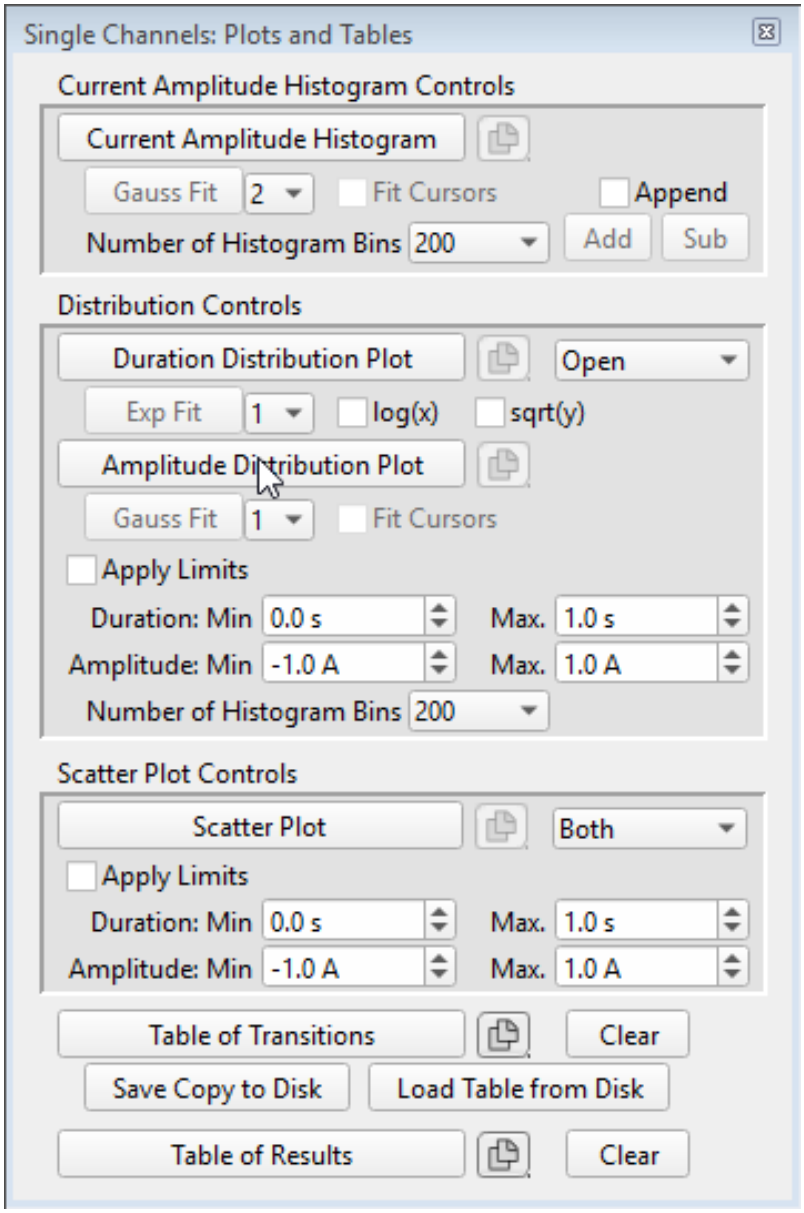


Figure 4-112. Plots and Tables Controls

Current Amplitude Histogram Controls

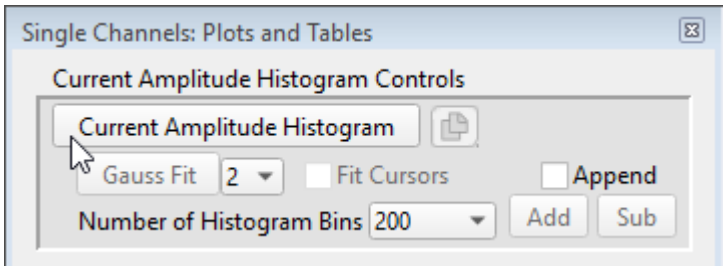


Figure 4-113. Current Amplitude Histogram Controls

A current amplitude histogram is often the first analysis performed on an uncharacterized channel, whereby all data points are binned by amplitude. It is used to determine:

- The quality of the recording.
- The number of levels in the open state.
- The first estimate of the open state amplitude(s).
- The first estimate of the baseline closed state.
- The frequency of openings.

[Current Amplitude Histogram]

Click to create a histogram plot of the raw data. No prior settings are needed to run this.

 Export Histogram

Export button with options list.

< button is disabled if no plot exists >

To Notebook (as text)	Copy the 'Current Amplitude Histogram' as text to the Notebook.
To Notebook (as graph)	Copy the 'Current Amplitude Histogram' as a graphic to the Notebook.
To Clipboard (as text)	Copy the 'Current Amplitude Histogram' as text to the system clipboard.
To Clipboard (as graph)	Copy the 'Current Amplitude Histogram' as a graphic to the system clipboard.
To Printer (as text)	Print the 'Current Amplitude Histogram' as text directly to the default printer as raw output.

To Printer (as graph) — Print the 'Current Amplitude Histogram' as a graphic directly to the default printer as raw output.

To Layout (as graph) — Copy the 'Current Amplitude Histogram' as a graphic into a new Layout window or append to an existing Layout page.

[Gauss Fit] — Click to perform Gaussian fits on the histogram plot, after first setting up the fit cursors.

< see the 'Table of Results' for the fitting components >

[< 1, 2, 3 >] [↓] — Select the number of terms in the fitting equation.

When more than one term is selected, the graph reports amplitudes (in relation to the closed state peak) and P(open) and P(closed) values. SutterPatch can automatically find up to the three largest peaks.

To fit additional smaller distributions, reposition the cursors and click the Append button.

[ ] Fit Cursors — Display fitting cursors in the plot window.

First create the histogram, and then enable 'Fit Cursors' for automatic cursors. Or, click the 'Scan or extract data' button in the plot and select 'Show fit cursors' for manual cursors - a 'Fit limits' floating window will display; then set the start and end points of the fitting range for each term.

Note: The applied fit might be less than the specified fitting range.

Number of Histogram Bins

[< 4000, 2000, 1000, 500, 200, 100, 50 >] [↓]

[ ] Append — Enable to modify the 'Current Amplitude Histogram' data set.

< available after a histogram is created >

[Add] — Add current data to the existing 'Current Amplitude Histogram'.

[Sub] — Subtract current data from the existing 'Current Amplitude Histogram'.

Amplitude Histogram plot window

Scan or extract data

Use to measure histogram data points or to extract data.

- Scan data

  Open a floating window to manually measure Current vs. Bin Count in histograms.

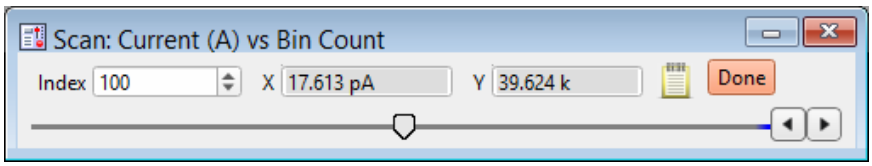


Figure 4-114. Scan Current Amplitude Histogram

Scan: Current (A) vs Bin Count

Index [< 0 to (n-1) >]

The selected data-point number in the plot.

A data-point number can be entered, or use the increment/decrement controls to increase/decrease the selected data-point by one point.

X [#]

The X-axis value of the selected data point.

Y [#]

The Y-axis value of the selected data point.

Write to Notebook

Click to write to the Notebook:

Scan: Current (A) vs Bin Count	Label.
index=#	Point.
x= #	X-data value.
y= #	Y-data value.

Done Close the “Scanner” floating window.

This window also automatically closes when you click outside of it.

X-slider bar

Click and drag the slider for the data-point cursor.

The data cursor display mode is set in 'Set Preferences / Graphs and Layouts'.

Click to decrement/increment the data cursor by one point at a time, or with the Shift-key, by 10 data points.

Or, the keyboard left/right-arrow keys decrease/increase the data selection by one point; with the Shift key, they decrease/increase the selection by 10 points.

Or, the keyboard Up/Down arrow keys increase/decrease the data selection by 10 points.

- Extract data

Open a floating window with data extraction controls.

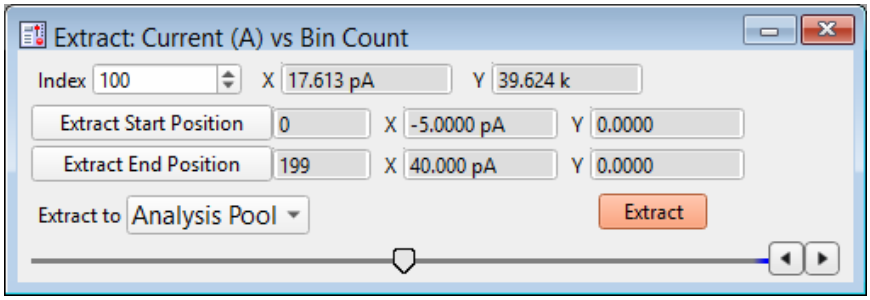


Figure 4-115. Extract Current Amplitude Histogram

Extract: Current (A) vs Bin Count

Index [< 0 to (n-1) >]

The selected data point number in the plot.

A data point number can be entered, or use the increment/decrement controls to increase/decrease the selected data point by one point.

X [#]

The X-axis value of the selected data point.

Y [#]

The Y-axis value of the selected data point.

Extract Start Position

Click to set the starting point of the data extraction.

[<#>] Index number of the extraction start.

X [#]

The X-axis value of the extraction start.

Y [#]

The Y-axis value of the extraction start.

Extract End Position

Click to set the ending point of the data extraction.

[<#>] Index number of the extraction end.

X [#]

The X-axis value of the extraction end.

Y [#]

The Y-axis value of the extraction end.

Extract to [<target>] [↓]

Select the data extraction target:

Analysis Pool — Extract the data to a Data / Data Browser wave, as configured in 'Set Preferences / Data Export / Copy Data Waves to Igor Folder.

Template Pool — Extract the plot to a Template Editor template wave.

Data Export Target Folder

Extract the data to a Data / Data Browser wave, as configured in Set

Preferences / Data Export / Copy Data Waves to Igor Folder.

To Standalone Graph
: Extract the plot to a separate graph window; if a fit has been performed, only the fitted line is extracted.

To Notebook
: Extract the graph as a graphic to the Notebook.

To Clipboard
: Extract the graph as a graphic to the system clipboard.

To Printer
: Print the graph as a graphic directly to the default printer as raw output.

[Extract]
: Click to extract the selected data.


: X-slider bar

Click and drag the slider for the data-point cursor.

The data cursor display mode is set in 'Set Preferences / Graphs and Layouts'.


: Click to decrement/increment the data cursor by one point at a time, or with the Shift-key, by 10 data points.

Or, the keyboard left/right-arrow keys decrease/increase the data selection by one point; with the Shift key, they decrease/increase the selection by 10 points.

Or, the keyboard Up/Down arrow keys increase/decrease the data selection by 10 points.

This floating window automatically closes when you click outside of it.

- Show fit cursors

  Open a floating window with fitting limits controls.

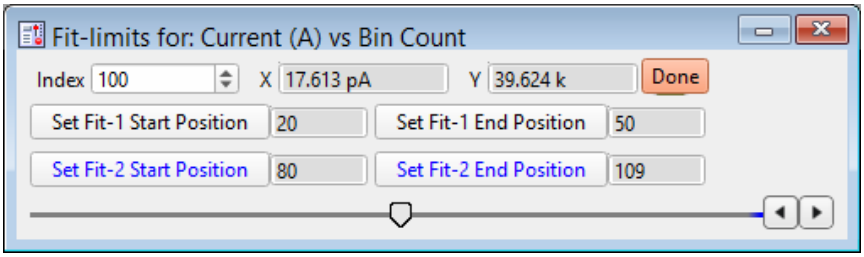


Figure 4-116. Fit Limits Current Amplitude Histogram

Fit-limits for: Current (A) vs Bin Count

Index [< 0 to (n-1) >]

The selected data point number in the plot.

A data point number can be entered, or use the increment/decrement controls to increase/decrease the selected data point by one point.

X [#]

The X-axis value of the selected data point.

Y [#]

The Y-axis value of the selected data point.

[Set Fit-1 Start Position]

[<#>] Index number of Fit-1 start.

[Set Fit-1 End Position]

[<#>] Index number of Fit-1 end.

[Set Fit-2 Start Position]

[<#>] Index number of Fit-2 start.

[Set Fit-2 End Position]

[<#>] Index number of Fit-2 end.

[Set Fit-3 Start Position]

[<#>] Index number of Fit-3 start.

[Set Fit-3 End Position]

[<#>] Index number of Fit-3 end.

Close the “Fitter” floating window and remove the fit lines in the graph.

However, while clicking outside of the window also automatically closes it and removes the fit lines in the graph, clicking in a Single Channel Analysis window closes the window but does not remove the fit lines in the graph.

X-slider bar

Click and drag the slider for the data-point cursor.

The data cursor display mode is set in ‘Set Preferences / Graphs and Layouts’.

Click to decrement/increment the data cursor by one point at a time, or with the Shift-key, by 10 data points.

Or, the keyboard left/right-arrow keys decrease/increase the data selection by one point; with the Shift key, they decrease/increase the selection by 10 points.

Or, the keyboard Up/Down arrow keys increase/decrease the data selection by 10 points.

After setting fitting limits, click the ‘Gauss Fit’ button in ‘Current Amplitude Histogram Controls’ to perform the fit.

Distribution Controls

Create amplitude and duration plots of the found Events.

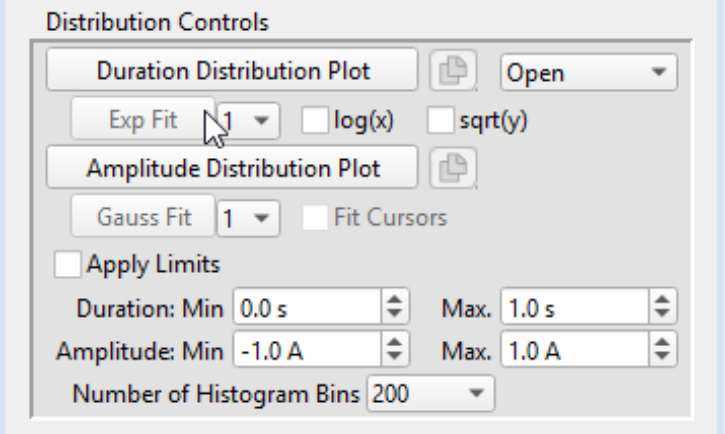


Figure 4-117. Distribution Controls

[Duration Distribution Plot]

Click to create a duration (dwell-time) histogram plot of the found Events. The histogram bin count is reported as "Relative Frequency" (to 1.0) on the plot's Y-axis.

Export Plot — Export button with options list:

< button is disabled if no plot exists >

To Notebook (as text)	Copy the 'Duration Distribution Plot' as text to the Notebook.
To Notebook (as graph)	Copy the 'Duration Distribution Plot' as a graphic to the Notebook.
To Clipboard (as text)	Copy the 'Duration Distribution Plot' as text to the system clipboard.
To Clipboard (as graph)	Copy the 'Duration Distribution Plot' as a graphic to the system clipboard.
To Printer (as text)	Print the 'Duration Distribution Plot' as text directly to the default printer as raw output.
To Printer (as graph)	Print the 'Duration Distribution Plot' as a graphic directly to the default printer as raw output.
To Layout (as graph)	Copy the 'Duration Distribution Plot' as a graphic into a new Layout window, or append to an existing Layout page.

[< state >] [↓] Select open or closed state data for the Distribution plots

- Open
- Closed

[Exp Fit] Click this button to apply an exponential fit to the data, and draw a fit line on the plotted data.

< button is disabled if no plot exists >

[< 1, 2 >] [↓] Select the number of terms in the fitting equation.

[log(x)] Enable to set the X-axis to a log scale.

[sqrt(y)] Enable to use the square-root of the Y-axis data.

Duration Distribution plot window

Scan or extract data

Use to measure Duration Distribution data points or to extract data.

- Scan data

Open a floating window to manually measure Event Duration vs. Frequency in plots.

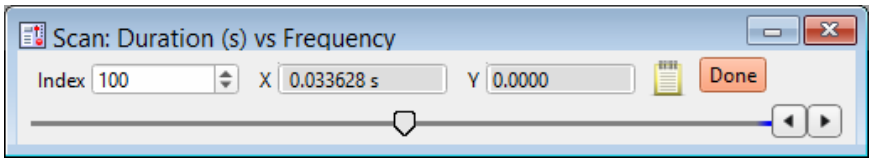


Figure 4-118. Scan Duration Distribution Plot

Scan: Duration (s) vs Frequency

Index [0 to (n-1)]

The selected data point number in the plot.

A data point number can be entered, or use the increment/decrement controls to increase/decrease the selected data point by one point.

X [#]

The X-axis value of the selected data point.

Y [#]

The Y-axis value of the selected data point.

Write to Notebook

Click to write to the Notebook:

Scan: Duration (s) vs Frequency Label.

index=# Point.

x=# X data value.

Y=# Y data value.

Close the “Scanner” floating window.

This window also automatically closes when you click outside of it.

X-slider bar

Click and drag the slider for the data-point cursor.

The data cursor display mode is set in ‘Set Preferences / Graphs and Layouts’.

Click to decrement/increment the data cursor by one point at a time, or with the Shift-key, by 10 data points.

Or, the keyboard left/right-arrow keys decrease/increase the data selection by one point; with the Shift key, they decrease/increase the selection by 10 points.

Or, the keyboard Up/Down arrow keys increase/decrease the data selection by 10 points.

- Extract data

  Open a floating window with data extraction controls.

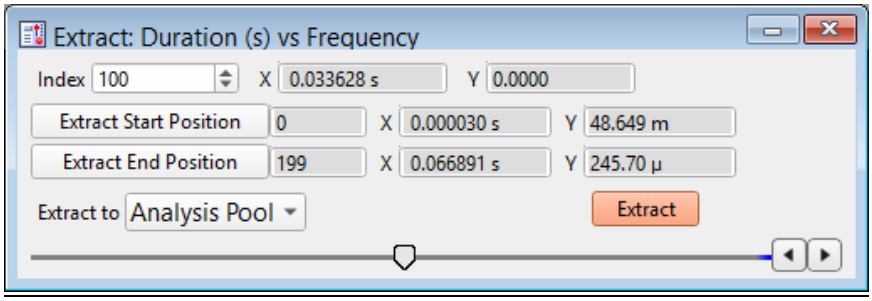


Figure 4-119. Extract Duration Distribution

Extract: Duration (s) vs Frequency

Index [0 to (n-1)]

The selected data-point number in the plot.

A data-point number can be entered, or use the increment/decrement controls to increase/decrease the selected data-point by one point.

X [#]

The X-axis value of the selected data point.

Y [#]

The Y-axis value of the selected data point.

[Extract Start Position]

Click to set the starting point of the data extraction.

[< # >] Index number of the extraction start.

X [#]

The X-axis value of the extraction start.

Y [#]

The Y-axis value of the extraction start.

[Extract End Position]

Click to set the ending point of the data extraction.

[< # >] Index number of the extraction end.

X [#]

The X-axis value of the extraction end.

Y [#]

The Y-axis value of the extraction end.

Extract to [< target >] [↓]

Select the data extraction target:

Analysis Pool

Extract the data to a Data Browser wave, as configured in 'Set Preferences / Data Export / Copy Data Waves to Igor Folder.

Template Pool

Extract the plot to a Template Editor template wave.

Data Export Target Folder

Extract the data to a Data Browser wave, as configured in 'Set Preferences / Data Export / Copy Data Waves to Igor Folder.

To Standalone Graph

Extract the plot to a separate graph window; if a fit has been performed, only the fitted line is extracted.

To Notebook Extract the graph as a graphic to the Notebook.

To Clipboard Extract the graph as a graphic to the system clipboard.

To Printer Print the graph as a graphic directly to the default printer as raw output.

[Extract] Click to extract the selected data.

X-slider bar

Click and drag the slider for the data-point cursor.

The data cursor display mode is set in 'Set Preferences / Graphs and Layouts'.

Click to decrement/increment the data cursor by one point at a time, or with the Shift-key, by 10 data points.

Or, the keyboard left/right-arrow keys decrease/increase the data selection by one point; with the Shift key, they decrease/increase the selection by 10 points.

Or, the keyboard Up/Down arrow keys increase/decrease the data selection by 10 points.

This floating window automatically closes when you click outside of it.

[Amplitude Distribution Plot] Click to create an amplitude histogram plot of the selected state's found Events. The histogram bin count is reported as 'Frequency' on the plot's Y-axis.

The Amplitude Distribution Plot bins "transition deltas", which measures the *directional change* in amplitude for each transition (not the raw amplitude).

For example, an opening transition to 15 pA bins on the X-axis at 15 pA, while a following closing transition back to 0 pA bins on the X-axis at -15 pA, i.e., the delta of the transition's Before and After amplitudes.

The histogram bins plot as colored lines:

Open = **red**

Closed= **blue**

 Export Plot

Export button with options list:

< button is disabled if no plot exists >

To Notebook (as text) Copy the 'Amplitude Distribution Plot' as text to the Notebook.

To Notebook (as graph)	Copy the 'Amplitude Distribution Plot' as a graphic to the Notebook.
To Clipboard (as text)	Copy the 'Amplitude Distribution Plot' as text to the system clipboard.
To Clipboard (as graph)	Copy the 'Amplitude Distribution Plot' as a graphic to the system clipboard.
To Printer (as text)	Print the 'Amplitude Distribution Plot' as text directly to the default printer as raw output.
To Printer (as graph)	Print the 'Amplitude Distribution Plot' as a graphic directly to the default printer as raw output.
To Layout (as graph)	Copy the 'Amplitude Distribution Plot' as a graphic into a new Layout window or append to an existing Layout page.

[Gauss Fit] Click this button to apply a Gaussian fit to the data and draw a fit line on the plotted data.

< button is disabled if no plot exists >

[< 1, 2, 3 >] [↓] Select the number of terms in the fitting equation.

[ ] Fit Cursors Display fitting cursors in the plot window.

First create the plot, and then enable 'Cursors'. A 'Fit limits' floating window will display. Set the start and end points for the fit terms. When 'Done', click the 'Gauss Fit' button.

[ ] Apply Limits Enable to apply data limits to the events used in distribution plots.

If enabled, further Min/Max changes are applied to the plot only after toggling the checkbox.

Duration: Min [0.0 – 1.0 s]

Max. [0.0 – 1.0 s]

Amplitude: Min [-1.0 – 1.0 A]

Max. [-1.0 – 1.0 A]

Number of Histogram Bins [1000, 500, 200, 100, 50, 20]

Amplitude Distribution Plot window

Scan or extract data — Use to measure Event Amplitude Distribution data points or to extract data. .

- Scan data

  Open a floating window to manually measure Transition Deltas vs. Frequency in plots.

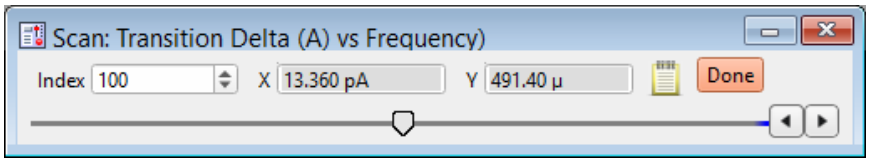


Figure 4-120. Scan Amplitude Distribution Plot

Scan: Transition Delta (A) vs Frequency

Index — [< 0 to (n-1) >]

The selected data-point number in the plot.

A data-point number can be entered, or use the increment/decrement controls to increase/decrease the selected data-point by one point.

X — [#]

The X-axis value of the selected data point.

Y — [#]

The Y-axis value of the selected data point.

Write to Notebook

Click to write to the Notebook:

Scan: Transition Delta (A) vs Frequency

Label.

index=# Point.

x=# X data value.

y=# Y data value.

Done — Close the “Scanner” floating window.

This window also automatically closes when you click outside of it.

 — X-slider bar

Click and drag the slider for the data-point cursor.

The data cursor display mode is set in ‘Set Preferences / Graphs and Layouts’.

 — Click to decrement/increment the data cursor by one point at a time, or with the Shift-key, by 10 data points.

Or, the keyboard left/right-arrow keys decrease/increase the data selection by one point; with the Shift key, they decrease/increase the selection by 10 points.

Or, the keyboard Up/Down arrow keys increase/decrease the data selection by 10 points.

- Extract data

  Open a floating window with data extraction controls.

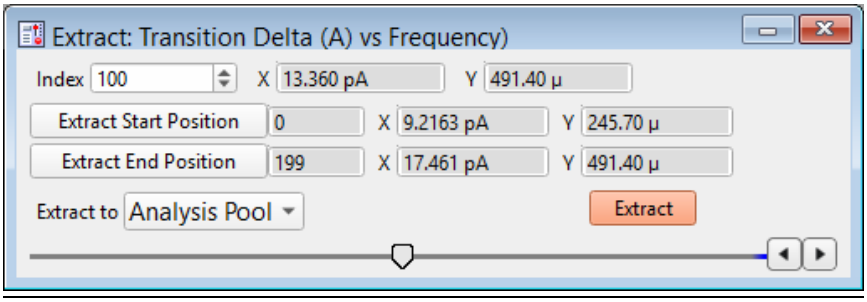


Figure 4-121. Extract Amplitude Distribution

Extract: Transition Delta (A) vs Frequency

Index [< 0 to (n-1) >]

The selected data-point number in the plot.

A data-point number can be entered, or use the increment/decrement controls to increase/decrease the selected data-point by one point.

X [#]

The X-axis value of the selected data point.

Y [#]

The Y-axis value of the selected data point.

[Extract Start Position]

Click to set the starting point of the data extraction.

[<#>] Index number of the extraction start.

X [#]

The X-axis value of the extraction start.

Y [#]

The Y-axis value of the extraction start.

[Extract End Position]

Click to set the ending point of the data extraction.

[<#>] Index number of the extraction end.

X [#]

The X-axis value of the extraction end.

Y [#]

The Y-axis value of the extraction end.

Extract to [< target >] [↓]

Select the data extraction target:

Analysis Pool

Extract the data to a Data / Data Browser wave, as configured in Set Preferences / Data Export / Copy Data Waves to Igor Folder.

Template Pool

Extract the plot to a Template Editor template wave.

Data Export Target Folder

Extract the data to a Data / Data Browser wave, as configured in Set Preferences / Data Export / Copy Data Waves to Igor Folder.

To Standalone Graph

Extract the plot to a separate graph window; if a fit has been performed, only the fitted line is extracted.

[Extract] Click to extract the selected data.

 X-slider bar

Click and drag the slider for the data-point cursor.

The data cursor display mode is set in 'Set Preferences / Graphs and Layouts'.

 Click to decrement/increment the data cursor by one point at a time, or with the Shift-key, by 10 data points.

Or, the keyboard left/right-arrow keys decrease/increase the data selection by one point; with the Shift key, they decrease/increase the selection by 10 points.

Or, the keyboard Up/Down arrow keys increase/decrease the data selection by 10 points.

This floating window automatically closes when you click outside of it.

- Show fit cursors

  Open a floating window with fitting limits controls.

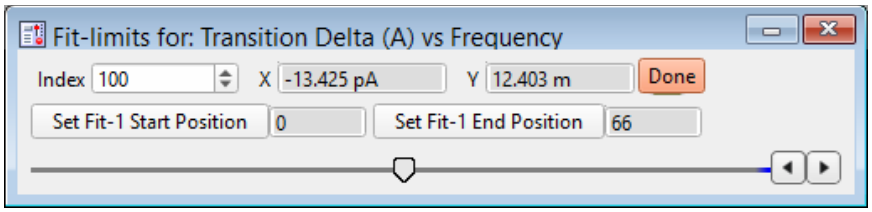


Figure 4-122. Fit Limits Amplitude Distribution

Fit-limits for: Transition Delta (A) vs Frequency

Index [<#>]

The selected data-point number in the plot.

A data-point number can be entered, or use the increment/decrement controls to increase/decrease the selected data-point by one point.

X [#]

The X-axis value of the selected data point.

Y [#]

The Y-axis value of the selected data point.

[Set Fit-1 Start Position]

[<#>] Index number of Fit-1 start.

[Set Fit-1 End Position]

[<#>] Index number of Fit-1 end.

[Set Fit-2 Start Position]

[<#>] Index number of Fit-2 start.

[Set Fit-2 End Position]

[<#>] Index number of Fit-2 end.

[Set Fit-3 Start Position]

[<#>] Index number of Fit-3 start.

[Set Fit-3 End Position]

[<#>] Index number of Fit-3 end.

Done — Close the “Fit Limits” floating window.

This window also automatically closes when you click outside of it.

X-slider bar

Click and drag the slider for the data-point cursor.

The data cursor display mode is set in ‘Set Preferences / Graphs and Layouts’.

Click to decrement/increment the data cursor by one point at a time, or with the Shift-key, by 10 data points.

Or, the keyboard left/right-arrow keys decrease/increase the data selection by one point; with the Shift key, they decrease/increase the selection by 10 points.

Or, the keyboard Up/Down arrow keys increase/decrease the data selection by 10 points.

After setting fitting limits, click the ‘Gauss Fit’ button in ‘Distribution Controls’ to perform the fit.

Scatter Plot Controls

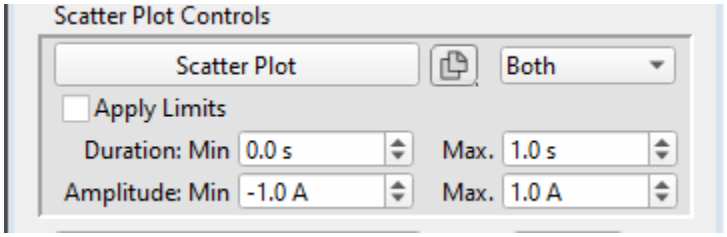


Figure 4-123. Scatter Plot Controls

The scatter plot uses “transition deltas” for Event amplitudes, which plot on the Y-axis as the *directional change* in amplitude for each transition; the X-axis plots the duration of the Event.

For example, an opening transition to 15 pA will plot on the Y-axis at 15 pA, while a following closing transition back to 0 pA plots on the Y-axis at -15 pA, i.e., the delta of the transition’s Before and After amplitudes.

[Scatter Plot] Click to create a scatter plot of the selected state’s found Events.

Export Table Export button with options list:

< button is disabled if no plot exists >

To Notebook (as text)	Copy the 'Scatter Plot' as text to the Notebook.
To Notebook (as graph)	Copy the 'Scatter Plot' as a graphic to the Notebook.
To Clipboard (as text)	Copy the 'Scatter Plot' as text to the system clipboard.
To Clipboard (as graph)	Copy the 'Scatter Plot' as a graphic to the system clipboard.
To Printer (as text)	Print the 'Scatter Plot' as text directly to the default printer as raw output.
To Printer (as graph)	Print the 'Scatter Plot' as a graphic directly to the default printer as raw output.
To Layout (as graph)	Copy the 'Scatter Plot' as a graphic into a new Layout window or append to an existing Layout page.

[< state >] [↓] Select which states are plotted. Events are plotted as colored symbols.

- Open **red**
- Closed **blue**
- Both **red** & **blue**

A selected Event (transition) is **green**.

[ ] Apply Limits Enable to apply data limits to the Events used in scatter plots.

Duration:	Min	[0.0 – 1.0 s]
	Max.	[0.0 – 1.0 s]
Amplitude:	Min	[-1.0 – 1.0 A]
	Max.	[-1.0 – 1.0 A]

Scatter plot window

Scan data Use to measure open/closed Events X-Y data points.

- Scan open/closed events

  Open a floating window to manually measure open or closed Events in plots.

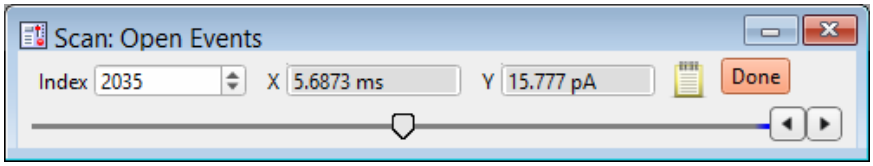


Figure 4-124. Scan Scatter Plot

Scan: Open/Closed Events

Index [< 0 to (n-1) >]

The selected Event number in the plot.

An Event number can be entered, or use the increment/decrement controls to increase/decrease the Event number by one point.

X [#]

The X-axis value of the selected Event.

Y [#]

The Y-axis value of the selected Event.

Write to Notebook

Click to write to the Notebook:

Scan: Open (or Closed) Events	
	Label.
index=#	Point.
x=#	X-data value.
y=#	Y-data value.

Done Close the “Scanner” floating window.

This window also automatically closes when you click outside of it.

X-slider bar

Click and drag the slider for the Event cursor.

The data cursor display mode is set in 'Set Preferences / Graphs and Layouts'.

Click to decrement/increment the Event cursor by one point at a time, or with the Shift-key, by 10 data points.

Or, the keyboard left/right-arrow keys decrease/increase the selection by one data point; with the Shift key, they decrease/increase the selection by 10 data points.

Or, the keyboard Up/Down arrow keys decrease/increase the selection by 10 data points.

- Extract open/closed events

  Open a floating window with data extraction controls.

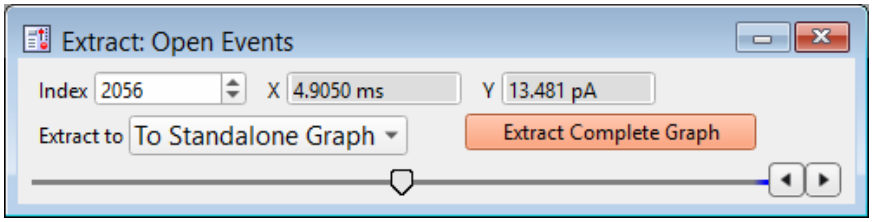


Figure 4-125. Extract Data

Extract: Wave Name

Index [< 0 to (n-1) >]

The selected Event number in the plot.

An Event number can be entered, or use the increment/decrement controls to increase/decrease the selected Event number by one point.

X [#]

The X-axis value of the selected Event.

Y [#]

The Y-axis value of the selected Event.

Extract to [< target >] [↓]

Select the data extraction target:

Analysis Pool

< unavailable >

Template Pool

< unavailable >

Data Export Target Folder

< unavailable >

To Standalone Graph

Extract the plot to a separate graph window.

To Notebook Extract the plot as a graphic to the Notebook.

To Clipboard Extract the plot as a graphic to the system clipboard.

To Printer Print the plot as a graphic directly to the default printer as raw output.

[Extract complete graph]

Click to extract the entire graph.

X-slider bar

Click and drag the slider for the Event cursor.

The cursor display mode is set in 'Set Preferences / Graphs and Layouts'.

Click to decrement/increment the Event cursor by one point at a time, or with the Shift-key, by 10 data points.

Or, the keyboard left/right-arrow keys decrease/increase the Event selection by one point; with the

Shift key, they decrease/increase the selection by 10 points.

Or, the keyboard Up/Down arrow keys increase/decrease the Event selection by 10 points.

This floating window automatically closes when you click outside of it.

Table Controls

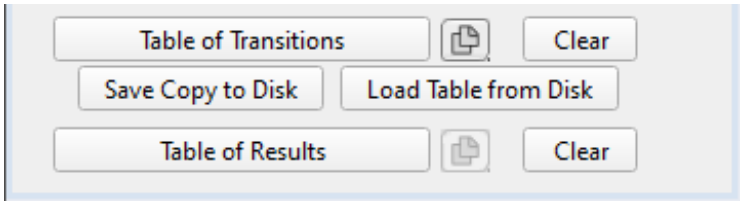


Figure 4-126. Table Controls

[Table of Transitions] Click for a listing of all transitions.

Layout of the table

Top Row: [Cell address | Cell value]

Column Number Row: Column numbers. [0, 1, 2, …]

Row 0: Status The operational status of the selected transition.

1	=	Accepted	Terminates the preceding event and starts a new open/close time. The selected transition is included in the idealized trace and all Plots.
2	=	Rejected	Terminates the preceding event and starts a new open/close time. However, the selected transition is considered inappropriate for analysis, and is excluded from the idealized trace and all Plots.
3	=	Suppressed	Does not terminate the preceding event or start a new open/close time. A suppressed event is considered as “not having happened”. The selected transition is excluded from the idealized trace and all Plots.

Row 1: Time Time of the start of the transition, i.e., the transition point.

Row 2:	Level	The open or closed state level number.
Row 3:	Amplitude_Before	Amplitude of the level preceding the transition, i.e., the level before the transition point.
Row 4:	Amplitude_After	Amplitude of the transition, i.e., the level after the transition point.
Row 5:	Duration	Duration of the transition. Note: The last column of transition data is preset to a zero duration.
Row 6:	Amplitude	Amplitude of the transition.
Row 7:	Amplitude_Valid	Include / Exclude the transition for processing 0 = Invalid A valid transition. 1 = Valid Not a valid transition. Note: The very first column of transition data is always defined to be 'Invalid', and is excluded from processing. Also, the last two columns of transition data are excluded from Plots.
Row 8:	Data_Index	The index into the data array The 'Data_Index' label is not displayed if the data was previously analyzed with an earlier version of SutterPatch.

 Export Table — Export button with options list:

To Notebook (as text)	Copy the 'Table of Transitions' as text to the Notebook.
To Notebook (as graph)	Copy the 'Table of Transitions' as a graphic to the Notebook.
To Clipboard (as text)	Copy the 'Table of Transitions' as text to the system clipboard.
To Clipboard (as graph)	Copy the 'Table of Transitions' as a graphic to the system clipboard.
To Printer (as text)	Print the 'Table of Transitions' as text directly to the default printer as raw output.

To Printer (as graph)	Print the 'Table of Transitions' as a graphic directly to the default printer as raw output.
To Layout (as graph)	Copy the 'Table of Transitions' as a graphic into a new Layout window or append to an existing Layout page.

[Clear]	Clear all transitions from the table and reset to the first found transition.
[Save Copy to Disk]	Save the 'Table of Transitions' to an Igor Pro wave (*.ibw) file.
[Load Table from Disk]	Load the 'Table of Transitions' from an Igor Pro wave (*.ibw) file.

[Table of Results] Click for a table of all fitting results.

Examples of reported fitting results:

< see the Help for "Curve Fitting / Built-in Curve Fitting Functions" >

Current Amplitude Histogram Fit

Amplitude	The computed amplitude, i.e. the distance between the first and second gauss distribution peak.
p(closed)	Closed probability, i.e. the integral under the "closed" amplitude distribution.
p(open)	Open probability, i.e. the integral under the "open" amplitude distribution.
Gauss_y	
Gauss_x	
Gauss_width	Sqrt(2) times the standard deviation of the peak.
Success	

Duration Distribution Linear Exponential Fit

Exp_y0

Exp_A

Exp_Tau

Exp_x0

Success

Duration Distribution Logarithmic Exponential Fit

LogNormal_k0

LogNormal_k1

LogNormal_k2

LogNormal_k3

Amplitude Distribution Fit

Gauss_y0

Gauss_A

Gauss_x0

Gauss_width

Success

 Export Results — Export button with options list:

To Notebook (as text)	Copy the 'Table of Results' as text to the Notebook.
To Notebook (as graph)	Copy the 'Table of Results' as a graphic to the Notebook.
To Clipboard (as text)	Copy the 'Table of Results' as text to the system clipboard.
To Clipboard (as graph)	Copy the 'Table of Results' as a graphic to the system clipboard.
To Printer (as text)	Print the 'Table of Results' as text directly to the default printer as raw output.

To Printer (as graph)	Print the 'Table of Results' as a graphic directly to the default printer as raw output.
To Layout (as graph)	Copy the 'Table of Results' as a graphic into a new Layout window or append to an existing Layout page.

[Clear]	Clear all entries from the table, and reset to the first found transition.

4.2.18 Synaptic Event Analysis

SutterPatch: Available Analysis Modules: Synaptic Event Analysis

Post-synaptic potentials and currents from excitatory and inhibitory Events (EPSPs, EPSCs, IPSPs, IPSCs) are analyzed with this application module. Access via the Reanalysis Scope window 'Measurements' button or the Data Navigator (signal) 'Available actions' menu.

"Minis" (mEPSPs, etc.), which generate small and often overlapping Events, are detected with an innovative deconvolution algorithm. This technique finds such Events with high temporal fidelity, while also greatly improving the signal-to-noise ratio (SNR).

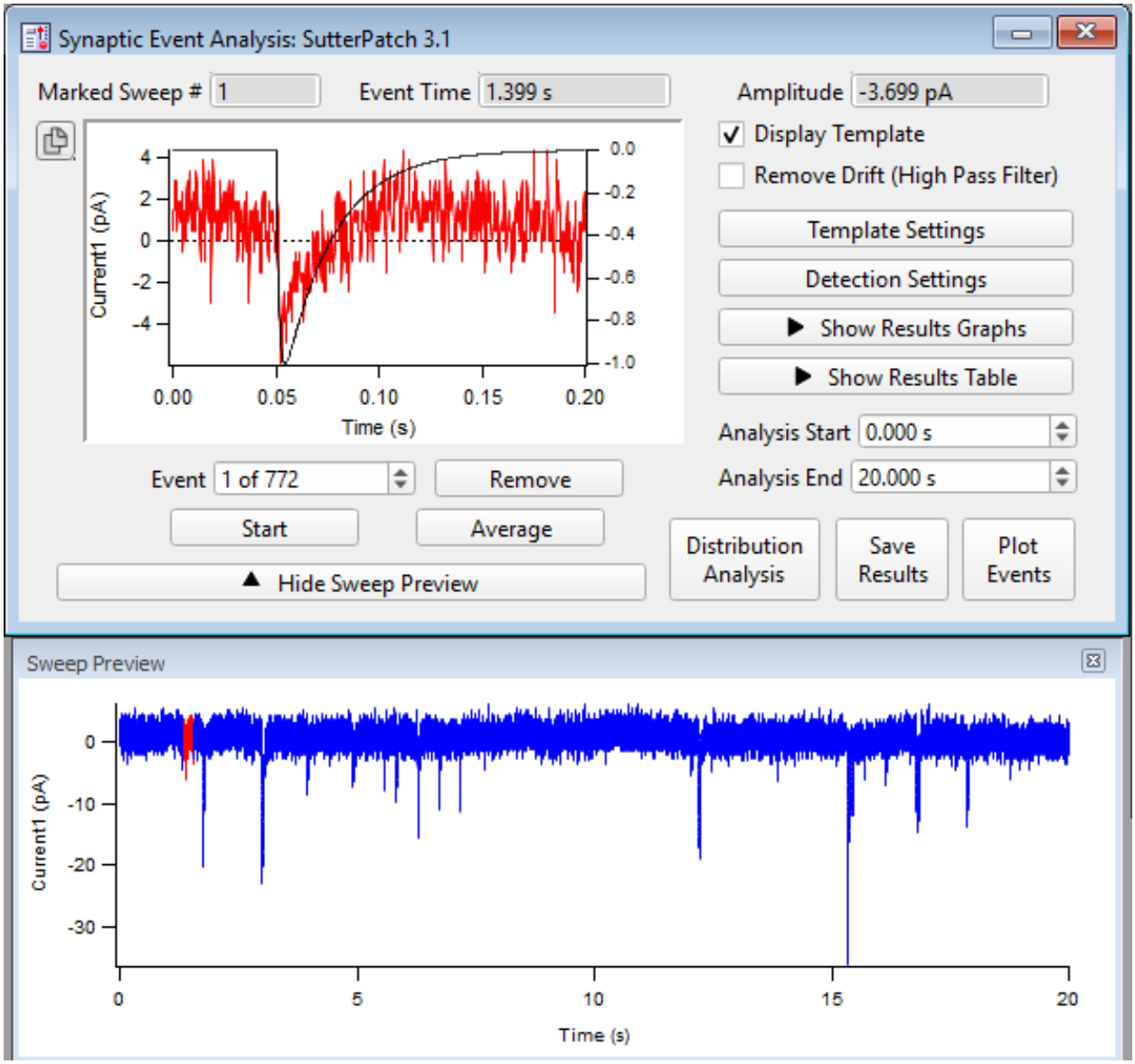


Figure 4-127. Synaptic Event Analysis

Sweep # The sweep number of the displayed data.

The Sweep # is set to '0' when the Average Event is displayed in the Event pane (or when the template is initially created prior to analysis.)

or

Marked Sweep [#]

Pre-select sweeps for processing by "marking" them in a Scope window during acquisition or reanalysis, or in the Data Navigator tree. If the Data Navigator "Enable Marks" checkbox is enabled, this field is renamed to 'Marked Sweep #', and only marked sweeps are displayed and analyzed.

Event Time [# s]

The time of the Event start relative to the start of the sweep.

 Export this graph to: < this button is disabled if no plot exists >

Export button with options list for the selected Event:

To Notebook (as text)	< unavailable >
To Notebook (as graph)	Copy the Event as a graphic to the Notebook.
To Clipboard (as text)	< unavailable >
To Clipboard (as graph)	Copy the Event as a graphic to the system clipboard .
To Printer (as text)	< unavailable >
To Printer (as graph)	Print the Event as a graphic directly to the default printer as raw output.
To Layout (as graph)	Copy the Event as a graphic into a new Layout window or append to an existing Layout page.

[Event pane] A graph of the selected event.

When overlaid by a template, the X-axis zero point is reset to the template starting point, and a normalized Y-axis of the template is displayed on the right edge of the graph.

Event [< # of # >]

The current Event number vs. total number of Events.

Increment, decrement, or type to replace the Event #. The selected event is highlighted in the Sweep Preview signal.

[Remove] Delete the current Event from the analysis, and renumber the remaining Events.

[Start] Click to find and analyze synaptic Events.

[Abort] After pressing the 'Start' button, this 'Abort' button temporarily displays to the right of the 'Start' button while the analysis is being calculated, so if the calculation is taking too long, you can press this button to abort the process and reset your parameters.

[Average] Click to display the averaged Event in the Event pane.

The Sweep # is set to '0'.

The Event number no longer applies, but is unchanged, and its highlight is removed from the Sweep Preview.

[Show/Hide Sweep Preview]

Show/Hide the sweep preview pane below.

[Sweep Preview pane]

Displays a sweep of data colored in blue, with the selected Event colored in red.

To resize or extract data, click and drag a box around the data with the mouse marquee tool, and right-click for the marquee menu.

The extra marquee menu option 'Add Selected Event' (also in the Sweep Preview pane general right-click menu) allows you to manually classify a raw data selection as a synaptic Event, to include an Event missed by the template detection. The new Event is highlighted in red, and included in new Results tables.

If the active Event is selected, a copy of the Event results is inserted into the Results table after the row of the active Event.

Note: Manually detected Events do not have an 'Event Strength' entry in the Results table, as an algorithm was not used to detect them.

Amplitude [#]

< read only field >

The amplitude averaged around the peak by ±1 ms, relative to the baseline.

For overlapping Events, the amplitude of the second Event is relative to the end of the decaying baseline of the first Event.

[ ] Display Template Enable to display the ideal Event's template on top of the selected Event in the Event pane - its normalized Y-axis displays on the right edge of the graph.

To better match the template to the Event, hover the mouse cursor over the right Y-axis line until a double-headed arrow displays, and then use the mouse wheel to rescale the template.

[ ] Remove Drift (High Pass Filter)

Enable to apply a 1 Hz high-pass filter to the signal to remove baseline drift.

[ ] Template Settings Open the Template sub-panel to configure a template.

Create a template of a typical Event as a double-exponential curve. The data will be deconvolved to this template for further analysis.

Event Polarity	[< 1, -1 >] [↓]	1 = positive -1 = negative
Rise Time (µs)	[< 10 – 5,000 >] [↓]	Time constant (τ) for the rising phase of the template Event.
Decay Time (us)	[< 100 – 100,000 >] [↓]	Time constant (τ) for the falling phase of the template Event.

[Create Template] Click to create a custom Event template.

[Use Average] Click to use the event Average as the Event template.

[ ] Realign average Enable to realign the 'Use average' template to keep the analysis from drifting.

[Detection Settings] Open a sub-panel to configure detection levels.

- xSD Base the detection threshold on the standard deviation of a fit.
- abs (A) Base the detection threshold on a fixed Event strength.

A detection threshold represents the "Event Strength". Adjust this threshold based on empirical testing of your data.

Lower # = weaker more events (false-positives)

Higher # = stronger less events (false negatives)

Threshold (xSD) [< 0.1 – 100 >]

This detection threshold is set to “n” times the standard deviation of a Gaussian fit to an all-points histogram of the (Fourier) deconvolved data signal.

Alert! This threshold is sensitive to the frequency of Events. While a 1 Hz frequency is considered normal, a 10 Hz frequency might cause computation problems.

or

Threshold (abs) [< 0 – inf A >]

This detection threshold uses a fixed Event strength of the set value multiplied by 100.

Min Amplitude [< 0 – inf A >]

Set an amplitude threshold for the minimum absolute size of Events.

Min Interval [< 0 – inf s >]

Set a minimum time interval between the onset of Events.

Decay tau [, <, >]

Select a comparison operator. Set the decay tau as “less than” or “greater than” a selected tau value, or disable the setting.

[< OFF, 500 – 1,000,000 µs >]

Set the decay tau threshold value.

[ ] Concatenate Sweeps

< only applies to continuous data >

Combine all sweeps into a single pseudo-sweep , ignoring marks and analysis start/stop times.

This sometimes improve performance of the detection algorithm signal-to-noise ratio with shorter sweeps.

[ ] Use Legacy Algorithm

Use the original detection algorithm (from SutterPatch v3.0 and earlier) to maintain consistency with earlier analyses.

Otherwise, minor improvements were made to improve the detection algorithm in SutterPatch v3.1.

< see Appendix F: SutterPatch Algorithms for the Event detection algorithm >

[Show / Hide Results Graphs]

A resizable pane of four graphs is displayed or hidden:

Cumulative probability vs. Amplitude

Amplitude vs. Time

Frequency vs. Sweep Number

Amplitude vs. Sweep Number

Export this graph

Each graph has an attached Export button with options list:

To Notebook (as text)	Copy the graph as text to the Notebook.
To Notebook (as graph)	Copy the graph as a graphic to the Notebook.
To Clipboard (as text)	Copy the graph as text to the system clipboard.
To Clipboard (as graph)	Copy the graph as a graphic to the system clipboard
To Printer (as text)	Print the graph as text directly to the default printer as raw output.
To Printer (as graph)	Print the graph as a graphic directly to the default printer as raw output.
To Layout (as graph)	Copy the graph as a graphic into a new Layout window or append to an existing Layout page.

Scan or extract data

Each graph has an attached “Scan or extract data” button to measure X-Y data points or extract data.

- Scan data

  Open a floating window to manually measure X-Y data points in a plot.

  Scan: Cumulative Probability vs Amplitude (A)

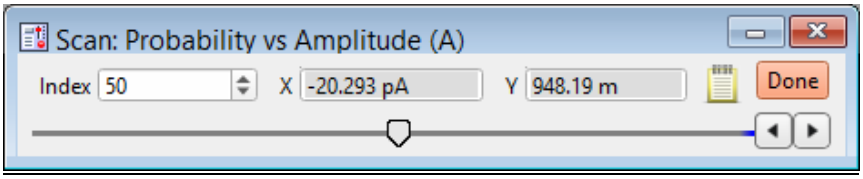


Figure 4-128. Scan Probability vs Amplitude

  Scan: Amplitude (A) vs Time (s)

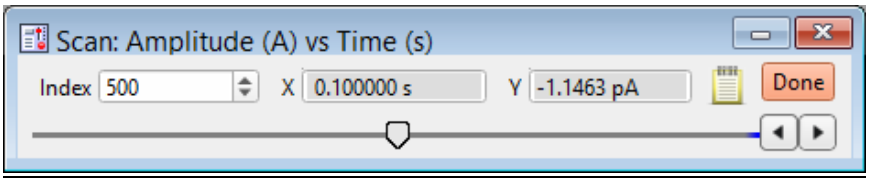


Figure 4-129. Scan Amplitude vs Time

  Scan: Frequency (Hz) vs. Sweep Number

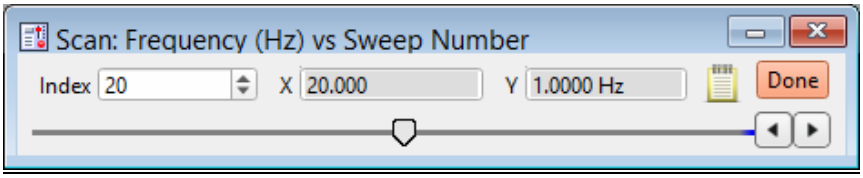


Figure 4-130. Scan Frequency vs Sweep #

  Scan Amplitude (A) vs Sweep Number

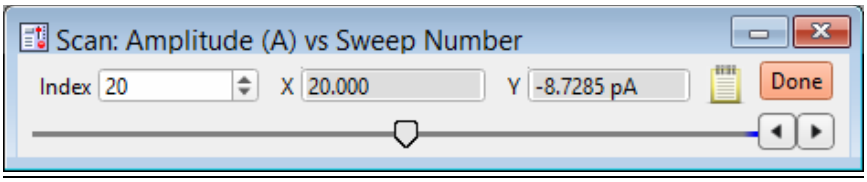


Figure 4-131. Scan Amplitude vs Sweep #

Index [< 0 to (n-1) >]

The selected data-point number in the plot.

A data-point number can be entered, or use the increment/decrement controls to increase/decrease the selected data-point by one point.

X [#]

The X-axis value of the selected data point.

Y [#]

The Y-axis value of the selected data point.

Write to Notebook

Click to write to the Notebook:

Scan: "X" vs "Y"	Label.
index=#	point.
x= #	X-data value
y= #	Y-data value

Done

Close the "Scanner" floating window.

This window also automatically closes when you click in another window.

X-slider bar

Click and drag the slider for the data-point cursor.

The data cursor display mode is set in 'Set Preferences / Graphs and Layouts'.

Click to decrement/increment the data cursor by one point at a time, or with the Shift-key, by 10 data points.

Or, the keyboard left/right-arrow keys decrease/increase the data selection by one point; with the Shift key, they decrease/increase the selection by 10 points.

Or, the keyboard Up/Down arrow keys increase/decrease the data selection by 10 points.

- Extract data

Open a floating window with data extraction controls.

Extract: Probability vs Amplitude (A)

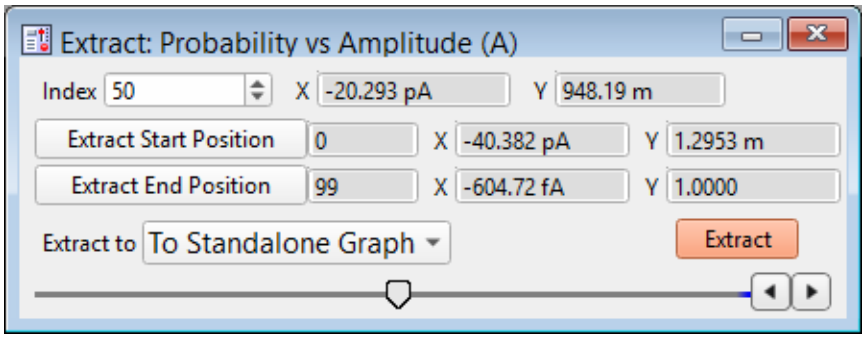


Figure 4-132. Extract Results Analysis

Extract: Amplitude (A) vs Time (s)

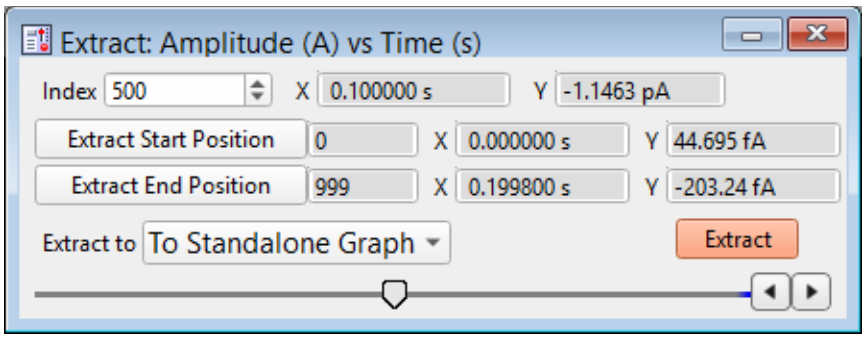


Figure 4-133. Extract Amplitude vs Time

Extract: Frequency vs Sweep Number

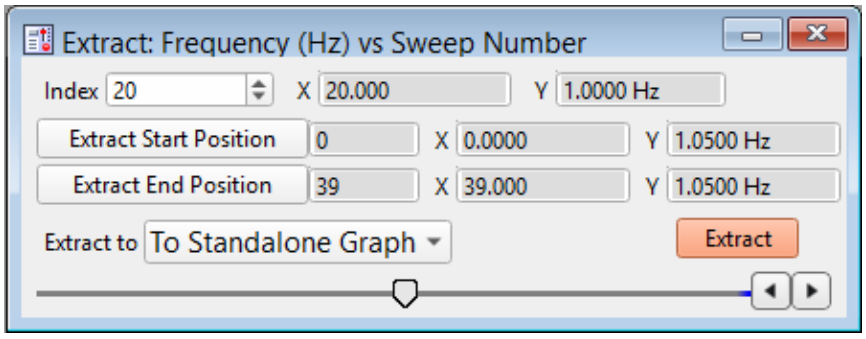


Figure 4-134. Extract Frequency vs Sweep #

Extract: Amplitude (A) vs Sweep Number

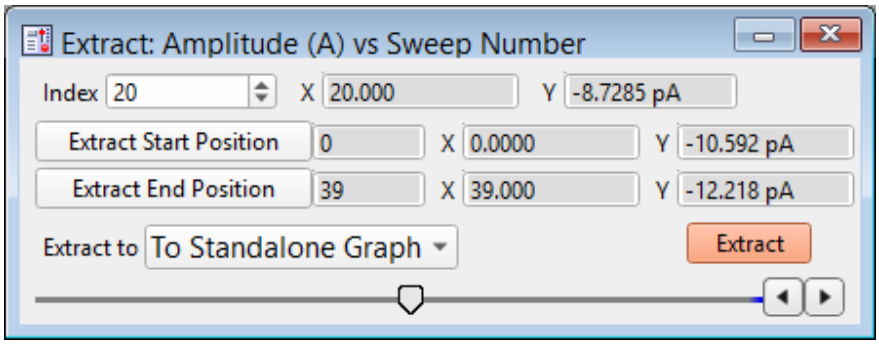


Figure 4-135. Extract Amplitude vs Sweep #

Index [< 0 to (n-1) >]

The selected data-point number in the plot.

A data-point number can be entered, or use the increment/decrement controls to increase/decrease the selected data-point by one point.

X [#]

The X-axis value of the selected data point.

Y [#]

The Y-axis value of the selected data point.

[Extract Start Position]

Click to set the starting point of the data extraction.

[<#>] Index number of the extraction start.

X [#]

The X-axis value of the extraction start.

Y [#]

The Y-axis value of the extraction start.

[Extract End Position]

Click to set the ending point of the data extraction.

[<#>] Index number of the extraction end.

X [#]

The X-axis value of the extraction end.

Y [#]

The Y-axis value of the extraction end.

Extract to [< target >] [↓]

Select the data extraction target:

Analysis Pool — Extract the data to the Data/ Data Browser / root:SutterPatch:Data: Analysis folder as:

APResults_#

Template Pool — Extract the plot to the Template Editor as:

APResults_ Extracted_[#]

Data Export Target Folder

Extract the data to the Data / Data Browser folder specified in Set Preferences / Export Data / Copy Data Waves as:

APResults_Extracted

To Standalone Graph

Extract the plot to a separate graph window; if a fit has been performed, only the fitted line is extracted.

To Notebook — Extract the graph as a graphic to the Notebook.

To Clipboard — Extract the graph as a graphic to the system clipboard.

To Printer — Print the graph as a graphic directly to the default printer as raw output.

[Extract] — Click to extract the selected data.

 — X-slider bar

Click and drag the slider for the data-point cursor.

The data cursor display mode is set in 'Set Preferences / Graphs and Layouts'.

Click to decrement/increment the data cursor by one point at a time, or with the Shift-key, by 10 data points.

Or, the keyboard left/right-arrow keys to decrease/increase the data selection by one point; with the Shift key, they decrease/increase the selection by 10 points.

Or, the keyboard Up/Down arrow keys increase/decrease the data selection by 10 points.

This floating window automatically closes when you click outside of it.

[Show/Hide Results Table]

A resizable results summary and table pane are displayed or hidden:

Summary Info

Signal name:	The signal name of the analyzed signal.
Total time analyzed = (s)	Includes the Start / End times for all sweeps.
Number of events detected = (#)	Total number of Events found.
Event Frequency = (Hz)	Events per second.
Average Event Amplitude = (pA)	±1 ms peak average.
Standard Deviation of Event Amplitude = (pA)	
'All Sweeps analyzed' or marked "Sweeps analyzed: #, #..."	

Export this text

Summary Export button with options list:

To Notebook (as text)	Copy the summary as text to the Notebook.
To Notebook (as graph)	< unavailable >
To Clipboard (as text)	Copy the summary as text to the system clipboard.
To Clipboard (as graph)	< unavailable >
To Printer (as text)	Print the summary as text directly to the default printer as raw output.

To Printer (as graph)	< unavailable >
To Layout (as graph)	Copy the summary as a graphic into a new Layout window or append to an existing Layout page.

Results Table

Column Headers

[ ]	Row number, one row per event.
Sweep Number	The sweep number the Event is in.
Event Time (s)	'Time to event' from the start of the sweep.
Event Strength (xSD)	A measure of how well the signal matches the template. Lower is weaker, higher is stronger.
Event Amplitude (A)	The Event peak amplitude ± 1 ms average.
Event Integral (A*s)	Area of the Event. The integral range is based on the template.
10-90% Rise Time (s)	Time to rise from 10% amplitude to 90% amplitude of the Event.
Event Decay Tau (s)	The (exponential) tau of the falling phase of the Event.
Absolute Event Time (s)	A continuous time scale from the start of acquisition, i.e., from the clicking of the 'Start' button, prior to the initial Sweep/Series external trigger.
Inter Event Interval (s)	The time from the start of an Event to the following Event.
Event Strength (x1e-10)	Estimate of confidence in the Event.
Halfwidth (s)	The duration of the Event at 50% of the Event amplitude.

 Export this table

Export button with options list:

To Notebook (as text)	Copy the table to the SutterPatch Notebook as text.
To Notebook (as graph)	Copy the table as a graphic to the Notebook.
To Clipboard (as text)	Copy the table to the system clipboard as text.
To Clipboard (as graph)	Copy the table as a graphic to the system clipboard.
To Printer (as text)	Print the table as text directly to the default printer as raw output.
To Printer (as graph)	Print the table as a graphic directly to the default printer as raw output.
To Layout (as graph)	< unavailable >

Analysis Start (s) [#]

Sweep time to start looking for an Event threshold.

Analysis End (s) [#]

Sweep time to stop looking for an Event threshold.

[Distribution Analysis]

A scatter plot of the Distribution Analysis is displayed in a sub-panel.

X [< target >] [↓]

Select the X-axis from the drop-down list,

and

Y [< target >] [↓]

select the Y-axis from the drop-down list:

< see Results Table Column Headers above for details >

Sweep Number

Event Time (s)

Event Strength (xSD)

Event Amplitude (A)

Event Integral (A*s)

10-90% Rise Time (S)

Event Decay Tau (s)

Absolute Event Time (s)

Interevent Interval (s)

Event Strength (abs)

Halfwidth (s)

Scan or extract the data

Measure X-Y data points or extract data.

- Scan distribution data

  Open a floating window to manually measure X-Y data points in the plot.

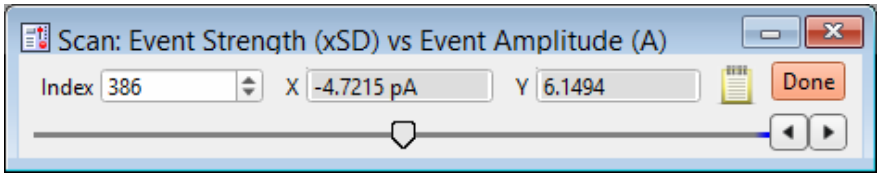


Figure 4-136. Scan Distribution Data

Scan: distribution analysis

Index [< 0 to (n-1) >]

The selected data-point number in the plot.

A data-point number can be entered, or use the increment/decrement controls to increase/decrease the selected data-point by one point.

X [#]

The X-axis value of the selected data point.

Y [#]

The Y-axis value of the selected data point.

Write to Notebook

Click to write to the Notebook:

Scan: “X” vs “Y”	Label.
index=#	Point.
x=#	X data value.
y=#	Y data value.

Close the “Scanner” floating window.

This window also automatically closes when you click outside of it.

X-slider bar

Click and drag the slider for the data-point cursor.

The data cursor display mode is set in ‘Set Preferences / Graphs and Layouts’.

Click to decrement/increment the data cursor by one point at a time, or with the Shift-key, by 10 data points.

Or, the keyboard left/right-arrow keys decrease/increase the data selection by one point; with the Shift key, they decrease/increase the selection by 10 points.

Or, the keyboard Up/Down arrow keys increase/decrease the data selection by 10 points.

- Extract distribution data

  Select to open a floating window with data extraction controls.

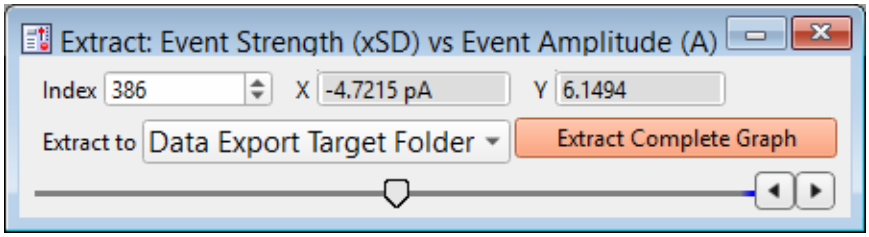


Figure 4-137. Extract Distribution Data

Extract: distribution analysis

Index [< 0 to (n-1) >]

The selected data-point number in the plot.

A data-point number can be entered, or use the increment/decrement controls to increase/decrease the selected data-point by one point.

X [#]

The X-axis value of the selected data point.

Y [#]

The Y-axis value of the selected data point.

Extract to [< target >] [↓]

Select the data extraction target:

Analysis Pool < not available >

Template Pool < not available >

Data Export Target Folder

< not available >

To Standalone Graph

Extract the plot to a separate graph window; if a fit has been performed, only the fitted line is extracted.

To Notebook	Extract the graph as a graphic to the Notebook.
To Clipboard	Extract the graph as a graphic to the system clipboard.
To Printer	Print the graph as a graphic directly to the default printer as raw output.

[Extract complete graph]

Click to extract the entire graph.

X-slider bar

Click and drag the slider for the data-point cursor.

The data cursor display mode is set in 'Set Preferences / Graphs and Layouts'.

Click to decrement/increment the data cursor by one point at a time, or with the Shift-key, by 10 data points.

Or, the keyboard left/right-arrow keys decrease/increase the data selection by one point; with the Shift key, they decrease/increase the selection by 10 points.

Or, the keyboard Up/Down arrow keys increase/decrease the data selection by 10 points.

This floating window automatically closes when you click outside of it.

Export this graph

Export button with options list:

To Notebook (as text)	Copy the graph to the Notebook as text.
To Notebook (as graph)	Copy the graph as a graphic to the Notebook.
To Clipboard (as text)	Copy the graph to the system clipboard as text.
To Clipboard (as graph)	Copy the graph as a graphic to the system clipboard.

To Printer (as text)	Print the graph as text directly to the default printer as raw output.
To Printer (as graph)	Print the graph as a graphic directly to the default printer as raw output.
To Layout (as graph)	Copy the graph as a graphic into a new Layout window or append to an existing Layout page.

Set Marker

Marker Size	[< Auto, 1 – 9 >]
Marker Type	Select a marker from a panel of 63 symbols.

Marquee

Click and drag the mouse to surround a region of interest, and right-click for a context menu:

Expand	Set the graph's Y-axis range from the marquee vertical data limits, and set the graph's X-axis range from the marquee horizontal data limits.
Horiz Expand	Set the graph's X-axis range from the marquee horizontal data limits.
Vert Expand	Set the graph's Y-axis range from the marquee vertical data limits.
Shrink	Set the graph's Y-axis range to the positions of the marquee vertical data limits, and set the graph's X-axis range to the positions of the marquee horizontal data limits.
Horiz Shrink	Set the graph's X-axis range to the positions of the marquee horizontal data limits.
Vert Shrink	Set the graph's Y-axis range to the positions of the marquee vertical data limits.
Remove Selected Events	Remove the selected Events from the plot and the analysis results.
Only Selected Events	Remove the unselected Events from the plot and the analysis results.

[Save Results] Click to update and display the Results Graphs pane, the Analysis Editor, and the Layout page.

A Shift-click will skip the Layout window.

Note: The Layout window is also accessible via Windows / Layouts.

Results Graphs

< see Show Results Graphs above >

Layout Window

Summary Info

Signal name: The signal name of the analyzed signal.

Total time analyzed = (s) Includes the Start/End times for all sweeps.

Number of events detected = (#)

Total number of Events found.

Event Frequency = (Hz) Number of events per second.

Average Event Amplitude = (pA)

±1 ms peak average.

Standard Deviation of Event Amplitude = (pA)

'All Sweeps analyzed', or marked "Sweeps analyzed: #, #..."

Results Graphs

Cumulative probability vs. Amplitude.

Amplitude (Average) vs. Time.

Frequency vs. Sweep Number.

Amplitude vs. Sweep Number.

Note: The individual graphs are also accessible via Windows / Graphs.

Analysis Editor

Four source waves are copied to the Analysis Editor:

R#_S#_#_mini_avg	A trace of the mini average.
R#_S#_#_ mini_hist	The cumulative amplitude histogram.
R#_S#_#_mini_results	The mini results table.
R#_S#_#_ mini_sweep	The frequency & amplitude vs. sweep #.

[Plot Events] Click to plot Event as overlapping sweeps in a floating graph window.

Plot Events dialog

[<#, # - #>] Enter a list of Events separated by a comma "," and/or a range of Events separated by a dash "-".

4.3 General

SutterPatch general operations.

Note: Hidden unminimized windows can be brought into view with the menu command Windows / Control / Retrieve All Windows.

4.3.1 Command Window

Window: Command Window

This window is an Igor Pro code interpreter, providing programmatic interaction with SutterPatch. You can manually execute Igor Pro and user-defined assignments, functions and operations in this window.

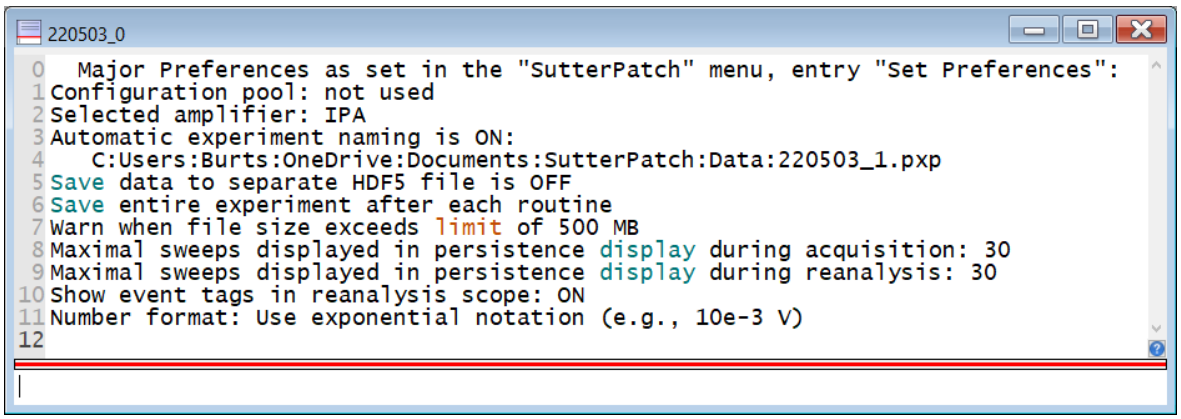


Figure 4-138. Command Window

The Command window is labeled with the current Experiment filename, and is accessed from the menu Windows / Command Window

A history of commands and responses displays in the upper portion of the window. Some warning messages also display here.

At program startup, some of the SutterPatch major preferences are written to the history:

Configuration pool: [filename]

Selected amplifier: dPatch

Automatic experiment naming is ON/OFF
["ON" file path]

Save data to separate HDF5 file is ON/OFF

Save entire experiment after each routine

Warn when file size exceeds limit of # MB

Persistence in reanalysis scope is Keep current setting

Scope time shown: Absolute Sweep Time

Set X- range of main P/N pulse in Scope is OFF

Maximal sweeps displayed in persistence display during acquisition: #

Maximal sweeps displayed in persistence display during reanalysis: #

Show event tags in reanalysis scope: ON/OFF

Number format: (for table export)

The lower section is a command buffer with a "command line", where commands to be executed are entered. Commands can be entered into the command buffer in multiple ways:

- Manually type (or copy and paste) a line of text into the "command line" in the lower section of the window.
- Highlight lines in the history section and press the Enter key to copy them into the command buffer in the lower section of the window. To select the entire history, use 'CTRL-A'.
- Use the Paradigm Editor Execute step buttons 'Copy to Command Line' or 'Expand to Command Line' (for vars) to transfer the step command to the command line.

Commands in the command buffer are processed when the 'Enter' key is pressed.

A maximum of 400 characters can be entered into the command buffer, however they can be spread across multiple commands on multiple lines.

Note: Igor Pro syntax usually requires that open/close parentheses "( )" be appended to the end of a command. However, exceptions include the "beep" and "print" commands, for which no parentheses are used.

The Command window has a resizing line between the upper history section and the lower command section – the mouse cursor will change to a double-headed arrow.

< for more information, see Igor Help file "Using Igor" >

4.3.2 Dashboard Panel

SutterPatch: Dashboard

The "small" Dashboard panel is a floating toolbar that provides access to the entire SutterPatch menu, while the "large" Dashboard panel provides a convenient gateway to key areas of the SutterPatch program.

Note: To reposition the Dashboard to its default location (on upper-left of screen), Shift-click when selecting the 'Dashboard' menu item.

Settings — Dashboard Settings menu.

- Large — Display key areas as large icons in a Dashboard pane.
  - Vertical — When the Dashboard 'Acquire Data' sub-pane is open, dock it below the main Dashboard pane.
  - Horizontal — When the Dashboard 'Acquire Data' sub-pane is open, dock it on the right-side of the main Dashboard pane.
- Small — Display the SutterPatch menu as small icons in a floating toolbar.
  - Vertical — Align the toolbar vertically on the left side of the computer screen.

    < this is the default configuration >
  - Horizontal — Align the toolbar horizontally on the left-side of the computer screen.
  - ----------
  - Show Defaults

    SutterPatch HDF5 File Menu

    < displays if HDF5 is enabled in Set Preferences >

Files and Naming >

else 'New Experiment'

Amplifier Control Panel

Membrane Test

Free Run (Scope)

Paradigm Editor

Routine Editor

Data Navigator

Set Metadata

View Last

Show All Entries — All icons are displayed in the toolbar.

Hide All Entries — No icons are displayed in the toolbar.

In the Settings for “Small”, select/deselect the icons to display in the toolbar:

Icon	Icon Name	Shortcut Key
	New Experiment	
or	< set this option in SutterPatch / Set Preferences / Files and Naming >	
	SutterPatch HDF5 File Menu	
	Abort selection ----------	
	Open SutterPatch HDF5 File	
	New SutterPatch HDF5 File	
	Update SutterPatch HDF5v File	
	Compact SutterPatch HDF5 File	
	Acquisition Control	Ctrl-0

	Scope Window	Ctrl-2
	Amplifier Control Panel	Ctrl-3
	Membrane Test	Ctrl-4
	Free Run (Scope)	Ctrl-5
	Paradigm Editor	Ctrl-6
	Routine Editor	Ctrl-7
	Template Editor	
	Equation Editor	
	Solution Editor	
	Camera Control	
	Data Navigator	Ctrl-8
	Analysis Editor	
	Layout Page	
	Set Metadata	Ctrl-9
	Set Preferences	
	Notebook	
	Shortcut Editor	
	View Last	FN-F2

Note: In certain computer chipsets, the small Dashboard is not directly draggable for repositioning from its title bar.

In this case, move the mouse cursor onto the toolbar's minimize button as a pointer (not a slanted double-headed arrow) and click it. If nothing happens, try to CTRL-click it. If the toolbar immediately closes, reopen it from the menu SutterPatch / Dashboard and try again.

A drop-down list should display:

- Restore < not available >
- Move
- Size < not available >
- Minimize
- Stay on top < does not apply to newly opened "Editor" windows, until the toolbar window is re-clicked >
- Close

Large Icons

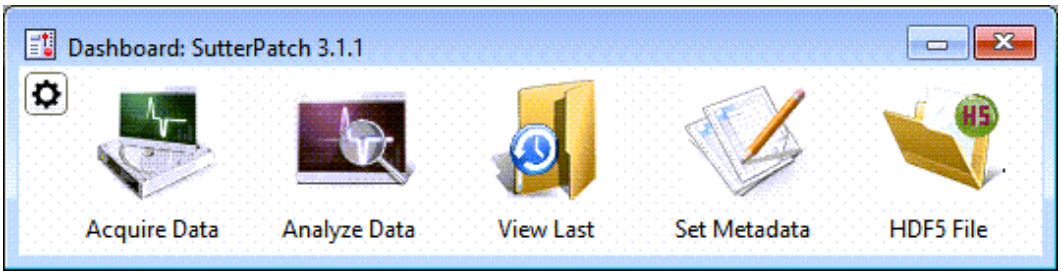


Figure 4-139. Dashboard Large Icons

Click the Acquire Data icon to open an adjoining secondary pane:

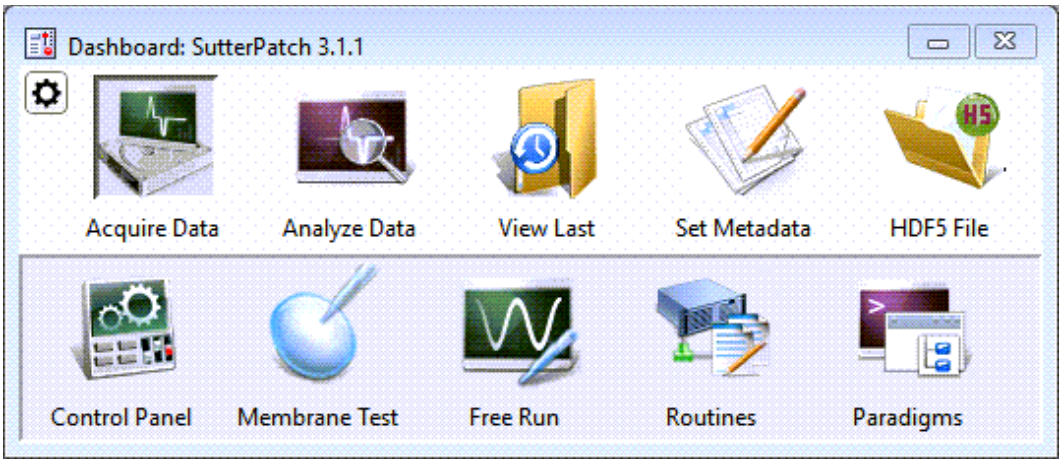


Figure 4-140. Dashboard Acquire Data

Acquire Data — Live recordings and acquisition configuration. Button stays depressed while its window is open.

Analyze Data — Review and analyze data in the Data Navigator.

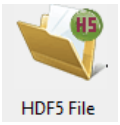
View Last Data — Open the Experiment's last recorded data Series. All sweeps (marked and unmarked) are visible in the initial display.

Set Metadata — Configure metadata settings and values.

New Experiment — Start a new Experiment, and/or switch the amplifier model or emulation mode.

Note: During the shutdown of the existing Experiment, it is highly recommended to say "Yes" to save changes, even if no changes were made. This is used by an internal Igor Pro cleanup process to ensure proper file reopening.

or



HDF5 File

< only displays if the HDF5 option is set in SutterPatch / Set Preferences / Files and Naming >

Abort selection

Open SutterPatch HDF5 File

New SutterPatch HDF5 File

Update SutterPatch HDF5 File

Compact SutterPatch HDF5 File

Large Icon Acquisition Pane

Control Panel — Hardware control via the Amplifier Control Panel.

Membrane Test — Monitor seal formation and cell health.

Free Run — Run an oscilloscope-style signal monitor.

Routines — Configure Routine acquisition settings.

Paradigms — Control the execution of commands.

4.3.3 Documentation

Help

Help: Igor Help Browser
Help: Help Topcis

Help files for the Igor Pro software, the SutterPatch software, and all models of Sutter Amplifier Systems.

The SutterPatch portion of the Help is arranged in nine different Help files.

SP_Acquisition

SP_Analysis

SP_Appendices

SP_General Software

SP_Getting_Started

SP_Hardware

SP_Paradigms

SP_Routines

SP_Troubleshooting

In the browser's 'Help Topics' tab:

1. Select a Help file starting with "SP_" to display its Topics.
2. Select a Topic to display its Subtopics.
3. Select a Topic or Subtopic and click 'Show Selected Topic'.
4. The Help file is opened to the Topic or Subtopic section.

Help: SutterPatch Help Topics

Displays an alphabetical listing of the SutterPatch main menu items, plus other topics of interest. Select a topic to open a Help file to that section.

Manual

Help: SutterPatch Manual

The SutterPatch manual is customized to your IPA amplifier, and installed as a PDF file in the following folders:

Windows: C:\Program Files\SutterPatch3\SutterPatch\Documentation\

macOS: Applications/SutterPatch3/SutterPatch/

To display a PDF Table of Contents with links:

In the PDF document, click the 'Contents' button on the left side of the Navigation Toolbar and select the 'List' button.

Tip! Use a commercial PDF viewer with extended PDF support to have PDF page numbers match to the PDF viewer page controls.

QuickStart Guide

A printed "quick" installation guide for your Sutter hardware and software.

Important! Contains your Igor Pro 9 Serial Number and Activation Key.

Release Notes

A list of new feature and bug fix highlights for the SutterPatch software is posted on the SutterPatch web product page in the 'Download' tab:

https://www/sutter.com/AMPLIFIERS/SutterPatch.html

Videos

View informative technical videos of Sutter Instrument products on our YouTube channel, including a 5-part walkthrough of SutterPatch:

https://www.youtube.com/c/SutterInstrument

or see our web site product pages 'VIDEOS' tabs.

View informative technical videos on using Igor Pro on our Wavemetrics YouTube channel, including a multi-part Guided Tour:

https://www.youtube.com/c/WaveMetricsInc

4.3.4 File Types

Analysis Files

Graphs in the Analysis Editor can be imported or exported as Igor Binary Wave (*.ibw) files, via the dialog's 'Files' options.

Note: Graph data for each axis can also be saved as Igor Pro 6 one-dimensional wave files, however files using this older format cannot be re-imported back into SutterPatch.

Individual graphs can also be saved with the experiment as Graph Macros - recall them via the Windows / Graph Macros menu.

Tables in the Analysis Editor can be imported or exported as text files (*.txt).

Equation Files

Equation pool files can be loaded and saved via the Equation Editor as SutterPatch text files (*.txt).

Experiments & Data

The "packed" Igor Pro file format is recommended for saving an Experiment for most purposes.

- Packed experiment: (*.pxp file)

  A SutterPatch Experiment is saved by default as a "packed" (Igor Pro) Experiment, which includes all data, analyses, graphs, routines, paradigms, etc., in one file.

  A Preferences option now allows a packed Experiment to save data to an HDF5 file, which has the advantage of an unpacked Experiment (like fast saving), without the disadvantage of much larger file sizes.

- Unpacked experiment: (*.uxp file, experiment Folder)

  A SutterPatch Experiment can also be saved as an "unpacked" (Igor Pro) Experiment, which saves all waves, procedure windows, and notebooks as individual files in an experiment or "home" Folder, along with an instruction (*.uxp) file.to recreate the Experiment.

  The advantage of an unpacked Experiment is:

  - Much faster processing of Experiment recordings that include very large numbers of waves (thousands or more), as existing data waves are not re-saved with each new recording.

  The disadvantages of an unpacked Experiment are:

  - Much more disk space is used, especially for Experiments that have a lot of small waves.

  - The UXP format is more "fragile", as you need to keep the Experiment file and its corresponding folder together when you copy or move the Experiment.

Saved Experiments can be re-opened during the SutterPatch start up. Or you can add the data only into the current Experiment via the Data Navigator 'Import' button.

Data file path defaults

Windows:	C:\Users\<User Account Name>\Documents\SutterPatch\Data\
macOS:	Applications/ SutterPatch3/SutterPatch/Data/

Note: If a SutterPatch Experiment file is opened into Igor Pro without SutterPatch running, its graphs and layouts can be displayed with the menu items Windows / Graphs, or Windows / Layouts, or Windows / Layout Macros.

HDF5 Files

HDF5 is a modern efficient file format for saving and managing high volumes of data.

Enable SutterPatch HDF5 files (*.h5) for Experiments with SutterPatch / Set Preferences / Files and Naming / 'Save data to separate HDF5 file'.

Multiple SutterPatch HDF5 files can be created during an Experiment to segregate or manage data.

< see the File menu for additional options >

HEKA Files

HEKA Elektronik PatchMaster Pulse Generator Files (*.pgf) can be opened in the Routine Editor 'Pools and Files' section and their Sequences merged with the current routine pool (however, real-time analysis is not supported.)

The Data Navigator 'Import' option for PatchMaster data files (*.dat) is only available if Sutter Amplifier Systems hardware has been attached and detected by the SutterPatch software at any previous point in time for the current OS user.

PatchMaster NEXT data files are also supported.

Igor Pro Files

Data can be selected and exported to the Igor Pro file format (*.ibw) via the Data Navigator 'Available Actions' menu. Select the Igor Binary format in SutterPatch / Set Preferences / Data Export.

Igor Pro binary waves (*.ibw) can be loaded into the current Experiment via Data / Load Waves / Load Igor Binary. Find the files in Data / Data Browser.

Note: If data is imported from other (non-Sutter) Igor Pro programs, adjust the scaling of the data as needed.

Layout Files

The Layout window of the current experiment can be saved to several file formats via the main menu File / Save Graphics command. Various formatting options are available here.

Paradigm Files

Paradigm pool files can be loaded and saved via the Paradigm Editor as SutterPatch Paradigm files (*.spp).

pCLAMP Files

Data can be exported to the Molecular Devices / Axon Instruments pCLAMP v1.8 file formats via the Data Navigator 'Available Actions' button or right-click menu. However, first set to the ABF or ATF file format in SutterPatch / Set Preferences / Data Export.

The Data Navigator 'Import' option for pCLAMP data is only available if Sutter Amplifier Systems hardware has been attached and detected by the SutterPatch software at any previous point in time for the current OS user. Only pCLAMP 'episodic' and 'gap-free' data import are supported.

Routine Files

Routine pool files can be loaded and saved via the Routine Editor as SutterPatch Routine files (*.spr).

Solution Files

Solution pool files can be loaded and saved via the Solution Editor as SutterPatch Output files (*.spo).

Template Files

Templates can be imported or exported via the Template Editor as Igor Binary Wave files (*.ibw).

Templates can also be used to export portions of data from a sweep.

4.3.5 Layout Window

SutterPatch: Layout Page: Show Layout

The Layout window is used to prepare your data for publication. Scope window input signals analysis graphs and other objects can be exported to a Layout window for graphical arrangement and editing.

A default Layout window is automatically created when SutterPatch is launched - display it with the menu command SutterPatch / Layout Page / Show Layout. Only one Layout window exists at a time.

If no Layout window exists, it can be manually created via the Copy to layout" button  located in various windows.
The Layout window can also be created by running a Paradigm 'Export' step.

Note: Layout windows are sometimes created hidden behind other windows.

Clicking a "Copy to layout" button appends its associated items into an existing Layout page (or a new Layout window.) Each signal and analysis graph is appended as an individual object, and might need manual adjustments to be fully visible.

The default configuration of "2 x 4" ('column' x 'row') objects per page can be changed in Preferences / Export Graphics or the Paradigm 'Export' step, and is applied when a new Layout window is created:

1	single pane
2 2	stacked panes
3 3	stacked panes
2 x 2	matrix
2 x 3	matrix
2 x 4	matrix

Once a Layout window page is filled, additional objects are automatically appended into additional Layout pages.

A toolbar displays in the upper-left edge of the Layout window – the upper two buttons reconfigure the toolbar buttons:

 Operate	Selection tools and object insertion mode.
 Draw Mode	Drawing tools mode.

Saving an Experiment also saves the Layout window.

"Importing" of an Experiment in the Data Navigator does not include its Layout window…

In SutterPatch, to display a Layout window from a saved Experiment, use File / Open Experiment on the ".pxp" file. Or, to open it in Igor Pro, at the SutterPatch startup Welcome screen, use the Open button. The menu items SutterPatch / Layout and Windows / Layout also provide access to any available Layout pages.

Note: The HDF5 file saving option must be disabled before starting the SutterPatch session or Experiment. You can check the state of this preference in the 'Summary of Major Preferences' window at startup, or in the Set Preferences / Files and Naming window.

The Layout window of the current Experiment can also be saved to several file formats via the main menu File / Save Graphics command - various formatting options are available there.

4.3.6 Log Window

SutterPatch: Log Window

The Log window displays time-stamped commands, responses, administrative information and error messages that provide a history of the steps having a possible influence on the execution of the experiment and its data. The Log window can also serve as a user laboratory notebook for free-form entries.

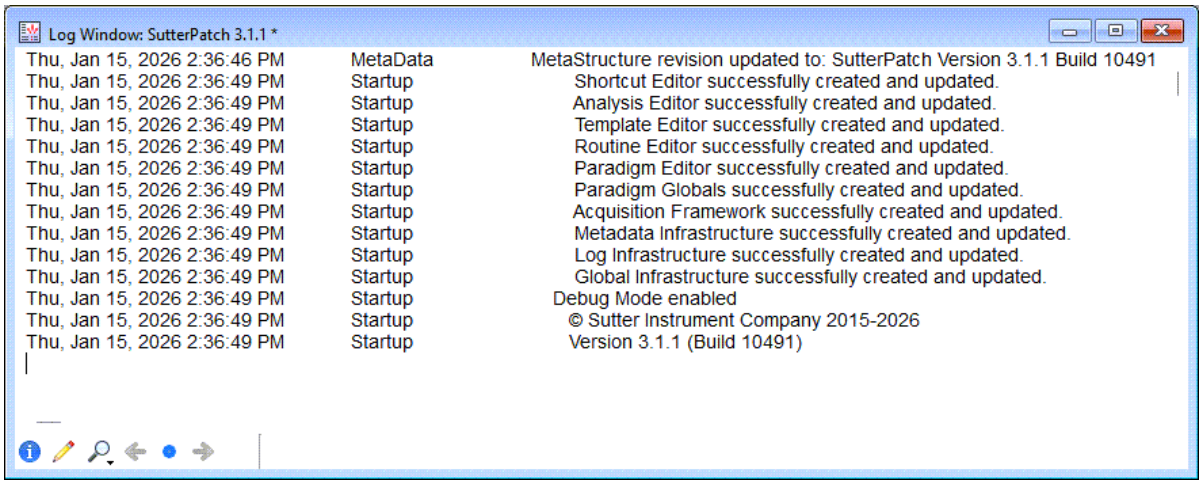


Figure 4-141. Log Window

At startup, the Log window displays the SutterPatch Version and Build numbers.

The following unnamed columns are used by the Log window:

Date & Time — Log entries are assigned a date/time stamp.

Day name, month name, day date, year date, time: hours:minutes:seconds, AM/PM

Event Type — Log entries are assigned an Event Type.

Data Acquisition	Acquisition operations, Membrane Test measurements.
Metadata	Tags.
Paradigm	Paradigm operations.
Startup	SutterPatch version information.
Unknown	Other operations.

Event Description — A text description of the log entry.

Each row with a Data Acquisition, Metadata or Paradigm entry is appended with the name of the appropriate Routine or Paradigm; if there is no value to list, just the name of the Routine or Paradigm is displayed.

4.3.7 Menus

The SutterPatch main menu item contains all of the SutterPatch-specific menu items. The rest of the main menu items provide the standard Igor Pro functionality. For documentation of the non-SutterPatch features, refer to the Igor Pro Help.

Window/Dialog Controls

Keyboard "Return" key	=	'OK / Yes' buttons
Keyboard ESC key	=	'Cancel' button

File

New Experiment	Unload the current Experiment and start a new Experiment. It is recommended that you create one Experiment per cell, to keep file sizes manageable. Note: If closing an existing Experiment, it is highly recommended to say "Yes" to save changes, even if no changes were made. This is used by an internal Igor Pro cleanup process to ensure proper file reopening. Data file path defaults: C:\Users\<User Account Name> \Documents\SutterPatch\Data\
Open Experiment	Open a previously saved SutterPatch Experiment (*.pxp, *.uxp) file. If a SutterPatch Experiment is opened into an Igor Pro-only session, SutterPatch is automatically loaded. Note: If closing an existing Experiment, it is highly recommended to say "Yes" to save changes, even if no changes were made. This is used by an internal Igor Pro cleanup process to ensure proper file reopening. If no active hardware is attached, the original amplifier configuration of the Experiment will be automatically used for the SutterPatch demo mode.

If the SutterPatch preference for HDF5 files was enabled, a SutterPatch Question will ask how to load the matching HDF5 file:

Load matching HDF5 File: [path name]

- Load in modify mode, i.e., add new data, store changes in analysis files

  Open the HDF5 file in read-write mode, i.e., the original metadata and experiment structure, analysis results, images, etc. are overwritten when closing the present experiment. However, raw data are NEVER modified.

- Load in read-only mode, i.e., don't store any change back to the file

  Open the HDF5 file in read-only mode. Routine acquisition is disabled. Anything done in this session is lost when closing the Experiment.

- Cancel loading HDF5 file

  Do not open the HDF5 Experiment.

  A normal Igor Pro session is launched. The SutterPatch menu is populated with blank submenus, and the command 'Reactivate SutterPatch' to re-open the HDF5 Experiment.

Save Experiment

If the current Experiment is already named, it is immediately saved; otherwise, a 'Save experiment as' file dialog is displayed with the default name 'Experiment' for renaming

Alert! The 'Save Experiment' menu selection saves all Igor Pro objects, including many that are temporary, but does no other cleanup, and HDF5 files are not updated to disk.

Therefore, to obtain a cleaned-up complete experiment file when exiting SutterPatch, or when executing 'New Experiment' or 'Open Experiment', select "YES" for the prompt:

> "Do you want to save changes to Experiment "XXXX"?

Save Experiment As

A 'Save experiment as' file dialog is displayed .

If 'Set Preferences / File' is enabled for automatic file naming, an incrementing Experiment name is displayed.

If 'Set Preferences / File' is disabled for automatic file naming, the default name 'Experiment' is displayed for renaming;

Alert! The 'Save Experiment As' menu selection saves all Igor Pro objects, including many that are temporary, but does no other cleanup, and HDF5 files are not updated to disk.

Therefore, to obtain a cleaned-up complete Experiment file when exiting SutterPatch, or when executing 'New Experiment' or 'Open Experiment', select "YES" for the prompt:

"Do you want to save changes to experiment "XXXX"?

Recent Experiments — A list of recently used Experiments.

Exit — An Experiment file 'Save' dialog is displayed before closing the program. If an Experiment is not saved, global variables and window sizes / positions are lost.

< HDF5 file options only display for Experiments started with the Preferences for Files and Naming / 'Save data to separate HDF5 file' enabled >

Open SutterPatch HDF5 File

Open a SutterPatch HDF5 data file to replace the data in the existing Experiment.

< the following options only ungray after data has been acquired or loaded >

New SutterPatch HDF5 File

Store all existing data into the present SutterPatch HDF5 file, clean up the Experiment, and create a new SutterPatch HDF5 file, so that acquisition can continue as if you had started a "New Experiment", but without starting a new SutterPatch session (or *.pxp file).

Update SutterPatch HDF5 File

Update the SutterPatch HDF5 data file without starting a new Experiment.

Compact SutterPatch HDF5 File

Any discarded data is removed from the active SutterPatch HDF5 data file, and the file is compacted without resaving the entire Experiment.

Merge SutterPatch HDF5 File

Display a “file open” dialog to select another HDF5 file to be merged with the active HDF5 file.

Data

Data Browser — Access all SutterPatch objects contained in the Experiment.

Analysis

The Analysis menu provides a wide assortment of mathematical transforms.

Curve Fitting — Create custom fitting equations.

Quick Fit — A variety of Igor Pro fitting equations.

Macros

Show File Controller — Display the File Controller menu for external application control of SutterPatch.

Windows

The Windows menu provides access all windows controls.

Command Window — A quick code interpreter to manually process SutterPatch and Igor Pro commands.

Control / Retrieve All Windows

Hidden unminimized windows can be brought into view with this menu command.

Layout

The Layout menu only displays when a Layout is the active window. Use it to modify the Layout window display and objects.

Notebook

Display options to customize the Notebook.

Python

Open Console — Open a Python console to communicate with SutterPatch.

SutterPatch

Dashboard — Display icons for core program functions.

Acquisition Control — Open a control panel with Start/Stop and other interactive acquisition controls for Routines and Paradigms.

Scope Window	Bring an open Scope window to the front.

Hardware Control	
Amplifier Control Panel	Open the hardware control panel.
Reset Control Panel	Return the Amplifier Control Panel to its default settings.
Lock-In Adjustments	Manually tune the “lock-in amplifier” system.
Reset USB	Re-initialize USB communication with the computer. If in Demo mode, you need to start a ‘New Experiment’ to access ‘Reset USB’.

Membrane Test	Open and run the Scope window to monitor seal formation and cell health.
Free Run	Open and run the Scope window in oscilloscope style.
Reset Acquisition	Stop the Paradigm and/or data acquisition and clear corrupted acquisition settings.

Paradigm Editor	Open a window to load, edit and run Paradigms.
Routine Editor	Open a window to load and edit Routines.
Template Editor	Open a window to manage templates.
Equation Editor	Open a window to load and edit Equations.
Solution Control	Open a window to control solutions.
Camera Control	Open a window to capture images.

Data Navigator	Open a window to organize and display the experiment Paradigm, Routine and acquisition data in a tree structure.
View Last	Open the last acquired data file of the Experiment into a Reanalysis window.
Analysis Editor	Open a window to manage and analyze graph data.
Layout Page	
Show Layout	Open the Layout window.

Delete Layout	Delete the existing Layout window.

Set Metadata	Open a window to configure user-specified experimental information.
Set Preferences	Open a window to modify the default program settings.
Log Window	Open a window to display a history of program actions.
Notebook	Open a window for laboratory text entries and notations.

Shortcuts	
Shortcut Editor	Open a window to manage keyboard shortcuts for SutterPatch commands.

Available Analysis Modules	
Action Potential Analysis	
Single Channel Analysis	
Synaptic Event Analysis	

Help

Igor Help Browser	Igor Pro and SutterPatch Help.
Help Topics	Igor Pro and SutterPatch Help.
SutterPatch Help Topics	Help Topics that match to the SutterPatch main menu.
SutterPatch Manual	PDF version of the SutterPatch manual.
About SutterPatch	SutterPatch version and contact information.

Scope right-click menus

Different areas of the Scope windows support additional functionality through "right-click" menus in Windows, or "Command-click" menus in macOS.

Scope X-Axis < right-click the X-axis >

- Autoscale All Axes

- Autoscale X Axis
- Set X Scale
- Axis Properties

Scope Y-Axis < right-click the Y-axis >

- Autoscale All Axes
- Continuous Autoscale Y Axis
- Autoscale Y Axis
- Full Scale Y Axis
- Set Y Scale
- Axis Properties
- Hide Signal '< signal name >'
- Show Signal '< signal name >' Only
- Stack All Signals

Acquisition Scope main window < right-click the blank area in a signal >

Display a limited data modification menu.

Note: If you click too close to the data, the full data modification menu displays instead. If you are having this issue, click near a horizontal or vertical edge of the signal pane.

- Autoscale All Axes
- Add Annotation
- Export Graphics Copy the selected signal to a Graph window.
- Colors
- Hide Signal '< signal name >'
- Show Signal '< signal name >' Only
- Stack All Signals

Reanalysis Scope main window < right-click in the blank area in a signal pane >

Display a limited data modification menu.

Note: If you click too close to the data, the full data modification menu displays instead. If you are having this issue, click near a horizontal or vertical edge of the signal pane.

- Autoscale All Axes
- Add Annotation
- Export Graphics — Copy the selected signal to a Graph window.
- Colors
- Hide Signal '< signal name >'
- Show Signal '< signal name >' Only
- Stack All Signals
- Show All Sweeps
- Show Marked Sweeps

Signal data < right-click on or near the data >

Display the full data modification menu.

- Browse < signal name >
- Edit < signal name >
- Remove Sweep_#
- Hide Sweep_#
- Duplicate Sweep_#
- Replace Sweep_#
- Copy
- Modify Sweep_#
- Customize at Point
- Mode
- Line Style
- Line Size
- Markers
- Marker Size
- Color
- Bring to Front

- Send to Back
- Forward
- Backward
- Move to Opposite Axis
- Quick Fit
- Parametric Plot
- Amplitude Histogram Plot
- Export Graphics
- Hide Signal '< signal name >'
- Show Signal '< signal name >' Only
- Stack All Signals
- Show All Sweeps
- Show Marked Sweeps

Scope Marquee window < click-and-drag a box in a signal pane >

- Expand
- Horiz Expand
- Vert Expand
- Shrink
- Horiz Shrink
- Vert Shrink

- Extract Template

4.3.8 Notebook

SutterPatch: Notebook

The SutterPatch Notebook is a free-form digital laboratory notebook for text edits, pasted objects, and automatic entries.

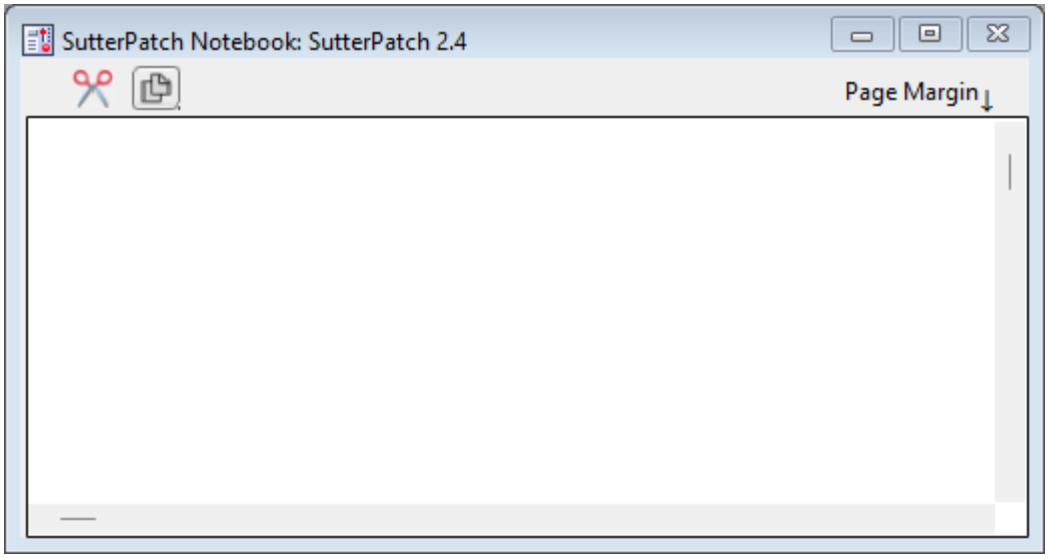


Figure 4-142. Notebook

Objects such as Graphs and Tables can be copied and pasted into the Notebook. Automatic entries include cursor measurements from graphically displayed data, Paradigm results, and system logging information.

Clear	Clear the complete Notebook content.
Copy text	Process the selected text, or if nothing is selected, process the complete Notebook according to the selected option: Copy Notebook (Text only) to Clipboard Copy Notebook (Text only) to Layout Copy as an annotation; if Shift key is also pressed, copy as standalone text. Save Notebook Copy (Text only) to plain Text File Save Notebook Copy (Text and Graphs) to “rtf” File Save Notebook Copy (Text and Graphs) to HTML File Print Notebook (Text and Graphs)

Print directly to the default printer as raw output.

[< text >]

Text window

Each line is numbered, and usually starts with the time in hh:mm:ss.xxx.

All entries can be edited or erased.

4.3.9 Sample Files

Sample settings files (subject to change) are included in the .. \ Documents \ SutterPatch \ Parameters folder:

Equation Pool

SP_EquationPool.txt

1.	X3pi	3*pi
2.	ElapsedTime	ParadigmTime - time
3.	Temperature	aux[1]*1.23 – 273.15

Paradigm Pools

LockIn / LockIn_IPA.spp

1. LockIn_Adjust_500Hz
2. LockIn _ Adjust_1kHz
3. LockIn _DoAdjust

SP_ParadigmPool_IPA.spp

1.	Amplifier_Setup	Set initial amplifier settings.
2.	Start_one_Series	Start acquisition of one routine.
3.	Set_amplifier_and_start_IV	Set amplifier to a known state, then start a routine.
4.	Interactive_acquisition_1	Run an interactive acquisition stopping at a given analysis condition.
5.	Start_two_Series	Start acquisition of two subsequent routines.
6.	Start_ForEachSweep	Start acquisition of a routine, individually triggering each sweep.

7.	Interactive_acquisition_2	Run an interactive acquisition loop that selects between 2 routines, and manually stops via a Checkbox.
8.	Tuning_with_Input	Use the paradigm "Input" control to increment or decrement a Routine's stimulus output.
9.	Toggle_Persistence	Use a Checkbox to toggle Scope window trace persistence while acquiring a routine.
10.	Switch_Headstages	Switch between multiple headstages.
11.	Tuning_with_Keys	Use the keyboard to increment or decrement a Routine's stimulus output by 10 mV.
12.	CellHealth_From_CC	Monitor the cell's resistance and capacitance in current clamp mode.

Routine Pools

LockIn / LockIn_DIPA.spr < for Double IPA systems >

1. phase_delay
2. LockIn_500Hz
3. LockIn_1kHz

LockIn / LockIn_IPA.spr < for IPA systems >

1. phase_delay
2. LockIn_500Hz
3. LockIn_1kHz

SP_RoutinePool.spr < for IPA systems >

1.	Amplitude Equations	Equations for a variety of stimulus waveforms.
2.	AT_InactRec_P4	Inactivation with leak subtraction.
3.	Bowtie_Test	Multi-channel input with incrementing ramp waveforms.
4.	ContinuousNoOut	Acquisition without any output waveform.
5.	IV	I-V for voltage-clamp mode.
6.	IV_CC	I-V for current-clamp mode.
7.	IV_Continuous	I-V with continuous acquisition.
8.	IV_P4	I-V with four leak-subtraction pulses.
9.	IV_tuning	I-V for sample "tuning" paradigms.
10.	Multi_Test	Multi-channel input with an incrementing square-step waveform.

11. Onset_SlowActivation	Onset Slow activation.
12. Recovery_Inactivation	Recovery from inactivation.
13. Recovery_SlowInact	Recovery from slow inactivation.
14. SS_Inactivation	Steady-state inactivation.
15. SS_SlowInactivation	Steady-state slow activation.
16. Synaptic_Stim	Synaptic stimulation.
17. Synaptic_Stim30	Synaptic stimulation for 30 s.
18. Synaptic_StimPlusDig	Synaptic stimulation with digital output.
19. Template_PlusVirtual	Template wave and recording virtual signals.
20. Template_SpontAct	Template wave from a recorded signal.
21. Template_Test	Template wave for waveform output.
22. Test_Pulse	Test pulse.

SP_RoutinePool_DIPA.spr < for Double IPA systems >

1. Amplitude Equations	Equations for a variety of stimulus waveforms.
2. AT_InactRec_P4	Inactivation with leak subtraction.
3. Bowtie_Test	Multi-channel input with incrementing ramp waveforms.
4. ContinuousNoOut	Acquisition without any output waveform.
5. IV	I-V for voltage-clamp mode.
6. IV_CC	I-V for current-clamp mode.
7. IV_Continuous	I-V with continuous acquisition.
8. IV_P4	I-V with four leak-subtraction pulses.
9. IV_tuning	I-V for sample “tuning” paradigms.
10. IV_VC_CC	IV for voltage- and current-clamp modes.
11. Multi_Test	Multi-channel input with an incrementing square-step waveform.
12. Onset_SlowActivation	Onset Slow activation.
13. Recovery_Inactivation	Recovery from inactivation.
14. Recovery_SlowInact	Recovery from slow inactivation.
15. SS_Inactivation	Steady-state inactivation.
16. SS_SlowInactivation	Steady-state slow activation.
17. Synaptic_Stim	Synaptic stimulation.
18. Synaptic_Stim30	Synaptic stimulation for 30 s.
19. Synaptic_StimPlusDig	Synaptic stimulation with digital output.

20.	Template_PlusVirtual	Template wave and recording virtual signals.
21.	Template_SpontAct	Template wave from a recorded signal.
22.	Template_Test	Template wave for waveform output.
23.	Test_Pulse	Test pulse.

Shortcut Pool

SP_ShortcutPool.sps

	Key	Description
1.	Right	Increase the Control Panel V-holding level by 10 mV.
2.	Left	Decrease the Control Panel V-holding level by 10 mV.
3.	Right+Shift	Increase the Control Panel V-holding level by 1 mV.
4.	Left+Shift	Decrease the Control Panel V-holding level by 1 mV.
5.	F2	Open the last acquired Series into a Reanalysis Scope window.
6.	F3	Stop the Scope acquisition.
7.	F4	Start acquisition in the open Scope window.
8.	F5	Stop the execution of a running Paradigm.
9.	F6	Pause the execution of a running Paradigm.
10.	F7	Resume execution of a paused Paradigm.
11.	F10	Toggle the Cursor Info bar On | Off
12.	; (period)	Highlight the next sweep in the Reanalysis Scope.
13.	, (comma)	Highlight the previous sweep in the Reanalysis Scope.

Solution Pools

SP_SolutionPool.spl	< no longer included - incompatible obsolete format from SutterPatch v2.2.2.1 or earlier >
SP_SolutionPool.spo	< for all Sutter amplifier systems from SutterPatch version 2.3 or later >

1.	undefined	No solutions are configured.

Template Pool

SP_TemplatePool.spt

1. RoutinePreview
2. Single_actionPotential
3. HodgkinHuxley
4. Noise

Experiments

Sample data (subject to change) are included in the ... / Documents / SutterPatch / Example folder:

ActionPotentials.pxp	Action potential data.
LargeAPs.pxp	Large action potentials data.
MiniExample.pxp	Spontaneous miniature synaptic potential data. To re-import into the same Experiment, first delete the file in Data Browser / Data "R..S1_untitled_3".

4.3.10 Set Metadata

SutterPatch: Set Metadata

A large variety (600+) of optional experimental parameters (preparation, electrode, etc.) can be associated with an Experiment, Paradigm or Routine as user-configurable “metadata”. Predefine the metadata parameter values here.

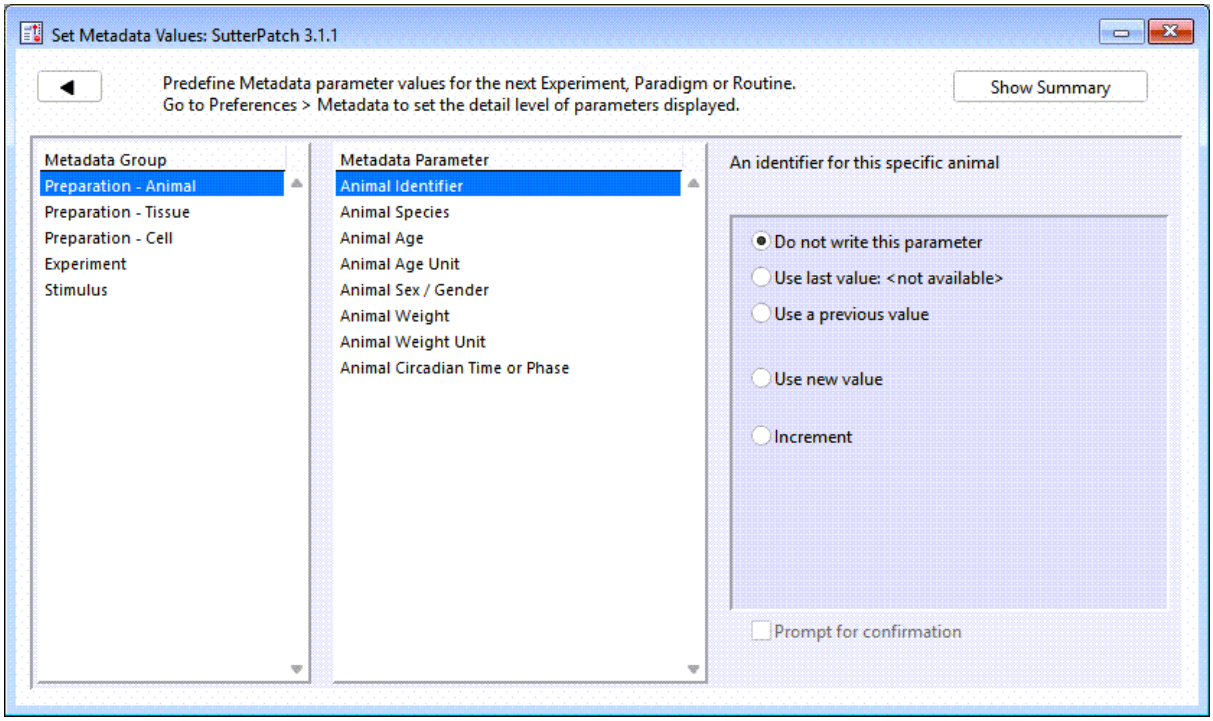


Figure 4-143. Set Metadata Values

◀ Close the ‘Set Metadata Values’ window.

[Show Summary] Click to display an overview of the user-defined metadata parameters.

Metadata Summary dialog

This list summarizes all Metadata parameters for which values have been defined. Double-click a line to show and edit the details for a parameter.

Metadata Parameter	Parameter name.
Current Value	Parameter value.
Increment Enabled	If enabled, double-click to review details.
Prompt before	Display metadata prompts before running:
▪ Expt	Experiment

- Pdgm Paradigm
- Routn Routine

Metadata Group — Availability is per the SutterPatch > Set Preferences > Metadata > Metadata detail level.

< see below for a table of all parameters >

Level 1: Basic — < five default Groups >

Preparation – Animal

Preparation – Tissue

Preparation – Cell

Experiment

Stimulus

Level 2: Extended — < enhancements plus two more Groups >

Electrode

Recording Solution

Level 3: Full — < enhancements plus five more Groups >

Operator

Paradigm

Cell Health / Quality Control

Series (= Routine Data)

Imaging

Metadata Parameter — Metadata parameters for the selected Group are displayed, as set in SutterPatch > Set Preferences > Metadata detail level.

< see table below >

[Parameter description] A description of the selected parameter.

Configuration choices for the selected parameter

Note: Values in this dialog are updated by acquisition changes after the dialog is closed and re-opened.

- Do not write this parameter

  This parameter is not used.

- Use last value — The parameter used in the previous acquisition is displayed and used for the next acquisition.

  < this field is updated when the Set Metadata window is closed and reopened >

- Use a previous value — Select from a drop-down list of the last previous 20 metadata values used for acquisition.

  < this field is updated when the Set Metadata window is closed and reopened >

- Use new value — Enter a new value for the metadata parameter.

- Increment — Numerically increment the value:

  By

  - Experiment — At the start of each Experiment.
  - Paradigm — At the start of each Paradigm.
  - Routine — At the start of each Routine.

  Prefix — Enter text to be prepended to the value.

  Start value — The initial value (including decimals and negative numbers.)

  Increment: — Select an arithmetic operator [+, -, *, /]

  [ ] — Enter the incremental amount.

  Suffix — Enter text to be appended to the value.

[ ] Prompt for confirmation:

- Experiment — At the start of an Experiment.
- Paradigm — At the start of a named Paradigm (i.e., pre-planned, not auto-triggered by a Routine.)
- Routine — At the start of a Routine.

Confirm Metadata Settings for Routine: < name >

This dialog displays whenever an Experiment, Paradigm or Routine is started with metadata prompts enabled.

Write	[ ] Enable to write the selected metadata parameter with the Experiment, Paradigm or Routine.
Metadata Parameter	[< parameter >] The name of the selected metadata parameter.
Next Value	[< value >] The metadata value to write.
Update	[ ] Enable so that edits made to 'Value' will update the 'last value' for the next prompt. This field is automatically disabled after each execution.
Prompt	[ ] Disable to remove the metadata parameter from those listed in the Confirm Metadata Settings dialog. The 'Confirm Metadata Settings' dialog only displays if a metadata parameter has been enabled for 'Prompt'.
[Continue]	Proceed with executing the Routine.
[Abort Routine]	Stop execution of the Routine.

BASIC	EXTENDED	FULL	GROUP / Parameters	NOTES
B			**OPERATOR**	
		F	Full Operator Name	
B			**PREPARATION - ANIMAL**	
B			Animal Identifier	
B			Animal Species	Binomial species name
	E		Animal Strain	Strain, breed or variety characterizing the animal
	E		Animal Genotype	
B			Animal Age	
B			Animal Age Unit	Ex.: h, d, m
B			Animal Sex / Gender	Ex.: 1: F, 2: M, 3: Undetermined
B			Animal Weight	
B			Animal Weight Unit	
B			Animal Circadian Time or Phase	
	E		Animal Preparation Date	ISO Date, Format: YYYY-MM-DD
	E		Animal Preparation Time	Time of Day, Format: hh:mm[:ss.000]
	E		Animal User Parameter 1 Name	
	E		Animal User Parameter 1	
	E		Animal User Parameter 2 Name	
	E		Animal User Parameter 2	
	E		Animal User Parameter 3 Name	
	E		Animal User Parameter 3	
	E		Animal User Parameter 4 Name	
	E		Animal User Parameter 4	
	E		Animal User Parameter 5 Name	
	E		Animal User Parameter 5	
B			**PREPARATION - TISSUE**	
B			Tissue Preparation Identifier	
B			Organ	
	E		Organ Region	
	E		Preparation Method	
	E		Tissue Preparation Date	ISO Date, Format: YYY-MM-DD
	E		Tissue Preparation Time	Time of Day, Format: hh:mm[:ss.000]
	E		Tissue Incubation Duration	
	E		Tissue Incubation Duration Unit	
	E		Tissue Incubation Temperature	
	E		Tissue Incubation Temperature Unit	
	E		Tissue Incubation Solution	

	E		Tissue User Parameter 1 Name	
	E		Tissue User Parameter 1	
	E		Tissue User Parameter 2 Name	
	E		Tissue User Parameter 2	
	E		Tissue User Parameter 3 Name	
	E		Tissue User Parameter 3	
	E		Tissue User Parameter 4 Name	
	E		Tissue User Parameter 4	
	E		Tissue User Parameter 5 Name	
	E		Tissue User Parameter 5	
B			**PREPARATION - CELL**	
B			Cell Preparation Identifier	
	E		Acutely Dissociated Cells	
	E		Cell Line	
	E		Slice Preparation	
	E		Whole-organ Preparation	
	E		In-situ Recording	
	E		Stem Cell Preparation	
	E		User-defined Preparation	
B			Cell Type	
B			Cell Identifier	
B			Cell Preparation Date	ISO Date, Format: YYY-MM-DD
B			Cell Preparation Time	Time of Day, Format: hh:mm[:ss.000]
	E		Cell Dissociation Solution	
	E		Cell Preparation Dissociation Temperature	
	E		Cell Prep. Dissociation Temperature Units	
B			Cell Preparation Incubation Duration	
B			Cell Prep. Incubation Duration Unit	
B			Cell Preparation Incubation Temperature	
B			Cell Prep. Incubation Temperature Unit	
B			Cell Preparation Incubation Solution	
B			Ion Channel	
	E		Cell Fluorescent Marker	
	E		Cell Diameter	
	E		Cell User Parameter 1 Name	
	E		Cell User Parameter 1	
	E		Cell User Parameter 2 Name	
	E		Cell User Parameter 2	
	E		Cell User Parameter 3 Name	
	E		Cell User Parameter 3	
	E		Cell User Parameter 4 Name	

	E		Cell User Parameter 4	
	E		Cell User Parameter 5 Name	
	E		Cell User Parameter 5	
B			**EXPERIMENT**	
		F	Experiment Category 1 Name	
		F	Experiment Category 1	
		F	Experiment Category 2 Name	
		F	Experiment Category 2	
		F	Experiment Category 3 Name	
		F	Experiment Category 3	
		F	Experiment Category 4 Name	
		F	Experiment Category 4	
		F	Experiment Category 5 Name	
		F	Experiment Category 5	
B			Experiment User Parameter 1 Name	
B			Experiment User Parameter 1	
B			Experiment User Parameter 2 Name	
B			Experiment User Parameter 2	
B			Experiment User Parameter 3 Name	
B			Experiment User Parameter 3	
B			Experiment User Parameter 4 Name	
B			Experiment User Parameter 4	
B			Experiment User Parameter 5 Name	
B			Experiment User Parameter 5	
	E		**ELECTRODE**	
	E		Electrode Identifier	
	E		Electrode Glass Manufacturer	
	E		Electrode Glass Item Number	
		F	Electrode Glass Lot Number	
		F	Electrode Glass Material	
		F	Electrode Glass Item Outer Diameter	
		F	Electrode Glass Item Inner Diameter	
		F	Filamented Glass	
	E		Electrode Glass Ramp Test Value	
	E		Pipette Puller Manufacturer	
	E		Pipette Puller Model	
		F	Pipette Puller Serial Number	
		F	Puller Filament Type	
		F	Puller Filament Item Number	
		F	Pull Program Number	
		F	Pull Program Parameters	
		F	Pull Program Air Mode	
		F	Pull Program Air Pressure	

		F	Puller Preheat Enabled	
		F	Pull Heat-on Time	
		F	Electrode Tip Diameter	
		F	Electrode Taper Length	
		F	Electrode Fire-polished	
		F	Electrode Coated	
		F	Electrode Coating Material	
		F	Electrode Beveled	
		F	Electrode Bevel Angle	
	E		Electrode User Parameter 1 Name	
	E		Electrode User Parameter 1	
	E		Electrode User Parameter 2 Name	
	E		Electrode User Parameter 2	
	E		Electrode User Parameter 3 Name	
	E		Electrode User Parameter 3	
	E		Electrode User Parameter 4 Name	
	E		Electrode User Parameter 4	
	E		Electrode User Parameter 5 Name	
	E		Electrode User Parameter 5	
	E		**RECORDING SOLUTIONS**	
	E		Solution Pair Identifier	
	E		Solution Pair Name	
	E		Bath Solution Identifier	
	E		Bath Solution Name	
		F	Bath Solution Batch	
		F	Bath Solution Composition	
		F	Bath Solution Preparation Date	
		F	Bath Solution Preparation Time	
		F	Bath Solution pH	
		F	Bath Solution pH Adjustment Agent	
		F	Bath Solution Osmolarity	
		F	Bath Solution Osmolarity Adj. Agent	
		F	Bath Solution Preparer	
	E		Pipette Solution Identifier	
	E		Pipette Solution Name	
		F	Pipette Solution Batch	
		F	Pipette Solution Composition	
		F	Pipette Solution Preparation Date	
		F	Pipette Solution Preparation Time	
	E		Pipette Solution pH	
		F	Pipette Solution pH Adjustment Agent	
	E		Pipette Solution Osmolarity	
		F	Pipette Solution Osmolarity Adj. Agent	

		F	Pipette Solution Preparer	
		F	Solution User Parameter 1 Name	
		F	Solution User Parameter 1	
		F	Solution User Parameter 2 Name	
		F	Solution User Parameter 2	
		F	Solution User Parameter 3 Name	
		F	Solution User Parameter 3	
		F	Solution User Parameter 4 Name	
		F	Solution User Parameter 4	
		F	Solution User Parameter 5 Name	
		F	Solution User Parameter 5	
		F	**PARADIGM**	
		F	Bath Temperature	
		F	Bath Temperature Unit	
		F	Ambient Temperature	
		F	Ambient Temperature Unit	
		F	Atmospheric Composition	
		F	Atmospheric Pressure	
		F	Atmospheric Pressure Unit	
		F	Atmospheric Humidity	% relative humidity ("-1" = uncontrolled)
		F	Paradigm User Comment	
		F	Paradigm User Parameter 1 Name	
		F	Paradigm User Parameter 1	
		F	Paradigm User Parameter 2 Name	
		F	Paradigm User Parameter 2	
		F	Paradigm User Parameter 3 Name	
		F	Paradigm User Parameter 3	
		F	Paradigm User Parameter 4 Name	
		F	Paradigm User Parameter 4	
		F	Paradigm User Parameter 5 Name	
		F	Paradigm User Parameter 5	
		F	**CELL HEALTH / QUALITY CONTROL**	
		F	Cell Health User Parameter 1 Name	
		F	Cell Health User Parameter 1	
		F	Cell Health User Parameter 2 Name	
		F	Cell Health User Parameter 2	
		F	Cell Health User Parameter 3 Name	
		F	Cell Health User Parameter 3	
		F	Cell Health User Parameter 4 Name	
		F	Cell Health User Parameter 4	
		F	Cell Health User Parameter 5 Name	
		F	Cell Health User Parameter 5	

		F	**SERIES (= ROUTINE DATA)**	
		F	Routine User Comment	
		F	**IMAGING**	
		F	Image Comment	
B			**STIMULUS**	
	E		Key Stimulus	
	E		Stimulus Duration	
	E		Compound Group	
	E		Compound Group Index	
B			Compound Identifier	
B			Compound Name	
B			Compound Concentration	
B			Compound Concentration Unit	
	E		Compound Batch	
	E		Compound Lot	
	E		Compound Counterion	
	E		Compound Solution	
	E		Compd. Vehicle / Solubility Enhancer	
	E		Compound Vehicle Concentration	
	E		Compound Vehicle Conc. Unit	
	E		Compound Reservoir Identifier	
	E		Application Tip Identifier	
	E		Compound Plate Identifier	
	E		Compound Plate Row	
	E		Compound Plate Column	
	E		Chem. Stimulus User Param. 1 Name	
	E		Chem. Stimulus User Parameter 1	
	E		Chem. Stimulus User Param. 2 Name	
	E		Chem. Stimulus User Parameter 2	
	E		Chem. Stimulus User Param. 3 Name	
	E		Chem. Stimulus User Parameter 3	
	E		Chem. Stimulus User Param. 4 Name	
	E		Chem. Stimulus User Parameter 4	
	E		Chem. Stimulus User Param. 5 Name	
	E		Chem. Stimulus User Parameter 5	
B			Light Stimulus Wavelength	
B			Light Stimulus Intensity	
B			Light Stimulus Intensity Unit	
	E		Light Stimulus User Param. 1 Name	
	E		Light Stimulus User Parameter 1	
	E		Light Stimulus User Param. 2 Name	
	E		Light Stimulus User Parameter 2	
	E		Light Stimulus User Param. 3 Name	

	E		Light Stimulus User Parameter 3	
	E		Light Stimulus User Param. 4 Name	
	E		Light Stimulus User Parameter 4	
	E		Light Stimulus User Param. 5 Name	
	E		Light Stimulus User Parameter 5	
B			Mechanical Stimulus Intensity	
B			Mechanical Stimulus Intensity Unit	
	E		Mech. Stimulus User Param. 1 Name	
	E		Mech. Stimulus User Parameter 1	
	E		Mech. Stimulus User Param. 2 Name	
	E		Mech. Stimulus User Parameter 2	
	E		Mech. Stimulus User Param. 3 Name	
	E		Mech. Stimulus User Parameter 3	
	E		Mech. Stimulus User Param. 4 Name	
	E		Mech. Stimulus User Parameter 4	
	E		Mech. Stimulus User Param. 5 Name	
	E		Mech. Stimulus User Parameter 5	
B			Acoustic Stimulus Frequency	
B			Acoustic Stimulus Intensity	
B			Acoustic Stimulus Intensity Unit	
	E		Acoust. Stimulus User Param. 1 Name	
	E		Acoust. Stimulus User Parameter 1	
	E		Acoust. Stimulus User Param. 2 Name	
	E		Acoust. Stimulus User Parameter 2	
	E		Acoust. Stimulus User Param. 3 Name	
	E		Acoust. Stimulus User Parameter 3	
	E		Acoust. Stimulus User Param. 4 Name	
	E		Acoust. Stimulus User Parameter 4	
	E		Acoust. Stimulus User Param. 5 Name	
	E		Acoust. Stimulus User Parameter 5	
B			Thermal Stimulus Temperature	
B			Thermal Stimulus Temperature Unit	°C, °F or K
	E		Therm. Stimulus User Param. 1 Name	
	E		Therm. Stimulus User Parameter 1	
	E		Therm. Stimulus User Param. 2 Name	
	E		Therm. Stimulus User Parameter 2	
	E		Therm. Stimulus User Param. 3 Name	
	E		Therm. Stimulus User Parameter 3	
	E		Therm. Stimulus User Param. 4 Name	
	E		Therm. Stimulus User Parameter 4	
	E		Therm. Stimulus User Param. 5 Name	
	E		Therm. Stimulus User Parameter 5	

B			Electrical Stimulus Frequency	The frequency of an external electrical stimulus
B			Electrical Stimulus Intensity	The intensity of an external electrical stimulus
B			Electrical Stimulus Intensity Unit	The intensity unit of an external electrical stimulus
	E		Electr. Stimulus User Param. 1 Name	
	E		Electr. Stimulus User Parameter 1	
	E		Electr. Stimulus User Param. 2 Name	
	E		Electr. Stimulus User Parameter 2	
	E		Electr. Stimulus User Param. 3 Name	
	E		Electr. Stimulus User Parameter 3	
	E		Electr. Stimulus User Param. 4 Name	
	E		Electr. Stimulus User Parameter 4	
	E		Electr. Stimulus User Param. 5 Name	
	E		Electr. Stimulus User Parameter 5	
	E		Other Stimulus User Param. 1 Name	
	E		Other Stimulus User Parameter 1	
	E		Other Stimulus User Param. 2 Name	
	E		Other Stimulus User Parameter 2	
	E		Other Stimulus User Param. 3 Name	
	E		Other Stimulus User Parameter 3	
	E		Other Stimulus User Param. 4 Name	
	E		Other Stimulus User Parameter 4	
	E		Other Stimulus User Param. 5 Name	
	E		Other Stimulus User Parameter 5	

Table 4-7. Metadata Parameters

4.3.11 Set Preferences

SutterPatch: Set Preferences

Preferences settings customize the default settings for several areas of the SutterPatch program. To access, go to the SutterPatch / Set Preferences menu.

A 'Summary of Major Preferences' window, by default, opens at SutterPatch startup.

Summary window

Major Preferences as set in the "SutterPatch" menu, entry "Set Preferences":

Configuration pool: not used

Selected amplifier: IPA

Automatic experiment naming is ON/OFF

< Experiment file path name >

Save data to separate HDF5 file is ON/OFF

Keep only one sweep in memory is ON/OFF

Update HDF5 file after each routine is ON/OFF

Compact HDF5 file on closing is ON/OFF

Save data as 4-byte reals is ON/OFF

Warn when file size exceeds limit of # MB

Persistence in reanalysis scope is Keep current setting

Scope time shown: Relative Sweep Time

Set X-range of main P/N pulse in scope is ON/OFF

Maximal sweeps displayed in persistence display during acquisition: #

Maximal sweeps displayed in persistence display during reanalysis: #

Show event tags in reanalysis scope is ON/OFF

Scope title contains Experiment, paradigm and routine

Exported number format: Engineering prefix (e.g., 1. 0 mv)

[ ] Show on startup	Enable display of the “Preferences Summary” window at startup. This window is only created at startup. If the Summary window is closed, a copy of the “Preferences Summary” can be found in the Command window history.
	Copy the summary information.
To Notebook (as text)	Copy the summary as text to the Notebook.
To Notebook (as graph)	Copy the summary as a graphic to the Notebook.
To Clipboard (as text)	Copy the summary as text to the system clipboard.

To Clipboard (as graph)	Copy the summary as a graphic to the system clipboard.
To Printer (as text)	Print the summary as text directly to the default printer as raw output.
To Printer (as graph)	Print the summary directly to the default printer as raw output.
To Layout (as graph)	< unavailable >

i. General

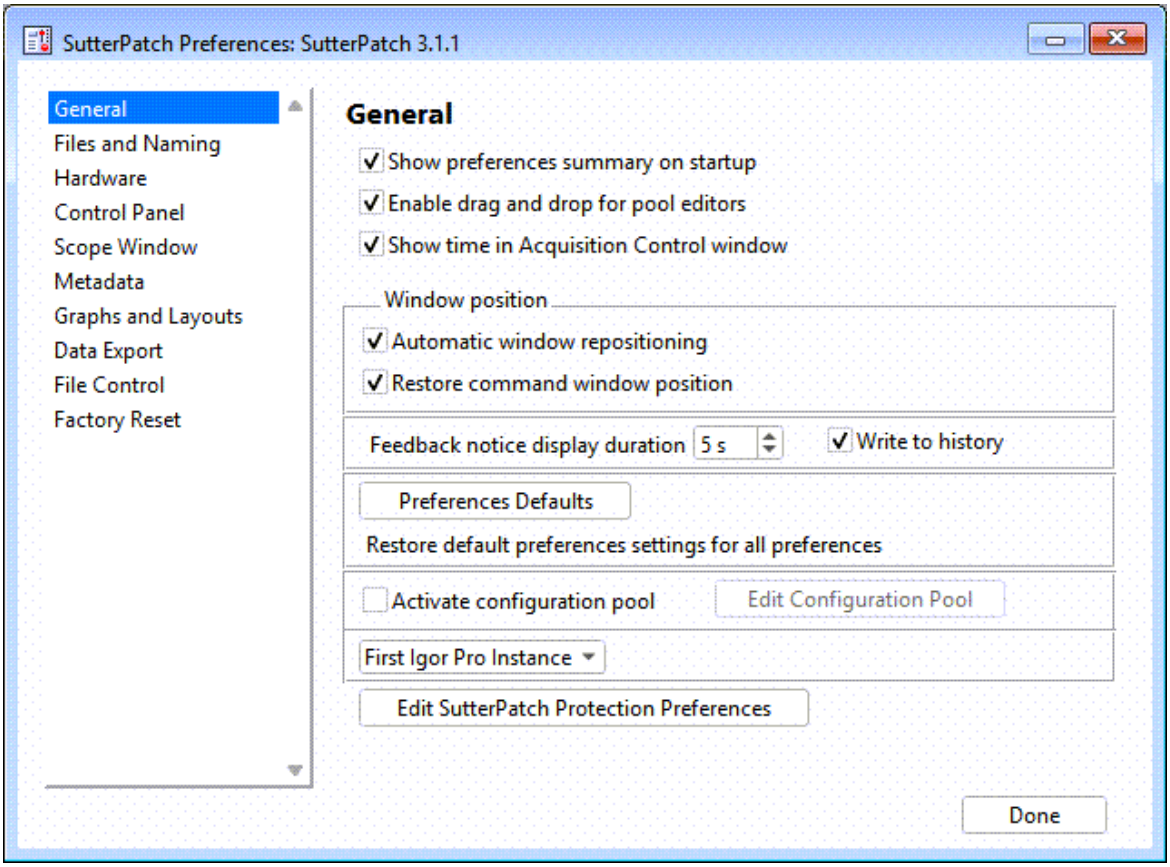


Figure 4-144. Preferences: General Settings

[ ] Show preferences summary on startup

Display the 'Summary of Major Preferences' pane when SutterPatch opens a new Experiment, and also display this summary at startup in the Command window.

[ ] Enable drag and drop for pool editors

Most SutterPatch "Editors" load a set of named configurations from a main

"Pool" file. These named items can be re-arranged in their Editor's Pool list by clicking and dragging with the mouse.

This also applies to the Paradigm Editor list of Paradigm Steps.

[ ] Show time in Acquisition Control window

Display a system "Time" clock [hh:mm:ss] in the Acquisition Control panel.

Window position

[ ] Automatic window repositioning

When SutterPatch windows or dialogs are opened or moved, when the action is done, they are automatically repositioned to be fully visible. If a "child" window is opened, the parent window is moved to the left until the child sub-window is fully visible or the parent window reaches the left edge of the main window/screen.

[ ] Restore command window position

Enable so the command window position is remembered for the next Experiment that opens. Otherwise, a new Experiment always returns the Command window to its default size and location.

You can bring all unminimized windows into view with the Windows > Control > Retrieve All Windows menu command.

Dual-monitor option < for macOS only >

One screen — Prevents windows spanning across multiple monitors.

If a "parent" window is moved to another monitor, it fully displays in the new monitor, while any child sub-window remains behind fully displayed in the original monitor.

Feedback notice display duration

[1 – 30 s]

Control how long SutterPatch messages display for reading, before automatically closing.

[ ] Write to history — Write SutterPatch feedback notices to the Command window.

[Preferences Defaults] Restore default settings for all preferences.

[ ] Activate configuration pool

Display the Configuration loading window when starting a new Experiment.

[Edit Configuration Pool] Create different user Preferences configurations, selectable for loading at the start of a new experiment.

Configuration Pool window

[Delete Configuration] Remove the named Configuration from the list.

[< configuration >] [↓] Select from a list of defined configurations.

[Add New Configuration] Click to create a new Preferences Configuration for the existing Preferences settings.

Give a description for this configuration - window

Description ["name"] [↓]

Select from a list of defined configurations.

Enter the name of a new Preferences Configuration in double quotes.

[Update Active Configuration (#)]

The "active" Configuration is updated with the existing Preferences settings.

This dialog opens with the active Configuration name listed. The number (#) indicates its position in the Configuration list.

Note: The 'Files and Naming' preference for HDF5 file saving cannot be disabled via running a Configuration; it must be manually disabled by the user in Set Preferences.

Also, while SutterPatch Preferences Configuration files use the *.spc file extension, this is reported by the OS as file type "PKCS #7 Certificates".

[< instance >] [↓]

- First Igor Pro Instance
- Second Igor Pro Instance

- Third Igor Pro Instance
- Fourth Igor Pro Instance

Multiple instances of Igor Pro can be run simultaneously via the File > 'Start another Igor Pro Instance' menu item. Set the Igor Pro preferences for a numbered instance to use for a new experiment of that instance.

[Edit SutterPatch Protection Preferences]

< contact Sutter Technical Support to activate SutterPatch Protection >

Limit user access and permissions for GLP.

Password protection.

Encrypt data.

ii. Files and Naming

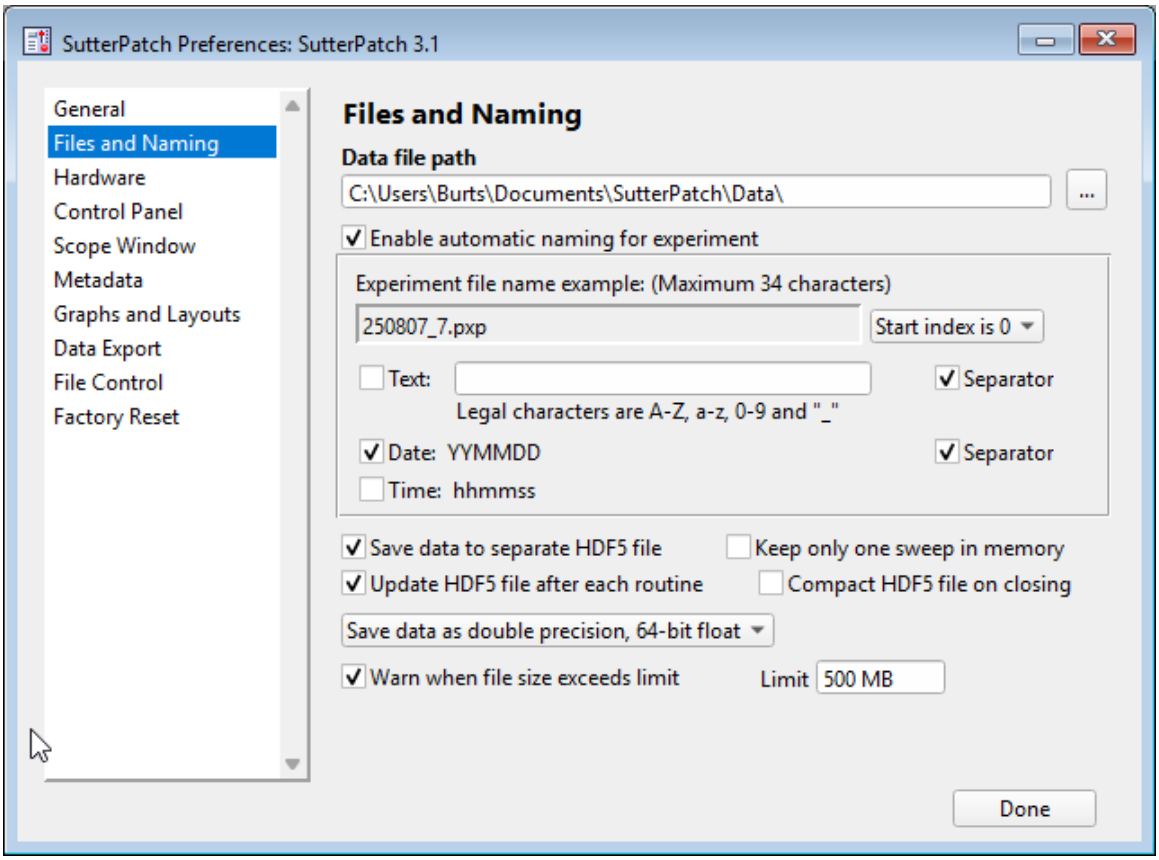


Figure 4-145. Preferences: Files and Naming

Data file path: [< path >] [↓]

Browse to select a folder to save data to.

The data folder should reside on a local disk drive. We do not recommend using a network drive, as speed/throughput bottlenecks can occur, including delays when saving Experiments.

Warning! Microsoft OneDrive is not supported. Do not use to store program files or to acquire data to, or unexpected problems can occur.

Default file paths

Windows: C:\Users\<User Account Name>\Documents\SutterPatch\Data\

macOS: Applications/SutterPatch3/SutterPatch/Data/

[ ] Enable automatic naming for experiment

< applies to the next Experiment session >

Experiment file name example: (Maximum 34 characters)

[< name >] To maintain the maximum limit, the Text portion of the file name can be automatically truncated.

Start index is [< 0, 1 >] [↓]

Append an increment counter to the file name. Choose the default start of numbering to match your lab's convention. Not applicable when automatic Time" naming is used.

At least one of the following file name components must be enabled:

[ ] Text: [< text >]

Optionally start the file name with user text. If the Date and Time components are disabled, at least one character is required.

Valid characters are A-Z, a-z, 0-9 and "_". A maximum of 28 characters are allowed.

[ ] Separator When Text is enabled, append a single underscore in the file name before any Date, Time or Index components.

[ ] Date: YYMMDD — Include the current date in the file name.

[ ] Separator — When Date is enabled, append an underscore in the file name after the Date component, before any Time or Index component.

[ ] Time: hhmmss — Insert the current time into the file name.

When enabled, an increment (Index) counter is not included in the file name.

[ ] Save data to separate HDF5 file

Store the Experiment data waves using the HDF5 file format, a modern efficient format for managing and saving high volumes of data.

Note: A Factory Reset does not affect this IPA setting.

Changes to this setting becomes active after starting a New Experiment or a new SutterPatch session.

Whenever a new HDF5 file is created, SutterPatch stores all existing data into the active HDF5 file, cleans up the Experiment, and creates a new HDF5 file so that HDF5 acquisition can continue as if you had started a "New Experiment", but without starting a new SutterPatch session.

The raw signal data are stored to the HDF5 disk file during acquisition after each sweep, instead of storing all data at the end of an Experiment, which can be a time-consuming experience.

Other waves from the SutterPatch Data folder (including metadata, Experiment structure, analysis results, Routines, Log, images) are stored to the HDF5 file at the end of a Routine or Experiment; items outside of the SutterPatch Data folder (such as graphs and layouts) are stored to the ".pxp" Experiment file.

Note: It is strongly advised to enable the "automatic naming" option above, so that '*.h5' HDF5 files and their parent '*.pxp' Experiment file are kept "in sync".

By default, the Experiment file is stored in a "packed"

(*.pxp) Experiment, where all experimental information is conveniently stored in one file.

However, for very long experiments, packed Experiments can result in delays when saving new data, as the entire Experiment is re-saved with each additional recording. Enable the HDF5 file option to avoid such delays.

< only displays when “Save data to separate HDF5 file” is enabled >

[ ] Keep only one Sweep in Memory

For the leanest operation, only hold the wave of one sweep in memory, so memory buffers do not need to be re-allocated for the Experiment.

The downside is that multi-sweep data cannot be processed during data acquisition, such as subtracting a reference sweep from other sweeps.

[ ] Update HDF5 file after each routine

When enabled, non-data information is automatically written to the HDF5 file at the end of each Series.

If disabled, non-data information is automatically written to the HDF5 file at the end of an Experiment.

For efficient processing, while the raw signal data are written after each sweep during acquisition, the other SutterPatch Data folder information (metadata, Experiment structure, analysis results, Routines, Log, images) is separately written to the HDF5 file.

[ ] Compact HDF5 file on closing

Decrease large file sizes by compacting the HDF5 file at the end of an Experiment.

[< precision >] [↓] Save options for data precision.

- Save data as double precision, 64-bit float
- Save data as single precision, 32-bit float

Tip! Saving the raw data as 32-bit floats can help to reduce file sizes for large Experiments, but at the cost of lesser precision.

< only displays when “Save data to separate HDF5 file” is disabled >

[< option >] [↓] Save options.

- Save to temp file after each routine

  The raw data are saved into a temporary file after each recording. This can help to speed up file-saving time for large Experiments composed of several smaller recordings.

  The temporary file starting size is based on the starting size of the Experiment. The temporary data are re-saved to the main Experiment when the Experiment is closed and/or saved.

  [ ] Retain temp files

  < only displays if 'Save to temp file' is enabled >

- Save entire experiment after each routine

  This default option re-saves the entire Experiment (all data and Experiment information) after each recording. This is the safest method of operation for data integrity, but can produce significant post-recording file-saving delays in larger Experiments.

- Don't save to temp file after each routine

  Data and information are held in memory until the Experiment is explicitly saved; there are no file-saving delays after a recording is stopped. This provides the fastest method of operation when making multiple recordings, but is also the least secure, as data loss can occur if the computer encounters problems.

[ ] Warn when file size exceeds limit

When a recording causes the Experiment to exceed the desired limit, a notification message displays after the Routine stops.

Limit [+10.0 MB]

Enter the size limit.

Note: It is advised to disable the Igor Pro 'Autosave' feature to prevent delays during data acquisition. See Misc / Miscellaneous Settings / Autosave.

iii. Hardware

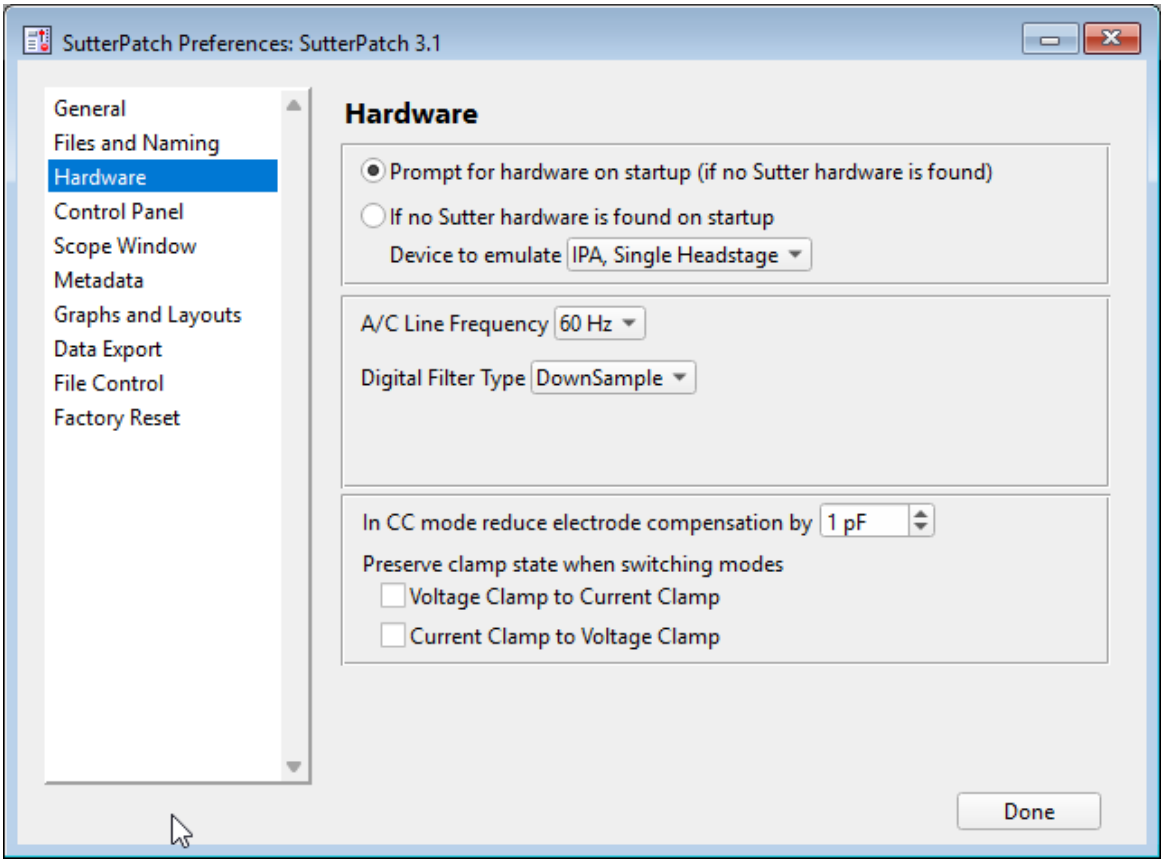


Figure 4-146. Preferences: Hardware

- Prompt for hardware on startup (if no Sutter hardware is found).

  When a new Experiment is started, if Sutter patch-clamp hardware is not connected to the computer and turned on, you are prompted to retry the USB connection or select an emulation mode.

- If no Sutter hardware is found on startup:

  When a new Experiment is started, if Sutter patch-clamp hardware is not connected to the computer and turned on, automatically start up in the selected hardware emulation mode.

  Device to emulate [< amplifier >] [↓]

  - IPA, Single Headstage

    Integrated Patch Amplifier system.

- Double IPA, Double Headstage

  Dual-headstage IPA system.

- dPatch, Single Headstage

  Digital Patch-clamp system (1 HS).

- dPatch, Double Headstage

  Digital Patch-clamp system (2 HS).

- Dendrite Data acquisition system.

A/C Line Frequency [< frequency >] [↓]

Select your electrical system's A/C (Alternating Current) Line Frequency, for use by the Virtual Input Channel "LineFreq", or by the Output Channel P/N Leak Subtraction "Line Frequency adjustment".

- 60 Hz 60 cycles per second

  Canada, (Caribbean), Central America, (Japan), Mexico, (South America), South Korea, Taiwan, USA.

  Regions in (parentheses) include both 50 Hz and 60 Hz frequencies.

- 50 Hz 50 cycles per second

  Most of rest of the world.

Digital Filter < applies to "CommandIn" input channels, Auxiliary input channels, and "DigitalFiltered" virtual input channels >

< filter bandwidths are also set in the Routine Editor / Input Channels >

[ ] High-pass Filter

[< # Hz >]

Low-pass Filter [< filter >] [↓]

- Bessel A frequency-domain filter with excellent response characteristics for preserving the shape of a biological signal.

This matches the amplifier hardware for headstage input (response) signals.

Order [< 2, 4, 8 >] [↓]

Phase Delay Adjust [Off, On] [↓]

Replace Shifted Data with [< value >] [↓]

- First Sample
- Zero
- NaN

- Gaussian — Best suited for step command waveforms to eliminate ringing on the sharp edges of vertical transitions.

  Phase Delay Adjust [Off, On] [↓]

  Replace Shifted Data with [< value >] [↓]

  - First Sample
  - Zero
  - NaN

- DownSample — Reduce the sampling rate of the signal data.

  < the downsample rate is set in the Routine Editor / Input Channels >

In CC mode reduce electrode compensation by [< 0.0 – 5.0 > pF]

During whole-cell patching, if the Electrode Compensation control is set too high, oscillations can occur, and the patch-clamp seal can become unstable and be lost. As the Voltage Clamp mode typically operates with higher electrode compensation values than the Current Clamp mode, this preference promotes “safe” switching between the Voltage Clamp and Current Clamp modes.

If you are routinely losing cells when switching into Current Clamp mode, increase this setting from the default ‘0.5’ to ‘1’ or ‘2’.

Note: The electrode compensation reduction is done in the background, and does not affect the Control Panel current-clamp settings.

iv. Control Panel

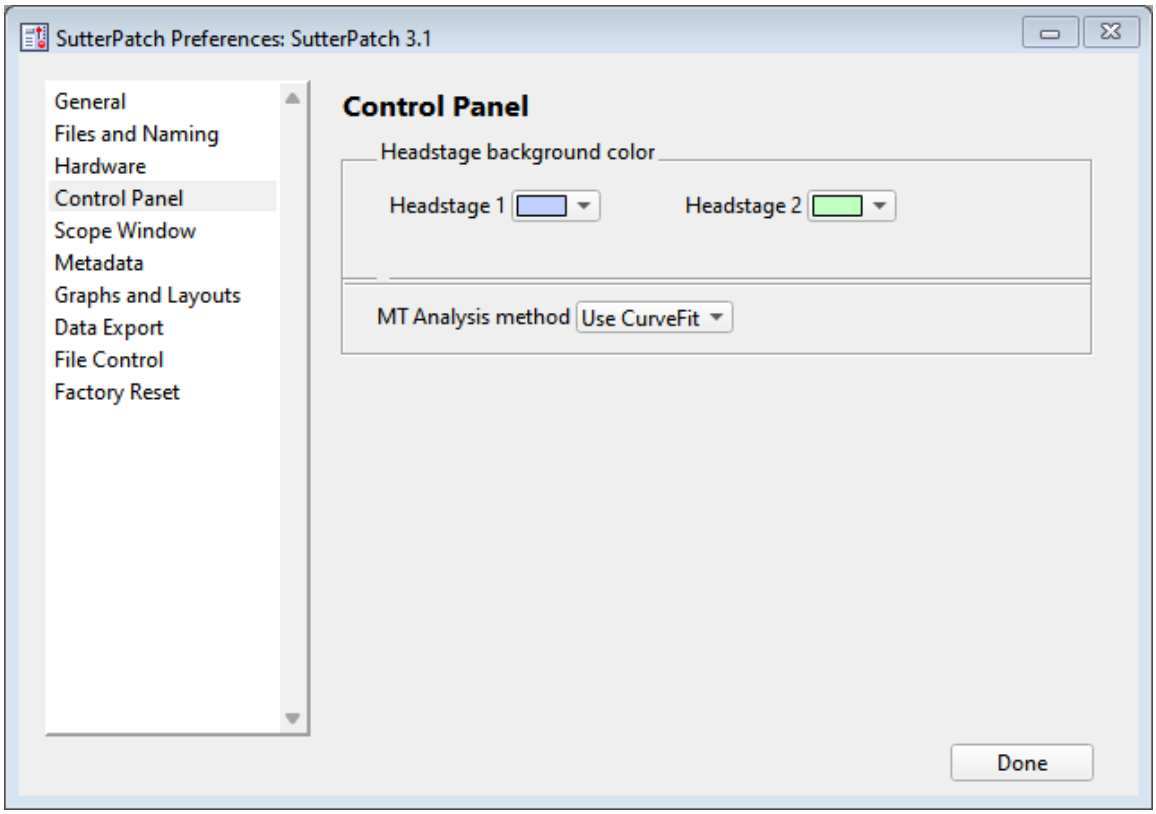


Figure 4-147. Preferences: Control Panel

Headstage background color

Customize the headstages background colors in the Amplifier Control Panel

Headstage 1 [< color >] [↓]

A color palette displays for selection.

Headstage2 [< color >] [↓]

A color palette displays for selection.

Note: Color assignment is only supported by two-headstage systems.

MT Analysis method [< method >] [↓]

Used by the Membrane Test Scope, and by the Real-Time Measurements MT analysis functions when a Waveform

Editor segment waveform is set to 'Membrane Test'.

- Use CurveFit
- Use Linear Regression Slope
- Use Linear Regression Intercept

v. Scope Window

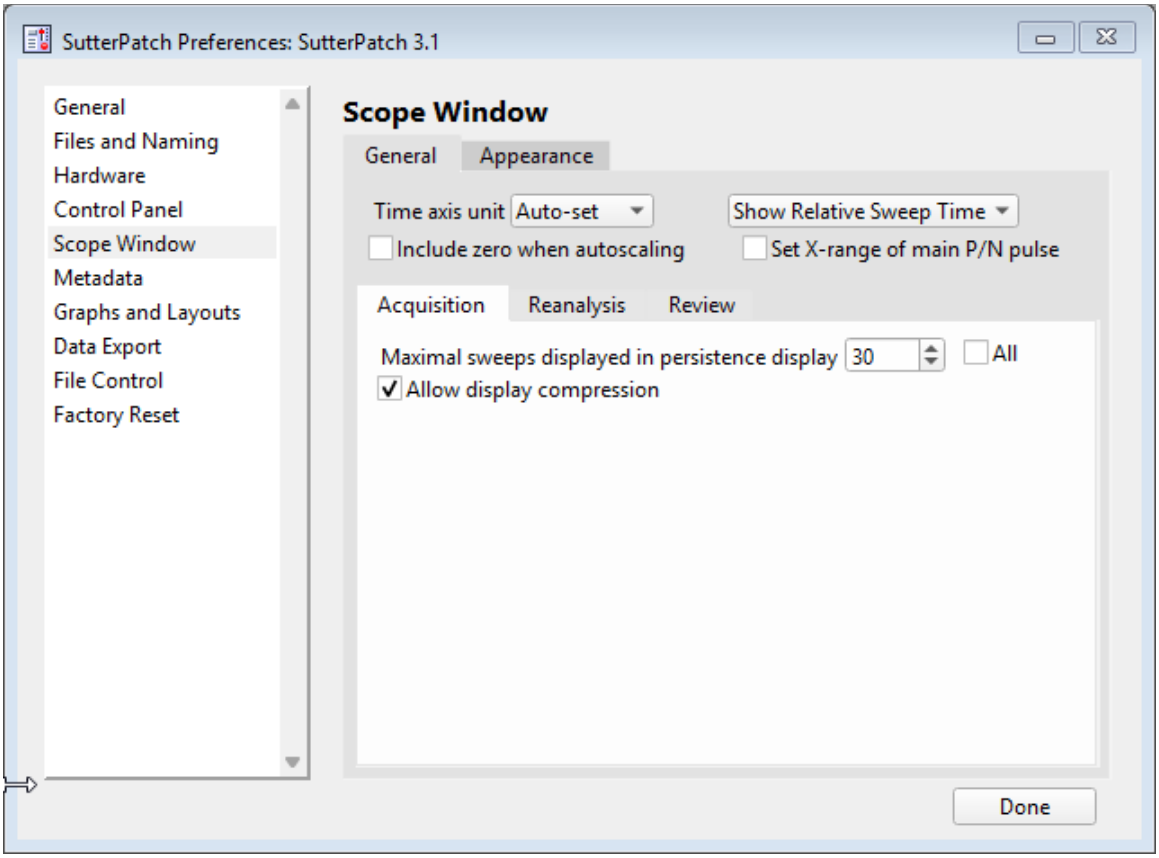


Figure 4-148. Preferences: Scope Window

Scope setting changes are applied to an acquisition Scope window at the time of window creation, and to a reanalysis Scope window when data is loaded.

General

Time axis unit

[< value >] [↓]

< applies to the Scope window axes and tags >

- Auto-set — Sweep duration < 120 s, use “s”

  Sweep duration >= 120 s, use “min”

  Sweep duration >= 7200 s, use “h”

- SI unit — Always use standard SI base units, such as “s” for time.

[< time >] [↓] Display time in a box on the left edge of the X-axis.

- Don’t Show Time — No timer box is displayed in the Scope window.
- Show Timer Time — Display the Timer time from the Acquisition Control Panel.
- Show Routine Time — Display the time for the start of the Routine.
- Show Absolute Sweep Time — Display the current clock time for the start of the sweep.
- Show Relative Sweep Time — Display the time for the start of the sweep from the start of the Routine.

[ ] Include zero when autoscaling

When using Scope window autoscaling, the Y-axes limits are rescaled with each sweep so that all data are visible. If the signal does not cross the zero line, the Y-axes ranges are extended to the zero amplitude.

[ ] Set X- range of main P/N pulse

Set a maximum time limit for the P/N pulse.

Acquisition

Maximal sweeps displayed in persistence display

[< 2 – 100 >] (30 = default value)

The last ‘N’ sweeps are displayed.

[ ] All “Maximal sweeps” is set to “inf”.

Improve data readability and system performance by restricting the number of sweeps displayed, which reduces the display processing load.

This preference cannot be changed while a Scope window is open.

[ ] Allow Display Compression

Display compression is applied to the data in all “live” Scope windows (Acquisition / Free Run / Membrane Test). This reduces the display processing load, and can improve system performance when resources are low.

When there are four times as many data points as the Scope width in pixels, the number of data points plotted are reduced, as the minima and maxima from two groups of up to 50 samples are displayed per screen pixel.

This preference cannot be changed while a Scope window is open.

Reanalysis

Persistence [< value >] [↓]

- On
- Off
- Keep current setting

Maximal sweeps displayed in persistence display

[< 2 – 100 >]

(30 = default value)

The last ‘N’ sweeps are displayed

[ ] All All sweeps are displayed. “Maximal sweeps” is set to ’inf’.

Improve data readability by restricting the number of sweeps displayed. This can also improve system performance by reducing

the display processing load.

[ ] Allow Display Compression

Display compression is applied to the data in the Reanalysis Scope window. This reduces the display processing load, and can improve system performance when resources are low.

When there are four times as many data points as the Scope width in pixels, the number of data points plotted are reduced, as the minima and maxima from two groups of up to 50 samples are displayed per screen pixel.

Note: Display compression is not applied to Single Channel Analysis data.

Review

[ ] Display compression (always off)

Grayed out, as "Review" windows do not support display compression.

[ ] Show event tags — Display tag lines and boxes in the Reanalysis Scope window, for the Continuous and Concatenated display modes.

[ ] Write tags to notebook — When you run the Reanalysis window in Time Course or Concatenated mode, any displayed tag information is copied to the Notebook.

Tag Position

- Frozen
- Movable

Tag types to show

- [ ] User
- [ ] Input-triggered
- [ ] System

Tag text box

Display tag information in the tag text boxes in the Reanalysis Scope window, for the Continuous and Concatenated display modes.

- [ ] Relative Time — Time from beginning of Paradigm or Series.

  [hours to milliseconds]

- [ ] Absolute Time — Clock time

  [hours to milliseconds]

- [ ] Description — User Comment, from 'Set Tag' in the Acquisition Control panel..

Tag appearance

- [ ] Color by type
- [ ] Transparent

Appearance — Choose signal component colors.

Title content — [< title >] [↓]

Choose name components for the Scope window title bar.

- Routine only
- Paradigm and routine
- Experiment, paradigm and routine

Click on the color panel drop-downs to display a color palette. Select a color square in the palette to set it as the active color. Default colors are listed below.

Active signal panel color — [< light gray >] [↓]

Inactive signal panel color — [< dark gray >] [↓]

Active sweep color — [< dark blue >] [↓]

Also applies to the corresponding analysis window results point for the active sweep.

Inactive sweep color — [< red >] [↓]

Graph background color	[< white >] [↓]
Grid color	[< light blue >] [↓]
Grid lines	[< status >] [↓]
• Off	Do not display any grid lines or axis ticks.
• On	Use major and minor ticks for grid lines.
	Note: Minor ticks are usually not generated, unless enabled in the Scope's Axis Properties 'Auto/Man Ticks'.
• Major only	Only use major ticks for grid lines.
Panel background color	[< white >] [↓]
Event tag line color	[< blue >] [↓]
[Preview Pane]	The updated Scope colors and grid lines are displayed in the preview pane.

Tip! For dark-room experiments, the window background color can be adjusted by the operating system:

- Windows: In the Windows Control Panel (Appearance and Personalization) Ease of Access Center window, in 'Make the computer easier to see', select Colors > Personalization > Colors > Choose your mode > Dark.
- macOS: Press 'Control-Option-Command-8' to set the System Preferences / Accessibility / Display / Invert Display colors option, or open its menu with 'Command-Option-5'.

vi. Metadata

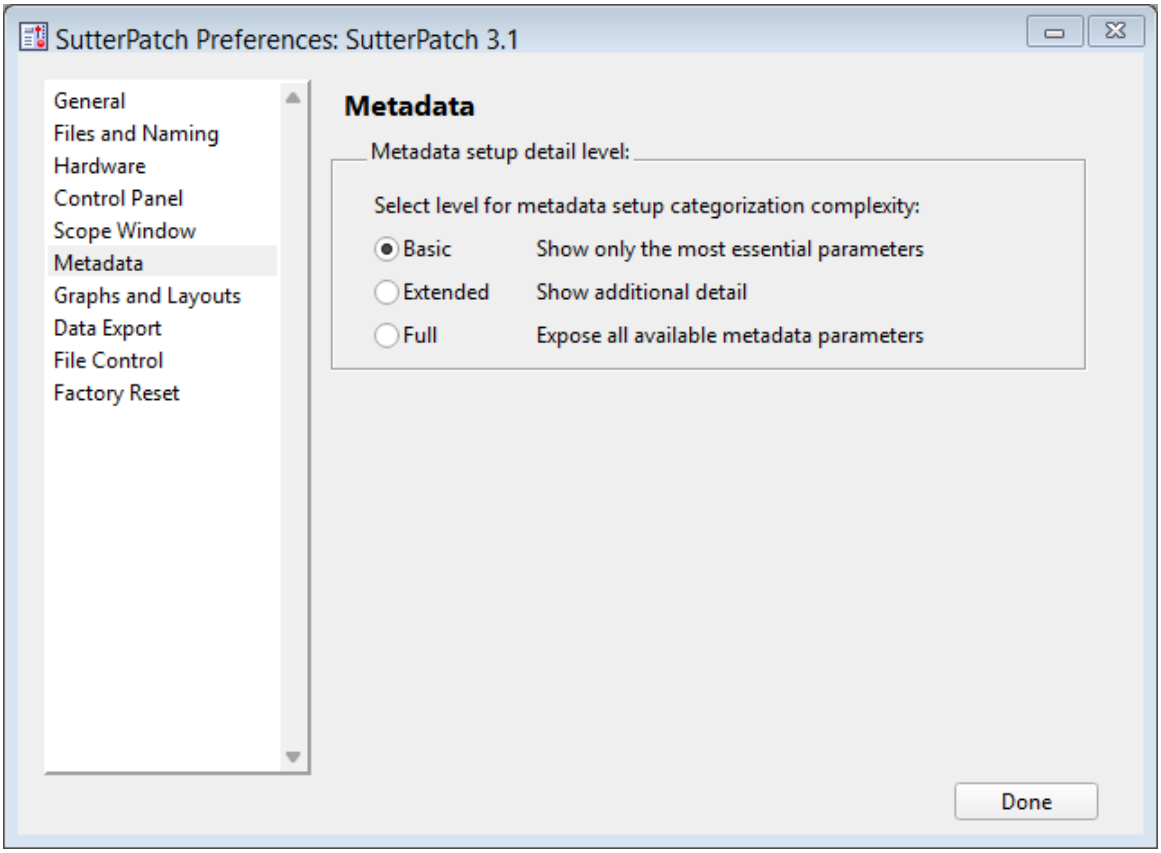


Figure 4-149. Preferences: Metadata

Metadata detail level:

Select levels for metadata setup categorization complexity.

Select which metadata Groups and their parameters are visible for configuration in 'Set Metadata' and in Data Navigator / 'Build Hierarchy'.

- Basic Show only the most essential parameters:

  < five default Groups >

  Preparation – Animal

  Preparation – Tissue

  Preparation – Cell

  Experiment

Stimulus

- Extended

  Show additional detail:

  < plus two more Groups >

  Electrode

  Recording Solution

- Full Expose all available metadata parameters:

  < plus five more Groups >

  Operator

  Paradigm

  Cell Health / Quality Control

  Series (= Routine Data)

  Imaging

Note: This setting does not affect Metadata Review windows - all user-defined metadata are always displayed.

This setting does not affect data acquisition metadata prompts – all configured prompts are always executed.

vii. Graphs and Layout

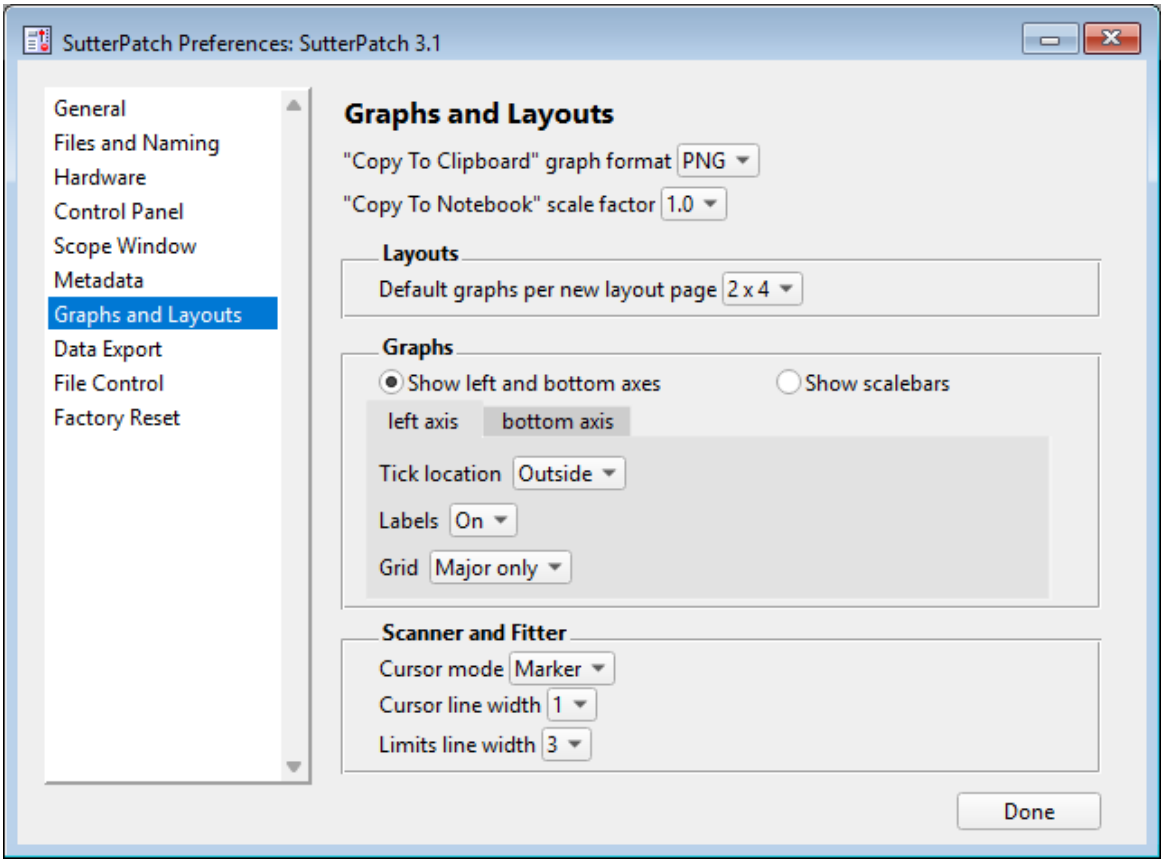


Figure 4-150. Preferences: Graphs and Layouts

< these settings apply to Layout windows and stand-alone graph windows (not graph files) >

"Copy To Clipboard" graph format [< format >] [↓]

Several popular file formats are supported:

- PNG Portable Network Graphics
- PDF Portable Document Format
- TIFF Tagged Image File Format
- JPEG Joint Photographic Experts Group

Note: When pasting, not all formats are supported by other programs.

"Copy To Notebook" scale factor [< 2.0, 1.5, 1.0, 0.75, 0.5, 0.25 >] [↓]

Layouts

Changes are applied when a new Layout window is created.

Default graphs per new Layout page: [< # >] [↓]

- 1
- 2
- 3
- 2 x 2 (Column x Row)
- 2 x 3 (Column x Row)
- 2 x 4 (Column x Row)

Graphs

- Show left and bottom axes

  Left axis < the Y-axis >

  Tick location:

  - Outside
  - Crossing
  - Inside
  - None

  Labels:

  - On
  - No Tick Labels
  - Off

  Grid:

  - Off
  - On
  - Major only

bottom axis < the X-axis >

Tick location:

- Outside
- Crossing
- Inside
- None

Labels:

- On
- No Tick Labels
- Off

Grid:

- Off
- On
- Major only

- Show scalebars

  Scalebars linewidth [1 to 5]

  Scalebars distance from left in pixels [-40 to 200]

  Scalebars distance from bottom in pixels [-20 to 200]

Scanner and Fitter

Cursor mode [< mode >] [↓]

Set the cursor mode.

- Marker Set the cursor as a “+”.
- Line Set the cursor as a vertical line.
- Marker and Line Set the cursor as a “+” on a vertical line.

Cursor line width [< 1, 3, 5 >] [↓]

Set the width of the vertical line cursor.

Limits line width [< 1, 3, 5 >] [↓]

Set the width of the fitting limits start/end lines.

viii. Data Export

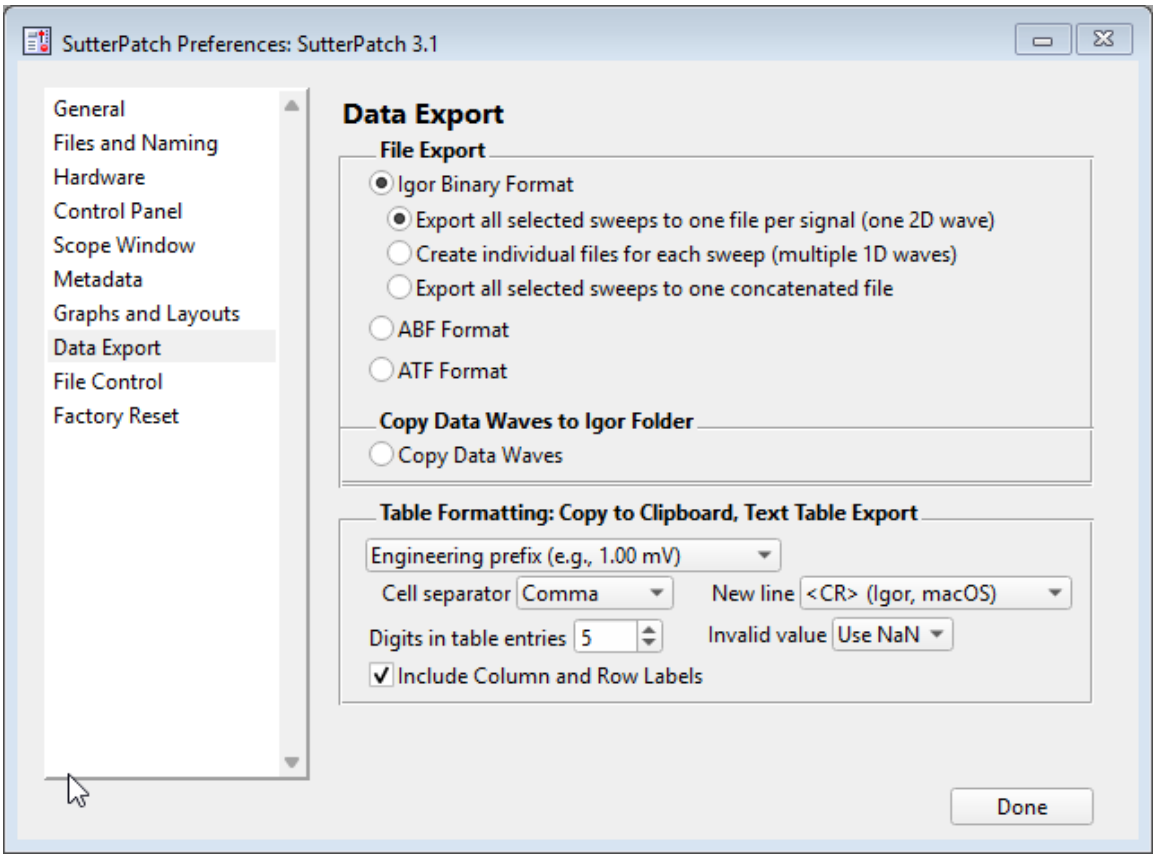


Figure 4-151. Preferences: Data Export

File Export

- Igor Binary Format Save sweeps to files formatted as IBF (Igor Binary Format)

  < 2 GB limit >

  - Export all selected sweeps to one file per signal (one 2D wave)
  - Create individual files for each sweep (multiple 1D waves)

- Export all selected sweeps to one concatenated file per signal

- ABF Format — Save all (or selected) signal of all (or selected) Routines to a file formatted as ABF (Axon Binary File) version 1.8.
    - Export all selected sweeps to one file (per signal)
        - Ignore unselected sweeps
        - Replace unselected sweeps with NaN
    - Create individual files for each sweep
- ATF Format — Save the first (or first selected) signal in the first (or first selected) Routine to a file formatted as ATF (Axon Text File).

  Uses the table formatting preferences below.
- HDF5 Format (signal waves only)

  Save all data in the entire Experiment to a file formatted as HDF5 (Hierarchical Data Format version 5).

Copy Data Waves to Igor Folder

- Copy Data Waves — Export data to a user specified internal Igor location in memory for use by custom procedures and functions.

  The exported data can be found in the Data / Data Browser.
    - Copy as 2D waves (one 2D wave per signal per series)
    - Copy as 1D waves (one 1D wave per signal per sweep)

  Target Igor Folder [root:]

  Enter a target path.
    - The target path must start with “root:”, as in “root:xxx” or “root:SutterPatch:xxx”
    - The path cannot be in “root:SutterPatch:Data” or “root:SutterPatch:AppControl”.
    - Spaces and special characters are not allowed in the path name.

Table Formatting: Copy to Clipboard, Text Table Format

Applies to:

Action Potential Analysis:	tables
Analysis Editor:	tables
"Copy to" buttons:	Copy to <destination> (as text)
Data Export:	File Export: ATF Format
Data Navigator:	Action: Export Data
Notebook:	text data
Single Channel Analysis:	tables
Synaptic Event Analysis:	tables

[< format >] [↓]

- Use exponential notation (e.g., 1.00e-3)

  This example is the equivalence to "1 mV", however no data units (V) are included with the copied data.

- Use engineering prefix (e.g., 1.00 mV)

  This default setting uses "powers of 3" to determine the data unit prefix (e.g., m, μ, n, p) for a non-zero number with 1 – 3 digits to the left of the decimal point.

  As the example shows, the data unit (V) is included with the copied data.

  The engineering prefix format is useful when exporting data to other applications and spreadsheets, such as Excel, which don't understand or support data units.

- Engineering without unit (e.g., 1.0 m)

  This setting uses "powers of 3" to determine the data unit prefix (e.g., m, μ, n, p) for a non-zero number, but does not include the unit itself.

- Igor's general number format

  A 64-bit double-precision IEEE floating-point number is used.

Note: Columns with “Number” or “Count” in the header will be formatted as integers.

Cell separator [< separator >] [↓]

- Tab
- Comma
- Semicolon

New line [< line option >] [↓]

- <CR>

  Use for compatibility with Igor Pro’s native default, or for macOS applications.

- <CR> <LF>

  Use for compatibility with most Windows OS applications

Digits in table entries [< # >]

[3 – 15] For general values.

[3 – 6] For dedicated Time values.

Invalid value [< option >] [↓]

- Use NaN
- Use empty string
- Use zero

[ ] Include Column and Row Labels

< applies to exported tables >

ix. File Control

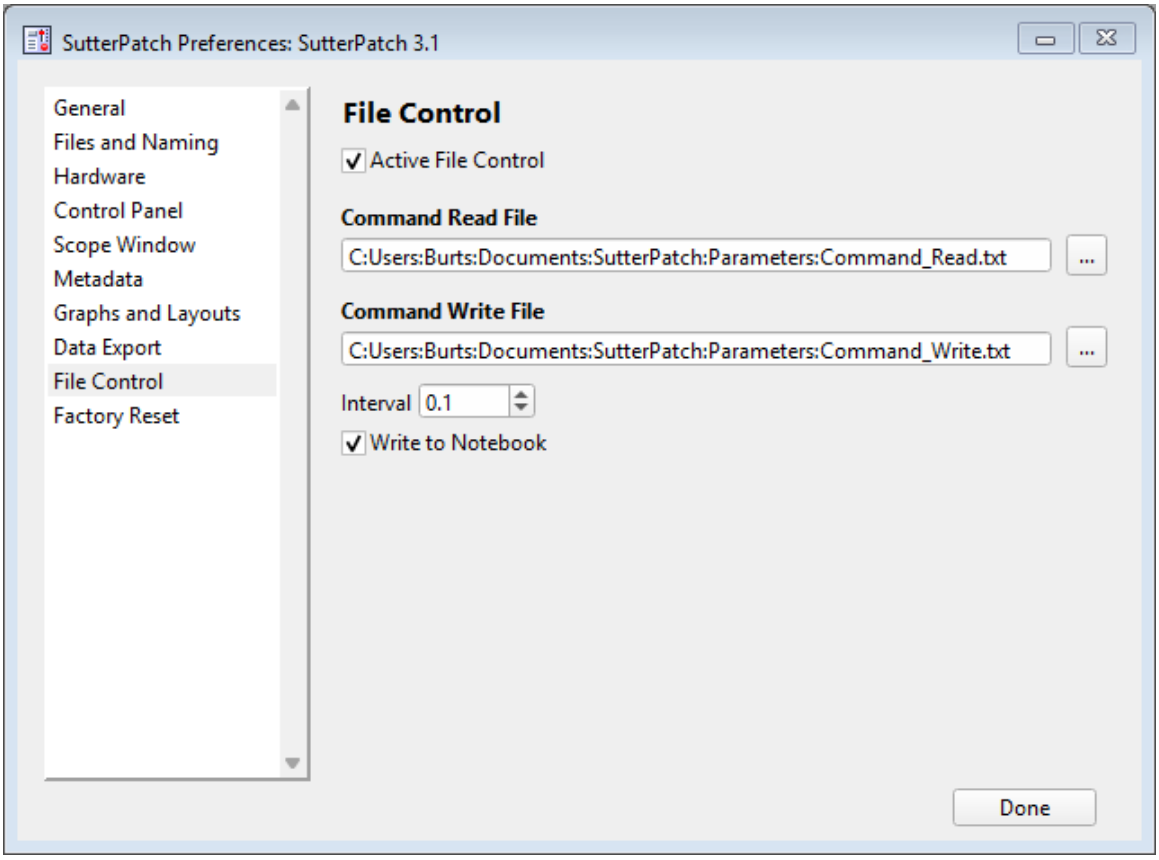


Figure 4-152. Preferences: File Control

For interactive programmatic control, use external programs to send commands to SutterPatch and receive back responses.

The application can be written in any computer language, a second instance of Igor, or even a simple word processor. It can reside on the same computer or be remotely connected. The only conditions are that it can create a simple text file (the command file) and write to it, and read the response from a second text file (the response file). The available commands are identical to the Paradigm steps of the Paradigm editor. Users can copy the commands in the Paradigm step editor and paste them into their applications as templates for their own command streams.

See an extensive description of the file communication protocol in the example procedure file "SutterFileControl.ipf" in the Program Files \ WaveMetrics \ SutterPatch3 \ SP_Code \ Special Igor Procedures folder

[ ] Active File Control — Once the read and write command files are selected, enable to activate and start the file control process.

Command Read File:

[< filename >]

[…] Select the read file.

[Create read file] Create a command “read” file with the following conditions:

Only the first 1024 bytes (1 kB) in the file are read.

The first line must contain a four-digit index number [0001 – 9999], and must start with a “+” to be interpreted, or a “-“ to not be interpreted.

If the index number has changed since the last read, the commands are interpreted and executed.

The second and subsequent lines contain one command per line. Supported commands are Paradigm steps without flow-control or conditional steps. An additional SutterPatch command is “GetValue”, which returns the result of the given equation.

Any trailing characters or spaces after a command will cause an error condition and skip processing of that line.

Each command line should end with the line terminator “<CR> <LF>”, or for the last command line, either “<CR> <LF>” or the end-of-file.

In Microsoft Word, the appropriate line terminator is inserted by the standard “Enter” key. Save the document as a Plain Text file (*.txt), and accept the default setting - no need to explicitly specify “CR / LF”.

Command Write File:

Command responses are written to the “write” file.

[< filename >]

[…] Select the write file.

[Create write file] The first line in the write file displays as:

+< index number > (from the read file)

The external user has to scan the write file until the first byte is "+" and the number in the first line is equal to the first number in the read file. This signals that the command in the input have been processed and the respective responses can be read from the write file.

The second and subsequent lines display as:

< command name >

hh:mm:ss.mmm (the time the Command Read file was read)

The following is written to the write file when the File Control session is ended:

+0000<CR>Terminated<CR>0x00

or, respectively in Igor notation:

+0000\rTerminated\r\000

If an error condition is encountered while reading a command, its read time is replaced with

"-> Error – Parsing Steps: unknown step "< command name >".

Interval

[0.02 – 1.00 s] The command read-in file is read and each line executes every "interval" seconds. A short interval makes the inter-program connection more responsive, but also causes more CPU load. The optimal response time depends on the external application and the performance of the respective computer system.

[ ] Write to Notebook Command responses are written to the Notebook.

The first line in the Notebook displays as:

File Control: Read file opened: <path name to the read file>

The second line in the Notebook displays as:

File Control: Write file opened: < path name to the write file >

The third (and subsequent) lines display as:

Command read: + < index number >,

hh:mm:ss.mmm, (the time the Command Read file was read)

<command_name>

[< response >]

until all command lines are processed.

If an error condition is encountered while reading a command, the line displays as:

"Error – Parsing Steps: unknown step "< command name >"."

x.Factory Reset

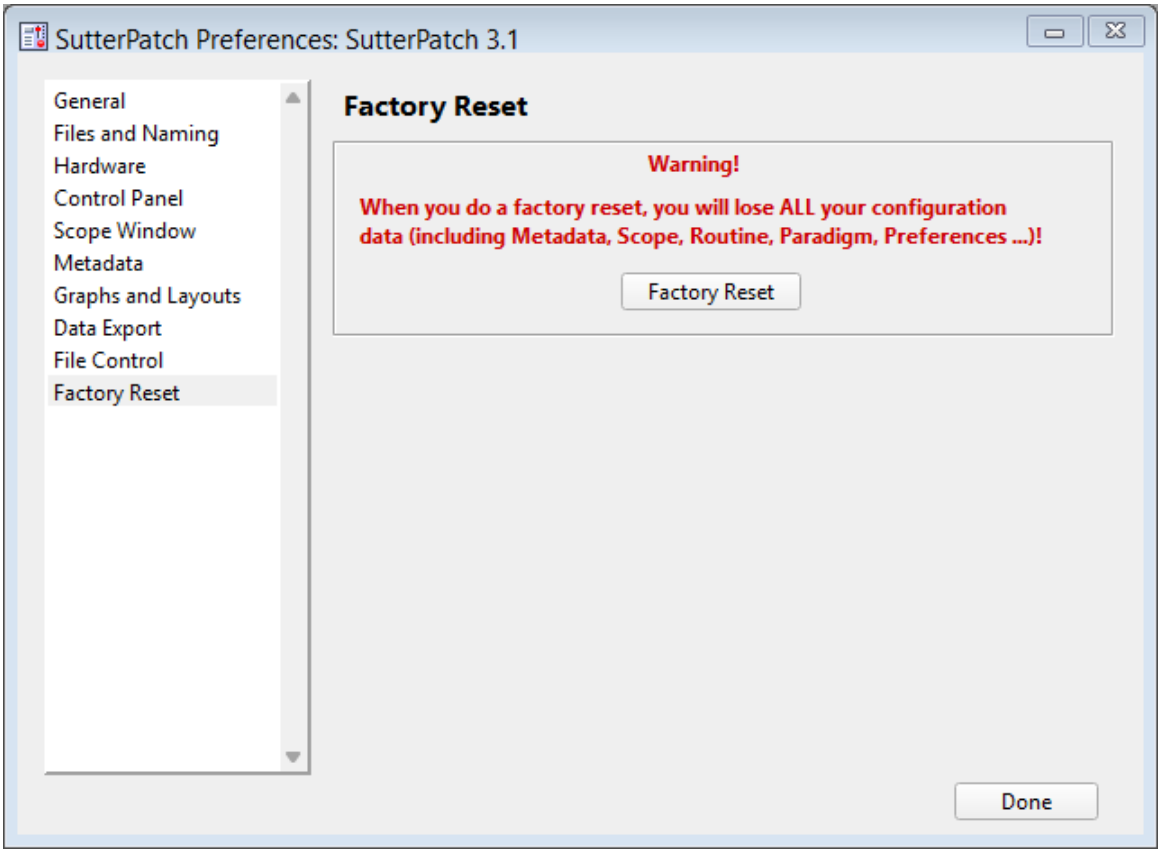


Figure 4-153. Preferences: Factory Reset

[Factory Reset] Click this button to reset the SutterPatch preferences and settings to their defaults.

Use a 'Factory Reset' to clean up the Igor Pro environment after you encounter software bugs or strange behavior.

SutterPatch will need to be exited and restarted to complete the factory reset. Any preferences changes made after a factory

reset are discarded for the next session.

Alert! When you do a factory reset, you will lose almost ALL your configuration data (including Metadata, Scope, Preferences, etc.).

However, the following items are not reset:

- HDF5 file saving in Set Preferences / Files and Naming / Save data to separate HDF5 file.
- Configuration pool activation in Set Preferences / General.
- Command window display state at Experiment startup.

  This is controlled by Igor Pro.

4.3.12 Shortcut Editor

SutterPatch: Shortcuts: Shortcut Editor

Keyboard control of SutterPatch is available by configuring keyboard shortcuts.

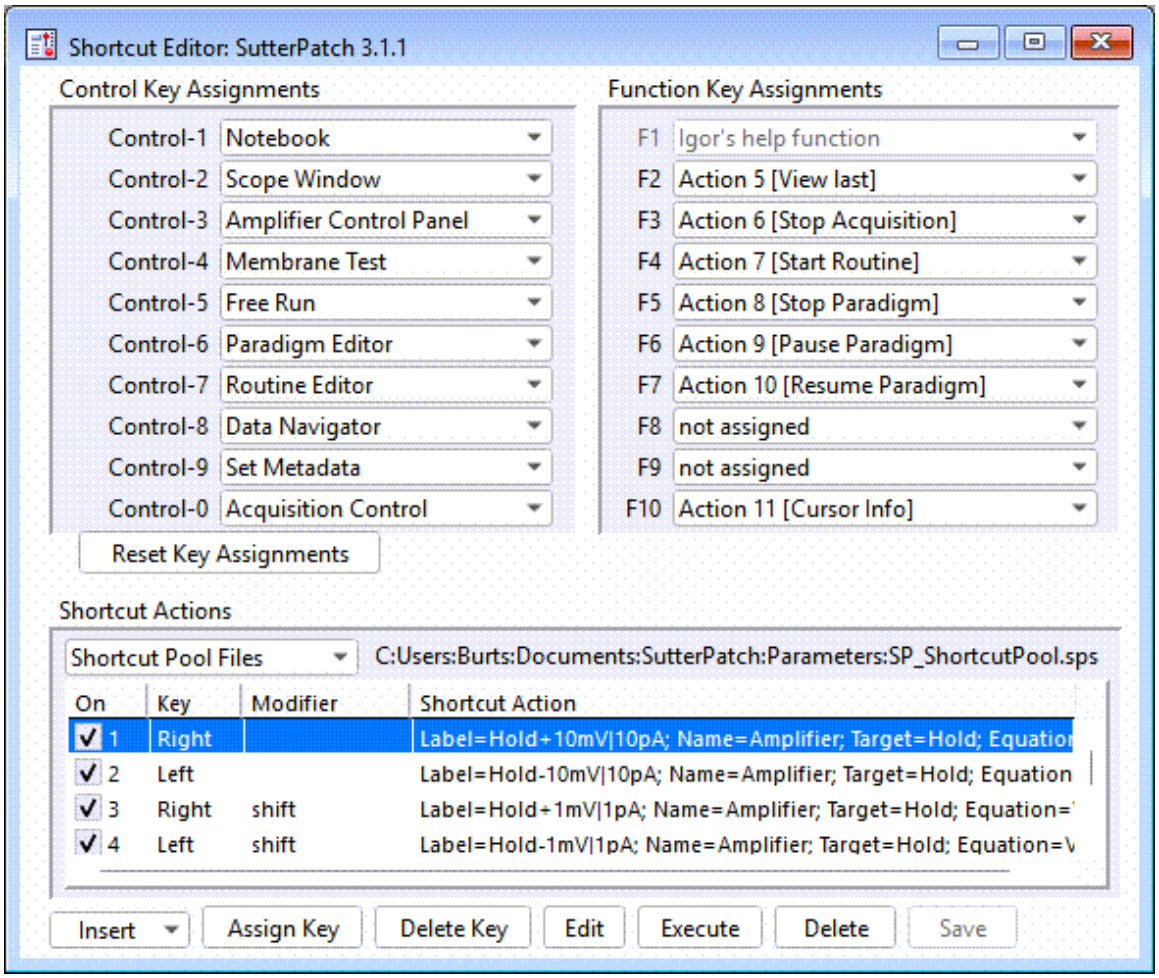


Figure 4-154. Shortcuts Editor

All assigned Control, Function and Shortcut Action key combinations are automatically added to the main menu SutterPatch / Shortcuts submenu. All Control and Function Key Assignments are automatically saved when the program is closed.

The Shortcuts main menu list is shared by the Control and Function keys, so each menu item can only be assigned to a single key. Prior duplicate entries are replaced by “not assigned”.

Control Key Assignments

A Control key assignment can be easily made by clicking on its drop-down list and selecting a new item from the list of SutterPatch menu items.

Use Control keys by holding down:

- Windows: Control key: Ctrl
- macOS: Command key: ⌘

and clicking its assigned number.

Control keys and their default SutterPatch menu assignments:

Control-1	[< Notebook >] [↓]
Control-2	[< Scope Window >] [↓] < a Scope window must be open >
Control-3	[< Amplifier Control Panel >] [↓]
Control-4	[< Membrane Test >] [↓]
Control-5	[< Free Run >] [↓]
Control-6	[< Paradigm Editor >] [↓]
Control-7	[< Routine Editor >] [↓]
Control-8	[< Data Navigator >] [↓]
Control-9	[< Set Metadata >] [↓]
Control-0	[< Acquisition Control >] [↓]

Other SutterPatch menu items available for assignment:

not assigned

Analysis Editor

Camera Control

Dashboard

Equation Editor

Lock-In Adjustments

Log Window

Reset Acquisition

Set Preferences

Shortcut Editor

Solution Editor

Template Editor

Function Key Assignments

Computer keyboards usually include a set of Function keys [0 – 9] for special functionality. Configure a 'Function Key' assignment by clicking on its drop-down list and selecting a new menu item or Action item.

Function keys and Control keys share the same menu items list, and each menu item can only be only be assigned to a single key. So, after any new assignment, any duplicate key is changed to "not assigned".

Function keys can also be assigned from Shortcut Actions – see below.

Note: On some keyboards, you also need to press the 'FN' key to use Function keys.

Also, macOS reserves nearly all Function keys for itself. In order to use Function keys for a macOS application, you must first check a checkbox in the macOS Keyboard control panel. Even then, macOS will intercept some Function keys.

Default Functions

F1 [< Igor's help function >] [↓]

< F1 is not available for assignment, as it is reserved for Igor Pro's Help function >

F2 [< Action 5 (View last) >] [↓]

F3 [< Action 6 (Stop Acquisition) >] [↓]

F4 [< Action 7 (Start Routine) >] [↓]

F5 [< Action 8 (Stop Paradigm) >] [↓]

F6 [< Action 9 (Pause Paradigm) >] [↓]

F7 [< Action 10 (Resume Paradigm) >] [↓]

F8 [< not assigned >] [↓]

F9 [< not assigned >] [↓]

F10 [< Action 11 (Cursor Info) >] [↓]

< target window must be open >

[Reset Key Assignments]

Click to reset all Control keys to their default settings. Function key “menu” items are reset to ‘not assigned’, while ‘Action’ items are unaffected.

Shortcut Actions

Additional custom keyboard Actions can be created, managed and stored in a file.

[< Shortcut Pool Files >] [↓]

New Shortcut Pool	Create a default Shortcut Pool.
Load Shortcut Pool	Load the Shortcuts of a previously saved Shortcut Pool file into the Shortcut Pool.
Revert to Last Saved	Undo any unsaved changes to the Shortcut Pool.
Save Shortcut Pool	Save the Shortcut Pool using its existing file name and path.
Save Shortcut Pool As	Save the Shortcut Pool to a new file, and switch to the new file. The default file name is the same as the original file name.
Save Shortcut Pool Copy	Save the Shortcut Pool to a new file, but do not switch to the new file. The default file name has ‘Copy of” prepended to it.
Merge Shortcut Pools	Append the Shortcut Actions from a previously saved Shortcut Pool file into the loaded Shortcut Actions table.

[< file path >] Shortcut Pool file path.

<u>Shortcut Actions Table</u>

Columns

On	[ ]
	Enable/disable the Shortcut Action.
Key	[< key >]
	The assigned keyboard key.
Modifier	[< modifier >]

The keyboard "modifier key" used in a key combination - all keys are simultaneously pressed.

Windows

- Ctrl — Only for use with keys '0 – 9'.
- Alt — Keys '0 – 2' reserved by Igor Pro for File / Recent Experiments.
- Shift — Shift key.
- FN — Function key.
- Caps Lock — Ignored.

macOS

- Command — Only for use with keys '0 – 9'.
- Option — Option key.
- Shift — Shift key.
- Control — Keys '0 – 2' reserved by Igor Pro for File / Recent Experiments.
- Caps Lock — Ignored.

Shortcut Action [< action >]

An Action's instructions and settings.

Click a field in the table to highlight an Action and make it the active entry. Click-and-drag a row to reposition it in the table.

Predefined Shortcut Actions

1	[Hold+10mV | 10 pA: Right]	Keyboard right arrow key ">" Increase holding by 10 mV | pA.
2	[Hold-10mV | 10 pA: Left]	Keyboard left arrow key "<" Decrease holding by 10 mV | pA.
3	[Hold+1mV | 1 pA: Right, shift]	Shift + right arrow key ">" Increase holding by 1 mV | pA.
4	[Hold-1mV | 1 pA: Left, shift]	Shift + left arrow key "<" Decrease holding by 1 mV | pA.

5	[View last]	F2 Open the last acquired Series into a Reanalysis Scope window.
6	[Stop Acquisition]	F3 Stop the Scope acquisition.
7	[Start Routine]	F4 Start acquisition using the active Routine.
8	[Stop Paradigm]	F5 Stop the execution of a running Paradigm.
9	[Pause Paradigm]	F6 Pause the execution of a running Paradigm.
10	[Resume Paradigm]	F7 Resume execution of a paused Paradigm.
11	[Cursor Info]	F10 Toggle the cursor panel display On | Off.
12	[Next sweep]	Keyboard period "." Highlight the next sweep in the Reanalysis Scope
13	[Previous sweep]	Keyboard comma "," Highlight the previous sweep in the Reanalysis Scope

The following buttons modify the Shortcut Actions:

[< Insert >] [↓] Adds an Action to the 'Shortcut Action' list and opens its Shortcut Actions Editor for setup.

These Actions operate similarly to Paradigm steps, with an additional Label field to name the Action in the Shortcuts menu.

Amplifier — Control an IPA amplifier's settings.

Analysis — Append, average, display and save analyses.

Camera	Take a photo or run live video.
Cursor Info	Use cursors to set a fitting range for graphical data
Data Navigator	Open the Experiment's data management center.
Execute	Run an Igor Pro or SutterPatch command.
Export	Send graphs to the Layout window.
Front Window	Set the specified window as the front window.
Hide Window	Hide the specified window.
Paradigm	Load & Run, Stop, Pause or Resume a Paradigm.
Reset Timer	Reset the Paradigm Editor Timer to zero.
Routine	Record data from a Routine.
Scope Operation	Control the display of the Scope window signals and sweeps.
Select Series	Select the next/previous series in the Reanalysis Scope window.
Select Sweep	Set a sweep to be the "active" sweep.
Set Axis	Modify the axis scaling of a signal.
Set Checkbox	Set local and global checkboxes for conditional processing in Paradigm 'If' steps.
Set Mark	The selected sweep in the Scope window is "marked" or "unmarked" for processing by the Data Navigator.
Set Tag	Write a comment tag to the Paradigm metadata.
Set Variable	'Label' entry only displays in the Shortcut Action column.
Start Acquisition	Start acquisition using the active Routine..
Stop Acquisition	Stop acquisition in the Scope window.
View Last	Display the last recording in a Reanalysis Scope window.
Write to Log	Write a note to the Log window.
Write to Notebook	Write a note to the Notebook.

[Assign Key] This button opens the Shortcut Key Input dialog (or double-click in a "Key" or "Modifier" field) to input the desired keyboard combination for a letter, number, or symbol.

If a function key is assigned to an Action, it will also show up in the 'Function Key Assignments' table; if a label is created when editing the Action, that label will also display in the table.

Note: Available keyboard letters, numbers, and symbols can vary from computer to computer, depending on the computer OS and Igor Pro's key usage. (Reserved keys typically open another window type, or are non-responsive.)

Keyboards often have a Function (FN) button to allow special access to the Function keys.

Although the F1 function key is reserved in Igor Pro, it can be assigned if used with a modifier key.

If the CAPS LOCK button is on when assigning a key, the key is case insensitive.

[Delete Key] Remove the Key entry for the selected Action.

[Edit] Open the Shortcut Actions Editor dialog (or double-click in a "Shortcut Action" field) to change the Action's parameters.

[Execute] Run the selected Action.

[Delete] Remove the selected Action from the 'Shortcut Action' list.

[Save] Saves any changes to the current Shortcut Pool file.

4.3.13 SutterPatch Startup

The SutterPatch application startup sequence:

1. Power-on the Dendrite system by pressing the silver POWER button on its front – it lights up as blue. (It can take a few seconds for the USB connection to be established.:

2. Click on the 'Igor Pro' icon: 

   Igor Pro opens and an Igor Pro "splash screen" temporarily displays in the Igor Pro window while Igor Pro files are compiling.

   Then the 'Welcome to SutterPatch' screen displays with launch options:

   - Igor Only Run Igor Pro (without launching SutterPatch).
   - Open Launch SutterPatch from a saved Experiment.
   - Start Launch SutterPatch for a new Experiment.

3. Click the 'Start' button, and a progress bar displays while compiling SutterPatch files, then the Welcome screen closes.

4. Next, if no Sutter amplifier is detected, the 'No USB Connection' pane allows you to retry establishing the USB connection, or to select a hardware-emulation (demonstration) mode:
   - IPA - Single Headstage
   - DIPA – Double Headstage
   - dPatch – Single Headstage
   - dPatch – Double Headstage
   - Dendrite – Data Acquisition System

   In emulation mode, Scope window signal panes are labeled with "Demo", the input and output channels use simulated data, and most SutterPatch functions are available.

5. The SutterPatch files are initialized, and default windows display:
   - Acquisition Control panel (for Routines, Paradigms and Tags)
   - Command window (execute Igor Pro commands)
   - Dashboard panel (a floating SutterPatch toolbar)
   - Notebook window (a laboratory notebook)

- Summary of Major Preferences window
  (from Set Preferences)

Additional SutterPatch windows display if they were open in the prior Experiment.

4.3.1 Windows

Most windows in SutterPatch allow you to expand them between 50% to 400% display magnification. Click just inside the bottom and/or side window borders to view an "expansion" menu.

The Command and Log windows are Igor Pro windows that use a "magnification" menu.

SutterPatch windows that cannot be expanded are:

Action Potential Analysis / Preview

Action Potential Analysis / Template Settings

Layout Page

Single Channel Analysis / Plots

Single Channel Analysis / Tables

Synaptic Events Analysis / Distribution Analysis

Synaptic Event Analysis / Preview

5. PROGRAMMING

5.1 Data Format

SutterPatch data are written in a binary 64-bit double-precision floating-point format. This supports a decimal precision of 17 significant digits.

The data are stored within an Igor Pro Experiment (*.pxp) file.

For large data sets, an optional HDF5 file format is available for streaming data acquisition without resaving the experiment at the end of a recording.

5.2 Data Paths

The Data Browser path references an internal Igor Pro "root" folder, and not the computer's file system. The Data Browser right-click 'Copy Full Path' command copies a Signal's data wave path to the system clipboard.

For advanced users, the object's path name can be used in user functions and executable commands. However, when referencing an active Scope window, the path name to the data wave can be substituted by "t[#]", where '#' refers to the signal position number in the Scope window.

5.3 Data Structure

SutterPatch recorded data are stored as multidimensional data waves, and are listed per signal in the Data Browser. Select a data wave in the Data Browser and right-click to 'Edit' the Signal data in a spreadsheet-style table. The two-dimensional data wave is displayed with one row per sample point and one column per trace, with the number of data table columns increasing with the number of sweeps.

Warning! The raw data can be directly edited in the Data Browser – this is not recommended, as it permanently alters the data.

Note: While SutterPatch does not read the older Igor Pro one-dimensional wave data-format, graph data for each axis can be separately exported to it.

< see the Analysis Editor / Files menu >

5.4 File Control

Use external text files to send commands to SutterPatch, and to receive back responses.

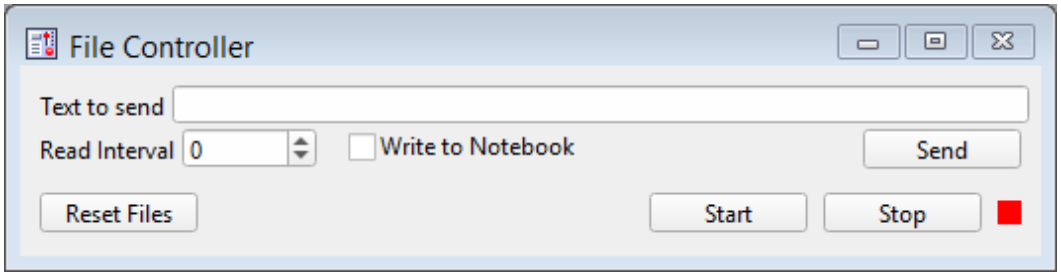


Figure 5-1. File Controller

This functionality is accessed via Macros / Show File Controller.

Text to send [< text >]

Read Interval [< 0.02 – 1 >] s

[ ] Write to Notebook

Command responses are written to the Notebook.

The first line in the Notebook will be:

File Control: Read file opened: < path name to the read file >

The second line in the Notebook will be:

File Control: Write file opened: < path name to the write file >

The third (and subsequent) lines display as:

Command read:

+ < index number >,

hh:mm:ss.mmm, (the time the Command Read file was read)

< command_name >

[< response >]

until all command lines are processed.

If an error condition is encountered while reading a command, the line displays as:

"Error – Parsing Steps: unknown step "< command name >"."

[Send]

[Reset Files]

[Start]

[Stop]

< contact Sutter Technical Support for more information >

5.5 SutterPatch Hooks

There are several places where SutterPatch can call external functions to provide additional control of the data-acquisition and analysis process. At given times during the acquisition or analysis process, SutterPatch looks for predefined functions with a specific names. If the named function exists, it is called. These hooks provide an additional level of experimental flow-control over what can be accomplished using Paradigms.

To use these pre-named functions, before starting Igor Pro, move the 'UserMeasurement.ipf' procedure file from the Program Files \ SutterPatch3 \ SP_Code \ Special Procedures folder into the Program files \ Wavemetrics \ Igor Pro 10 Folder \ Igor Procedures folder.

UserAnalysis( )

The UserAnalysis function is called after a sweep is collected, but before any real time analysis is performed. The active Routine name is passed as an argument.

UserAP( )

UserAP can be used when analyzing data using the UserAP Analysis Module. If the function is present, SutterPatch will pass each detected event to the function. The function can perform any analysis on the event, which is then passed back to SutterPatch using the 'return' keyword. This analysis is then appended to the results table.

UserMeasurement( )

This analysis function provides Routine real-time analysis.

UserMeasurement parameters are defined in the Routine Editor Real Time Measurements settings window. Note that all of the waves and variables must be declared in the function, whether or not they are used. The UserMeasurement results are written to the ResultWave. Place the Analysis Editor in Table mode to inspect the results.

UserStart( )

The UserStart function is called at the beginning of a Routine, before data is collected. The active Routine name is passed as an argument.

Example:

Open a procedure Window (Ctrl-M) and copy the following text into it:

```
Function UserStart()
Print "Start"
End
```

Press the compile button in the Procedure window. Now, every time you run a Routine, 'Start' will be written to the command window.

UserTraceEquation( )

Use to modify a DataWave.

< for more information on these functions, see the Program Files \ SutterPatch3 \ SP_Code \ Special Igor Procedures folder, or contact Sutter Instrument Technical Support >

5.6 User Functions

SutterPatch functionality can be extended within Igor Pro through the use of user-defined Functions.

To create a user Function:

1. Open the menu for Windows / Procedure Windows / Procedure Window.

2. Enter your user code into the Procedure window, following its '#pragma' and '#include' lines.

   Example:

   ```
   #pragma TextEncoding = "Windows-1252"
   #pragma rtGlobals=3    // Use modern global access method…
   #include "SP_Globals", optional

   Function SayHello()

       DoAlert 0, "Hello World!"

   End
   ```

   Note: The Function name must include trailing open/close parentheses "( )".

3. Click on the Compile button at the bottom of the window.

4. Enter the Function name (including parentheses) into the Command window and press 'Enter', or use it in a Paradigm 'Execute' step.

For more information on creating your own functions, see the Igor Pro 'Help/ Help Topics' on Programming / User-Defined Functions, and Procedure Windows.

Alert! User-defined functions only exist during the Experiment. They are not stored when the Experiment is closed. If you plan to re-use them in other Experiments, save them to a separate file, such as with a word processor.

Also, while user-defined functions are stored internally by Igor Pro, there is no visible list, so you will need to maintain such a list manually.

6. TROUBLESHOOTING

6.1 Technical Support

Technical support is provided to customers at no charge.

Support hours:	8:00 AM - 5:00 PM PST (Pacific Standard Time).
Telephone:	(+1) 415.883.0128
Fax:	(+1) 415.883.0572
Email:	sutterpatch@sutter.com
Address:	Sutter Instrument Company One Digital Drive Novato, CA 94949

When contacting us for technical support, please provide your SutterPatch version and "build" numbers to help us troubleshoot your situation. These numbers are found in Help / About SutterPatch.

For issues regarding Igor Pro features (all non-SutterPatch menu items), please contact Wavemetrics, Inc. for technical support.

6.2 Manual

The IPA manual is installed as a PDF file along with the SutterPatch software. It can be opened from the program's main menu Help / SutterPatch Manual.

The latest version of the manual can also be downloaded from our web site:

https:www.sutter.com/AMPLIFIERS/SutterPatch.html

You can navigate through the PDF document using Table of Contents links or page thumbnails (usually found on the upper left corner of the PDF screen):

 or 

or with the Page Navigation toolbar (usually at the top or bottom, middle of the PDF screen).

Note: Adobe Acrobat and other full-featured PDF viewers use the PDF display preference "Use logical page numbers" to properly display all page numbers in the Page Navigation toolbar.

However, for "lite" or free PDF viewers (such as integrated into web browsers), their Page Navigation toolbar might not support multiple page numbering sections. This means that after the

initial Roman numeral pages, the toolbar page numbers can differ from the Table of Contents page thumbnails and the manual's page numbering.

6.3 Help for SutterPatch

The main SutterPatch Help topics are available from the main menu Help / SutterPatch Help. This list matches the main menu 'SutterPatch' listing,

For the full listing of SutterPatch Help topics, go to the main menu Help / Igor Help Browser or Help Topics. The SutterPatch 'Help Files' names start with "SP_".

The Help includes the same information as found in the PDF manual, except that only a few figures are included.

Most items in SutterPatch also include a short description as a tool tip. Hover the mouse over an item to see the tool tip.

6.3.1 Error Messages and Notifications

Some SutterPatch error messages or notifications will flash to get your attention, automatically close after several seconds, and then write to the "History" window. The display duration is controlled in SutterPatch / General / Feedback notice display duration.

To review such messages, see the Command window (Windows / Command Window).

6.4 Q&A: Startup Issues

6.4.1 Installation Fails

Problem: The SutterPatch installation on Windows fails due to language pack incompatibilities.

Solution: Support for foreign language packs has been added. If language versions still cause problems, please contact Sutter Technical Support.

6.4.2 Startup Compiler Errors

Problem: The SutterPatch software loading on Windows fails due to compiler errors.

Solution: Instead of using the SutterPatch updater, run the full SutterPatch installer.

6.4.3 Application Not Loading

Problem: The SutterPatch application does not load – the startup sequence only loads Igor Pro.

Solution: If available, execute the Igor Pro menu command 'Macros / Autocompile', else use the Command window to compile. Autocompile should not be disabled.

If Procedure windows have uncompiled code, they will need to be compiled.

6.4.4 Startup EEPROM Errors

Problem: When starting up the SutterPatch program and simultaneously powering on the amplifier generates an EEPROM error.

Solution: The attached hardware might be using incorrect settings. Close the SutterPatch program, power cycle the IPA amplifier, and then relaunch the SutterPatch program.

6.4.5 USB Communication Fails

Problem: When starting up the SutterPatch program, there is no USB communication with the computer, or a USB communications error occurs during operation.

Solution: In the IPA Control panel, click the Reset USB button  . If the button does not turn from red to green, then test the USB hardware:

1) Power off the IPA amplifier, then unplug and re-plug both ends of the USB cable from the amplifier to the computer, and then power on the amplifier.

2) Try another USB cable.

3) Try another USB port.

4) Detach any external USB hubs from the computer.

Or, sometimes automatic Windows 11 updates automatically putUSB ports "to sleep" or suspending them to save power.

To prevent this situation, modify the Windows 'Control Panel':

1) In the Windows taskbar Search box, enter "edit power plan"

2) Click the "Change plan settings" link.

3) Expand the 'USB settings' node.

4) Expand its sub-node 'USB selective suspend setting' .

5) Select 'Disabled' for the 'On battery' and 'Plugged in' settings, then click the 'OK' button, and then click the 'Cancel' button in the prior screen.

For specific USB hubs, or if no "power plan", you can modify the Windows 'Device Manager':

1) In the Windows taskbar Search box, enter "device manager".

2) Expand the 'Universal Serial Bus controllers' node.

3) Right-click on the desired 'USB Root Hub device' and select '**Properties'**.

4) In the Power Management tab, uncheck 'Allow the computer to turn off this device to save power', and then click 'OK'.

5) Repeat for other hubs if desired.

In rare cases, the USB port has internal issues and disconnects itself. In this case, try installing a PCI Express USB expansion card into the computer (contrary to the IPA Installation / Computer Requirements section). Note that some Dell computers are especially prone to this situation.

6.4.6 Sample Parameter Files Not Installed

Problem: The SutterPatch installer fails to install the sample parameter files, as access is blocked to the Program Files or Users\..\Documents folders.

Solution: Disable any virus scanners or firewalls. If that does not help, then manually copy the sample parameter files into the Users\..\Documents\SutterPatch \Parameters folder.

6.4.7 SutterPatch/Igor Pro Software Crashes on Computer Wake Up

Problem: When a computer with external monitors wakes up from sleep, the SutterPatch/Igor Pro software crashes.

Solution: Close the SutterPatch/Igor Pro software before letting the computer go to sleep, or disconnect the external monitors. This is an OS issue we have no control over.

6.5 Q&A: Acquisition Issues

6.5.1 Routine Loading Delays

Problem: Selecting a Routine in the Routine Editor temporarily hangs the SutterPatch program.

Solution: Hide the Routine Editor Preview pane.

If there is a very large number of data or sweeps to display, the Preview pane can take a long time to redraw, and the program becomes temporarily unresponsive.

6.5.2 Acquisition Does Not Restart

Problem: Unable to start an acquisition because the SutterPatch program thinks a prior acquisition is still in progress.

Solution: Use the menu command SutterPatch / Reset Acquisition to clear the acquisition status.

6.5.3 Acquisition Start Delayed

Problem: After starting an acquisition, if a very large command waveform has to be generated, it takes a long time for the actual recording to begin.

Solution: It can take a long time to create very large output waves, which can delay the start of acquisition.

If command stimuli are not needed, disable those output channels. This does not affect holding level outputs.

6.5.4 Sweep Loading Delays

Problem: Sweep-by-sweep loading takes longer than expected.

Solution: If the intersweep time is less than 1/5 of the sweep duration, sweep loading delays can occur.

6.5.5 Acquisition Windows Lock Up

Problem: The Scope window, Routine Editor or Paradigm Editor lock up during acquisition.

Solution: Use the menu command SutterPatch / Reset Acquisition to halt acquisition.

A combination of SutterPatch-related and computer-related issues can contribute to your system's performance. For suggestions to improve it, see the Troubleshooting item 'Sluggish Acquisition' below.

6.5.6 Acquisition Terminates

Problem: During acquisition, the recording terminates unexpectedly.

Solution: Close the Analysis / Data Browser window, if it is open.

This window can consume a large amount of system resources, which can interfere with data acquisition.

6.5.7 Signals Flat

Problem: Scope headstage signals are completely flat (at zero amplitude) during acquisition.

Solution: The corresponding headstage might not be firmly attached to its port, as the IPA headstage connectors do not "lock on".

"Power off" the IPA amplifier and firmly reconnect the headstage plug to its HDMI port until it "clicks". Then "power on" the amplifier and reset the USB connection (click the red square button in the IPA Control panel).

6.5.8 Signals Saturated

Problem: Scope headstage input signals are completely saturated (at raw +10V) during data acquisition.

Solution: The corresponding headstage might not be firmly attached to its port, as the IPA headstage connector does not "lock on".

"Power off" the IPA amplifier and firmly reconnect the headstage plug to its HDMI port until it "clicks". Then "power on" the amplifier and reset the USB connection (click the red square button in the IPA Control panel).

If the headstage is properly attached, the IPA Control panel 'Gain' setting might be set too high. Reduce the gain.

6.5.9 Signals Intermittent

Problem: Scope headstage signals are intermittent during data acquisition.

Solution: The corresponding headstage's plug might not be firmly attached to its HDMI port, as the IPA headstage connectors do not "lock on".

"Power off" the IPA amplifier and firmly reconnect the headstage plug until it "clicks". Then "power on" the amplifier and reset the USB connection (click the red square button in the dPatch Control panel).

6.5.10 Headstage Noise 1

Problem: The noise level of the instrument sometimes suddenly and erratically increases.

Solution: All attached headstages should be well grounded and fully contained in a Faraday cage. Also, if headstages are accidentally touched, the noise level will greatly increase.

6.5.11 Headstage Noise 2

Problem: The noise level of the IPA amplifier suddenly and permanently increased from ~0.8 pA to 2 pA (with a 5 kHz input filter).

Solution: If early model headstages are "hot swapped", i.e., plugged in or unplugged while the instrument power is on, their operational amplifiers can be damaged. Contact Sutter Technical Support for service.

Best practices is to turn off the instrument power before plugging/unplugging its headstages.

6.5.12 Axon Amplifier Attenuation

Problem: Axon Instruments amplifier analog output levels are attenuated when connected to a Sutter analog input channel.

Solution: The Axon Instruments analog output circuitry and IPA amplifier analog input circuitry interact to create a voltage divider, which attenuates the signal between them. Adjust for the 5% attenuation by scaling a routine input channel using a factor of "1.052632".

6.5.13 Paradigm Sound Reduced

Problem: The Paradigm 'Sound' step volume is attenuated at lower frequencies.

Solution: Upgrade the computer speaker, such as with add-on speakers.

6.5.14 Offset Delay

Problem: The 'Auto Offset' button in the IPA Control Panel has a short delay before it responds.

Solution: This can occur after running the Membrane Test due to internal processing.

6.5.15 Post-Acquisition Delay

Problem: After acquisition completes, there is a delay with the program operations.

Solution: The entire *.pxp Experiment file is resaved when a recording stops.

Create new Experiments more often, so that file sizes are smaller and more manageable.

Or, change the file saving settings in Set Preferences / Files and Naming, such as saving to temporary files or separate HDF5 data files.

6.5.16 Sluggish Acquisition

Problem: Data acquisition is sluggish.

Solution: The computer's available resources need to be increased to handle the system load.

A combination of SutterPatch-related and computer-related issues can contribute to your system's performance. Here are some suggestions to improve it:

Disable: Computer screen saver, Power Save or Sleep modes.

Disable: Scope window persistence display.

Close: Scope Analysis windows.

Disable: Routine Editor / Input Channels / Virtual channels.

Reduce: Routine / Acquisition & Routine Parameters / Output sampling rate.

Close: Background software.

Remove: Software for certain license protection USB keys (dongles).

Optimize: Hard disk (defragment).

Upgrade: Computer graphics card.

Increase: Computer RAM, cache size or CPU speed.

6.5.17 Buttons Unresponsive

Problem: When using a slower computer in emulation (demo) acquisition mode, acquisition-related actions might be difficult, such as clicking the Stop button, especially when acquiring a very large number of sweeps.

Solution: You may need to click the button more than once or hold it down longer than usual.

Also, try slightly moving the Scope or Acquisition Control window before trying to stop the acquisition.

A combination of SutterPatch-related and computer-related issues can contribute to your system's performance.

< see 'Sluggish Acquisition' above >

6.5.18 System Freezes

Problem: The IPA system "hangs up" or "freezes" after changing the IPA Control panel I-filter, V-Filter, or "VC/CC" mode selection.

Solution: Reset the USB port via the IPA Control panel USB reset button  or the SutterPatch / Hardware Control / Reset USB menu item.

6.5.19 IPA Control Panel Issues

Problem: The IPA Amplifier Control panel is having odd problems.

Solution: Reset the hardware controls to default settings by right-clicking on blank space in the IPA Control panel and selecting 'Reset Amplifier Controls', or via the SutterPatch / Hardware Control./ Reset Control Panel menu item.

Otherwise, reset the SutterPatch program settings to their factory defaults via the SutterPatch / Set Preferences menu command, and perform a Factory Reset.

6.5.20 Headstage Overheats in CC Mode

Problem: The IPA headstage overheats in current clamp (CC) mode.

Solution: Avoid running the headstage in a "no load" open-circuit configuration for prolonged periods of time in CC mode, or damage can occur to the headstage.

For "old headstages, overheating can occur after ½ hour.

For "new headstages, overheating can occur after 2 hours
The SutterPatch program now monitors this situation, and if detected, will alert the user. If no action is taken within 15 minutes of issuing the prompt, the IPA amplifier is automatically set to VC mode.

6.6 Q&A: Analysis Issues

6.6.1 Analysis Not Deleted

Problem: An analysis cannot be deleted in the Analysis Editor.

Solution: The analysis is still in use, i.e. displayed in another window, such as a graph window - close the window to allow the analysis to be deleted.

6.6.2 Signal Axes Overlay

Problem: The X-axis and units are overlaid in the Scope window.

Solution: There is not enough room for the X-axis and units due to the number of signals displayed. Switch to a tiled signal layout, or reduce the number of visible signals by right-clicking a signal and selecting 'Hide Signal'.

6.6.3 Graphs & Layouts Not Visible

Problem: Cannot see SutterPatch Experiment graphs or layouts on non-SutterPatch computers.

Solution: Use the Igor Pro menu command Windows / Graph, or Windows / Layout or Layout Macros, to see the object. Right-click it to modify with Igor Pro options.

6.6.4 Heavy Duty Processing

Problem: Very large data sets puts the CPU performance, memory requirements and disk speed under stress.

Solution: Modifications can be made to maximize the throughput:

General Analysis

Enable: Set Preferences / Scope Window / Y axis initial settings / Use last y-scale.

Bypass the extra processing time of Continuous autoscale.

Enable: Set Preferences / Scope Window / Reanalysis / Allow display compression.

Reduce display memory and processing requirements and usage.

Don't: Resize the Scope window.

Avoid a redraw of the window.

Check: SSD is the primary drive for system and data storage.

Check: SSD drive has enough free space for the analysis.

Data acquired for one channel for 1 minute at 5 MHz creates a sweep 2.4 GB in size.

Check: CPU is a dual-core processor (i5) or higher.

This is a base requirement for SutterPatch.

Use: Igor Pro 10.

This version is much more responsive than Igor Pro 8.

Routines

Hide: Routine Editor Preview pane

If there is a very large number of sweeps to display, the Preview pane updates can take a long time to redraw, and the program becomes temporarily unresponsive.

Data Navigator

Hide: Preview pane.

The time to scroll through data can be excessive.

Reanalysis Scope

Enable: Set Preferences / Scope Window / Reanalysis / Allow display compression.

Reduce memory and processing requirements and usage.

6.7 Q&A: General Issues

6.7.1 Slow Display of Sweeps

Problem: When displaying a large number of sweeps, the display slows down.

Solution: Disable 'Persistence' display in the Scope window, or reduce the Preference / Scope Window / "Maximal sweeps displayed in persistence display" setting.

6.7.2 Window Maximizing

Problem: Maximizing a window only maximizes the title bar.

Solution: Certain fixed-size windows and panels will not maximize:

Action Potential Analysis

IPA Control Panel

Dashboard

Synaptic Event Analysis

Log window

Paradigm Editor

Set Metadata

Set Preferences

Also, if the active window is maximized, creating a new window might automatically maximize the new window.

6.7.3 Slow Window Opening/Closing

Problem: Window opening and closing is slow on the macOS.

Solution: Close the SutterPatch 'Data Browser'. This function consumes a lot of system resources.

6.7.4 Windows Slowly Move Up or Down the Screen

Problem: Various SutterPatch windows in the Windows OS slowly creep up or down the screen, until they get to the top or bottom frame of the SutterPatch main window.

Solution: Click and hold the title bar of the window, or

a) Disable the SutterPatch option Set Preferences / General / 'Automatic window positioning', or

b) Disable the Windows 10 option Start / Settings / Devices / Mouse / 'Scroll inactive windows when I hover over them', or

in the Windows 11 taskbar Search box, enter “control panel”, then select “Devices and Printers”, and in the ‘Bluetooth & devices’ screen select ‘Mouse’, and disable “Scroll inactive windows when hovering over them”.

c) Reduce the Windows 10 option Start / Settings / System / ‘Scale and layout’ to 100%, or

in the Windows 11 taskbar Search box, enter “control panel”, then select ‘Devices and Printers”, and in the ‘Bluetooth & devices screen’ select ‘Display’, and in ‘Scale and layout’ set the ‘Scale’ to “100%”.

6.7.5 Command Window Frozen

Problem: The Command Window is blank and/or unresponsive.

Solution: Use Ctrl-J, or click on the IPA Control Panel, and the Command window is redrawn as an active window.

6.7.6 File Operations Crash

Problem: In Windows 10, file opening or saving crashes SutterPatch.

Solution: Remove the Dell Backup and Recovery utility v1.8, or upgrade it to a newer version.

6.7.7 Wrong Preference Settings

Problem: Program preferences are non-standard or corrupted.

Solution: Reset the SutterPatch preferences to their defaults via the SutterPatch / Set Preferences / General / Preferences Defaults button.

6.7.8 Font Size Too Large

Problem: The font sizes are too large when using the Windows 10 Settings > System > Display > Scale and Layout > Scale.

Solution: This can occur on high-resolution monitors running on older versions of Windows 10. Upgrade to the latest version of Windows 11.

6.7.9 Font Size Too Large in Titles and Fields

Problem: The font size is so large that SutterPatch dialog titles and field names are cut off.

Solution: Reduce the Windows 10 Settings / Accessibility ‘Text Size’ to 100%, or

in the Windows 11 taskbar Search box, enter “control panel”, then select (by icons) ‘Devices and Printers”, and in the ‘Bluetooth & devices screen’ select ‘Display’, and in ‘Scale and layout’ reduce the ‘Scale’ to “100%”.

6.7.10 Magnification Corrupts Window

Problem: After applying right-click Expansion to a window, returning to normal magnification corrupts the window.

Solution: Disable the Set Preferences / General / ‘Automatic window repositioning’. Or, use an expansion factor which does not increase the window size beyond the screen size.

6.7.11 Odd Program Behavior

Problem: When starting up or running the SutterPatch program, odd program behavior or errors occur..

Solution: If this occurs after a SutterPatch update, close and re-open the SutterPatch program.

If this occurs after an OS update, close the SutterPatch program and roll back the OS software update.

Otherwise, reset the SutterPatch program settings to their factory defaults via the SutterPatch / Set Preferences menu command, and perform a Factory Reset.

6.7.12 Igor Pro Features

Problem: There are a very large number of standard features in the Igor Pro software that can be used in conjunction with the SutterPatch application.

Solution: Refer to the Igor Help Browser or to the Wavemetrics Support Center regarding issues with Igor Pro features.

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Section 10.5. The relationship established by this Agreement between Licensee and Licensor shall be that of licensee and licensor. Nothing contained in this Agreement shall be construed as creating a relationship of agency, joint venture or partnership between Licensee and Licensor, so that neither party shall have any right whatsoever to incur any liabilities or obligations on behalf of the other party.

Section 10.6. The laws of California shall govern this Agreement. Any action or proceeding brought by either party against the other arising out of, or related to, this Agreement shall be brought only in a state or federal court of competent jurisdiction located in California and the parties hereby consent to the personal jurisdiction of said courts.

Section 10.7. In the event that any provision of this Agreement is found invalid or unenforceable pursuant to a judicial decree or decision, the remainder of this Agreement shall remain valid and enforceable according to its terms.

Section 10.8. The headings provided in this Agreement are for convenience and reference purposes only. In the event of a conflict between the terms and conditions listed in Articles 1 through 10, and the attached Schedules, the terms and conditions shall govern.

Section 10.9. A waiver of a breach, violation, or default under this Agreement shall not be a waiver of any subsequent breach, violation or default. Failure of either party to enforce compliance with any term or condition of this Agreement shall not constitute a waiver of such term or condition.

Section 10.10. All notices and communications shall be in writing and shall be deemed to have been duly given when delivered or three (3) Business Days after mailing by certified mail, return receipt requested, postage prepaid, addressed to the parties at their respective addresses or at such other addresses as the parties may designate by written notice in accordance with this section.

Section 10.11. Any amendments or addenda to this Agreement, may be executed in counterparts, each of which will be considered an original, but all counterparts together will constitute one agreement. A facsimile of a signed copy of this Agreement, or an electronic or other digital signature imprinted on this Agreement, may be relied upon as an original.

APPENDIX C: ACCESSORIES

- IPA Patch Panel — Rack-mountable analog and digital I/O BNC panel.
- Ground Point — Instrument grounding point hardware.
- Ground Wiring Kit — Grounding wire attachment hardware
- Rack Pack — Rack-mounting hardware
- Low-drift Pipette Holder — Thermoplastic pipette holder.
- Refresher Kit — Replacement parts for holders and headstages.
- Silver Wire — Consumable for assembling electrodes.

IPA Patch Panel IPA-PCH

This optional rack-mountable panel provides BNC ports for easy access to digital and analog I/O channels on the IPA and DIPA systems.

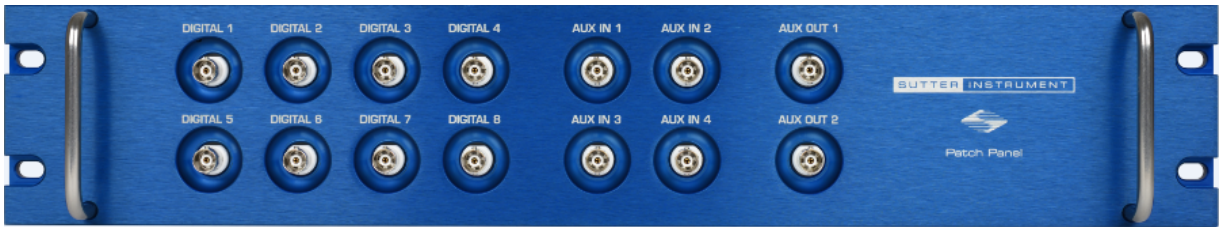


Figure C-0-1. Patch Panel

IPA Patch Panel	
Dimensions (in)	18.8 x 2 x 3.5
Dimensions (cm)	48 x 5 x 9
Weight (lbs)	3.5
Weight (kg)	1.6
Digital Output BNCs	8
Auxiliary Analog Input BNCs	4
Auxiliary Analog Output BNCs	2

Table C-0-1. IPA Patch Panel

Ground Point GP-17

For system grounding, this optional machined brass tower provides reliable low-resistance connections for electrophysiology setups. The base plate mounts directly to air table tops (imperial and metric) with the included ¼-20 and M6 screws. The plated connectors accept up to 9 banana plugs and 8 bare wires (up to 10 gauge). A "star" ground configuration is used to avoid ground loops.

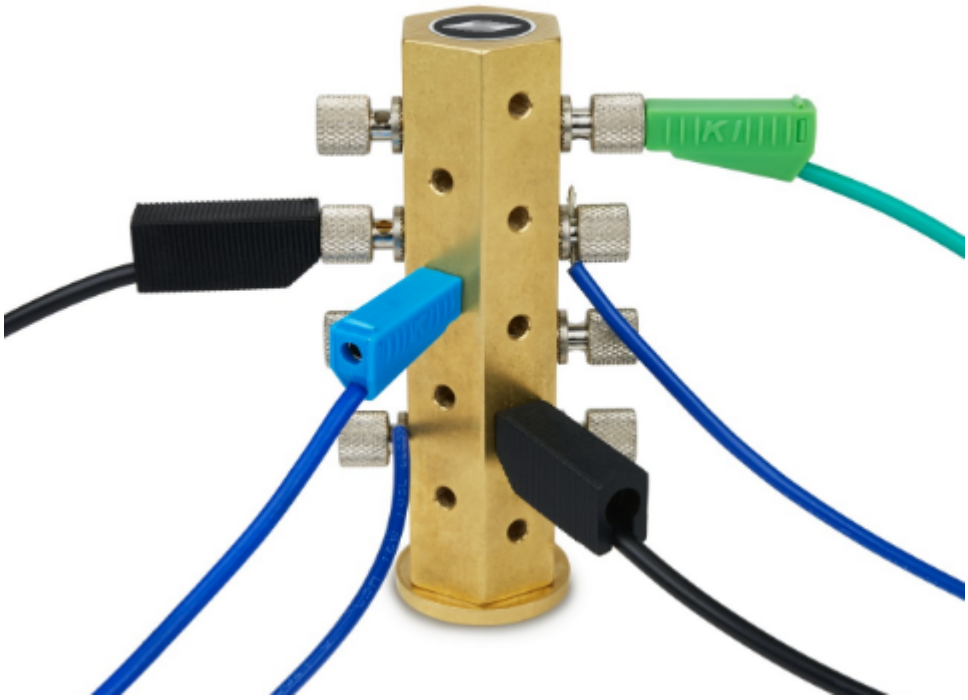


Figure C-0-2. Ground Point

The Ground Point 10-item kit includes cables with banana plugs and alligator clips. For very complex rigs, two sets of cables might be needed.

Ground Wiring Kit GP-W10

Includes 10 assorted cables, 5 alligator clips, and assorted clamp rings.

Rack Pack RACK-PK

Hardware to attach the amplifier to an equipment rack.

Standard Pipette Holder EH-L170

The default micropipette holder is made of polycarbonate.

Low-drift Pipette Holder **EH-L170**

The EH-L170 is a drop-in replacement for a standard Sutter micropipette holder, but undergoes significantly lower thermal expansion than a polycarbonate holder (> 60% reduction).

The thermoplastic base material is highly durable and resistant to impact and cracking.

The thermoplastic base material is highly chemically resistant. It can be safely washed with, or even submerged in, ethanol or isopropanol, with no risk of damage.

This holder has a thinner physical profile, allowing more freedom of movement for objectives, etc.

Note: While the ultra-low-noise quartz pipette holder option EH-Q170 is no longer available, the EH-L170 is of particular interest for investigators concerned about mechanical stability during their patch-clamp recordings. While its thermal properties are not ideal as with a quartz holder, it undergoes significantly less thermal expansion than a polycarbonate holder.

Refresher Kit EH-TLC

This refresher kit is suitable for all models of Sutter holders and headstages.

Double cone gaskets:	6 each of silicone O-rings:
	1.0, 1.2, 1.5 and 1.7 mm
Headstage gold connector pins:	2 with solder cup headers
	2 with flat headers
Grounding pins:	4
Silver wire:	0.67 inches, 1.7 cm
Silicone tubing:	2.5 inches, 5 cm

Silver Wire EH-SWIRE

Pure silver wire:	Length:	2 meters
	Diameter:	0.010 ±0.0005 inches
	Purity:	99.99% silver

APPENDIX D: FUSE REPLACEMENT

In the event that the instrument fails to power up when it is switched on, the power-line fuses should be checked to determine whether they have blown. Two fuses are located in the fuse holder in the power cord module on the rear of the amplifier.

To replace a fuse:

1. Unplug the power cord from the power entry module, revealing the fuse holder below.
2. Remove the fuse holder.
3. If a fuse is blown, it is recommended to replace both fuses.
4. Insert appropriately-rated replacement fuses.
5. Replace the fuse holder in the power entry module and reconnect the power cord.

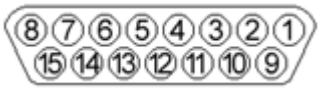
Mains Power Source	Fuses (Type: Time Delay/Time Lag, 5mm x 20mm, glass tube)	
	Fuse Rating	Manufacturer Examples
100 – 240 VAC	T2.0A, 250V	Bussmann: GMC-2-R, S506-2A, Littelfuse: 239.002.P

Table D-0-1. IPA Fuses

APPENDIX E. TECHNICAL SPECIFICATIONS

General Specifications

IPA & Double IPA Amplifiers	
Dimensions (in.) < includes handles & connectors >	IPA: 18.8 (W) x 11.8 (D) x 1.8 (H) DIPA: 18.8 (W) x 11.8 (D) x 3.5 (H)
Dimensions (cm) < includes handles & connectors >	IPA: 48.25 (W) x 30.0 (D) x 4.5 (H) DIPA: 48.25 (W) x 30.0 (D) x 9.0 (H)
Weight (lb) < with headstages >	IPA: 8.1 DIPA: 8.1
Weight (kg) < with headstages >	IPA: 3.7 DIPA: 3.7
Case	IPA: steel DIPA: aluminum
Communications	USB 2.0 (High Speed)
BNC Channels	IPA: 2 SCOPE analog outputs (current sourcing: ±30 mA) IPA: 1 COMMAND analog input (impedance: 1 MΩ) DIPA: 4 SCOPE analog outputs (current sourcing: ±30 mA DIPA: 2 COMMAND analog inputs (impedance: 1 MΩ) 1 Digital output trigger (current sourcing: 20 mA) 1 Digital input trigger (impedance: 1 MΩ)
Rack use	IPA: 19” rack-mount (1U) DIPA: 19” rack-mount (2U)
Benchtop use	Rubber feet

Signal Ground	4 mm Banana socket
Earth Ground	4 mm Banana socket
Safety	CE marking (Conformité Européenne)
Auxiliary I/O Port	DB-15 female connector 

Auxiliary I/O Pinout

Pin	Definition
1	Digital Output 1
2	Digital Output 2
3	Digital Output 3
4	Digital Output 4
5	Digital Output 5
6	Digital Output 6
7	Digital Output 7
8	Digital Output 8
9	Auxiliary Analog Input 1
10	Auxiliary Analog Input 2
11	Auxiliary Analog Input 3
12	Auxiliary Analog Input 4
13	Auxiliary Analog Output 1
14	Auxiliary Analog Output 2
15	Signal Ground

Configurations	Voltage-clamp Current-clamp
Whole Cell Capacitance Compensation	0 – 100 pF
Current-Clamp Rise Time < with 20 kHz low-pass filter & 100 MΩ load >	17.5 µs
Analog Output Gain	0 – 25x

Table E-0-1. IPA & DIPA Amplifier Specifications

IPA Headstage - Physical	
Construction	Anodized aluminum case

Dimensions (in.)	4.0 (L) 4.25 (L) w/threads x 1.375 (W) back end x 0.75 (H) x 0.825 (H) w/dovetail
Dimensions (cm)	10.16 (L) 10.795 (L) w/threads x 3.493 (W) x 1.9 (H) x 2.096 (H) w/dovetail
Cable Length (feet)	6
Cable Length (m)	1.83
Weight (lb) w/o cable w/cable	 0.21 0.294
Weight (kg) w/o cable w/cable	 0.095 0.133
Ground Socket (mm)	1
Feedback Resistor	500 MΩ

Table E-0-2. IPA Headstage - Physical

IPA Headstage - Noise < measured with 8-pole Bessel filter >	
Bandwidth	**Open-Circuit Noise (RMS)**
0.1 – 1 kHz	< 0.25 pA
0.1 – 5 kHz	< 0.75 pA

0.1 – 10 kHz	< 1.40 pA

Table E-0-3. IPA Headstage Noise

IPA Data Acquisition	
Analog I/O Channel Type	Full Differential
Analog I/O Channel Amplitude (voltage)	±10 V
Analog I/O Channel Amplitude (current)	±20 nA
Analog I/O Channel Resolution	16-bit
Headstage Input Sample Rates	0.1 - 50 kHz
Headstage Input Filter Bandwidth	0.5 - 20 kHz
Headstage Output Sample Rates	0.1 -10 kHz
Auxiliary In Sample Rates	0.1 - 200 kHz
Auxiliary Out Sample Rates	0.1 - 100 kHz
Digital In States	0 - 0.8 V = Low 2.0 – 5.5 V = High
Digital Out States	0 – 0.4 V = Low 2.4 – 3.3 V = High
Digital In Trigger Width	Edge triggered (ns)
Digital Out Trigger Width	100 µs
Digital In Sample Rates	0.1 – 50 kHz
Digital Out Sample Rates	0.1 – 10 kHz

Digital Out Current (max)	20 mA

Table E-0-4. IPA Data Acquisition

IPA Electrical	
Power consumption	18 Watts maximum
Mains fuse	250V 1A Slow Blow (5 mm x 20 mm) T2.0
Cables	Shielded grounded power line cord
Line Voltage	100 VAC – 240 VAC

Table E-0-5. IPA Electrical

IPA System Components

Carefully remove all items from the shipping container.

The following components are included:

Component Name	Catalog Number
• (1) IPA Amplifier	IPA/E-1
• (1) IPA Headstage	IPA-HS
• (1) Polycarbonate Pipette Holder	EH-P170
• (1) Model Cell	MCELL
• (1) Rack-Mount Kit	RACK-PK
• (1) Auxiliary I/O Adapter Cable	
• (1) Power Cord	
• (1) USB 2.0 Cable	
• (1) Quick Start Guide	< with Igor Pro Serial # >
• (1) USB Flash Drive	< with SutterPatch and Igor Pro software >

Double IPA System Components

Carefully remove all items from the shipping container.

The following components are included:

Component Name	Catalog Number
• (1) Double IPA Amplifier	IPA/E-2
• (2) IPA Headstages	IPA-HS
• (2) Polycarbonate Pipette Holders	EH-P170
• (1) Model Cell	MCELL
• (1) Rack Mount Kit	RACK-PK
• (1) Auxiliary I/O Adapter Cable	
• (1) Power Cord	
• (1) USB 2.0 Cable	
• (1) Quick Start Guide	< with Igor Pro Serial # >
• (1) USB Flash Drive	< with SutterPatch and Igor Pro software >

Pipette Holder Parts

• Body/Barrel	Standard: polycarbonate
• Pin Cap	
• Gold Pin	
• Lockdown Ring	
• End Cap	
• Silver Wire	
• Silicone Gaskets	O-rings, 6 of each size:

Gasket ID	Color
1.1 mm	Clear
1.2 mm	Green

1.5 mm	Orange-Red
1.75 mm	Blue
• Tubing	Clear
	1/32” ID: < preferred >
	< see https://www.mcmaster.com/5327N101/ >
	0.025”" ID: < alternate >
	< see https://www.mcmaster.com/51845K67/ >

Model Cell Parts

- Model Cell
- Connector pins with crimp
- Ground wire

Pipette Holder Diagrams

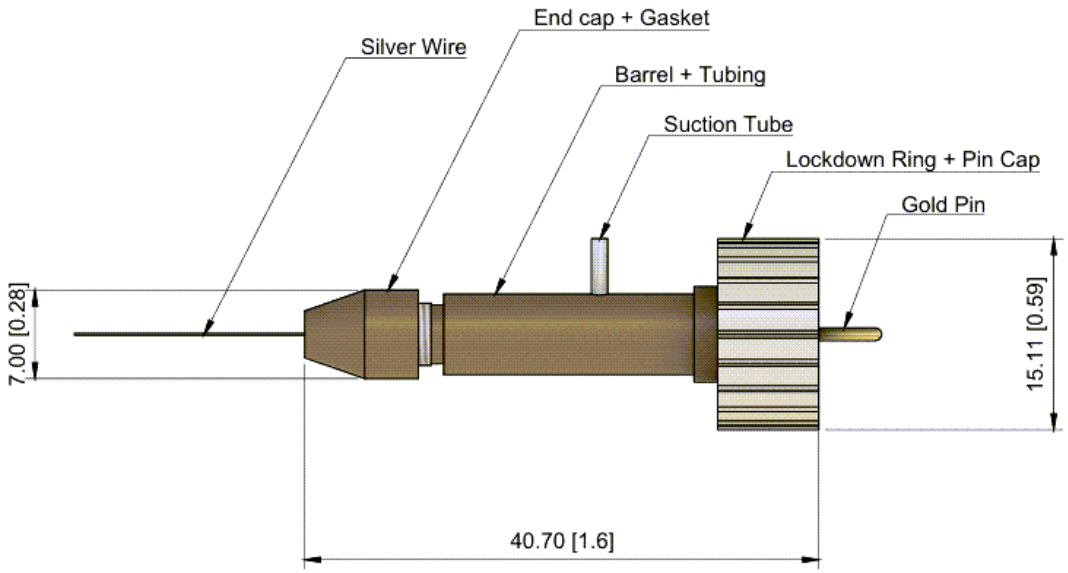


Figure 0-1. New Polycarbonate Holder

Figure dimensions are in “mm [inches]”.

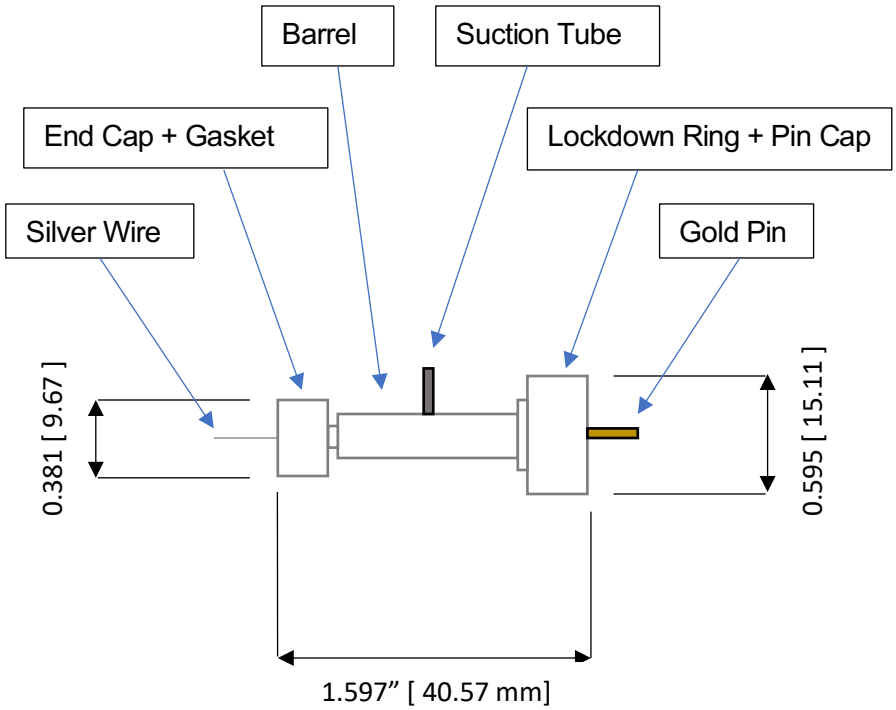


Figure E-0-2. Old Pipette Holder

Figure dimensions are in “inches [mm]”.

APPENDIX F. SUTTERPATCH ALGORITHMS

1. Action Potential Threshold Algorithm

< for Action Potential Analysis >

Results pane 'Threshold potential' computation:

The Event starts when the signal slope is > 1 mV/100 µs (10 V/s), or when 25% of the maximum slope is reached, whichever is smaller.

The exact 'Threshold potential' timepoint is based upon differentials using a central differences algorithm.

2. Auto 'Cell Compensation' Algorithm

< for the Amplifier Control Panel >

A train of 11 square pulses is applied with a cycle length being 5 times the expected tau of the transient. The routine adjusts the pulse length, if the transient would be too short or too long. Typically, the pulse amplitude is ±5 mV, i.e. 10 mV peak-to-peak. The routine reduces the pulse amplitude, if saturation would occur. See figure 3 for an overview.

The resulting step responses are averaged, skipping the first transient and averaging the central 10 square cycles. Then the negative transients response is reversed in polarity and averaged with the positive transients response, resulting in an average composed of twenty transients.

The input is acquired with a 10 kHz filter bandwidth and a 100 kHz sampling rate.

The measured transient of the whole cell capacitance starts to rise at about 60 µs, measured with an apparent pipeline delay of 5 samples.

The time of half-decay is searched, starting at the first peak. The transients half-time must end in the first half of the stimulus pulse length. Otherwise, acquisition is repeated with an adjusted pulse length.

First estimates for Rs and Cm are computed:

Rs = exp(Xintercept)

Semi-logarithmic regression from the peak, over a time range of 4 * half-decay time. The mean of the last 10% is used as the baseline.

Cm = Integral / dV

Integral from latency (i.e., pipeline samples plus stimulus-filter delay) over a time range of 4 * half-decay time.

These first estimates are iteratively improved by the method as described by Sigworth et al (1995), J Neurosci. Methods, 56:195-202.

Iterations are terminated when the improvements get less than 2%, or after 10 iterations.

Notes:

- Estimating Rs by Rs = tau * dV / Qt (as used in the membrane test), underestimates Rs by about 20 %.
- The method as described by Sigworth et al. fails to get starting estimates.

3. Auto 'Electrode Compensation' Algorithm

< for the dPatch Amplifier Control Panel >

This algorithm adjusts for the "Cp Fast" portion of a capacitive transient.

A train of 11 square pulses is applied with a cycle length of 2 ms each. Typically, the pulse amplitude is ±5 mV, i.e., 10 mV peak-to-peak. If saturation occurs, the routine reduces the pulse amplitude.

The resulting step responses are averaged, skipping the first transient and averaging the central 10 square cycles. Then the negative transients response is reversed in polarity and averaged with the positive transients response, resulting in an average composed of twenty transients.

The input is acquired with a 50 kHz filter bandwidth and a 500 kHz sampling rate.

The measured transient of the electrode capacitance starts to rise at about 22 µs, measured with an apparent pipeline delay of 7 samples.

The transient terminates at about 40 µs.

The transient is integrated from the 13th sample to the 21st sample, i.e., over 8 samples (sampling interval is 2 µs per sample). The integration baseline is the mean of the samples after the transient.

The raw Integral is converted to capacitance by:

capacitance = (Integral * SampleInterval) / (PulseAmplitude * CurrentGain)

where

"PulseAmplitude" is the test pulse amplitude (typically 5 mV),

and

"CurrentGain" is the gain of the dPatch current input, 50 MΩ or 5 MΩ, as defined by feedback mode (or 50e6 V/A and 5e6 V/A, since an Ohm is defined as 1 V/A.)

The computed capacitance value is used as a correction value that is added to the electrode capacitance magnitude.

The measurement is repeated until the correction value gets too small (< 2% of electrode capacitance magnitude), or after 10 iterations.

The electrode capacitance tau is optimized by acquiring the same averaged transient while changing tau and measuring the RMS value, and using the tau giving the smallest RMS value. The first iteration starts at a tau value of 1 µs, and increments by 2 µs. Then it is refined, as the iteration cycle is repeated starting at the minimum tau minus 2 µs and incrementing by 0.5 µs, followed by an iteration incrementing by 0.1 µs.

4. Auto Offset Algorithm

< for the Amplifier Control Panel >

- Input is acquired with a 10 kHz filter bandwidth and a 100 kHz sampling rate.
- A 40 ms interval is acquired, of which the second half, i.e., 20 ms, is averaged and used as the offset to be nulled.
- The iteration is repeated until the offset is less than full-scale/10000, i.e., 0.2 mV in VC-mode, or after 20 iterations.

5. Liquid Junction Potentials

< for the Amplifier Control Panel 'Liquid junction' correction >

I Bath Offsets

Command Offsets

When a micropipette is placed into the bath, a voltage-clamp "zero-volt" stimulus command can still generate a small amount of unwanted current flow.

Correspondingly, a current-clamp "zero-current" stimulus command can generate a small amount of unwanted voltage charge.

In these cases, the stimulus command output is inaccurate, i.e., non-zero, due to hidden voltage offsets inherent in the physical system.

Offset Factors

Contributory factors to system offsets include the amplifier circuitry, the

micropipette, the metal electrode, the liquid-metal junction of the electrode and the micropipette solution, and the liquid-liquid junction of the micropipette and bath solutions.

Liquid Junction Potential

Liquid-liquid solution offsets occur when two dissimilar solutions are in contact. Due to differences in their ion species charges, mobilities and concentrations, the two solutions create an unwanted voltage offset. The Liquid Junction Potential (LJP) is the reverse polarity calculation of the offset.

System Offset

The system's hardware-based offsets are fairly stable, and can be corrected for by a simple one-time tuning of the amplifier.

However, the solution-based liquid-junction offset is more complex, and requires further processing.

II Potential Polarities

Membrane Polarity

The electrical polarity of a cell membrane is defined as being measured in relation of the ***outside*** of the cell to the ***inside*** of the cell, i.e., the outside membrane is more positive compared to the inside membrane.

Inside of Cell → **Outside** of Cell
(Positive Polarity) →

Also by convention, the potentials on the outside of the cell membrane and the bath solution are equivalently at '0 V':

Inside of Cell → **Outside** of Cell **| Bath** (0 V)
(Positive Polarity) →

Membrane Potential

Membrane potential (V_m) is defined as:

$$V_m = V_{in} - V_{out}$$

for

V_{in} Voltage on the cell inner membrane.

V_{out} Voltage on the cell outer membrane.

As in the bath,

$$V_{out} = 0$$

then

$$V_m = V_{in} - 0$$

$$V_m = V_{in}$$

Liquid Junction

However, the polarity of LJP values is reversed from that of membrane potentials, as by historical convention (Barry), the LJP is defined as the potential of the ***bath*** solution with respect to the ***micropipette*** solution.

Bath ← Micropipette
← *(Positive Polarity)*

Therefore, as the liquid junction measurement direction (polarity) is reversed from that of V_m, the sign of LJPs needs to be properly addressed in membrane equations.

III Offset Changes

Seal

After a seal is formed on a cell, the micropipette's "open circuit" configuration changes to a 'cell-attached' patch configuration.

The micropipette solution now contacts the cell membrane, not the bath solution, so a liquid-liquid junction no longer exists. This means a liquid junction offset no longer contributes to the system offset. This situation occurs with all patch configurations, and is addressed by LJP correction.

IV Patch Configurations

Voltage Levels

In a patch-clamp experiment, baseline voltage levels change (pre- vs. post-seal) by the magnitude of the liquid junction offset. However, the polarity of the LJP correction is handled differently for the various patch configurations.

"Outside-Out" Configurations

Outside of cell membrane: in **bath**

Inside of cell membrane: attached to **micropipette** (or via ICF)

Micropipette → **Inside** of Cell → **Outside** of Cell | Bath
Outward Current → (Positive Polarity)

The **outside** of the cell membrane is measured in respect to the **inside** of the cell membrane for conventional polarity:

- "**Outward**" currents flow from the *inner* to *outer* membrane, so these currents flow *out* of the micropipette with a **positive** polarity.
- "**Inward**" currents flow from the *outer* to *inner* membrane, so these currents flow *into* the micropipette with a **negative** polarity.

These "outside-out" patch configurations use conventional cell membrane polarity:

Whole-Cell

< This is the only patch configuration supported by SutterPatch automatic LJP correction. >

A cell-attached patch is ruptured, and the cell membrane reseals onto the outside of the micropipette.

Outside of cell membrane:	in **bath**
Inside of cell membrane:	in contact with **micropipette** via intracellular fluid (ICF)
Note:	The ICF-micropipette liquid junction is usually ignored, as it's offset is small compared to the bath liquid junction, and the micropipette and intracellular solutions equilibrate fairly quickly.

The polarity of calculated LJP values is reversed (by convention) from that of conventional cell membrane measurements. So, to "add" an LJP value into a membrane equation, you actually subtract it.

The Membrane voltage equals the Command voltage "minus" the LJP.

$$V_m = V_{cmd} - V_{LJP}$$

For whole-cell Current Clamp mode, where "V_{rec}" is the measured voltage from the cell:

$$V_m = V_{rec} - V_{LJP}$$

Outside-Out

A cellular patch is specially excised and reformed, so that:

Outside of excised membrane patch: in **bath**

Inside of membrane patch: in contact with **micropipette**

This configuration is useful for studying the effect of extracellular compounds, such as adding neurotransmitters to the bath.

However, the polarity of calculated Liquid-Junction Potential (LJP) values is reversed (by convention) from that of conventional cell membrane measurements. So, to "add" an LJP value into a membrane equation, you actually subtract it.

The Membrane voltage equals the Command voltage "minus" the LJP.

$$V_m = V_{cmd} - V_{LJP}$$

"Inside-Out" Configurations

The membrane orientation to the bath and micropipette is reversed from the "outside-out" configurations:

Inside of cell membrane: in **bath** (or **ICF**)

Outside of cell membrane: attached to **micropipette**

Micropipette → **Outside** of Cell → **Inside** of Cell
Inward Current → (Positive Polarity)

The **inside** of the cell membrane is measured in respect to the **outside** of the cell membrane, for a reversed polarity:

- "**Inward**" currents flow from the *outer* to *inner* membrane, so these currents flow *out* of the micropipette with a **positive** polarity.
- "**Outward**" currents flow from the *inner* to *outer* membrane, so these currents flow *into* the micropipette with a **negative** polarity.

These "inside-out" patch configurations utilize reversed polarity from "conventional" cell membrane polarity:

Inside-Out

This configuration is useful for studying single channel activity, while modifying the internal milieu.

A cellular patch is excised:

Outside of membrane patch: in contact with **micropipette**

Inside of membrane patch: in **bath**

As the polarity of an estimated LJP value is already reversed (by convention) from that of cell membrane values, the LJP value now matches V_m in reverse polarity. So, to "add" an LJP value into a membrane equation, you simply add it in.

The Membrane voltage equals the negative Command voltage plus the LJP.

$$V_m = -V_{cmd} + V_{LJP}$$

Cell-Attached

This is the initial patch configuration after making a seal on an intact cell membrane:

Outside of cell patch: in contact with **micropipette**

Inside of cell patch: in contact with **ICF**

As the polarity of a calculated LJP value is already reversed (by convention) from that of cell membrane values, the LJP value now matches V_m in reverse polarity. So, to "add" an LJP value into a membrane equation, you simply add it in.

The Membrane voltage equals the negative of the Command voltage, plus the LJP, plus the cell Resting Membrane Potential (RMP).

$$V_m = - V_{cmd} + V_{LJP} + V_{RMP}$$

Note: The RMP for most neuronal cells is between -50 mV to -90 mV.

3. LockIn Computation

< for Routine Editor Virtual Input Channels >

LockIn paper:

Lindau, M., Neher, E. Patch-clamp techniques for time-resolved capacitance measurements in single cells. Pflugers Arch. 411, 137–146 (1988).

https://doi.org/10.1007/BF00582306

Math used in the LockIn computation:

Factor = (2.0 / SinePointsPerCycle) / sine_amplitude^2

A = Factor * ∑(current * stim_real)
∑ over one SinePointsPerCycle

B = Factor * ∑(current * stim_imag)
∑ over one SinePointsPerCycle

DC = 1/SinePointsPerCycle * ∑(current)
∑ over one SinePointsPerCycle

	VC-mode	CC-mode
Phase =	atan(B/A)	atan(B/A)
RealY =	A	A / (A^2 + B^2)
ImagY =	B	B / (A^2 + B^2)

Omega = (2 * pi) / SineCycleDuration

Gt = Idc / (Vdc – Et)

Gs = (A^2 + B^2 - A * Gt) / (A - Gt)

Gm = Gt * Gs / (Gs - Gt)

Cm = (A^2 + B^2 - A * Gt)^2 / ((A - Gt)^2 + B^2) / (Omega * B)

4. Membrane Test

< for Membrane Test in voltage-clamp “Cell” mode >

Parameters

The following parameters are calculated:

Exponential curve fitting

Transient peak amplitude (It)

Fitted curve time constant (τ or tau)

Electrode access resistance (Ra)

Membrane resistance (Rm)

Steady-state response (I1, I2)

Steady-state current (Iss)

Charge (Q)

Membrane capacitance (Cm)

Stimulus

The stimulus is a square-pulse wave, i.e., each pulse width is 50% of the pulse period (cycle), with the peak-to-peak amplitude centered around the cell's resting potential.

Fitting

Capacitive decay transients (current responses) from each pulse edge (positive and negative) are averaged (10x) for noise reduction and fit by a single (log) exponential.

Fitting range: 10 – 80% The curve fit is applied to the data between the % amplitudes of the transient peak and its steady state response.

Note: The fit and decay time constant (tau) can be extremely sensitive to the electrode capacitance compensation.

Tau The fitted curve decay time constant (tau) is calculated.

Peak The fitted curve is also used to calculate the peak of the transient (It).

This theoretical calculation is used to indirectly measure the peak, as it is less sensitive to low-pass filtering effects.

Steady-State Response

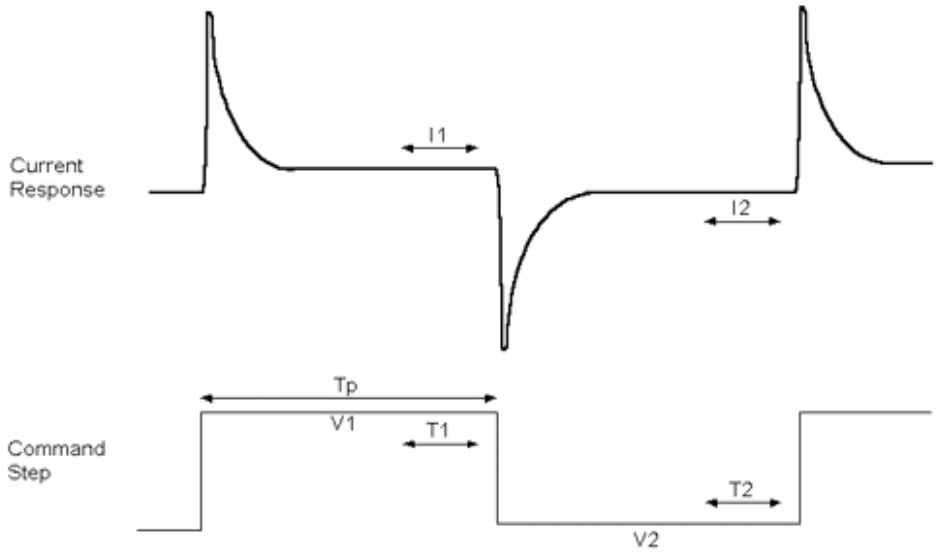


Figure F-0-1. MT Command Pulse & Response

A square-pulse stimulation generates a pair of equal duration amplitude levels.

The pulse level amplitudes (V1, V2) should be centered around the cell's resting potential.

Note: The SutterPatch Membrane Test sets the pulse ***first*** level amplitude (V1) ***relative*** to 'V-holding', and the pulse ***second*** level amplitude (V2) ***at*** 'V-holding'.

The "steady-state response" current **(I1)** is averaged during the last 20% (T1) of the duration of the ***first*** level (V1) in the pulse, and is the baseline for the transient of the ***second*** level (V2) in the pulse.

Correspondingly, the "steady-state response" current **(I2)** is measured during the last 20% (T2) of the duration of the ***second*** level (V2) in the pulse, and is the baseline for the transient of the ***first*** level (V1) in the pulse.

Iss The steady-state current (Iss) for the cell is calculated as the average of the steady-state responses I1 and I2:

$$Iss = (I1 + I2) / 2$$

Rt The total resistance (Rt) is calculated from the steady-state response:

$$Rt = \Delta V / \Delta I, \qquad \Delta I = I1 - I2$$

Ra The access resistance Ra is derived,

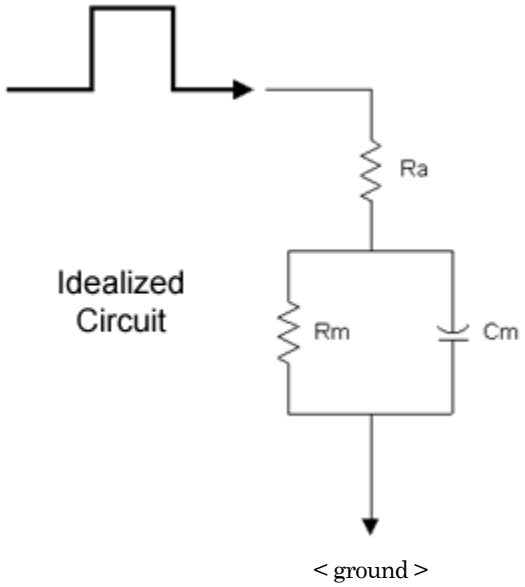


Figure F-0-2. Idealized Membrane Circuit

as:

$$Tau / Cm = (Ra * Rm) / (Ra + Rm)$$

or:

$$(Ra + Rm) * (Tau/Cm) = Ra * Rm$$

Substituting in above for resistance terms:

$$Rt = Ra + Rm$$

$$Rm = Rt - Ra$$

$$Rt * (Tau/Cm) = Ra * (Rt - Ra)$$
$$= (Ra * Rt) - Ra^2$$

and:

$$(Rt * (Tau / Cm)) - ((Ra * Rt) - Ra^2) = 0$$
$$(Rt * (Tau / Cm)) - (Ra * Rt) + Ra^2 = 0$$
$$Ra^2 - (Ra * Rt) + (Rt * (Tau/Cm)) = 0$$

Solved iteratively using the Newton-Raphson method.

Rm The membrane resistance is derived:

$$Rt = Ra + Rm$$

$$Rm = Rt - Ra$$

Cm Cell capacitance measurements are derived from the “area under the curve” charge calculations.

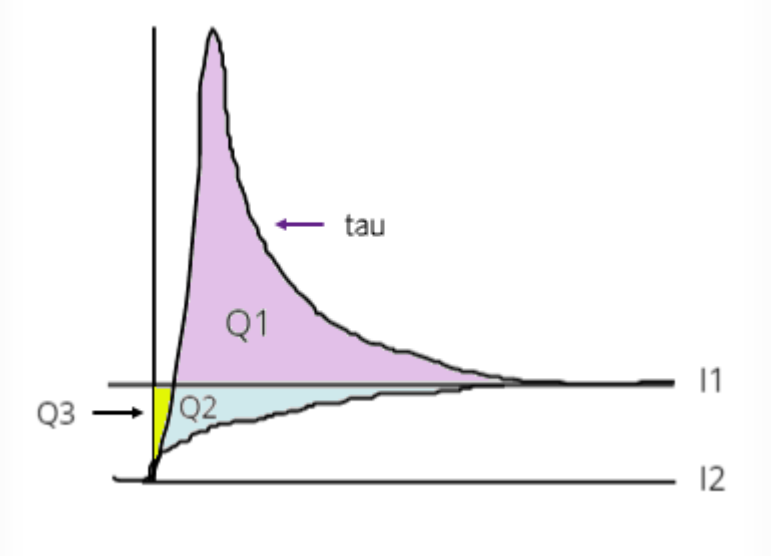


Figure F-0-3. Membrane Charge

The total charge (Qt) is composed of three parts:

Q1	Main charge:	The area between a response transient and its steady-state response (I1).
Q2	Correction charge:	The area between the start of a pulse and the tau decay from its baseline (I2), relative to its steady-state response (I1). This area compensates for the settling time of the voltage step.
Q3	Error charge:	The area between the start of a pulse and its response transient, relative to its steady-state response (I1). This area represents the settling time of the voltage step before Q1, and is included in Q2.

For simplification, the small error charge (Q3) is ignored in our calculations.

So:

$$Qt = Q1 + Q2$$

The main charge (Q1) under the response transient is integrated. However, first the baseline steady-state response current (I1) is subtracted from the maximum peak response (Ip), so only the current difference (Id) is integrated:

$$Id = Ip - I1$$

The correction charge (Q2):

$$Q2 = \Delta I * \tau, \qquad \Delta I = I1 - I2$$

Cm is derived from:

$$Qt = Cm * \Delta V, \qquad \Delta V = V1 - V2$$

$$Cm = Qt / \Delta V$$

5. Rs Correction

< for Whole-cell Series Resistance compensation >

Math used in Lag:

$$Lag = 1 / (2 * \pi * Bandwidth)$$

6. Single Channel Fitting

< for Single Channel Analysis >

Math used in single channel fitting:

Gaussian Fit

$$y = y0 + A * \exp(-((x - x0) / width)^2)$$

y0 = offset
A = height of curve's peak
x0 = position of center of peak
width = $\sqrt{2} * \sigma$
σ = standard deviation of the peak

Linear Exponential Fit

$$y = y0 + A * \exp(-(x - x0) / tau$$

Logarithmic Exponential Fit

$$y = k0 + k1 * \exp(-(\ln (x / k2) / k3)^2)$$

7. Standard Error of the Mean (SEM) Algorithm

< for Analysis Editor Error Bars >

'Standard Error of the Mean' computation:

SEM = √ (SumSq – Mean2 * N) / (N-1)

SumSq = sum of all squared samples

Mean = sum of all samples / N

Note: The SEM algorithm is similar to the Standard Deviation "√ (variance)", but using 'Mean' vs. 'sum of all samples'.

8. Synaptic Event Detection Reference

< for Synaptic Event Analysis >

A deconvolution method was selected to improve the signal-to-noise ratio (SNR), event characteristics, and temporal sensitivity over threshold and derivative-based detection algorithms, and also to template detection algorithms under in vivo conditions. In particular, superimposed events are detected with high fidelity.

This method uses the convolution of the time course of transmitter release and quantal conductance.

Deconvolution paper:

https://pubmed.ncbi.nlm.nih.gov/23062335/

Pernía-Andrade AJ, Goswami SP, Stickler Y, Fröbe U, Schlögl A, Jonas P. A Deconvolution-Based Method with High Sensitivity and Temporal Resolution for Detection of Spontaneous Synaptic Currents In Vitro and In Vivo. Biophys J. 2012 Oct;103(7):1429–39.