Dendrite™

Data Acquisition, Management and Analysis System

ELECTROPHYSIOLOGY
DATA ACQUISITION 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:	**DENDRITE** Data Acquisition, Management, and Analysis System
Model(s):	Controller digital to analog converter
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 Dendrite system hardware consists of one electronic digitizer. 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 Dendrite 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)
T2.0A, 250V	Bussmann: GMC-2-R, S506-2A Littelfuse: 239.002.P

Table 0-1. Dendrite 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.**

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1. INTRODUCTION

Welcome to the latest addition to low-noise patch-clamp technology! Our expert team has created a dependable low-noise electrophysiology data acquisition system. Its digital design makes it exceptional for low-noise whole-cell and single-channel recording.

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, light sources and wavelength switchers. We are proud to apply this same commitment to the next generation of patch-clamp instrumentation.

1.1 Overview

Integrated Design

The Dendrite™ Data Acquisition System is a complete digital system for high-speed high-fidelity voltage and current recordings. The electronics used in stimulating and recording from preparations are integrated into a single printed circuit board.

The accompanying SutterPatch® software brings the controls and displays for full-featured data acquisition, data analysis, and graphics together into a single unified program.

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 0set of built-in functions and routines for scientific programs.

From concept to production, from hardware to software, this integrated data acquisition system was designed for easy-to-use, low-noise, fast cellular recording.

1.2 Software Highlights

- Full-featured electrophysiology package
- Single program for data acquisition, data 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 always kept together with their complete contexts.

Automation: Automate your experiment using a rich set of data acquisition and analysis 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.

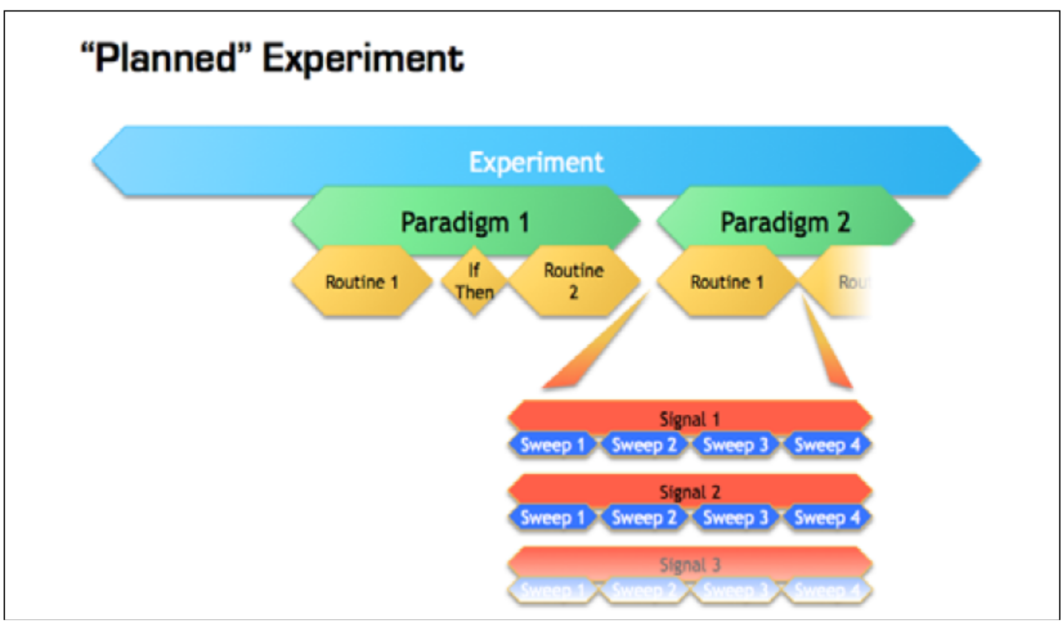


Figure 1-1. Data Structure - Planned Paradigms

An Experiment with two "Planned" Paradigms running Routines.

However, if a Routine is manually run, an "auto-triggered" Paradigm is created to maintain the Experiment structure. 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.

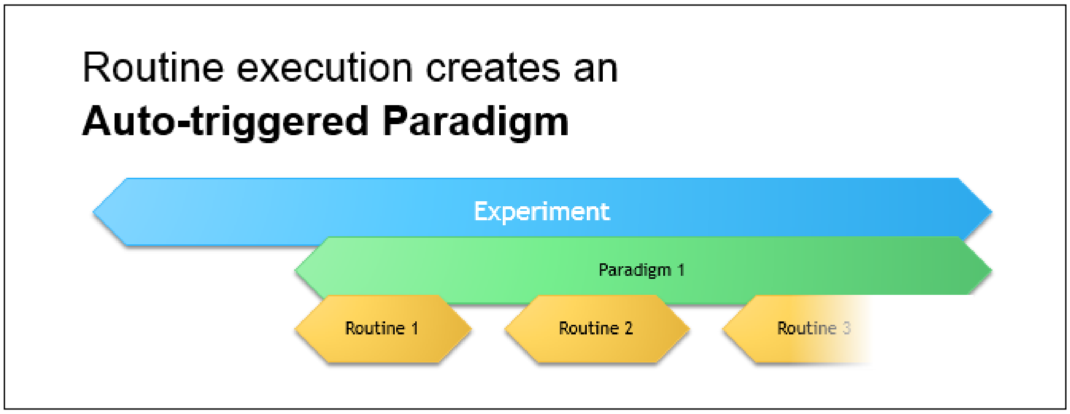


Figure 1-2. Data Structure – Auto-triggered Paradigms

An Experiment with manually run Routines uses 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 online 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 Dendrite system.

Analog input channels are used to record data from external instruments, and are displayed in their own panes in the Acquisition Scope window. Virtual input channels allow creative further processing of any input channels.

Analog output channels are used to send electrical stimuli, such as stimuli or command waveforms, to the external instruments.

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

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 of all data from all Signals, acquired from time zero, for a fixed duration. In SutterPatch software, the Sweep duration is determined by the length of the longest command waveform.

Trace:

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

Segment:

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

SutterPatch 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 dynamically 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 subject animal or cell, the animal species, age and genotype, the recording solutions, and the electrodes or stimuli applied during the experiment. SutterPatch keeps track of hundreds of 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

2. INSTALLATION

2.1 Computer Requirements

Minimum Configuration

OS (Operating System):	Windows:	Version 10 (64-bit versions) Most language packs are compatible. (listed in OS: Control Panel > System)
	macOS:	Version 10.11 (El Capitan) 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 The drive should be configured as the primary system drive.	
Display Resolution:	XGA (1024 x 768)	
Computer Ports:	(1) USB 2.0 High Speed port 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. The newer USB 3.x ports are backwards compatible to USB 2.0 ports, with an appropriate cable. Cables extenders, cables longer than 10 feet, external USB hubs and docking stations are not supported, as they can cause timing issues. 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): Note: Mac computers based on the Apple Silicon M1 architecture are not yet fully supported by Igor Pro.

See https://www.wavemetrics.com/news/igor-and-apple-arm-processors for technical details. Preliminary experiments indicate that SutterPatch Software runs on these computers, both under Igor Pro 8 and 9, and with each of the Sutter Amplifier Systems connected. However, as with each new technology, we cannot fully exclude incompatibilities at this early stage.

RAM: 8 GB

Hard Disk (Free Space): Solid State Drive (SSD) 500 GB or greater.

The drive should be configured as the primary system drive.

Display Resolution: Full HD (1920 x 1080)

High resolution displays (> 96-DPI), 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 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 data analyses.
- Image display and processing.
- High-quality presentation graphics.
- Graphical and command-line user interfaces.
- Automation.

- Extensibility via C and C++ modules.
- Extensive online Help and PDF manual.

2.3 Mounting Instructions

Rack Mounting:	The Dendrite instrument is ready for mounting in a standard 19" wide equipment rack in a 1U 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 Dendrite instrument.

2.4 Electrical Connections

AC Power:	60 Hz
	50 Hz

The Dendrite instrument 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, the surge protector should be rated > 1000 joules and > 40 kA.
- If you experience brownouts or voltage sags, use a switching power supply (SPS) to supply clean power to your instrument.
- To protect against power interruptions, use a universal power supply (UPS) for uninterrupted clean power.

2.5 Install Hardware

1. Plug the male end of the included power cord into a grounded electrical mains outlet.
2. Plug the female end of the power cord into the Dendrite rear panel power receptacle.

Figure 2-1. Rear of Dendrite Cabinet

3. Connect the supplied USB cable to your computer's USB port and the Dendrite rear panel USB port.
4. Push the Dendrite power button to ON (lit position).

Figure 2-2. Front of Dendrite Cabinet

2.6 Install Software

A. Locate the Files

Use your web browser to locate the latest versions of the SutterPatch v2.3 installer software at:

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

and choose the 'Download' tab.

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

The SutterPatch 'Release Notes' PDF file for recent fixes and changes to the software is also found here.

B. Choose Installer File

Windows	macOS
Full: SP + Igor 9	Full: SP + Igor 9
Full: SP + Igor 8	Full: SP + Igor 8
Updater: SP (Igor 9)	
Updater: SP (Igor 8)	

Separate "Full" installers (4) are provided for Windows OS and macOS for Igor Pro 9 and Igor Pro 8: both the Igor Pro and SutterPatch software are updated.

It is strongly recommended to run the **Igor Pro 9 Full installer** for optimum data processing performance.

However, if you do not want to upgrade to Igor Pro 9, the last version of Igor Pro 8 (v8.0.4) still supports SutterPatch v2.2, Additionally, multiple versions of Igor Pro and SutterPatch can be installed on your computer, each with independent settings and parameters.

Full

The Windows Full installers install both 64-bit and 32-bit English-language versions of Igor Pro. Only the 64-bit version supports SutterPatch. The 32-bit version is for any Windows 3rd party applications that require it.

The macOS Full installers install a 64-bit English-language version of Igor Pro. For macOS Igor Pro 32-bit support, you need to run Igor Pro 7.

Update

Separate Updater installers (2) are provided for Windows OS running SutterPatch on Igor Pro 9 or Igor Pro 8: only the existing SutterPatch software is updated.

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, please use the full installer (for the same Igor Pro version) to update the existing version of Igor Pro and install SutterPatch v2.3.

The included Igor Pro single-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: Japanese versions of Igor Pro do not support SutterPatch.

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 downloaded installer file and run it.

1. Install the full software for 'All Users' by double-clicking on:
   - Windows: sutterpatch_win_full
   - macOS: sutterpatch_mac_full
2. Follow the installer prompts:
   - We recommend replacing any prior versions of Igor Pro with the latest version of Igor Pro 9, after making a backup copy of all user files and parameter files in the program folder and its sub-folders.
   - If an existing version of Igor Pro is found, the Igor Pro Preferences are overwritten.

- If an existing version of SutterPatch is found, the SutterPatch sample files are overwritten.

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

• Dendrite QuickStart Guide	PDF file with installation instructions and the Igor Pro 9 Serial Number and Key.
• SutterPatch manual	PDF file of the Dendrite Operation manual.

<u>Windows folders</u>

SutterPatch data:	C:\Users\<User Account Name>\Documents\SutterPatch\Data\
SutterPatch code:	C:\Program Files\Wavemetrics\Igor Pro 9 Folder\

<u>macOS folders</u>

SutterPatch (sample) data & Pools	Applications/SutterPatch2/SutterPatch /Data/
SutterPatch code:	Applications/SutterPatch2 /SP_Code/
	Applications/SutterPatch2/SP_Drivers/ (XOP)

4. Launch Igor Pro 9 by clicking on its 'Igor Pro' icon

   .

5. Activate its license as instructed.

   You will need to enter the Igor Pro 9 Serial Number and Activation Key found in your printed Dendrite Quick Start Guide.

6. "Eject" the flash drive - wait for the "Safe to Remove Hardware" prompt, and then unplug it from the computer.

2.7 Test System

2.7.1 Startup

1. Power-on the Dendrite instrument 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 9' icon .

   An Igor Pro splash screen displays while opening files.

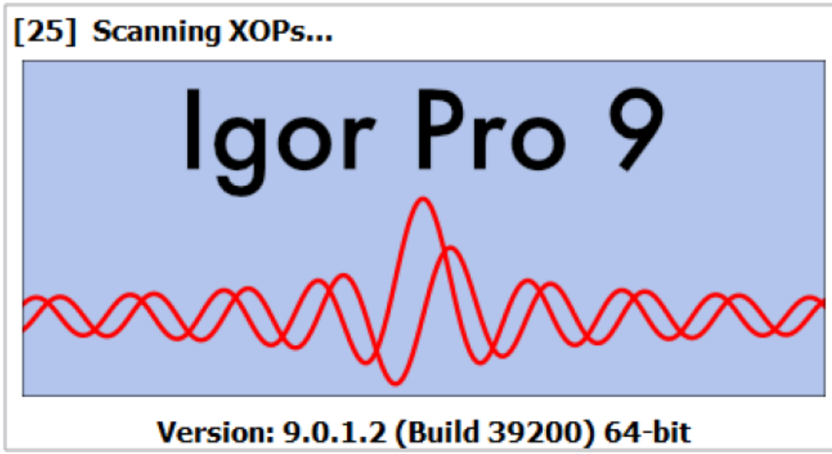


Figure 2-3. Igor Pro Splash Screen.

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

Figure 2-4. 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.

Don't wait at Startup

Skip this Welcome screen and automatically start a new SutterPatch experiment during startup.

3. Click the 'Start' button and a progress bar displays while compiling SutterPatch files, the Igor Pro Command window displays, then the Welcome screen closes.

4. Next, the Igor Command window opens.

   Then, if the Dendrite instrument 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:

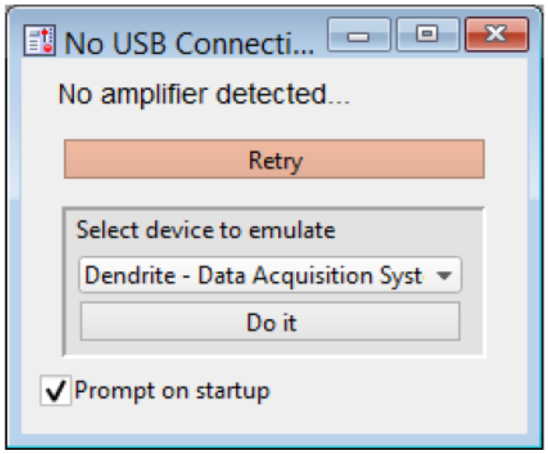


Figure 2-5. Emulation Modes.

a. Reconnect the Dendrite instrument and then click 'Retry', or

b. Click in 'Select device to emulate' and select 'Dendrite', then click 'Do it'.

Note: If Sutter hardware is not attached, and 'Prompt on startup' is disabled, the program automatically starts up in the last known emulation state.

5. A SutterPatch splash screen temporarily displays:

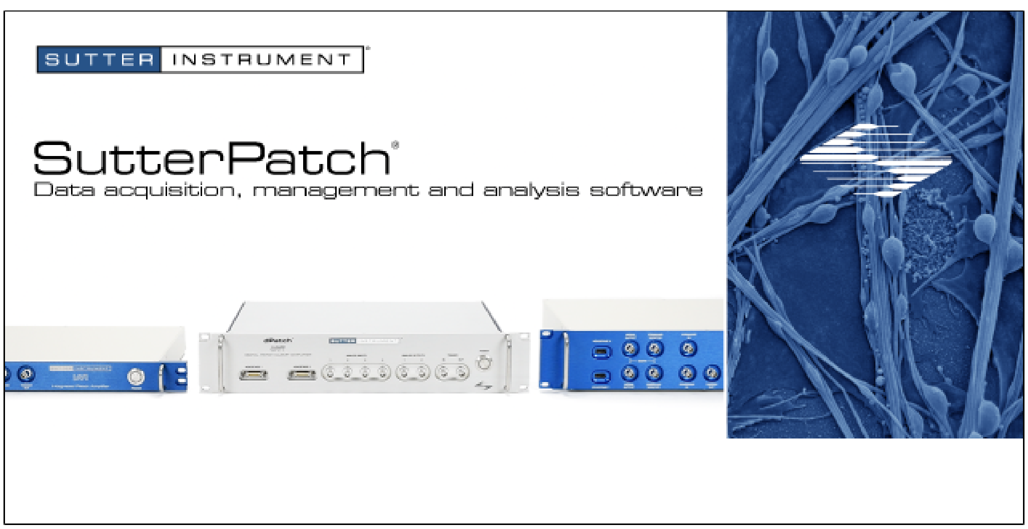


Figure 2-6. SutterPatch Splash Screen.

and then a 'Summary of Major Preferences' window displays:

Major Preferences as set in the "SutterPatch" menu, entry "Set Preferences":

Configuration pool: not used

Selected amplifier: Dendrite

Automatic experiment naming is ON: <pathname>

Save data to separate HDF5 file is OFF

Save entire experiment after each routine

Warn when file size exceeds limit of 500 MB

Maximal sweeps displayed in persistence display during acquisition: 30

Maximal sweeps displayed in persistence display during reanalysis: 30

Show event tags in reanalysis scope: ON

Number format: Use exponential notation (e.g., 10e-3 V)

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

6. Other windows that also display are:

    Dashboard

    Acquisition Control Panel

    dPatch Control Panel

   and any other windows that were open in the prior Experiment session.

7. Click on the 'Acquire Data' icon:

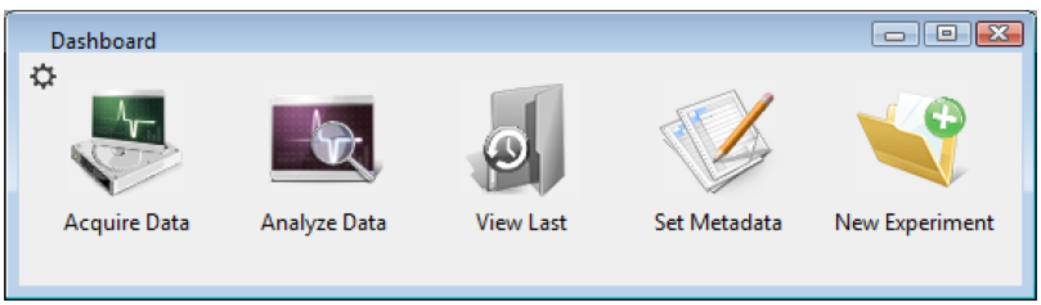


Figure 2-7. Dashboard.

   and a second level of the Dashboard is displayed:

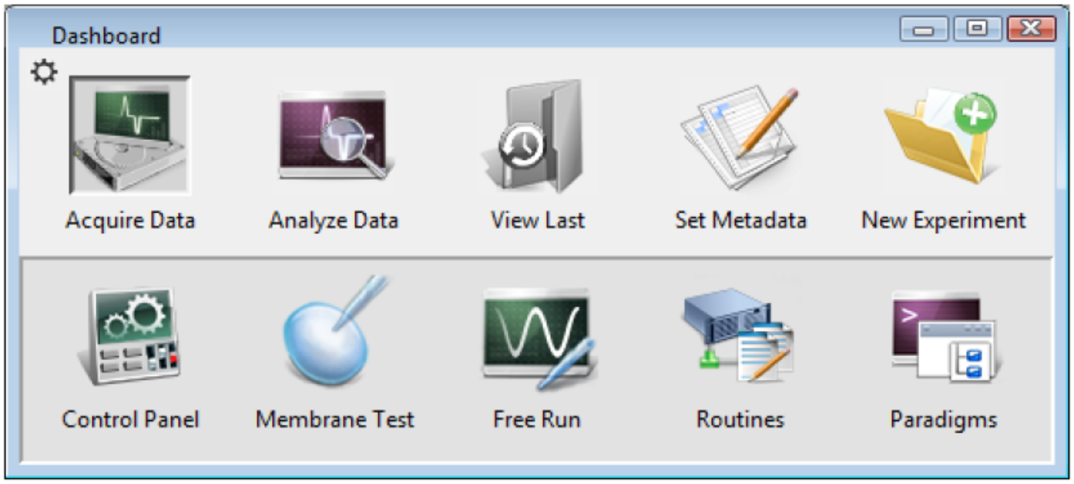


Figure 2-8. Acquisition Dashboard.

8. Click on the 'Control Panel' icon, and the 'Dendrite Control Panel' is displayed:

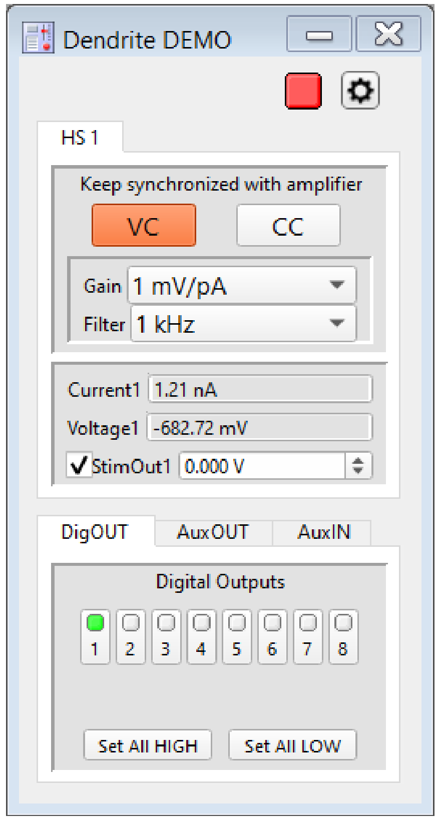


Figure 2-9. Dendrite Control Panel

If "DEMO" displays in the Dendrite Control Panel title bar, you are running in a hardware emulation mode. To run the physical instrument, ensure that the unit is powered on and its USB cable is connected, then choose "New Experiment" from the Dashboard and select "Dendrite".

2.7.2 Run a Test

The 'Free Run' functionality is useful for a quick check of the Dendrite system. It tests the basic steps necessary for recording.

1. Go to the Dashboard window and click on the 'Acquire Data' icon:

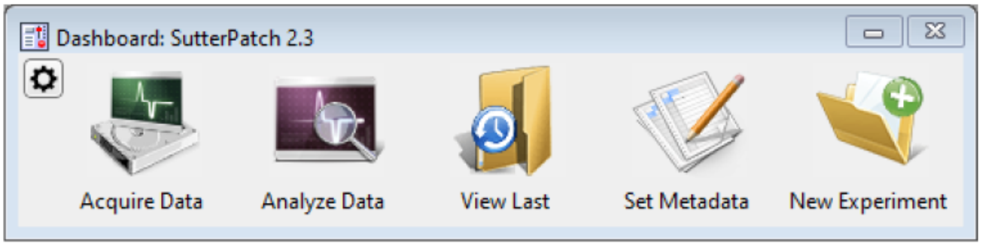


Figure 2-10. Dashboard

2. Click on the 'Free Run' icon:

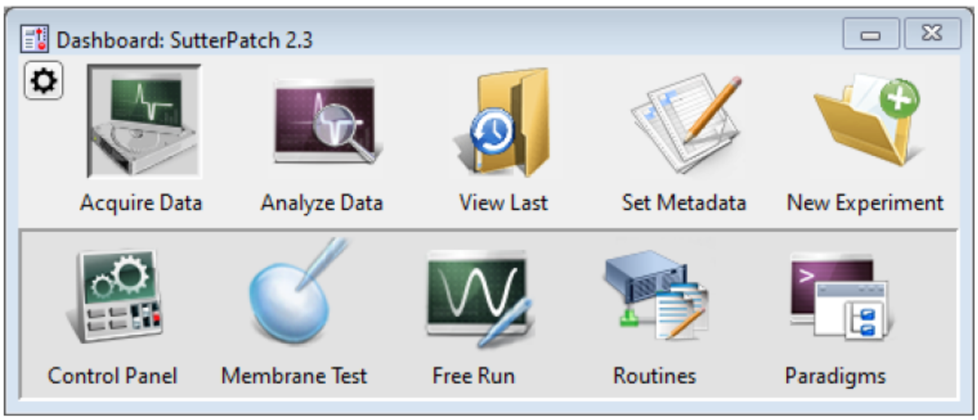


Figure 2-11. Acquisition Dashboard.

3. A noise signal should display in the Acquisition: Free Run scope channel AuxIN1.

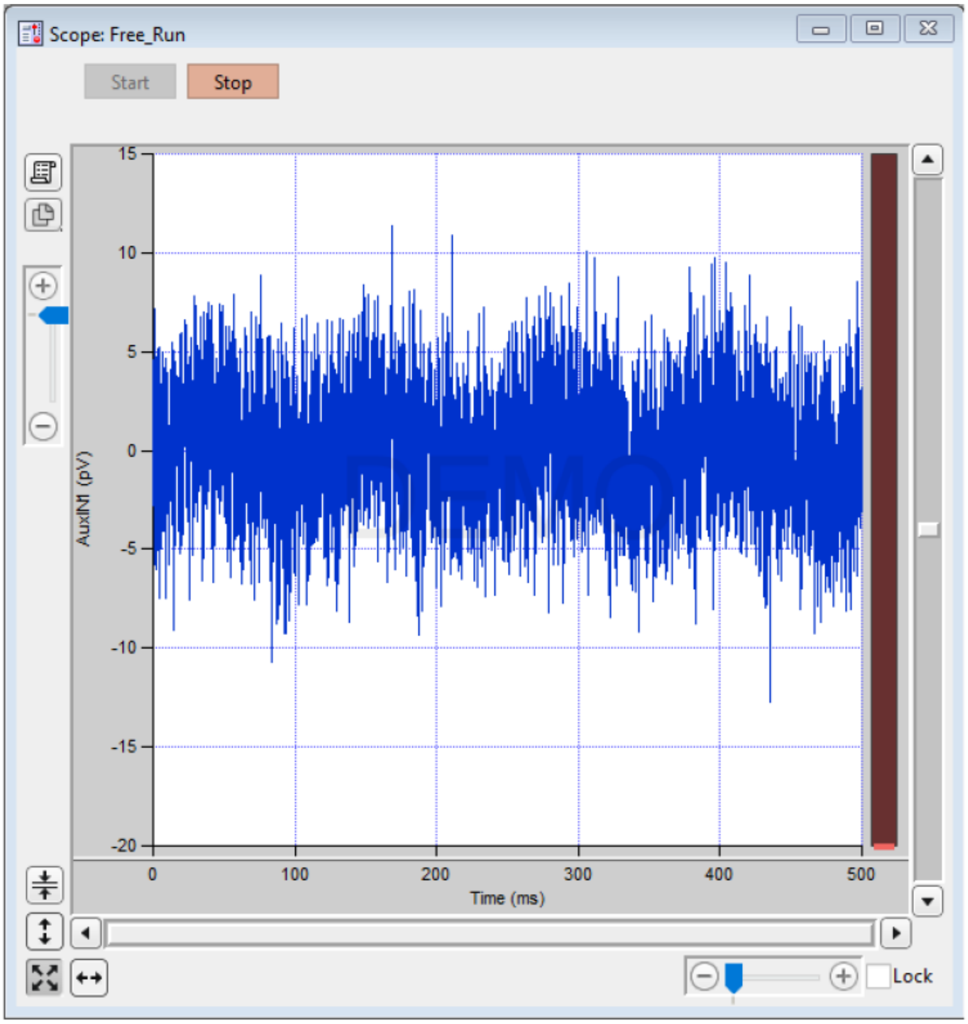


Figure 2-12. Free Run Noise

3. HARDWARE OPERATION

3.1 Dendrite Front Panel

The front panel of the Dendrite instrument is used for external I/O connections and a power button.

Figure 3-1. Front of Dendrite Cabinet

The front panel, from left to right:

ANALOG IN 1 – 8:	BNCs	Analog inputs from external sources.
ANALOG OUT 1 – 4:	BNCs	Analog outputs to external targets.
DIGITAL OUT 1 – 8:	BNCs	Digital outputs to external targets.
POWER:	Button	Turns power to unit On / Off. Lights up blue when 'On'.

3.2 Dendrite Rear Panel

The rear panel of the Dendrite instrument is used for power, trigger I/O, grounding and USB connection.

Figure 3-2. Rear of Dendrite Cabinet

[unlabeled]:	Power-entry receptacle	For AC power cord.
TRIGGER IN:	BNC	Digital input trigger.
TRIGGER OUT:	BNC	Digital output trigger pulse A 100 µs square pulse is automatically sent at the start of continuous acquisition or each triggered

		sweep (including Membrane Test).
GROUND REF:	Toggle switch	ON / OFF
EARTH GROUND:	4 mm Banana socket	Instrument grounding.
USB:	USB Type B receptacle	USB 2.0 computer communication.

3.3 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 needed for cellular recordings. While AC (mains) line-noise (hum) 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 a 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 can make this easier to accomplish. Consider standardizing your setups by using a GP-17 Ground Point on each rig.

"Signal" ground is a sensitive ground for 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.

3.4 Dendrite Control Panel

SutterPatch: Hardware Control: Amplifier Control Panel

This software interface controls the Dendrite settings. It replaces all physical switches and dials, such as found on manually-controlled instruments.

These settings can also be programmatically controlled in a Paradigm.

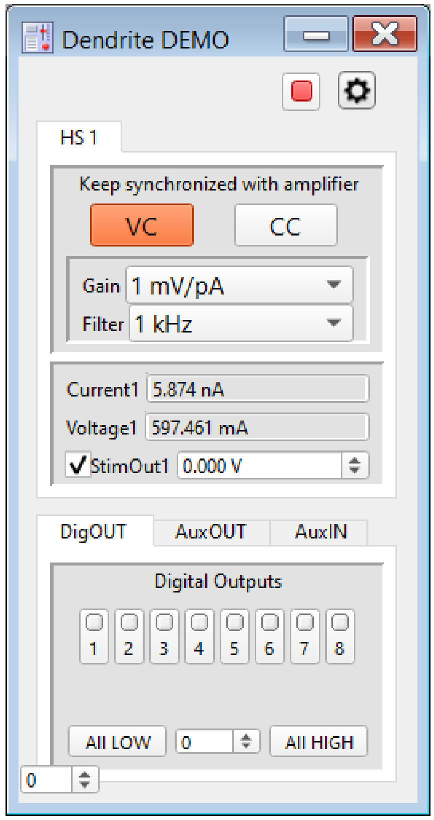
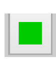


Figure 3-3. Dendrite Control Panel

Reset USB

Click to re-establish the USB connection to a disconnected Sutter data acquisition system.

- All USB channels are reset.
- A green button indicates that a stable USB connection to the instrument has been established.



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

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

Settings Menu

Show the Settings menu for configuring headstages, parameter monitors, and various options.

Note: The Settings icon is disabled during acquisition.

Add Headstage	Add a headstage tab to the Control Panel. Up to four external headstages can be configured.
Delete Headstage	Remove the active headstage tab from the Control Panel.
Configure Headstage	Setup the Dendrite system to support external amplifier headstages. Opens the 'Configure Headstage Signals' panel for the active headstage. (see full Configuration panel below)
Configure AnIN Monitors	Open a 'Configure Monitor Signal' panel for the Analog Inputs. (see full Configuration panel below)
Show Monitors	Display the 'Parameter Monitors' section in the Control Panel.

Monitors in Floating Window

Display the 'Parameter Monitors' section in a separate floating window.

Halt Background Monitor Updates

Show Channel Controls	Display the "DigOUT/AnOUT/AnIN" section in the Control Panel.

Externally Triggered Membrane Test Acquisition

AutoScale Membrane Test on Start

HS [1 – 4] Headstage tabs.

Keep synchronized with amplifier

VC	Select for voltage-clamp operation.
CC	Select for current-clamp operation.

Gain	[0.5, 1, 2.5, 5. 10, 25] mV/pA	[VC mode]

[10, 20, 50, 100, 200, 500] mV/mV [CC mode]

Filter [500 Hz; 1, 2, 5, 10, 20 kHz]

Apply a low-pass 4-pole Bessel 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: Routine 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 (such as action potentials, etc.), 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 Routine Editor / Acquisition & Routine Parameters 'Sampling Rate', or the Membrane Test Editor: Settings: Signal Parameters 'Sampling rate'.

Current# Current channel reading for headstage #.

Voltage# Voltage channel reading for headstage #.

StimOut# [±1.000 V, ±20.000 nA]

'Command Output' to headstage #. Can be used as a holding level.

When enabled/disabled during acquisition, a tag is inserted into the data recording.

DigOUT Digital OUT tab.

<u>Digital Outputs</u>

This section controls the holding bit pattern generated by the digital outputs of the Dendrite system. Eight TTL-compatible digital channels are displayed.

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

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

All LOW Set all digital channels ‘Off’.

[digital word]

Displays the decimal value of the bit pattern.

Or, enter a decimal value to set a bit pattern.

All HIGH Set all digital channels ‘On’.

AnOUT Analog Output tab.

<u>Analog Outputs</u>

AnOUT[1 – 4] [±10.000 V]

Select a general-purpose analog output channel and directly edit its voltage level, or use the spinners to change the value in 1 mV increments.

When a headstage is configured for the AnOUT channel, this value is a read-only field of the raw output.

Set to zero Click this button to set all analog outputs to ‘0.000 V’.

Note: If an analog output level is changed during continuous acquisition, the only system notification of this is a tag in the metadata of the recording

AnIN Analog Inputs tab.

<u>Analog Inputs</u>

AnIN[1 – 8] [±10.000 V]

General-purpose analog input channels display raw voltage levels.

<u>Configure Headstage Signals</u>

[from Settings Menu above]

Up to four external headstages can be configured.

 Close panel button.

[ ] Information field.

Amplifier Model — Dagan: 3900A
Dagan: CA-1
Dagan: TEV-200A
Generic
HEKA: EPC 800
MolDev: Axopatch-1D
MolDev: Axopatch 200A
MolDev: Axopatch 200B
MolDev: MultiClamp 700B
Sutter: IPA/DoubleIPA
Warner: OC-725D
Warner: PC-505B

Headstage Model — [ ]

Writeable text field for non-Sutter amplifiers.

Gain

- Set Manually
- From Gain Telegraph — [AnIN1 – 8]

[Dagan 3900A
Dagan CA-1
Dagan TEV-200A
HEKA: EPC 800
MolDev: Axopatch-1D
MolDev: Axopatch 200A
MolDev: Axopatch 200B
Warner: OC-725D
Warner: PC-505B]

Filter

- Set Manually
- From Bandwidth Telegraph — [AnIN1 – 8]

[Dagan 3900A
Dagan CA-1
Dagan TEV-200A

HEKA: EPC 800
MolDev: Axopatch-1D
MolDev: Axopatch 200A
MolDev: Axopatch 200B
Warner: OC-725D
Warner: PC-505B]

Mode

- Set Manually
- From Mode Telegraph [AnIN1 – 8]
  [HEKA: EPC 800
  MolDev: Axopatch 200B]

Voltage Clamp Tab — Configure the headstage signals for voltage-clamp mode.

Current Input [AnIN1 – 8]

Select the analog input channel for current readings from the active external headstage.

Label — Enter a signal name for the channel.

Unit — [A] Set as Amperes for the signal amplitude.

Scaling

Offset — Enter an offset for the input signal.

[±10.000 V]

Factor (V/A) — Enter the scaling factor for the headstage.

Use a value or equation.

Voltage Input [AnIN1 – 8]

Select the analog input channel for voltage readings from the active external headstage.

Label — Enter a signal name for the channel.

Unit — [V] Set as Volts for the signal amplitude.

Scaling

Offset — Enter an offset for the input signal.

[±10.000 V]

Factor (V/V) — Enter the scaling factor for the headstage.

Use a value or equation.

Command Output [AnOUT1 – 4]

Select the analog output channel to the active external headstage.

Label — Enter a signal name for the channel.

Unit — [V] Set as Volts for the signal amplitude.

Scaling

Offset — Enter an offset for the output signal.

[±10.000 V]

Factor (V/V) — Enter the scaling factor for the headstage output. This is applied to the raw AnOUT voltage, resulting in the scaled StimOUT signal.

Use a value or equation.

Current Clamp Tab — Configure the headstage signals for current-clamp mode.

Voltage Input [AnIN1 – 8]

Select the analog input channel for voltage readings from the active external headstage.

Label — Enter a signal name for the channel.

Unit — [V] Set as Volts for the signal amplitude.

Scaling

Offset — Enter an offset for the input signal.

[±10.000 V]

Factor (V/V) — Enter the scaling factor for the headstage.

Use a value or equation.

Current Input — [AnIN1 – 8]

Select the analog input channel for Current readings from the active external headstage.

Label — Enter a signal name for the channel.

Unit — [A] Set as Amperes for the signal amplitude.

Scaling

Offset — Enter an offset for the input signal.

[±10.000 V]

Factor (V/A) — Enter the scaling factor for the headstage.

Use a value or equation.

Command Output — [AnOUT1 – 4]

Select the analog output channel to the active external headstage.

Label — Enter a signal name for the channel.

Unit — [A] Set as Amperes for the signal amplitude.

Scaling

Offset — Enter an offset for the output signal.

[±10.000 V]

Factor (V/A) — Enter the scaling factor for the headstage. This is applied to the raw AnOUT voltage, resulting in the scaled StimOUT signal.

Use a value or equation.

Configure Monitor Signal

[from Settings Menu above]

 Close button.

[ ] Information field.

Channel Tab [AnIN1 – 8]

Enable

Metadata

Parameter Select a metadata parameter from a drop-down list:

none
Bath Temperature
Ambient Temperature
Atmospheric Pressure
Atmospheric Humidity
Recording Mode
Current Gain
Voltage Gain
Headstage Gain
Filter Cutoff Frequency
Secondary Lowp. Filt. Cutoff Freq.
Secondary Highp. Filt. Cutoff Freq.
Input Offset Voltage
Cell Comp – Membrane Capacitance
Light Stimulus Frequency
Light Stimulus Intensity
Mechanical Stimulus Intensity
Acoustic Stimulus Frequency
Acoustic Stimulus Intensity
Thermal Stimulus Intensity
Electrical Stimulus Frequency
Electrical Stimulus Intensity

	Granularity	Set a numeric value in Y-units.
	Last Written	Read-only field of last written value.
Label		Enter a signal name for the channel.
Y-unit		Configure the signal amplitude.
	Unit	Editable unit field. [A, V, S, Ohm, F, °C, °K, F, Pa, N, %, dB SPL] Drop-down list of standard and edited units.
	Format	• Engineering • Floating Point • Decimal
	Prec	Set the number of decimals. [0, 1, 2, 3, 4, 5] [for Engineering & Floating Point formats]
Scaling		
	Offset	Enter an offset for the input signal. [±10.000 V]
	Factor (V/Unit)	Enter the scaling factor for the input signal. Use a value or equation.
Parameter Update		
	Granularity	Enter a numeric value of the Y-unit.
Update Interval		[300.000 ms – 60.000 s]
Revert		Set all fields to their default settings.
Apply		Apply the signal changes immediately.

3.5 System Integration

The Dendrite system can be integrated with other laboratory equipment.

3.5.1 Using Peripheral Equipment

The Dendrite system can control peripheral equipment, such as:

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

The Dendrite system interfaces to external instrumentation via front- and rear-panel BNC connections.

Dendrite analog and digital "holding" levels are set in the Dendrite Control Panel.

The analog output signals have a range of ±10 V. The digital output signals use TTL-compatible (+3.3V) voltage signals.

Digital command outputs can be formatted as either a single "bit" or an 8-bit "word", as selected in the Routine Editor / Output Channels & Waveform section. Command output patterns are configured in the Routine Editor / Output Channels & Waveform / Waveform Editor.

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

3.5.2 Using Non-Sutter Amplifiers

The Dendrite data acquisition system interfaces to external non-Sutter amplifiers via front- and rear-panel BNC connections:

ANALOG IN 1 – 8	Analog input channels to digitize signals from non-Sutter amplifiers.
ANALOG OUT 1- 4	Analog output channels to send stimulus signals to non-Sutter amplifiers.
DIGITAL OUT 1 – 8	Output channels to send digital signals to external instrumentation.

TRIGGER I/O IN/OUT	A digital output trigger is automatically sent at the start of continuous acquisition or each triggered sweep (including Membrane Test).

Configure headstages via the Dendrite Control Panel settings menu / Configure Headstage selection.

After configuring headstage signals here, make sure to enable the corresponding Routine Editor / Output Channels to see the proper scaling information in the corresponding Routine Editor / Input Channels.

Analog and digital “holding" levels are set in the Dendrite Control Panel.

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

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

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

3.6 Dendrite Maintenance

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

3.6.1 Inspection

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

3.6.2 Cleaning

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

3.6.3 Calibration

The Dendrite data acquisition system is calibrated at the factory and cannot be re-calibrated by the user.

4. SOFTWARE OPERATION

4.1 Acquisition

SutterPatch acquisition operations.

4.1.1 Acquisition Control

SutterPatch: Hardware Control: Amplifier Control Panel

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

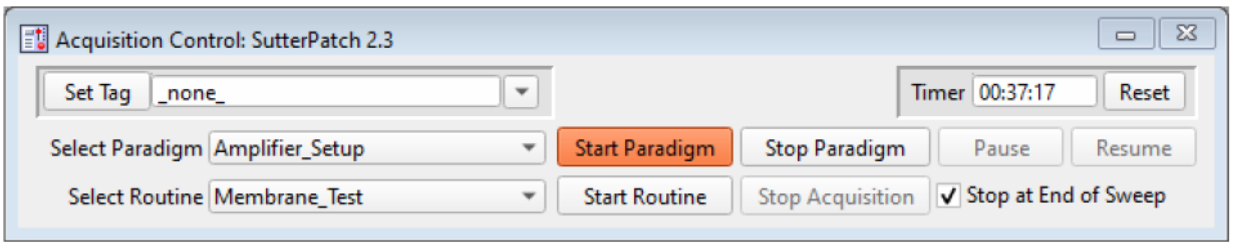


Figure 4-1. Acquisition Control

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

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

Time	[hh:mm:ss] The system time. [only displays if enabled in Set Preferences / General / 'Show time in Acquisition Control window']
Timer	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	Reset the Timer to 00:00:00.
Select Paradigm	The active Paradigm is selected from the loaded 'Paradigm Pool' list. See the Paradigm Editor to load a different Paradigm Pool.
Start Paradigm	Manually run the selected Paradigm. Any acquisition in a Scope window is stopped, and a "planned" (user named) Paradigm is created and executed.
Stop Paradigm	Terminate the current Paradigm. If not followed by a planned Paradigm, starting a Routine creates a new date/time-stamped "auto-triggered" Paradigm.
Pause	Temporarily halt a running Paradigm or Routine.
Resume	Continue running the paused Paradigm or Routine.
Select Routine	Select an Acquisition type or an active Routine from the loaded 'Routine Pool' list. See the Routine Editor to load a different Routine Pool.
Start Routine	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. If no prior auto-triggered Paradigm is running, a new date/time-stamped Paradigm is created.
Stop Acquisition	Terminate any running data acquisition. If clicked during a sweep,
Stop at End of Sweep	When 'Stop at End of Sweep' is enabled, and you click the 'Stop Acquisition' button in the middle of a sweep, the sweep completes before data acquisition is stopped; otherwise, when disabled, acquisition stops immediately and the partial sweep is discarded.

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

<u>Default file path</u>

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

macOS: Applications/ SutterPatch2/SutterPatch/Data/

4.1.2 Acquisition Measurements & Graphs

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

To access this dialog, click on the Acquisition: Routine S

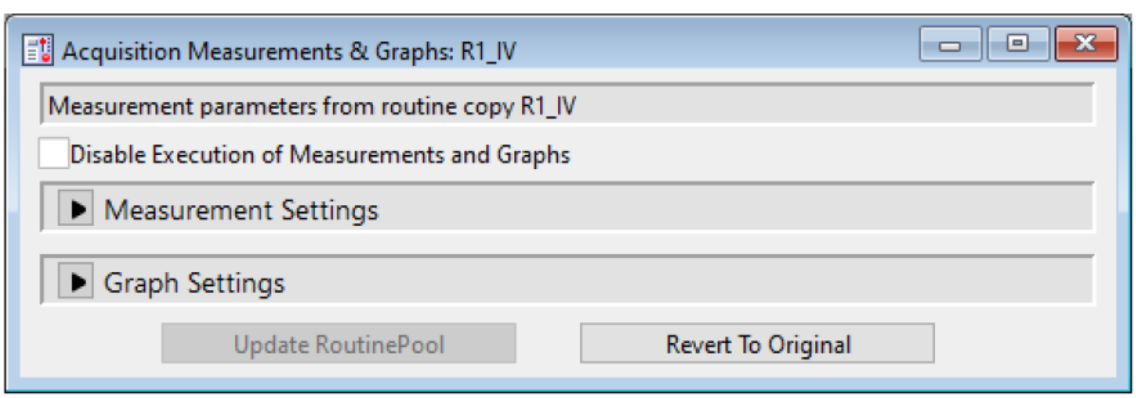


Figure 4-2. Acquisition Measurements & Graphs

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.

4.1.3 Acquisition: Routine Scope

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

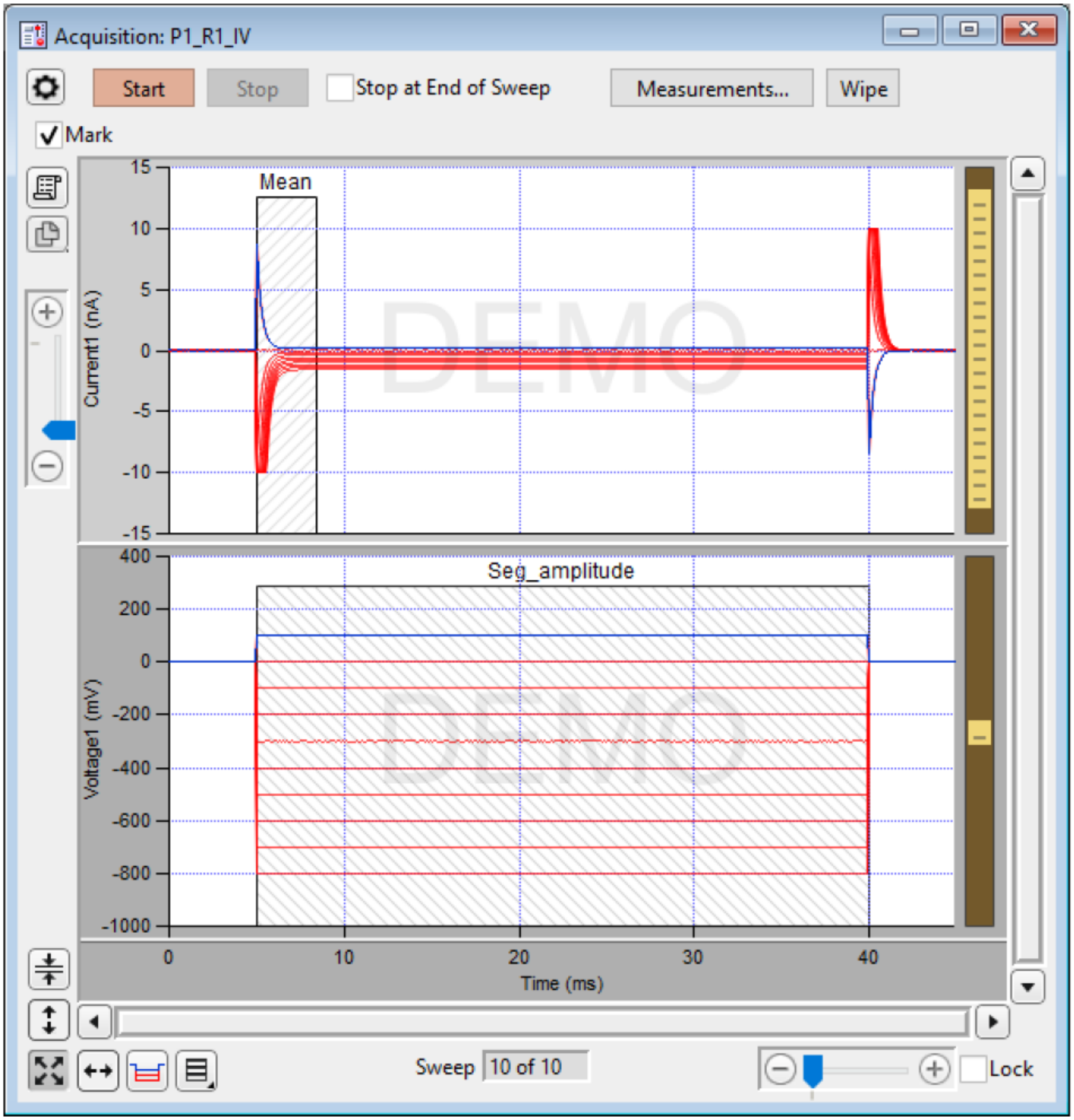


Figure 4-3. Acquisition: Routine Scope Window

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: Routine Scope window is open for data acquisition, then opening Membrane Test, Free-Run, or the Reanalysis Scope will close the Acquisition: Routine Scope window, and re-open it as the new type of Scope window.

Signals

The central area of the Scope window graphically displays input data in up to 16 separate signal panes. Click on a signal pane to make it "active" - the Y-ais 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 signals 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

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

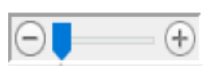
Cursors

Measurement cursors are visible 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.)

Signal Controls

- 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; the X-axis magnification controls all signals.

- Lock

  Enable to retain the X-axis scaling and position for the next 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.

- Axis Zoom

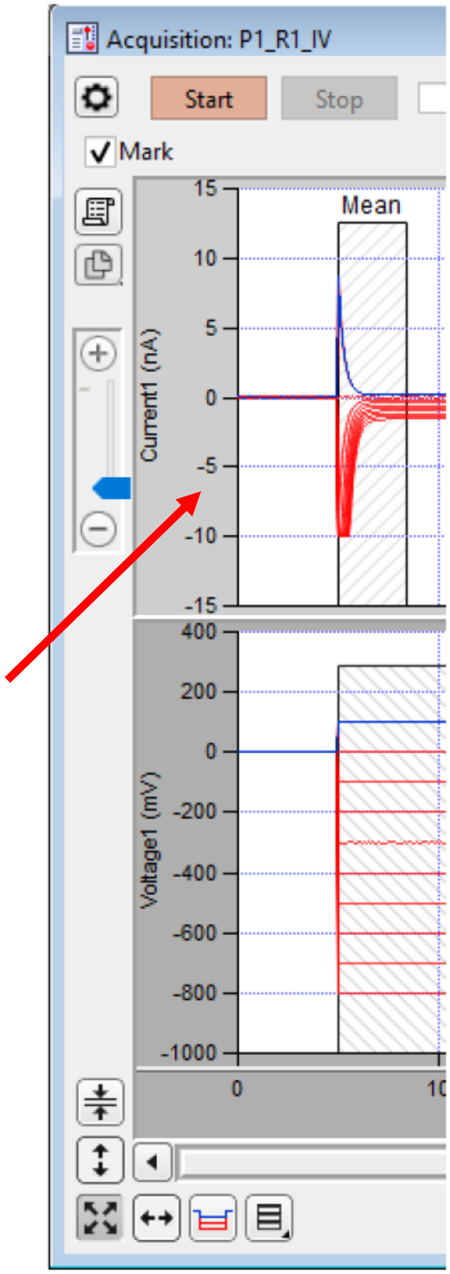


Figure 4-4. Axis Magnification

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 region 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

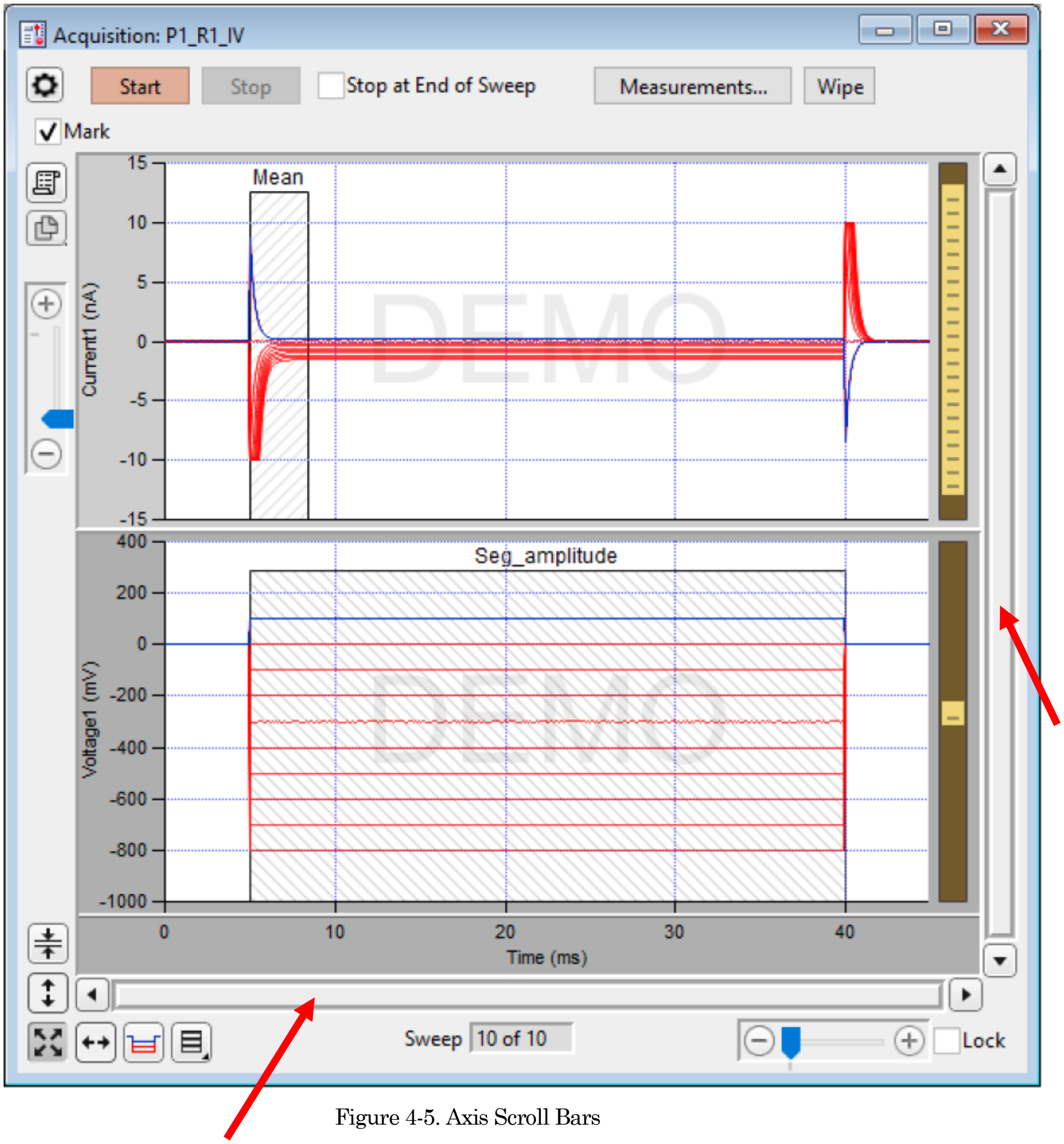


Figure 4-5. Axis Scroll Bars

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.

- Center

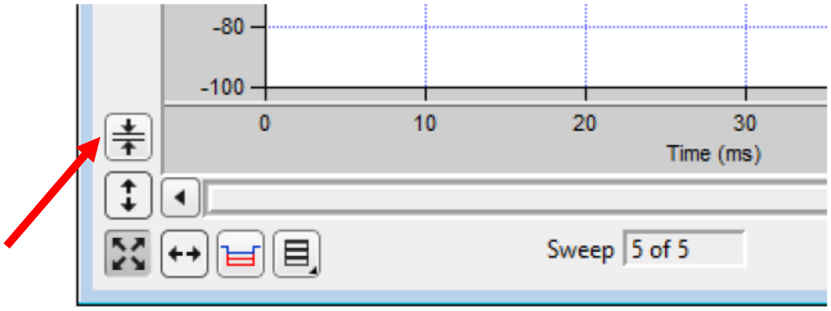


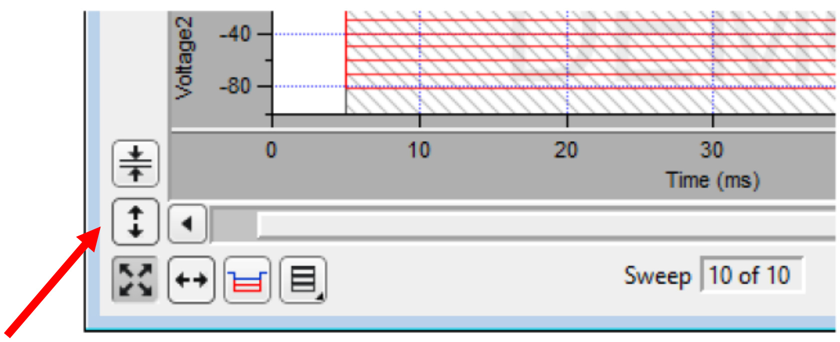
Figure 4-6. Center Button

Center signal.

Center the mean of the 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



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, configure “Continuous autoscale from zero” 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.

- Autoscale Axes

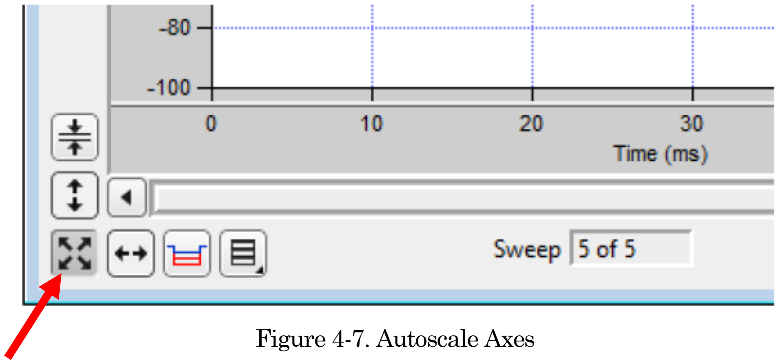


Figure 4-7. Autoscale Axes

Autoscale all axes.

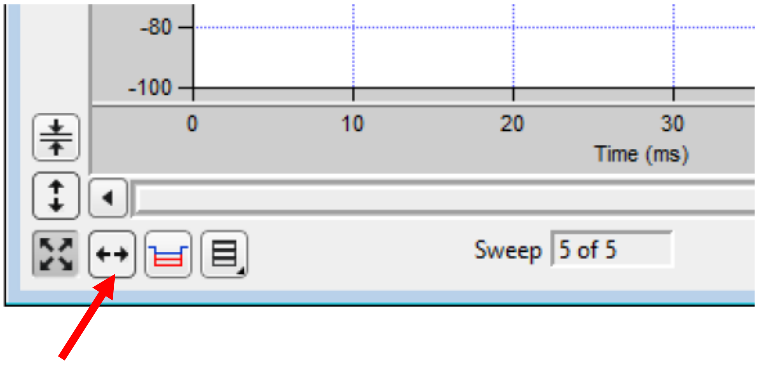
This autoscale setting is used by the Acquisition, Membrane Test, and Free Run Scope windows.

Click to 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 continuously autoscale the Y-axes of all visible signals during acquisition, in “Windows” right-click (or Shift-click or Ctrl-click) the button, or in “macOS” Control-click the button; this also sets the X-axis range to the maximum defined sweep duration for all signals. The Autoscale button remains depressed (grayed) 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.

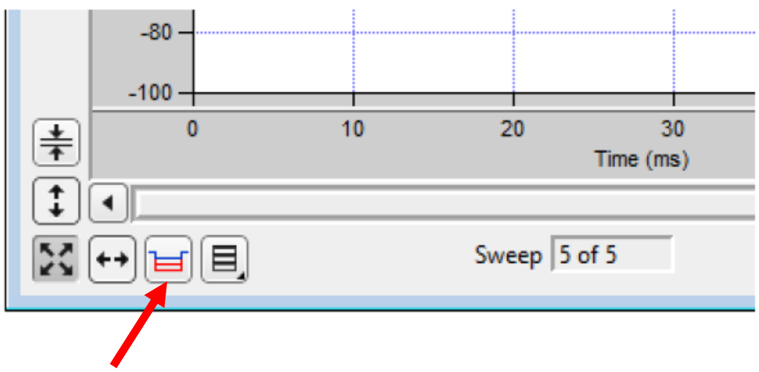
- X-Scale



Autoscale all X-axes.

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

- 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.

Applies to the Scope window, and its (right-click) graphs:

Parametric Plot

Amplitude Histogram Plot.

- Signal Layout

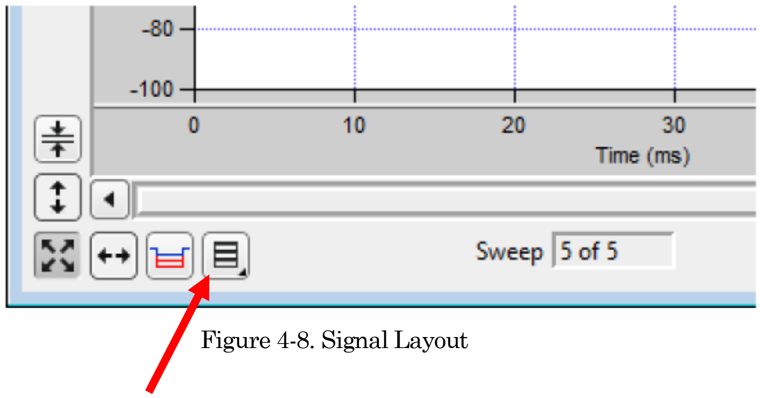


Figure 4-8. Signal Layout

Signal pane layout.

Set how the input signals are graphically arranged:

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

- Amplitude Meters

Amplitude meters are displayed on the right border of signal panes (excluding virtual channels). They provide visual feedback on the integrity of your data recordings, similarly to how audiometers monitor audio signals.

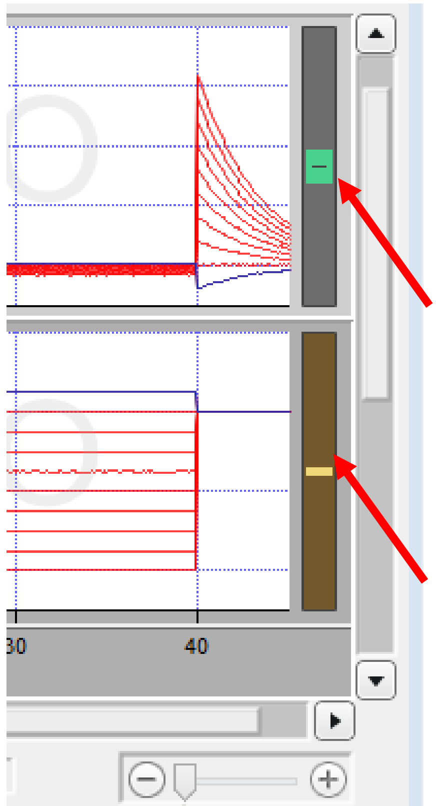


Figure 4-9. Amplitude Meters

For the Triggered Sweeps acquisition mode, each displayed signal has its own Y-axis amplitude meter on the inner right-side of its pane.

For the Continuous Sweep acquisition mode, or if acquisition has not yet started, these meters are completely black.

The height of the colored meter bars represents a signal's data range vs. the full recording range of the Dendrite digitizer. 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 is green.
• Yellow:	Caution	Signal approaching upper limit. (within 10% of range limit)

		If too much hardware gain is applied, and there is a danger that saturation will occur (as the data are near the upper limit), the amplitude meter is yellow, as a warning sign to decrease your hardware gain. If too little hardware gain is applied, and the recorded signal has insufficient amplitude resolution, the amplitude meter will be a thin yellow line. When this occurs, the digitizer is not utilizing enough bits to accurately represent the data, and your signal of interest might be contaminated with noise. In this case, consider increasing your hardware gain.
• Red:	Danger	Signal too large or small. (within 1% of, or at range limits) When an amplitude meter is displayed in red, it indicates that the data might have gone out of range and be invalid. If too much hardware gain is applied, the recorded signal will be in danger of saturating, i.e., your data will exceed the amplitude limit of the digitizer. If the data saturates, those data points are substituted with the maximum amplitude of their input channel. If too little hardware gain is applied, the signal is too small for accurate measurement, and the hardware gain needs to be increased.

Other Buttons

	Scope Settings Marks selectively flag sweeps for later 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 or use the Reanalysis Scope window to analyze or process marked sweeps.
Start	Start recording and displaying digitized analog data in the Scope window input channels. When you click the 'Start' button, the Scope window is cleared, 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 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. If no prior paradigm is running, an "Auto-triggered Paradigm" is generated and assigned a Paradigm name with the current Date/Time.
Stop	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. 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)". --- No Measurements or Graphs Analyze with Active Measurements Analyze with Original Routine Measurements Analyze with Routine Last Executed Measurements --- Analyze with Saved Default Measurements Save as Default Measurements --- Edit Measurements: Open a special Real Time Measurements & Graphs dialog where all changes apply instantly to the measurements and graphs, even during acquisition. These edits override the loaded routine for quick interactive control. --- 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)

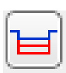
Wipe	The 'Wipe Scope' button clears the Scope of all sweeps prior to the active sweep, and also clears any corresponding measurements from the Analysis window.
Do Trigger	This green button appears when acquisition is started for a Routine configured with an external trigger, and provides a manual trigger option. The message "Waiting for trigger…" also displays.
Copy to Layout 	Copy all visible Scope signals and analyses into a new Layout window, or append to an existing Layout page.
Copy to Clipboard 	Copy the active signal to the system clipboard or, if the 'Shift' key is pressed, the complete Scope window.
Persistence Display 	Enable: Overlay each new sweep onto the display of any prior sweeps. (per Ma Scope Preferences limits). Disable: Previous sweeps are cleared, and the last acquired sweep is displayed. Applies to the Scope window, and its (right-click) graphs: Parametric Plot and Amplitude Histogram Plot.
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.

Table 4-1. Other Scope Buttons

Scope window "Gear" Settings

Set all marks in sweeps of active series by equation

Opens the 'Sweep Mark: Equation Editor' to enter an equation for the sweeps to mark.

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
Odd(sweep)
Even(sweep)

Do Mark — Evaluate the equation and update the sweep marking.

[Status message]

value >= 0.1 = 1 (marked)

value < 0.1 = 0 (unmarked)

<u>Scope window Measurements button menu:</u>

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

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 Parametric Plot window.

Y-signal — Select an input signal for the Y-axis.

X-signal — Select an input signal for the X-axis.

Plot — Update the plot using the new parameters.

Copy to Layout — Copy the Parametric Plot graph into a new Layout window, or append to an existing Layout page.

Copy to Clipboard — Copy the Parametric Plot graph to the system clipboard.

Time Range — The time range of the data to be plotted.

Full Trace — Use the entire trace for the time range.

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

Start Time — 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 — 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.

Uses the Segment timing from the input signal's "Parent Output Channel".

Segment — Select the Segment number.

Start Ratio — [0 = beginning of Segment]

Set the starting time ratio.

End Ratio — [1 = end of Segment]

Set the ending time ratio.

Measurements can be made on the parametric graph using Igor cursors (Ctrl-I). The cursor measurement is written to the SutterPatch Notebook window.

Amplitude Histogram Plot

Open a real-time histogram plot window. The amplitude data are plotted in "real time" as samples are acquired and binned. The window is cleared at the start of a new Series.

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 Amplitude Histogram Plot window.

Y-signal	Select the input signal to be analyzed.
Time Range	The time range of the data to be plotted.

- Full Trace — Use the entire trace for the time range.
- Sweep Time — Set relative to the start time of a sweep.
  - 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 — [0 = beginning of Segment]

Set the starting time ratio.

End Ratio — [1 = end of Segment]

Set the ending time ratio.

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.

Plot — Refresh the plot for any Time Range settings changes.

 Copy to Layout — Copy the Amplitude Histogram Plot graph into a new Layout window, or append to an existing Layout page.

 Copy to Clipboard

Copy the Amplitude Histogram Plot graph to the system clipboard

[graph pane]

Measurements can be made on the amplitude histogram graph using Igor Pro cursors (Ctrl-I). The cursor measurement is written to the SutterPatch Notebook window.

Color Plot — Plot amplitude data in a false-color graph of Sweep vs. Time. This "heat map" display mode is commonly used in fast-scan cyclic voltammetry.

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.

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

Signal — List of 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 Y Range Use an autoscaled Y-axis range for the data.
- Scope Y Axis min and max

  Use the existing Y-range for the data.
- Given Y min and max

  Set the upper and lower Y-axis boundaries.

Color Table List of color lookup tables.

Reverse Reverse the color lookup table.

Plot Plot the selected signal as a false-color graph using the selected Y-range and color lookup table.

Copy to Layout

Copy the Color Plot graph into a new Layout window, or append to an existing Layout page.

Copy to Clipboard

Copy the Color Plot graph to the system clipboard.

Measurements can be made on the color graph using Igor Pro cursors (Ctrl-I). The cursor measurement is written to the SutterPatch Notebook window. Once set, clicking and dragging a cursor will dynamically update its measurement value in the notebook.

<u>Right-click Menus</u>

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 scaling.

X-min The minimum X-axis range.

X-max The maximum X-axis range.

Axis Properties… Modify the axis style 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 Scale a 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 minimum Y-axis value.

Y-max The maximum Y-axis value.

Copy Y scale of signal

[input signals list]

Apply the Y scaling from another signal.

Axis Properties… Modify the axis style and components.

To reverse the Y-axis polarity (such as for inside-out or cell-attached patches)…

Axis Range tab

<u>Manual Range Settings</u>

Minimum: Enable and enter a positive number.

Maximum: Enable and enter a negative number.

Or, if autoscaling will be used:

Click the 'Uncheck Both' button, and ...

<u>Autoscale Settings</u>

Reverse axis: Enable.

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

Main Window

Limited data modification menu

Right-click in the blank area of 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 the X-axis range for all signals to the maximum defined sweep duration.
Add Annotation	Add a floating text box label to the signal. To edit or delete an annotation, double-click on it.
Export Graphics	Copy the signal and open in a separate window. Saves to Windows / Graph Macros.
Toggle Cursor Info	Show the Cursor Info pane to measure X-Y data points or set a fitting range. (See the 'Signal data' section below.) Select 'Toggle Cursor Info' again to hide the Cursor Info pane, and any cursor symbols in the active pane.
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	Display only the last [marked] sweep of the selected signal,
or	
Show All Sweeps of '<name>'	Restore the display of all [marked] sweeps in the selected signal.
Stack All Signals	Display all signals in a stacked signal layout.

<u>Marquee</u>

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

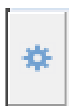
Full data modification menu

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

To manually measure X-Y data values, or to set a fitting range, open a Cursor Info pane.

Toggle Cursor Info	Select 'Toggle Cursor Info' to show/hide the Cursor Info pane, and any cursor symbols in the active pane.

Cursor Info pane



Options menu

-  One Mover Moves All — Draggable cursor mover tool moves all cursors together with a single control.
- All Styles — Change the cursor symbol style.
- Show Cursor Pairs — Display up to 5 sets of cursor symbol pairs.

Cursor A

	Cursor symbol for data point 'A'.
A:	Symbol letter (beginning cursor of the pair).
R1_A_IV	(Default) wave name.
	Draggable cursor mover tool for the cursor pair.
pnt:	Data point number (starting from zero).
X:	X-axis value of data point 'A'.
Y:	Y-axis value of data point 'A'.
ΔY	Difference of the cursor pair Y values.

Cursor B

⊠	Cursor symbol for data point ‘B’.
B:	Symbol letter (ending cursor of the pair).
R1_A_IV	(Default) wave name.
	Draggable cursor mover tool for the cursor pair.
pnt:	Data point number (starting from zero).
X:	X-axis value of data point ‘B’.
Y:	Y-axis value of data point ‘B’.
ΔX	Difference of the cursor pair X values.

Cursor Instructions

1. Click on symbol ‘A’ to enable it.
2. Manually drag the highlighted symbol onto a data point in a signal pane, or enter the data point number in the ‘pnt’ field.
3. Click on symbol ‘B’ to enable it.
4. Manually drag the highlighted symbol onto a data point in the signal pane, or enter the data point number in the ‘pnt’ field.

   X- and Y-measurements are displayed for the cursor pair data points.
5. Fitting can also be applied to the cursor pair data. Right-click on the data, and select ‘Quick Fit’ for a list of built-in Igor Pro fitting functions.

   The fit is displayed in the graph, and the fitting information is written to the Command window.

4.1.4 Camera Control

The Camera Control window displays still pictures or live video.

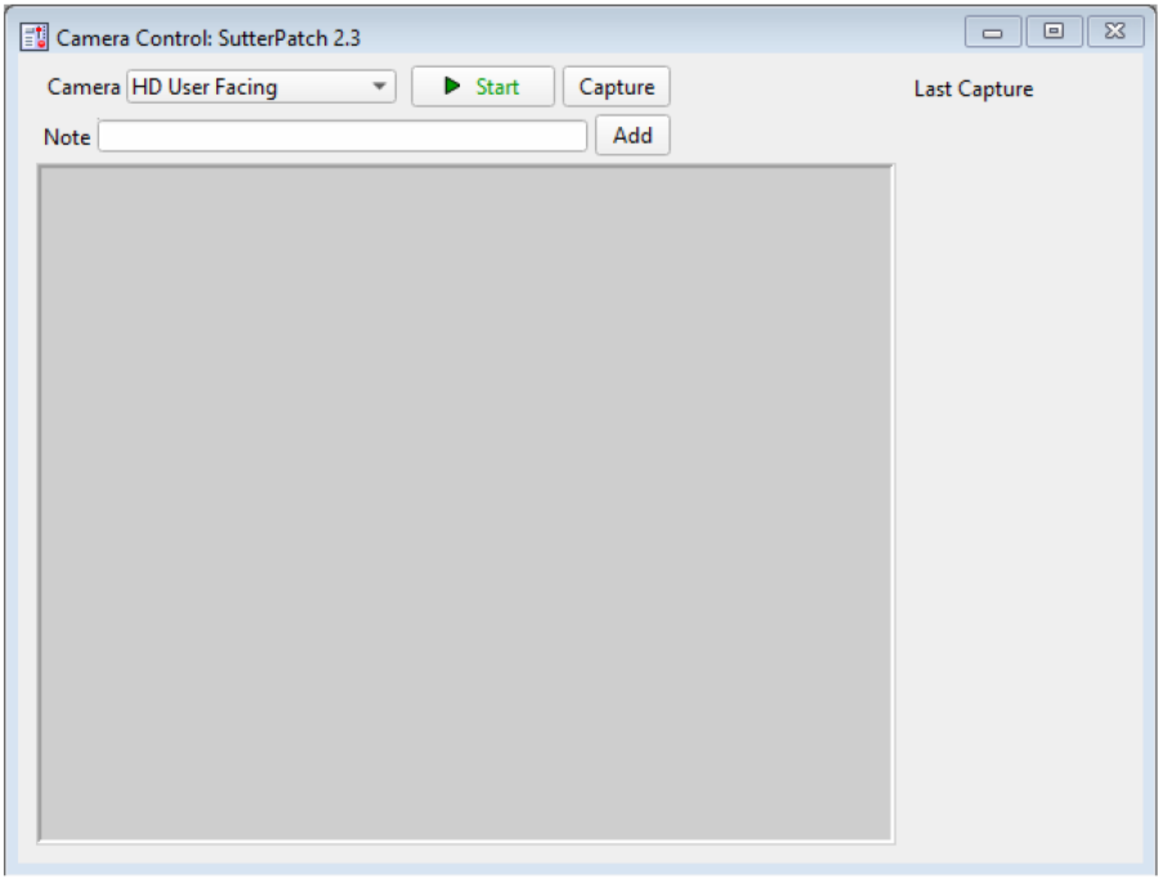


Figure 4-10. Camera Control

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	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 / Personalization window, scroll down and select the High Contrast Black theme, or use the Magnifier tool with option 'Turn on color inversion' enabled.

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'.

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

4.1.5 Free Run

The Acquisition: Free Run Scope window simulates a one-channel oscilloscope, and is a quick method of viewing repetitive data.

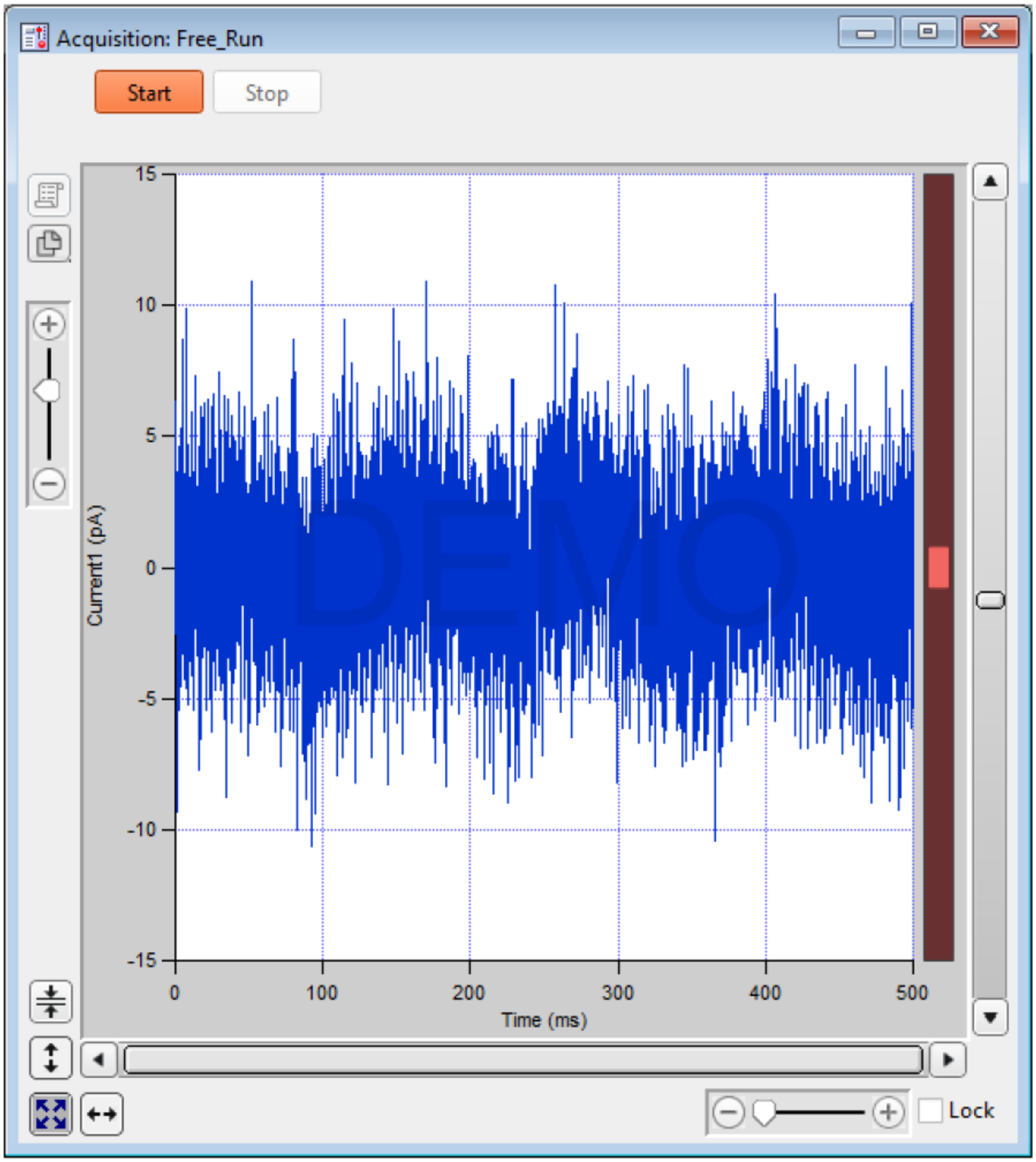


Figure 4-11. Free Run Scope

This window operates similarly to the Acquisition: Routine 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.

<u>Free Run Settings Window</u>

Signal Parameters

Channel: Select an input channel to monitor:

Analog_IN[1 – 8]

Duration: The duration of the data sweep.
[100, 200 ms, 0.5 , 1 , 2 s]

Sampling rate: [5, 10, 20, 50 kHz]

4.1.6 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. However, current-clamp mode operation is also supported.

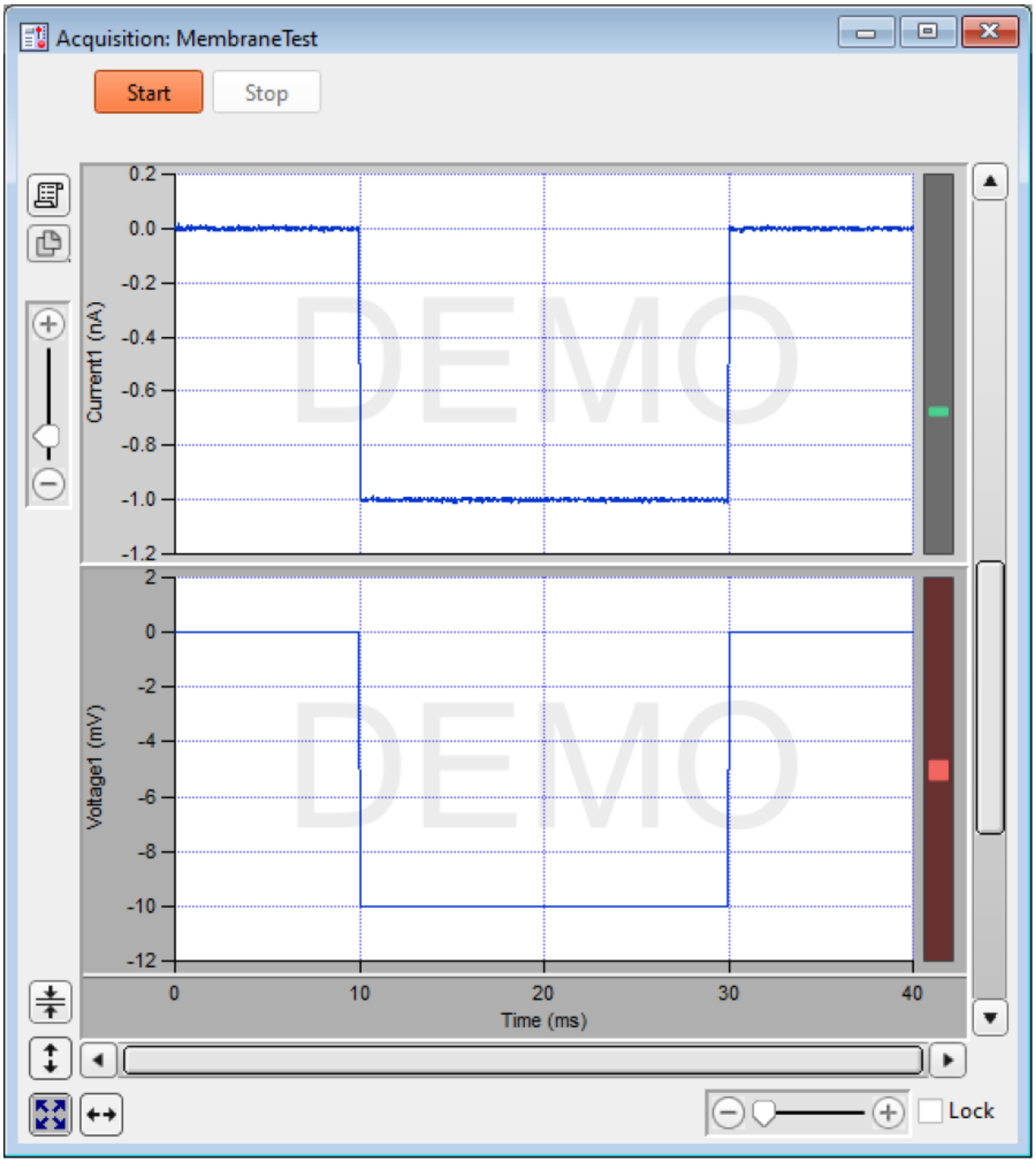


Figure 4-12. Membrane Test Scope

<u>Acquisition: Membrane Test</u>

This Scope window operates similarly to the Acquisition: Routine Scope window. By default, this Scope window's top pane displays the Current signal from the active headstage, and the pane beneath it displays the corresponding Voltage command signal.

Differences to the Scope window for the Membrane Test:

- Unsupported 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.
- During an Experiment, the Autoscale button state persists between windows.
- The Membrane Test opens in a "running" state.
- Closing the Membrane Test Settings panel halts acquisition.
- If a signal is hidden via the right-click menu, retrieve it with the 'Stack All Signals' menu item.

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.

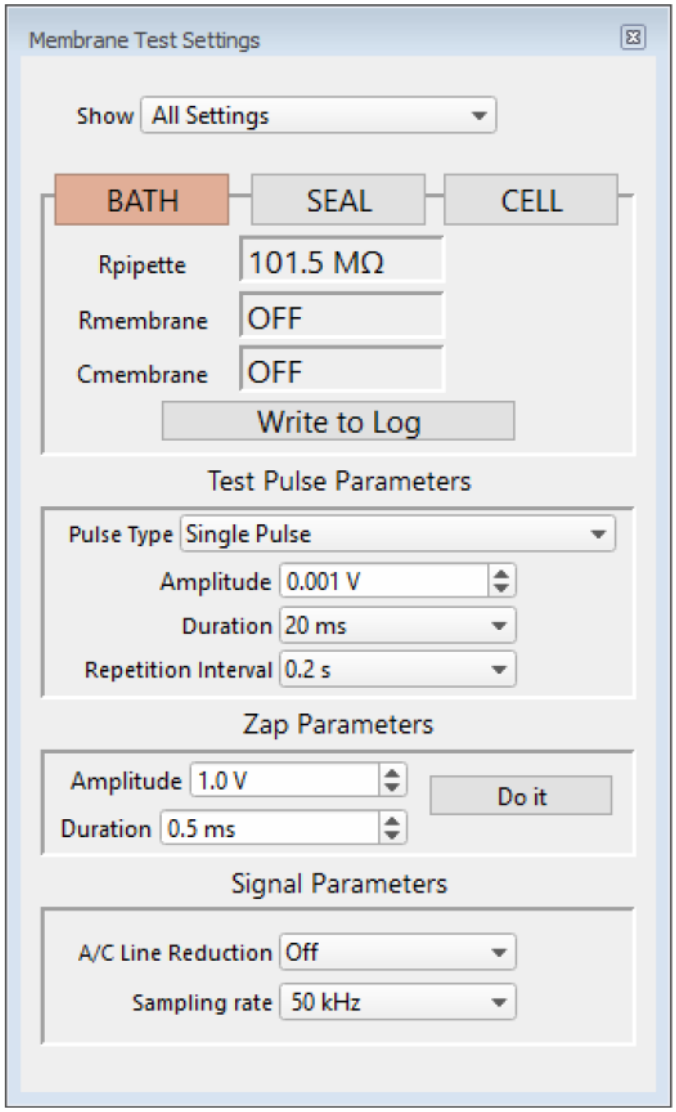


Figure 4-13. Membrane Test Settings

Show

- Monitor Only
- All Settings

The Membrane Test Analysis 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 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. (These values are automatically written to the metadata when the test mode is switched.)

Bath	Rpipette (MΩ)	Pipette Resistance meter. [Model cell = ~10 MΩ]
Seal	Rseal (MΩ)	Seal Resistance meter. [Model cell = ~1 GΩ to 1 TΩ] (open circuit)
Cell	Rseries (MΩ)	Series Resistance meter. [Model cell = ~10 MΩ]
	Rmembrane (MΩ)	Membrane Resistance meter. [Model cell = ~500 MΩ]
	Cmembrane (pF)	Membrane Capacitance meter. [Model cell = ~28 pF]

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

Monitoring the Series Resistance is also helpful, as if it increases by more than 5%, the electrode tip might be clogged.

Tip: 'Series Resistance' and 'Access Resistance' are equivalent terms.

Alert! For the Membrane Test 'Cell' mode, disable 'Capacitance Compensation' and 'Series Resistance Correction' (in the Amplifier Control Panel), so that uncompensated whole-cell capacitance spikes are generated for the calculation of the Series Resistance (Rseries) and Membrane Capacitance (Cmembrane) values. Otherwise, these fields 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.

Parameters used in “Cell” mode measurements:

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

Filter: 10 kHz	Set in Amplifier Control Panel.
Sampling Rate: 50 kHz	Set in Membrane Test
Averaging: 10	Set in MT Measure Parameters ‘Num to Average’.

Also, the amplifier adjustments, as set in the control panel, 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 Log — Click the ‘Write to Log’ button to write the last acquired measurements for that mode to the Log window. Valid measurements are logged for the active headstage.

<u>Test Pulse Parameters</u>

Pulse Type

- Single Pulse — [1, 2, 5, 10, 20, 50, 100, Other: ±999.00 mV]

  A single monopolar square pulse.
- Double Pulse — A symmetrical bipolar (biphasic) square pulse.
- Triangle — [dPatch only]

  A train of 5 symmetrical bipolar triangular pulses.

- Sine — [dPatch only]

  A train of 5 sine wave pulses.

- RMS Noise — No pulse – the holding level is output. The RMS noise of the signal is measured.

  The noise is measured 5 – 10x per second, and averaged from 10 repeats. The bandwidth is 5 kHz.

Amplitude

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 — [10, 20, 50, 100, 200 ms]

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

Repetition Interval — [0.1, 0.2, 0.5, 1.0, 2.0, 5.0, 10 s]

Sweep start-to-start interval.

<u>Zap Parameters</u>

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.

Amplitude — [0.1 - 1.0 V]

Set the amplitude of the square wave zap pulse.

Duration — [0.1 – 2.0 ms]

Do It — Click the 'Do It' button to send a single square wave voltage pulse from the headstage to the preparation.

<u>Signal Parameters</u>

A/C Line Reduction — Off

50 Hz

60 Hz

Sampling rate	10 kHz
	20 kHz
	50 kHz

4.1.7 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" for automating your experiments.

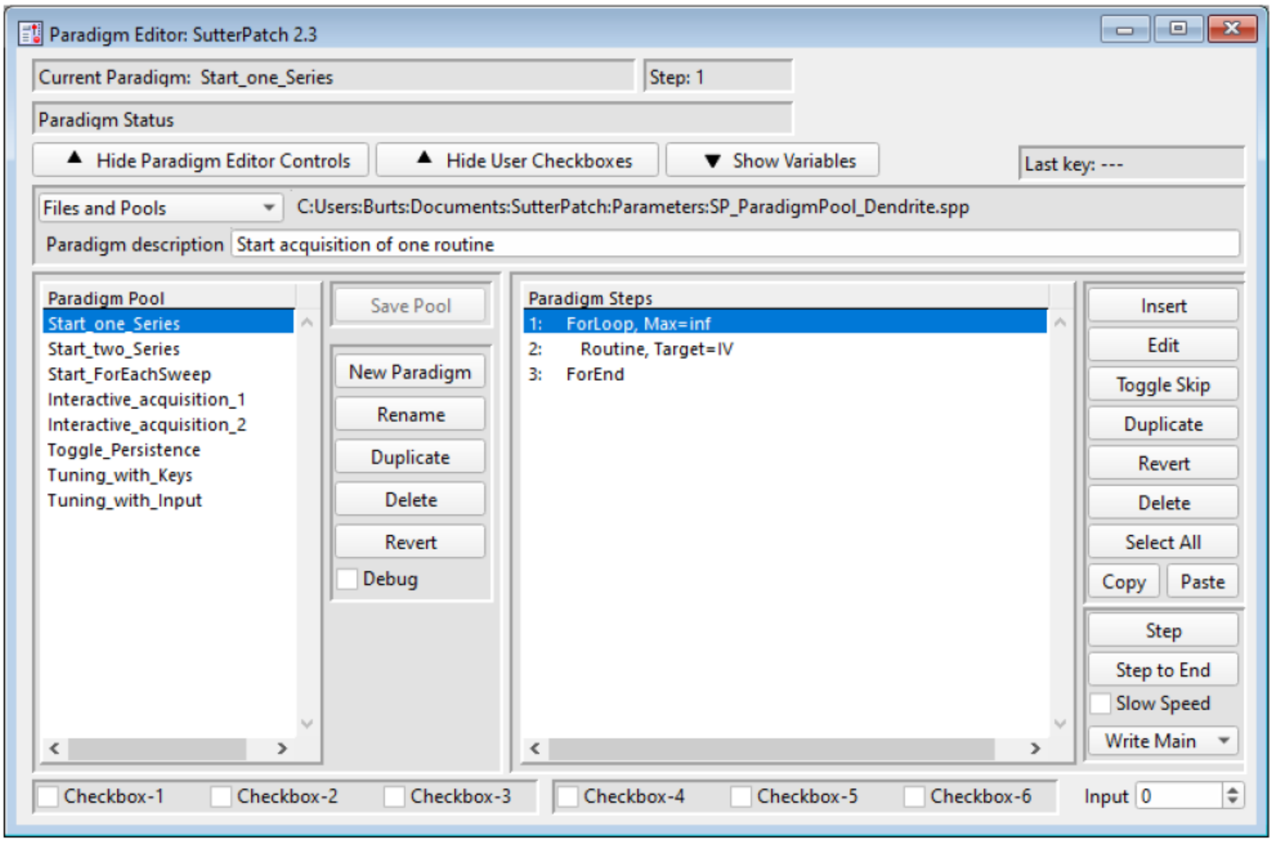


Figure 4-14. Paradigm Editor

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.

<u>Controls</u>

Start/Stop Paradigm, Set Tag and Reset Timer controls are located in the Acquisition Control panel.

Current Paradigm:	The name of the currently loaded Paradigm.
Step:	The highlighted Paradigm Step.
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.

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: The last key (or key combination) pressed on the keyboard is displayed here, such as used in Shortcuts or the 'If" and 'ElseIf" Paradigm steps. (See sample Paradigm 'Tuning with Keys'.)

Note: Function and Control (Ctrl/Cmd) Shortcut key combinations are not displayed.

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

[ ] List of the 5 most recently used Paradigm Pool files.

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 Dendrite factory defaults into the sample Paradigm Pool file (SP_ParadigmPool_Dendrite.spr).

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 pathname of the 'Files and Pools' last used Paradigm Pool into the Command window history.

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

[ ] — Pathname of the loaded Paradigm Pool file.

Paradigm description: — A user 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 start execution of the Paradigm and display its steps.
- 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 "_".
- 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 26 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 Paradigm Pool; an underscore and autoincrement number are appended to the name.

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 values, as long as the Paradigm Pool has not been saved.

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.

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

<u>Step Buttons</u>

Note: Most of these buttons can handle multiple steps. To select multiple steps, click each step with a Ctrl-click.

Insert — Inserts a new command Step into the Paradigm Steps column:

Amplifier

Each Sweep

Routine

Analysis

Camera

Clear Key

Execute

Export

Front Window

Hide Window

Reset Timer

Scope Operation

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, clicking the Edit button (or double-clicking the step) will 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.

The following buttons (Toggle Skip, Duplicate, Delete, Copy, Paste) can handle multiple steps. To select multiple steps, click each step with a Shift-click.

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 be reverted, and click the Revert button. Editable fields are reset to their originally loaded values, as long as another Paradigm has not been loaded.
Delete	Delete the selected step. For multi-line steps, optionally delete the step without deleting the contents of the step .
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, then move to the next step. Executing a single step does not terminate a running Paradigm, even if it is 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.
Slow Speed	Execute 'Step to End' at ~1 second per step.
Log Main Steps	Action-oriented steps are recorded in the Paradigm metadata (visible in the Metadata 'By Event' view): Amplifier Break Camera Chain Execute For Each Sweep

Reset Timer

Routine

Set Checkbox

Set Solution

Set Variable

Wait

Log All Steps — Log the main steps and additional steps into the Paradigm metadata (visible in the Metadata 'By Event' view.)

<u>Insertable Steps</u>

<u>Amplifier</u>

Control the Dendrite hardware.

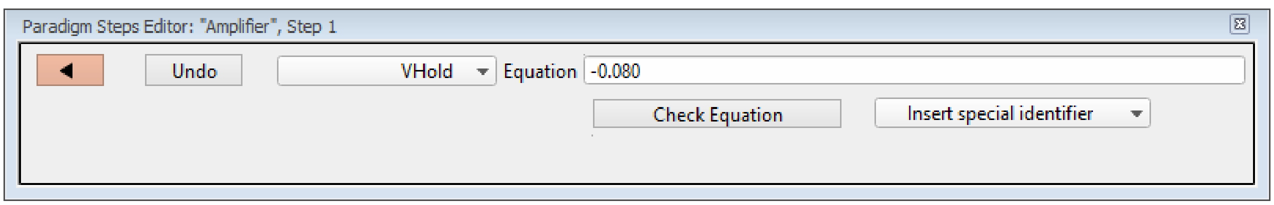


Figure 4-15. Paradigm Step: Amplifier

Default Setting: *Amplifier, Target=AnOUT1, Equation=-0.00*

 Close the 'Paradigm Steps Editor'.

Undo — Remove any unsaved edits to this step.

[drop-down list] — Amplifier options

<u>Analog Output</u>

AnOUT1 (Analog Output-1, V)

AnOUT2 (Analog Output-2, V)

AnOUT3 (Analog Output-3, V)

AnOUT4 (Analog Output-4, V)

Digital Output

DigOUTWord (Digital Output Word)

DigOUT1 - 8 (Digital Output-1 - 8)

[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 processed 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.

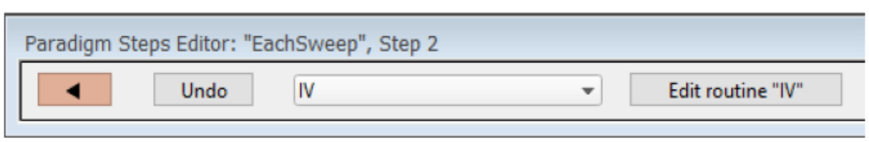


Figure 4-16. Paradigm Step: Each Sweep

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

 Close the 'Paradigm Steps Editor'.

Undo Remove any unsaved edits to this step.

[drop-down list] Select a Routine name from the loaded Routine Pool.

Edit routine ‘<name>’
Open for editing in the Routine Editor.

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.

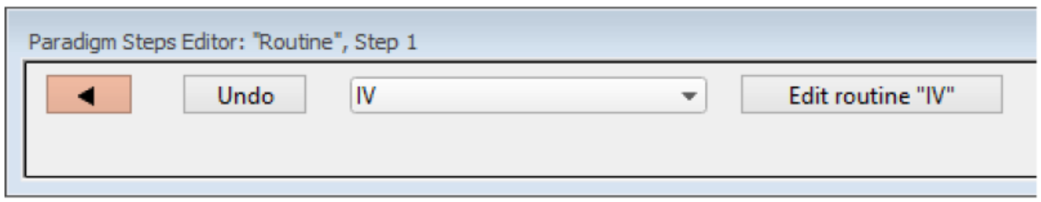


Figure 4-17. Paradigm Step: Routine

Default Setting: *Routine, Target= Amplitude_Equations*

 Close the ‘Paradigm Steps Editor’.

Undo — Remove any unsaved edits to this step.

[drop-down list] — Select an acquisition type, or a Routine to record a data Series.

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 Metadata — Write any measurements to the Log window.

  Test Amplitude — [No change, ±100 mV, ±2000 pA]

  Test Duration — [No change, 0.5 – 500 ms]

  Pulse Type — [No change,
  Single Pulse,
  Double Pulse,
  Triangle,

Sine,
RMS Noise]

Configuration [No change, Bath, Seal, Cell]

Add Channel [Clear]

Clear the selected channels list.

[Headstage1 – 2, AuxIN1 – 8]

Available input channels.

[selected channels]

- Free Run

Total Duration [100 ms – 999.9 s]

Indefinitely Acquire for an “infinite” duration.

Store Save the recorded data.

Add Channel [Clear]

Clear the selected channels list.

[Headstage1 – 2, AuxIN1 – 8]

Available input channels.

[selected channels]

- List of Routine names from the loaded Routine Pool

[selected Routines]

Edit routine “<name>” Open for editing in the Routine Editor.

Edit Routine “Routine name”

Open the Routine Editor with the selected Routine loaded.

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.

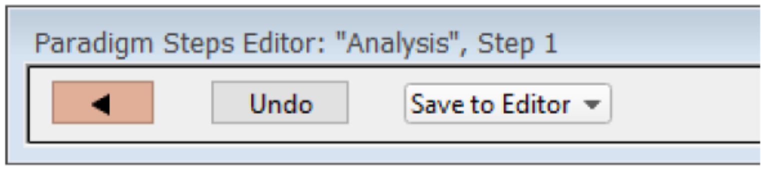


Figure 4-18. Paradigm Step: Analysis

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

 Close the 'Paradigm Steps Editor'.

Undo Remove any unsaved edits to this step.

[Operations]

- Save to Editor Save the latest analysis.
- Append to Last Append to the prior analysis.
- Average with Last Average with the prior analysis.
- Concatenate

- 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.

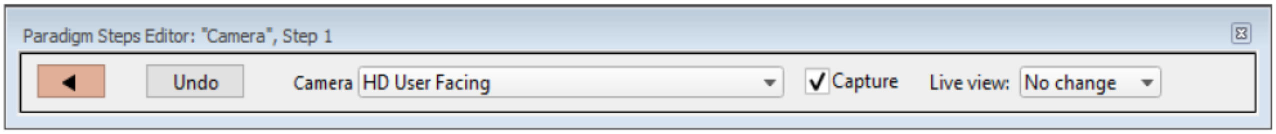


Figure 4-19. Paradigm Step: Camera

Default Setting:	*Camera, Camera=_Camera_Name, Capture =true*
	Close the 'Paradigm Steps Editor'.
Undo	Remove any unsaved edits to this step.
Camera	Select a camera on the computer system.
Capture	Take a picture when executed.
Live view:	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*

Execute

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

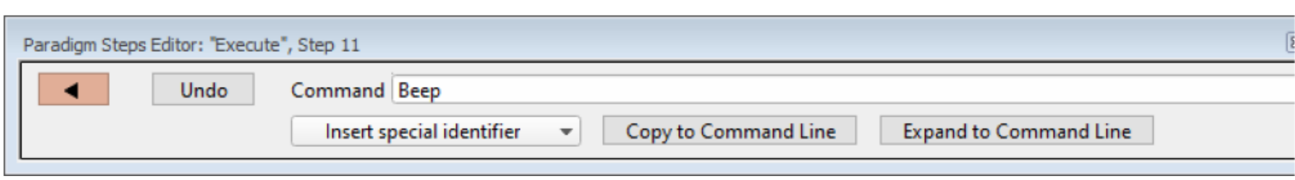


Figure 4-20. Paradigm Step: Execute

Default Setting: *Execute, Command=Beep*

 Close the ‘Paradigm Steps Editor’.

Undo — Remove any unsaved edits to this step.

Command — [ ]

Run 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:

- s[series-count, sweep-count, trace-count, routine-name]

  (trace of specified series)

  Reference an input trace in an open Scope window via counts of Series #, Sweep #, Trace # (scope channel position), and the Routine name.

  <u>Acquisition: Routine scope window:</u>
  The active trace has count values of zero. If a count number is non-zero, it is used as a relative offset (positive or negative) from the active trace.

  <u>Reanalysis Scope window:</u>
  The first Series/sweep/trace has count values of one. All counts are positive relative to the first trace.

Any fractions in count numbers are truncated to integers.

If the routine name is left blank, the current routine name is used.

Ex: s[0,0,0,]

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

- t[#] (trace of current sweep of current series)

  Reference the input trace in the open Scope window channel position "#", for the active sweep of the active Series of the active Routine.

- p[1..16] (n'th Paradigm variable)
- eq[equation](result of the given equation)

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: Routine Scope's second input trace.

Export

Export data graphs into a new or open Layout window.

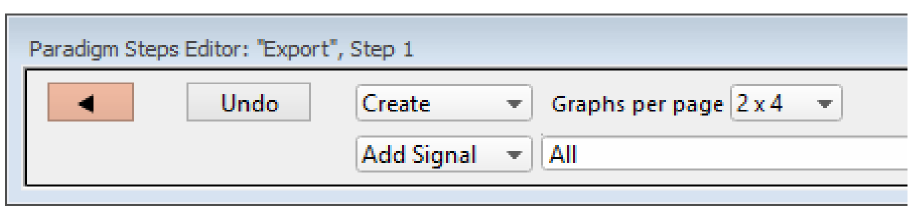


Figure 4-21. Paradigm Step: Export

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 — Graphs stacked.
- 3 — Graphs stacked.
- 2 x 2 — Matrix display.
- 2 x 4 — Matrix display.

[Add Signal list] — 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.
- [list of input signals]
- All Analyses — Select all Analysis graphs.
- [list of Analysis graphs][List of selected signals]

User-edited names can be directly entered into the signal 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.

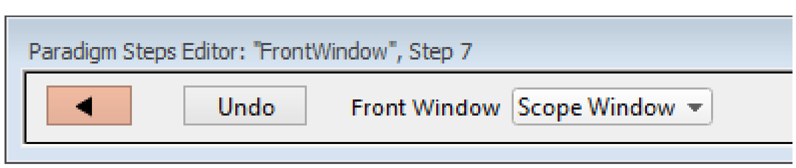


Figure 4-22. Paradigm Step: Front Window

Default Setting: *Front Window, Target=Scope Window*

Close the 'Paradigm Steps Editor'.

Undo — Remove any unsaved edits to this step.

Front Window — Analysis Editor
Camera Window
Control Panel
Dashboard
Data Navigator
Equation Editor
Log Window
Paradigm Editor
Routine Editor
Scope Window
Shortcut Editor
Solution Editor
Template Editor

Hide Window

Hide the specified window.

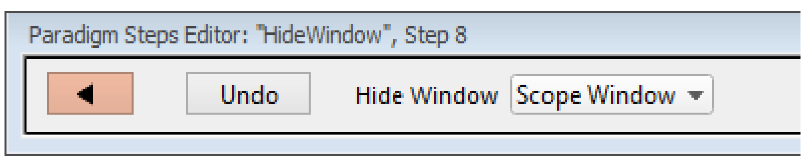


Figure 4-23. Paradigm Step: Hide Window

Default Setting: *HideWindow,Target=Scope Window*

Close the 'Paradigm Steps Editor'.

Undo — Remove any unsaved edits to this step.

Hide Window — Analysis Editor
Camera Window
Control Panel
Dashboard

Data Navigator

Equation Editor

Log Window

Paradigm Editor

Routine Editor

Scope Window

Shortcut Editor

Solution Editor

Template Editor

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.

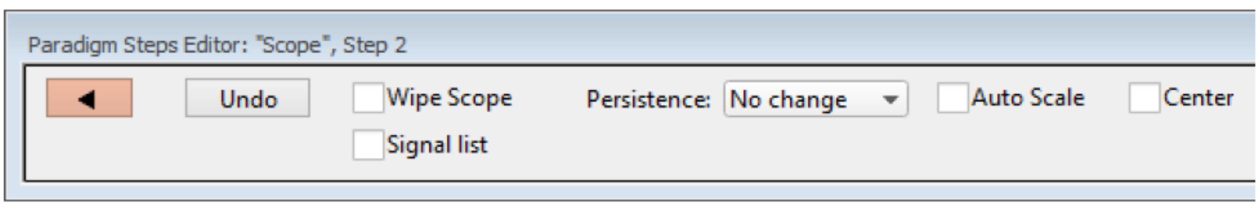


Figure 4-24. Paradigm Step: Scope Operation

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.

Signal list: — Enable to display a list of input signals.

Add Signal	Clear	Clear the signal list.
	All Signals	Select all signals.

[List of all possible input signals]

[list of selected input signals]

You can directly edit the list. User-defined signal labels can also be used.

Persistence: 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.

Set Axis

Modify the axis scaling of selected signals in the open Scope window.

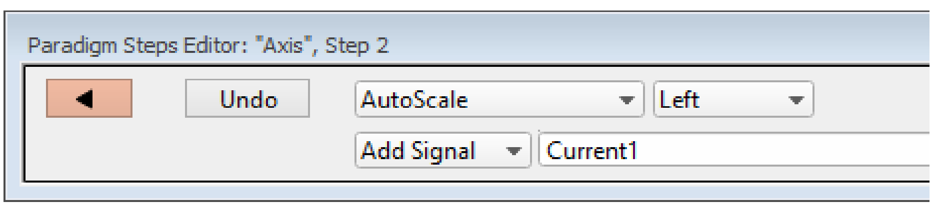


Figure 4-25. Paradigm Step: Set Axis

Default Setting: *Axis, Axis=Autoscale, Kind=Left, Target=Current1*


Close the 'Paradigm Steps Editor'.

Undo — Remove any unsaved edits to this step.

[drop-down list] — [Left]

Select the Y-axis scaling to apply.

- Autocenter — Center the Y-range of the X-axis data.
- Autoscale — Match the axis range to the data range.
- Autoscale from Zero

Display from zero to the largest value.

- Full scale — Display the full range of the axis.
- Set scale — Enter custom range settings:
  Min.
  Max.

[drop-down list] Select the axes orientation.

- Full scale — Display the full range of the axis.
- Set scale — Enter custom range settings:

[drop-down list] [Bottom]

Select the X-axis scaling to apply.

- Full scale — Display the full range of the axis.
- Set scale — Enter custom range settings:
  Min.
  Max.

[drop-down list] [only displays for 'Left' axis]

Add the selected signals to the list.

- Clear — Clear the signal list.
- All Signals — Select all signals.
- [list of all available input signals]
  Select individual signals.

[a list of the selected signals]

[only displays for 'Left' axis]

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".

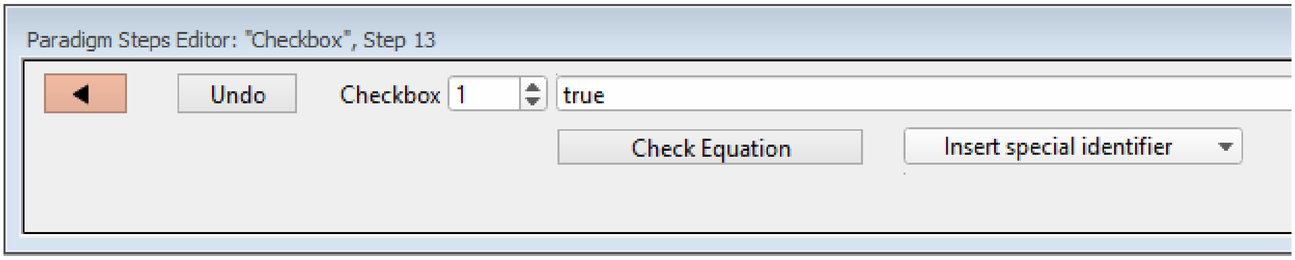


Figure 4-26. Paradigm Step: Checkbox

Default Setting: *Checkbox, Count=1, Equation=true*

Close the 'Paradigm Steps Editor'.

Undo: Removes any unsaved edits to this step.

Checkbox: Checkboxes [1 – 3] are local: they are cleared whenever a Paradigm is started.

Checkboxes [4 – 6] are global: their status persists across all Paradigms in the Experiment.

[Equation field]: A free-form text field, evaluated to a value, and applied to the Checkbox.

[Errors 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."

- 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) the active sweep for later processing by the Data Navigator.

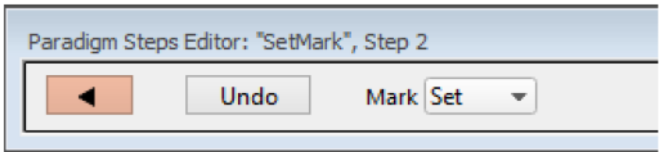


Figure 4-27. Paradigm Step: Set Mark

Default Setting: *SetMark, Value=Set*

 Close the ‘Paradigm Steps Editor’.

Undo Remove any unsaved edits to this step.

Mark

- Set
- Clear
- Toggle

“Marking/unmarking” a sweep mark/unmarks that sweep in all signals in the same Series. Marked sweeps are loaded into the Data Navigator as “marked”.

Use within a conditional paradigm step to mark or unmark a sweep, based upon experimental conditions.

For example, when used within a paradigm ‘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 the 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:

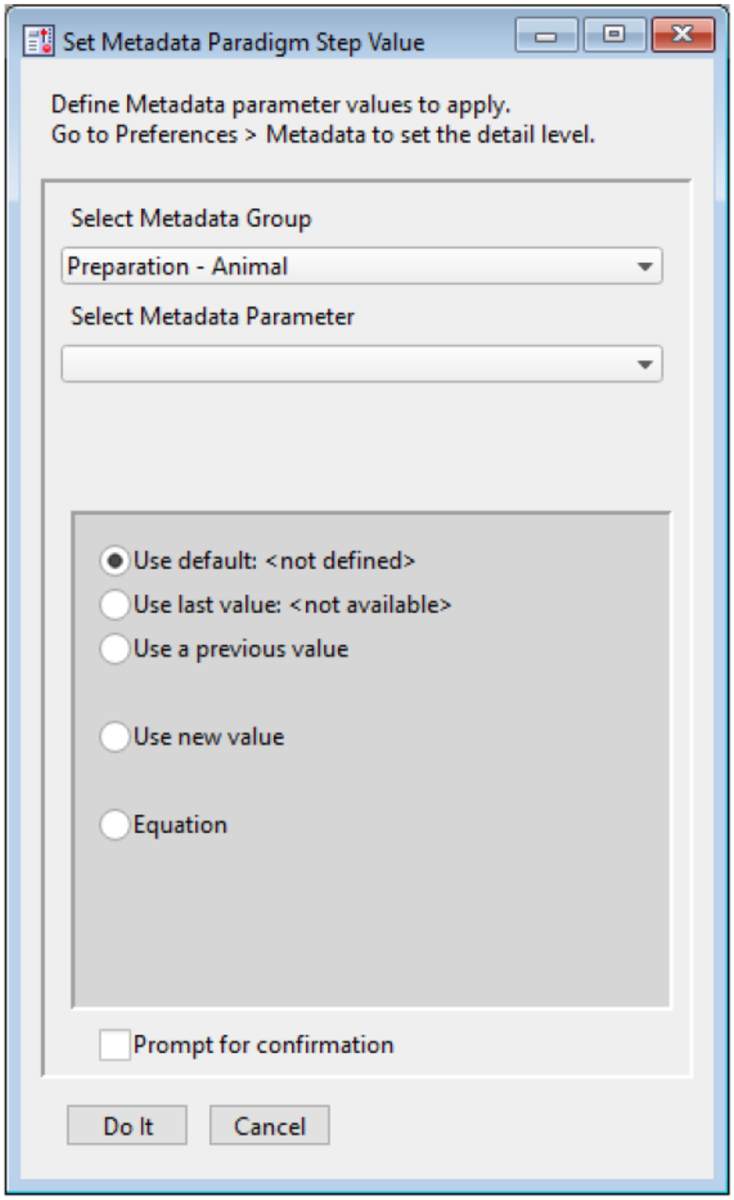


Figure 4-28. Paradigm Step: Select Metadata Group

Default Setting: *Metadata, Value=*

Select Metadata Group

To change the metadata detail level, go to Preferences > Metadata.

- Operator (Full detail level)
- Preparation – Animal (Basic detail level)
- Preparation – Tissue (Basic detail level)
- Preparation – Cell (Basic detail level)

• Experiment	(Basic detail level)
• Electrode	(Extended detail level)
• Recording Solutions	(Extended detail level)
• Paradigm	(Full detail level)
• Cell Health / Quality Control	(Full detail level)
• Series (= Routine Data)	(Full detail level)
• Stimulus	(Basic detail level)

Select Metadata Parameter — Entries depend on the selected Group.

[Metadata Parameter Info]

- Use default:
- Use last value:
- Use a previous value
- Use new value
- Equation

  [<Define Equation>]

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

  Special identifier — Acquisition and reference settings are available for use in equations. (See list below.)

Prompt for confirmation — Display a metadata prompt before acquisition.

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.

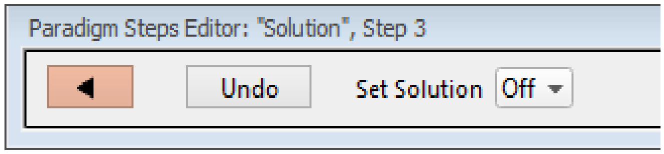


Figure 4-29. Paradigm Step: Set Solution

Default Setting: *Solution, Target=Off*

 Close the 'Paradigm Steps Editor'.

Undo — Removes any unsaved edits to this step.

Set Solution — [1 – 24]

Select a solution number to activate its valve. The number of available solutions depends on the Solution Editor configuration.

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 black vertical cursor displays at that time point.

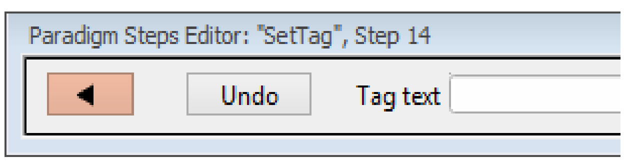


Figure 4-30. Paradigm Step: Set Tag

Default Setting: *SetTag, Text=*

 Close the 'Paradigm Steps Editor'.

Undo — Removes any unsaved edits to this step.

Tag 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 that uses equations.

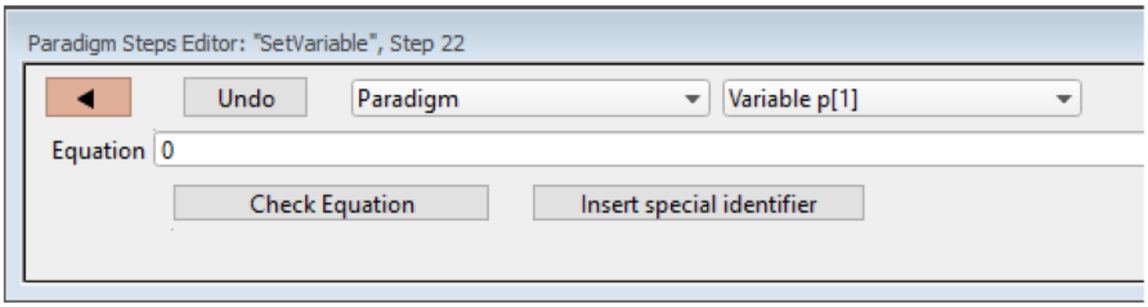


Figure 4-31. Paradigm Step: Set Variable

Default Setting: *SetVariable, Target=Paradigm, Count=1, Equation=p[1]*

 Close the 'Paradigm Steps Editor'.

Undo — Removes any unsaved edits to this step.

[List of targets]

- Paradigm — Set the value of a Paradigm Variable_p[#].

  [1 – 16. All 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 unchanged. If a list value is blank, the corresponding variable is unchanged.

- Paradigm_Input

  Set the value of the Paradigm Editor 'Input' control.

- [Routine Names]

Select a Routine and set the value of its Variable_r[#]

[1 – 16, All 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 unchanged. If a list value is blank, the corresponding variable is unchanged.

Equation — Evaluates to a value, used 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 Write Steps

Configure the level of logging Paradigm metadata.

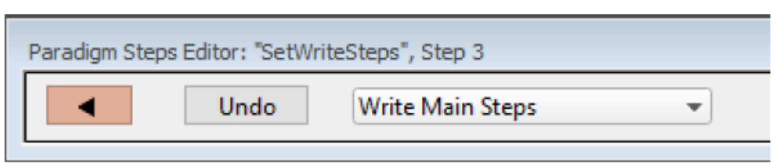


Figure 4-32. Paradigm Steps: Set Write Steps

Default Setting: *SetWriteSteps, Value=Main*

	Close the ‘Paradigm Steps Editor’.
Undo	Remove any unsaved edits to this step.

[Drop-down list]

- Write No Steps
- Write Main Steps

  Action-oriented steps are recorded in the Paradigm metadata (visible in the Metadata ‘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 Paradigm metadata (visible in the Metadata ‘By Event’ view.)

Sound

Output a note from the computer speaker.

The frequency can be defined by a fixed value or an equation.

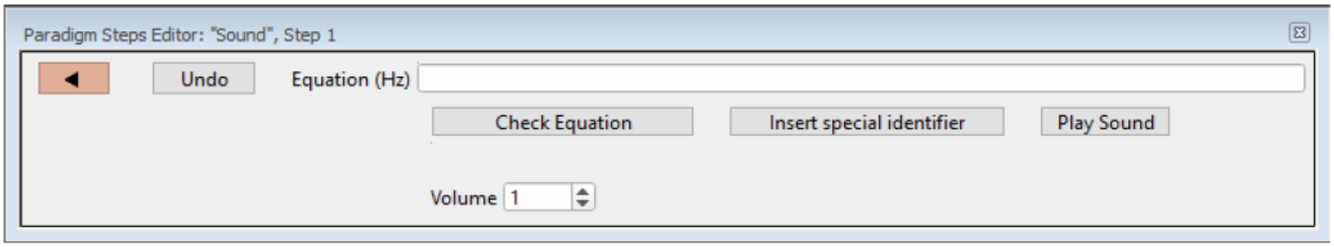


Figure 4-33. Paradigm Step: Sound

Default Setting:	*Sound, Equation=, Volume=1*
	Close the 'Paradigm Steps Editor'.
Undo	Removes 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.
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.

  Note: Lower frequency tones are attenuated in volume on lower-quality 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.

Update Inputs

Read a “live” data point from all auxiliary input channels. This is useful for monitoring slowly changing parameters, such as temperature, without acquiring an entire sweep of data.

View Last

Display the data from the last recording in a Reanalysis Scope window.

Write to Log

Enter text to be written to the Log window.

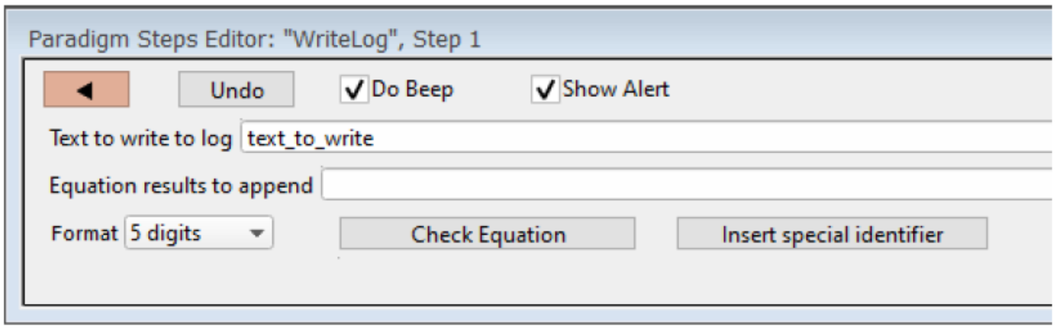


Figure 4-34. Paradigm Step: Write to Log

Default Setting: *WriteLog, Alert=true, Text=text_to_write, Equation=, DoBeep*

 Close the ‘Paradigm Steps Editor’.

Undo: Removes 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 send to log [ ]

Equation result to append [ ]

Multiple equations in a comma-separated list can be evaluated.

Format: Time
Date
1 – 12 digits

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.)

Paradigm: Write to log

This run-time dialog displays when the Paradigm step is executed:

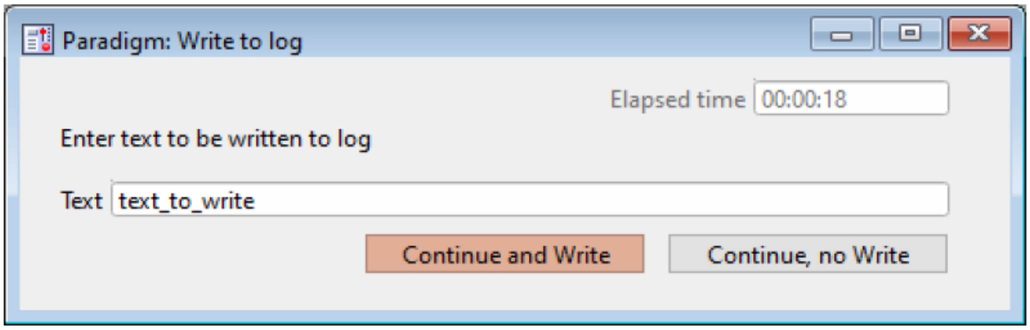


Figure 4-35. Paradigm Step: Write to Log Run Time Window

Elapsed time	A time counter for the Alert.
Text	Edit the text message.
Continue and Write	Write to the metadata.
Continue, no Write	Do not write to the metadata.

Write to Notebook

Enter text to be written to the Notebook.

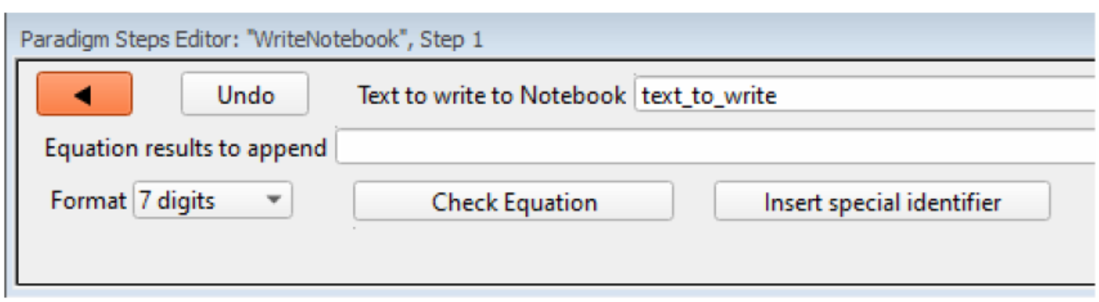


Figure 4-36. Paradigm Step: Write to Notebook

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

[ ]

Equation results to append

[ ]

Format [Time, Date, 3 – 12 digits]

For the 'Time' format, seconds are converted into Hours:Minutes:Seconds.Milliseconds.

For 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.

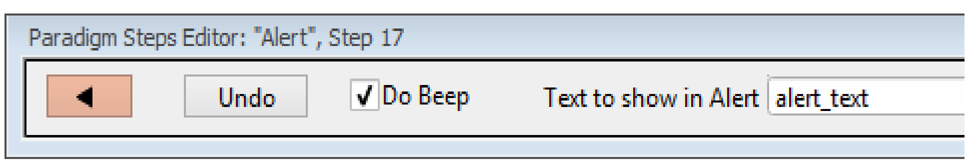


Figure 4-37. Paradigm Step: Alert

Default Setting: *Alert, Text=alert_text, DoBeep=true*

 Close the 'Paradigm Steps Editor'.

Undo Removes any unsaved edits to this step.

Do Beep Sound a "beep" from the computer.

Text to show in Alert

Enter a message to the user.

Beep

Generate a “beep” sound from the computer speaker.

Default Setting: *Beep*

Comment

A text message can be displayed in a floating window.

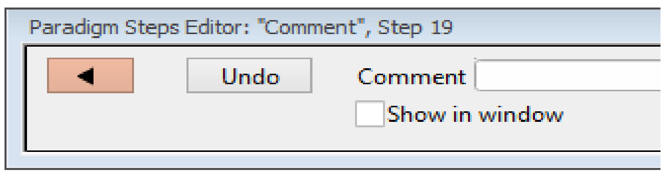


Figure 4-38. Paradigm Step: Comment

Default Setting: *Comment, Text=*

 Close the ‘Paradigm Steps Editor’.

Undo Removes any unsaved edits to this step.

Comment 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 A ‘Paradigm Comment’ window is displayed with the comment text, and closes when the paradigm ends.

Pause

Pause execution of the Paradigm until the Resume button is manually clicked.

Wait

Temporarily pause execution of the Paradigm for a defined duration.

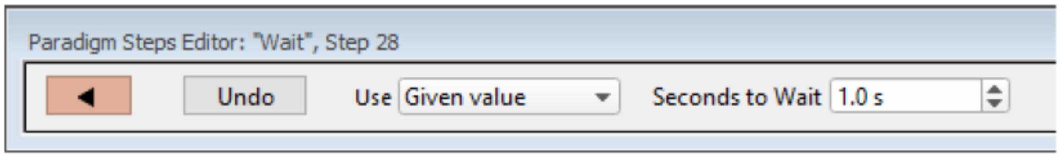


Figure 4-39. Paradigm Step: Wait

Default Setting:	*Wait, Time=1*
	Close the 'Paradigm Steps Editor'.
Undo	Removes any unsaved edits to this step.
Use	[Given value, Variable p[1] – p[16]]
Seconds to Wait	[displays for "Given value"] 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.

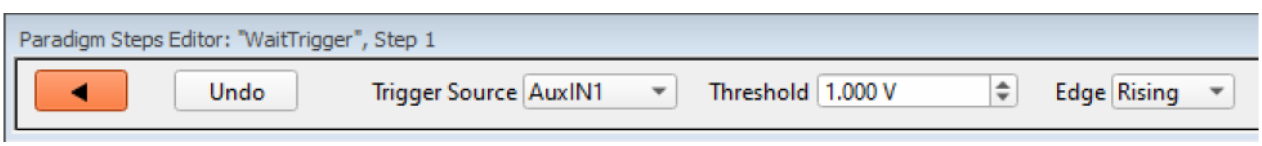


Figure 4-40. Paradigm Step: Wait for Trigger

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 For Loop and For Each Sweep loops.

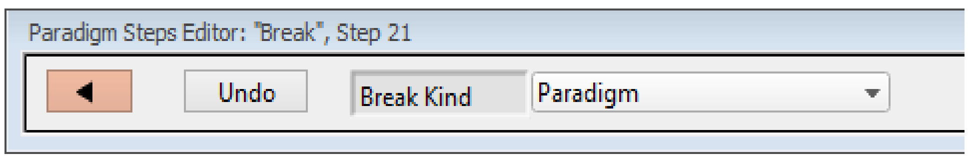


Figure 4-41. Paradigm Step: Break

Default Setting:	*Break, Kind=Paradigm*
	Close the 'Paradigm Steps Editor'.
Undo	Removes any unsaved edits to this step.
Break Kind:	Paradigm ForLoop

Flow Control: Chain

Use to link step execution to another Paradigm.

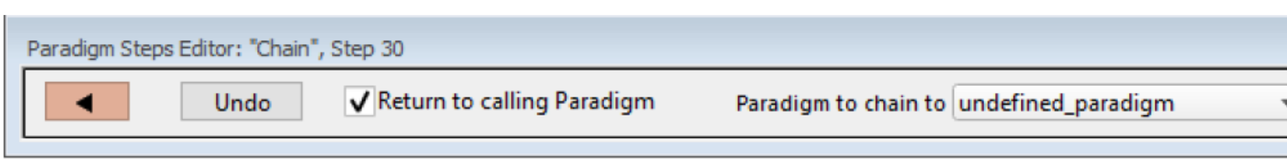


Figure 4-42. Paradigm Step: Chain

Default Setting:	*Chain, Target=undefined_Paradigm, Return=true*

Close the ‘Paradigm Steps Editor’.

Undo — Removes 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 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>“

Load the selected Paradigm for editing.

Flow Control: For Loop

Use a standard programming “For loop” to repeat a set of steps.

Note: A “For loop” is processed as one step.

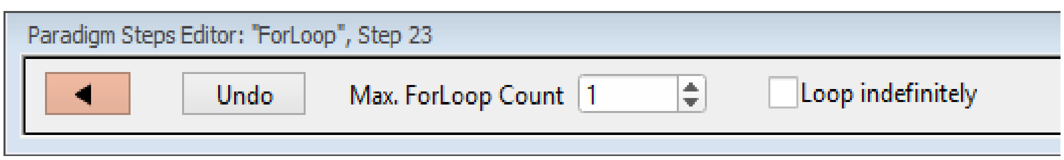


Figure 4-43. Paradigm Step: For Loop

Default Setting: *ForLoop, Max=1*
ForEnd

Close the ‘Paradigm Steps Editor’.

Undo — Removes any unsaved edits to this step.

Max. ForLoop Count — Number of loop cycles to run.

Loop Indefinitely — Sets ‘Max. ForLoop Count’ to ‘inf’.

Flow Control: Jump

Shift the Paradigm sequence to an arbitrary step. When executed, a jump occurs to the step after the target Label.

Figure 4-44. Paradigm Step: Jump

Default Setting: *Jump, Target=jump_label*

 Close the 'Paradigm Steps Editor'.

Undo Removes any unsaved edits to this step.

Jump Target Enter the Label of the step to jump to.

Flow Control: Label

Create a Label for a Jump step.

Figure 4-45. Paradigm Step: Label

Default Setting: *Label, Target=jump_label*

 Close the 'Paradigm Steps Editor'.

Undo Removes any unsaved edits to this step.

Label name Assign a name to the Label.

Condition: If

This step allows conditional Paradigm flow control between multiple choices.

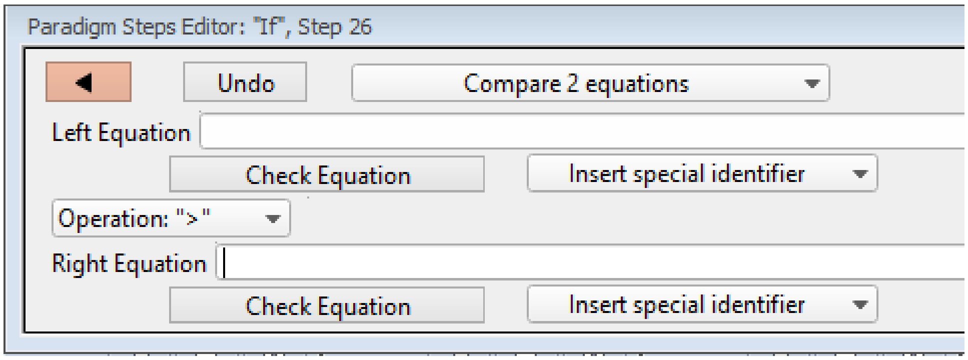


Figure 4-46. Paradigm Step: If

Default Setting: *If, Left=, Operation='>', Right=*
EndIf

 Close the 'Paradigm Steps Editor'.

Undo — Removes any unsaved edits to this step.

[drop-down list] — Operation selection.

- Compare 2 equations

  Left 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	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.)
• Check for key pressed	The “Last key” typed on keyboard during the current Paradigm. The “Last key” field is cleared at the start of a Paradigm.
Key to check for	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 – 3]	Paradigm-level “local” checkboxes, cleared at start of Paradigm.
[4 – 6]	Experiment-level “global”

checkboxes, persists across Paradigms.

- Answer of yes-no alert

Do Beep	Your computer beeps once when the alert displays.
Alert Text [ ]	Enter your alert question text.

<u>Run-time dialog</u>

Elapsed Time	A time counter for the alert.	
Yes	'Yes' button	(value = 1)
No	'No' button	(value = 0)
Stop Paradigm	Manually abort the Paradigm.	

<u>Condition: ElseIf</u>

Allow conditional Paradigm flow control between multiple choices.

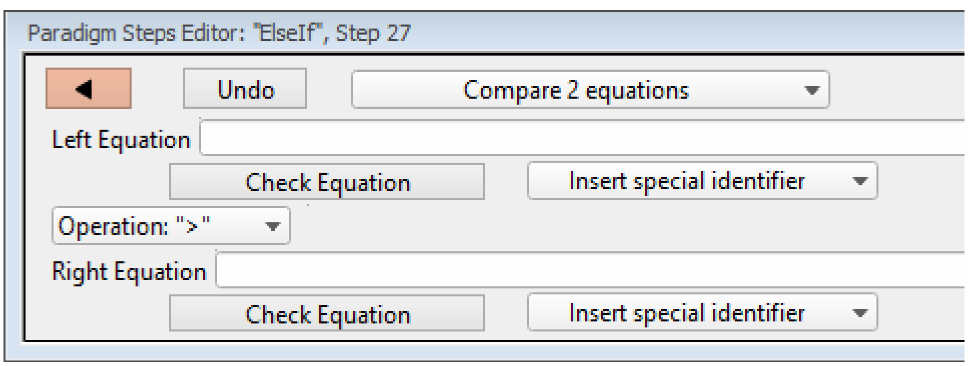


Figure 4-47. Paradigm Step: Else If

Default Setting:	*ElseIf, Left=, Operation='>', Right=*
	Close the 'Paradigm Steps Editor'.
Undo	Removes any unsaved edits to this step.
[drop-down list]	Operation selection.

- Compare 2 equations

Left 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	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.)
• Check for key pressed	The “Last key” typed on the keyboard during the current Paradigm. The “Last key” field is cleared at the start of a Paradigm.
Key to check for	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 – 3]	Paradigm-level "local" checkboxes.
[4 – 6]	Experiment-level "global" checkboxes.
• Answer of "Yes/No" alert	
Do Beep	Your computer beeps once when the alert displays.
Alert Text [ ]	Enter your alert question text.
Run-time dialog	
Elapsed Time	A timer of how long the Alert has been displayed.
Yes	'Yes' button (value = 1)
No	'No' button (value = 0)
Stop Paradigm	Manually abort the Paradigm.

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. They are visible at the bottom of the Paradigm Editor window.

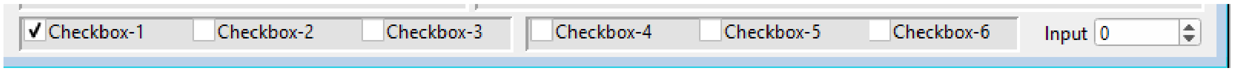


Figure 4-48. Paradigm Checkboxes

[1 – 3] These "local" checkboxes are cleared when a Paradigm starts. They provide Paradigm-specific controls that are only valid for the current Paradigm session.

[4 – 6] 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. Manually enter a value, or set via the Paradigm step 'Set Variable / Insert special identifier / Paradigm Parameters'.

[-1.00 – 1.00]

This value is restricted to ±1.00 to enable scrolling through a defined range of values. It can be rescaled when used in an equation.

Paradigm Variables

The Paradigm Variables table displays at the bottom of the Paradigm Editor.

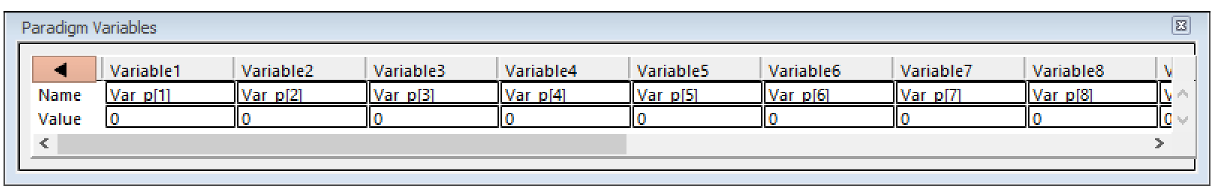


Figure 4-49. Paradigm Variables

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’.

Special identifiers List

SutterPatch acquisition, analysis and reference selections are appended to an equation with a “plus” sign.

Timing

Time	(present date-time, s)
Timer	(timer time, s)
ParadigmTime	(time at start of paradigm, s)
RoutineTime	(time at start of routine, 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)

[0 = the last acquisition completed]
[1 = the last acquisition was stopped]

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)

p[1..16] (n'th paradigm variable)

r[1..16] (n'th routine stimulus variable)

<u>Analysis Results</u>

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 graph[#].

gy[1..16] (n'th analysis graph y value)

The Y-value of the last data point in the latest version of graph[#].

<u>Signal Readings</u>

AuxIN[1..8] (analog input, V)

A single-point reading from an Analog Input channel, such as from a slowly changing temperature probe.

Note: This usage does not require setting up a Routine Input channel.

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)

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 online analyses. The Routine Editor is the central place to create and manage saved Routine Pools and data acquisition settings.

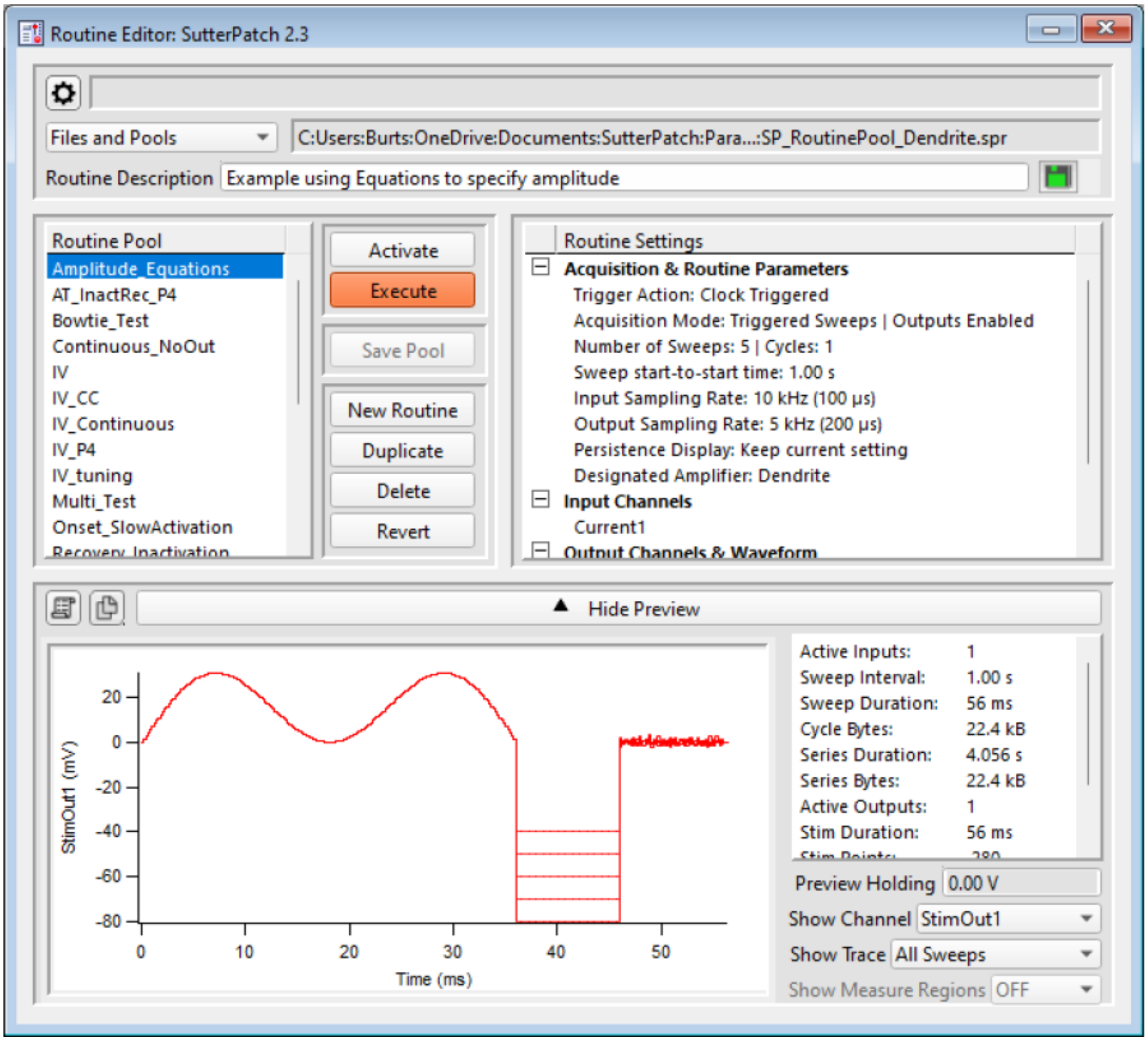


Figure 4-50. Routine Editor

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.

Routine Settings	Set Membrane Test Segment Amplitude.	
[ ]	Status field: Notifications on edits and Routine names are displayed.	
Files and Pools	[drop-down list …]	
	Most recently used list of the last 5 used Routine Pool files. To remove a file from the list, Shift-click it.	
	Load Routine Pool	Load the Routine Pool of a previously saved Routine Pool file.
	New Routine Pool	Create a new Routine Pool with a default Routine, or populated with Routines from the currently loaded Routine Pool. (see below)
	Get Sample Routine Pool	Load the Dendrite factory defaults into the sample Routine Pool file. SP_RoutinePool_Dendrite.spr
	Revert to Last Saved	Undo any unsaved changes to the Routine Pool.
	Save Routine Pool	Save the Routine Pool using its existing filename 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 file, but do not switch to the new file. The default file name has 'Copy of' prepended to the original file name.
	Merge Routine Pools	Insert the Routines from a previously saved Routine Pool file into the loaded Routine Pool.
	Merge PatchMaster PGF File	Insert the "Routines" (PGF Sequences) from a PatchMaster PGF file into the loaded Routine Pool. Re-assign the analog input and output channels in a 'Mappings' dialog that opens. [The Sutter hardware must be attached to enable this option.]

	Convert Routine Pool	Convert the loaded Routine Pool (designed for other instruments) to be compatible with the attached amplifier or emulation mode. The original file is overwritten. All conversion changes are written to the Command window
	Send Last Used List to Command	Copy the pathname of the 'Files and Pools' last used Routine Pool into the Command window history.
	Clear Last Used List	Clear the "Last Used" Pool list of all entries.
	Sort Routine Pool – Ascending Order	Sort the 'Files and Pools' list in increasing order.
	Sort Routine Pool – Descending Order	Sort the 'Files and Pools' list in decreasing order.

Table 4-2. Routine Files and Pools

New Routine Pool dialog:

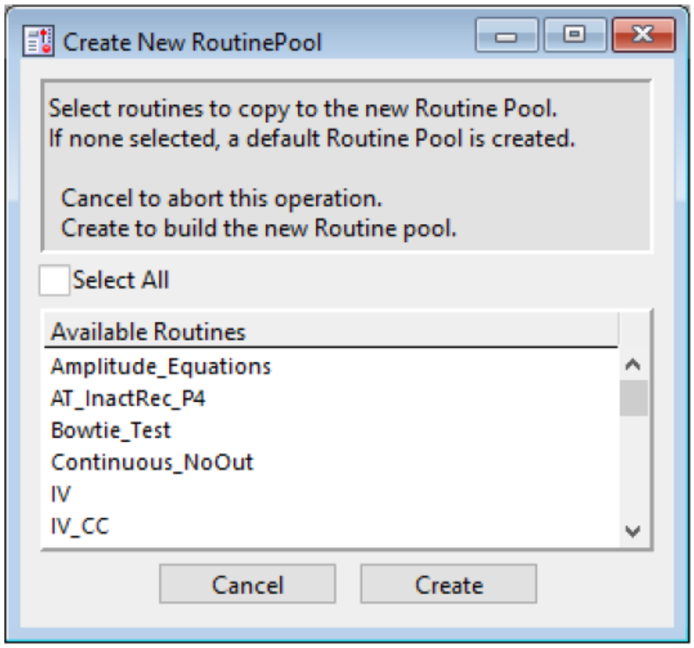


Figure 4-51. New Routine Pool

Create a new Routine Pool populated with a default Routine, or select Routines from the loaded pool to populate the new pool.

[ ]

File path of the loaded Routine Pool file.

Routine Description

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.

<u>Routine Pool</u>

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 auto-increment 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: Routine Scope window with the latest Routine settings, but do not start acquisition. This button is re-named to "In Progress" during a recording.
Execute Convert	Open or refresh the Acquisition Scope window and immediately start recording. The latest Routine settings are applied to the Scope window. 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.
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

<u>Waveform Preview</u>

The stimulus waveform is graphically displayed at the bottom of the Routine Editor.

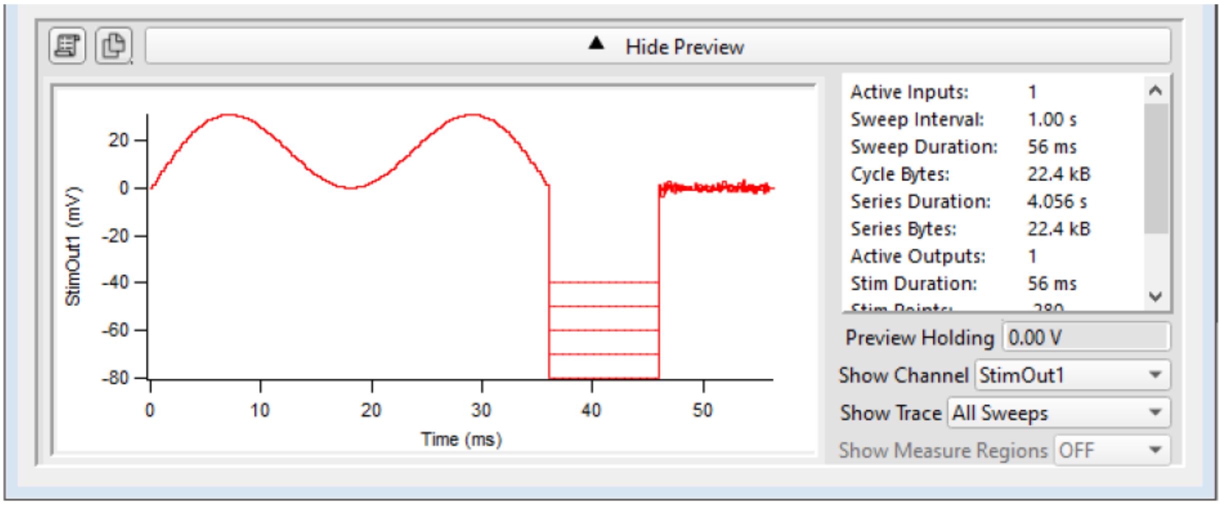


Figure 4-52. Waveform Preview Pane

The waveform preview and its settings are updated live to reflect changes in the Waveform Editor and Dendrite 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 right-edge cursor; its Region Timing ‘End Time’ setting is updated, while its ‘Start Time’ is unchanged.

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 to Layout	Copy the stimulus graph into a new Layout window, or append to an existing Layout page.
	Copy to Clipboard	Copy the stimulus graph to the system clipboard.
Show / Hide Preview		Expand or collapse the Preview pane.

<u>X- and Y-axis Control</u>

- 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.

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.
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 Dendrite Control Panel.

<u>User selectable settings</u>

Show Channel:	A list of output channels to preview.
Show Sweep:	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:	A list of measurement regions to preview.		
		• None	No regions displayed.
		• All	All regions displayed.
		• m[#]	Select a single region to display.

Routine Settings

The Routine Settings are split into 5 main sections. Click on a section header or its items to open its sub-window for editing.

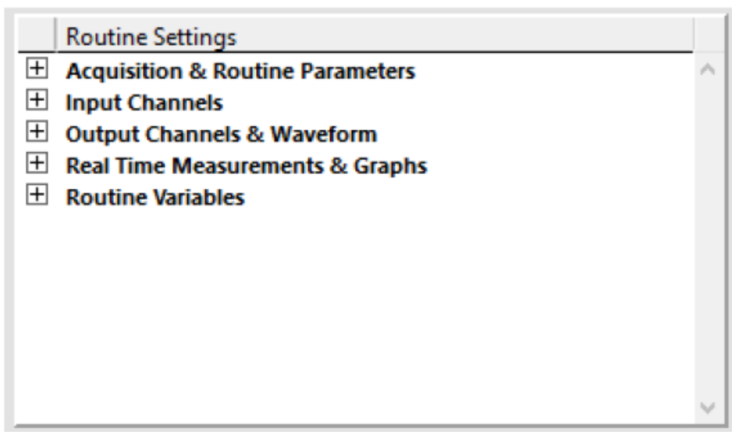


Figure 4-53. Routine Settings

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.

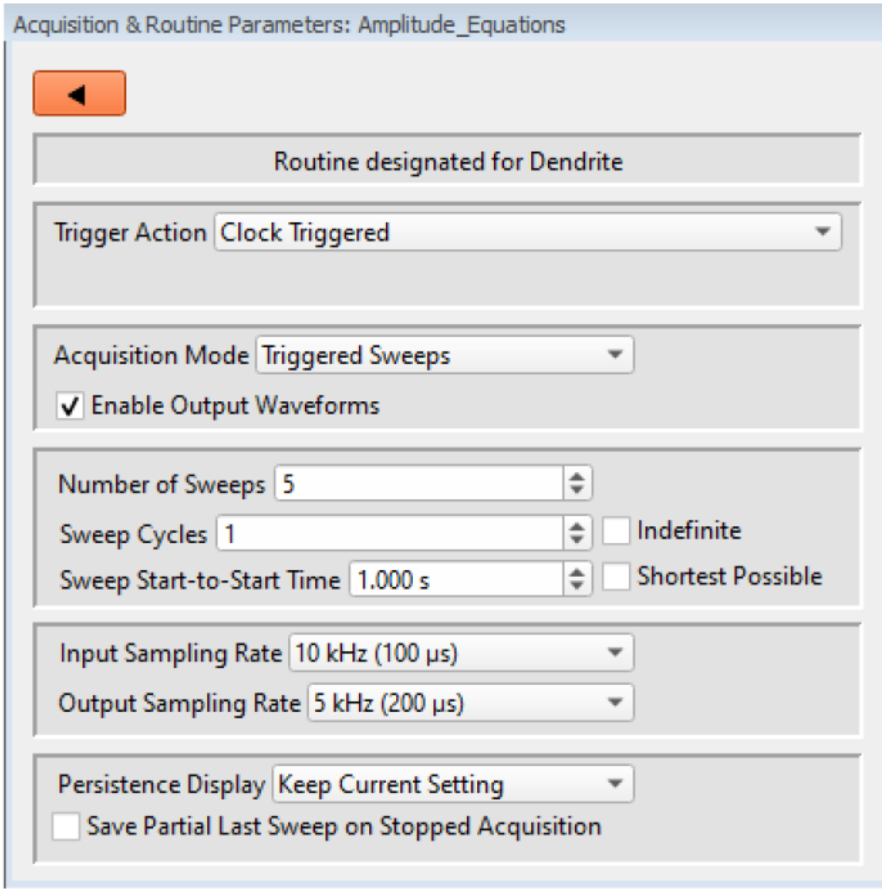


Figure 4-54. Acquisition & Routine Parameters

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 signal to the 'Trigger In' BNC on the rear panel of the Dendrite digitizer.

  However, if a Routine is run from within a Paradigm via an 'Each Sweep' step, then the hardware trigger is substituted by 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, first set the Trigger Action to 'Clock Triggered' or 'Externally Triggered Series', then change the Acquisition Mode from 'Continuous Sweeps' to 'Triggered Sweeps', to ungray the option.

- Externally Triggered Series:

  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.

  Connect the trigger signal to the 'Trigger In' BNC on the rear panel of the Dendrite system.

  However, if a Routine is run within a Paradigm 'Each Sweep' step, then the hardware trigger is substituted by a software trigger 'generated by the Paradigm.

- 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, or to align random events within sweeps.

  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

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
		[±0.75 V] voltage input
	Trigger Polarity	Rising Edge ▲
		Trailing Edge ▼
	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 (~100 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 Dendrite demo mode display of continuous sweeps includes artificial gaps between them. Recording with hardware attached does not have any gaps

Enable Output Waveforms

Output channel waveforms can be optionally disabled or enabled.

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.

Number of Sweeps [0, 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.

Sweep Cycles [0, 1 – 65000]

The number of times to automatically repeat the entire set of sweeps recorded by a single Series.

Indefinite — The number of Sweep Cycles is undefined - sweeps continue to record until acquisition is stopped.

[for Triggered Sweeps] — A value of zero is replaced by "indefinite", and the Indefinite checkbox is enabled.

Indef Post Stim — [for 'Continuous Sweeps' with Output Waveforms]

After the designated number of Sweep Cycles is reached, the Output Waveform is disabled and Post Stimulation Cycles continue to passively record Sweeps until acquisition is stopped.

Sweep Start-to-Start Time ['s' or 'ms']

The time from the start of recording a sweep to the start of the next sweep recording.

Shortest Possible — [for 'Triggered Sweeps']

Set to the longest waveform duration in the Series + overhead processing time (100 ms).

Sweep Duration — [for 'Continuous Sweeps']

The sweep duration is the longest waveform duration in the Series (as configured in the Waveform Editor.)

Note: In demo mode, the sweep start-to-start time can vary during acquisition, especially on slower computers.

Input Sampling Rate Drop-down list 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: Drop-down list 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 Rate (set in the Amplifier Control Panel).

Channel Timing Delays:

The Dendrite system records both command 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

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.

Input Channels

Configure the input channels.

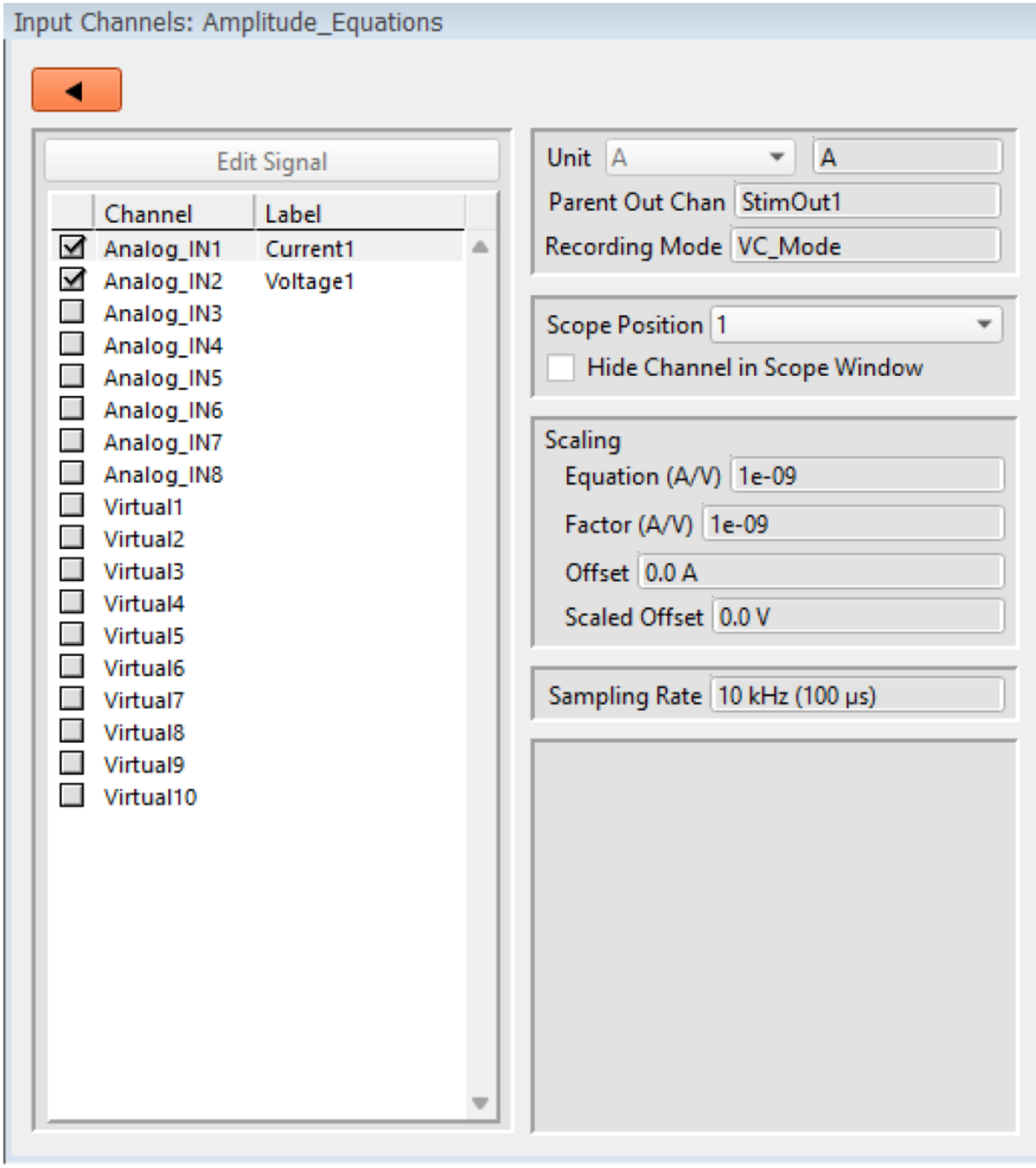


Figure 4-55. Input Channels

Edit Signal

[for disabled Output Waveforms]

When Output Waveforms are disabled in the Acquisition Parameters section, Segment timing can still be controlled via a modified Waveform Editor. This signal editor is a “timing only” version of the Waveform Editor, and only controls the duration of Segments, to facilitate Segment-based measurements.

When this button is enabled, double-clicking a channel will open the signal editor.

Channel

Enable up to sixteen Input Channels for recording data:

Analog_IN[1 – 8]	Eight analog input channels allow you to directly digitize and record input signals from connected non-Suttter external equipment. Note: In Emulation mode, the Analog_IN 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 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 label is used by another channel, an underscore and increment number are appended to the new label.

When a Virtual input channel is enabled, its default 'Math Type' label is automatically generated for it.

Unit

The base unit of measurement.

• 'Analog_IN' Channels	[read-only for headstage channels] Fixed at 'A' for current channels, and 'V' for voltage channels.

The unit resolution is automatically adjusted in the signal.

- ‘Analog_IN’ Channels — [editable for non-headstage channels]

  Enter the base unit of measurement from a drop-down list. (Default is ‘V’.) The unit resolution is automatically adjusted in the signal.

  [A, V, S, Ohm, °C, °K, °F]

  Or edit the text field to add new nomenclature to the 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]

  Enter the base unit of measurement from a drop-down list. (Default is ‘V’.) The signal’s unit resolution is automatically adjusted.

  [A, V, S, Ohm, °C, °K, °F]

  Or edit the text field to add new nomenclature to the list.

Parent Out Chan

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 Analog input channels]	Select any output channel from the list.
[for Virtual input channels]	Displays its ‘Source’ channel’s Parent Output channel.

Recording Mode

[only editable for non-headstage Analog 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.

Hide Channel in Scope Window

The selected input channel is hidden in the Scope window.

Scaling

[headstage channels are read-only]

Equation ('Unit'/V)

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]

The input channel Scaling factor is evaluated from the equation. Raw values are converted to input units.

Note: The Dendrite digitizer uses a high-resolution 16-bit ADC with 64-bit data, so data resolution is not an issue when scaling input signals.

Offset (V) Apply an amplitude offset to the input signal, before any scaling.

Tip: To use 'mV' units, enter: '#m' or '#e-3'

To use 'pA' units, enter: '#p' or '#e-12'

Scaled Offset [only displays for "non-unity" evaluated equations]

The amplitude offset of the input signa, after any scaling. Raw offset values are converted to input units.

Sampling Rate

[read-only field]

[kHz (µs)] The sampling rate (and sampling interval), before low-pass filtering.

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 — Apply a data transformation to a Virtual input channel.

Baseline Subtract

Bessel Filter

Cycle Average

Differentiate

Downsample

Equation

Integrate

Leak

Line Frequency

LockIn

Smooth

Stimulus

Sweep Average

Sweep Subtract

- 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 — Select an input channel to process.

  Baseline From — 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 — [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]

- BesselFilter — A frequency-domain filter with excellent response characteristics for preserving the shape of a biological signal.

  Source Channel — Select an input channel to filter.

  Filter Bandwidth — Select a frequency range.

  - LowPass — 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.

  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.

Apply Filter Delay Correction

[only for 'LowPass' filter setting]

Correct the signal for estimated digital filtering delays by shifting the signal forwards in time.

Cutoff Frequency — [0.01 Hz to < ½ the sampling rate]

Restrict frequencies from this boundary point onwards.

- CycleAverage — 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 — 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 — 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 — Select an input channel to downsample.

  Source Sampling Interval — [read-only field (μs)]

  Reduction Factor — [2 – 100]

  Only whole numbers are used; non-whole numbers are rounded up or down.

  Sampling Rate — [read-only field (Hz)]

  New sampling rate of the reduced signal.

- Equation — Specify an equation to process an input signal.

  Post-analysis can be limited to marked sweeps via the Reanalysis Scope Measurements button / Edit Virtual Signals.

Source Channel	Select an input channel to process.
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.

Errors 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".

Insert special identifier

A limited set of identifiers are available for virtual equation traces. However, special references can also be used within commands.

- s[series-count, sweep-count, trace-count, routine name]

Trace of specified series.

Access an arbitrary input trace (data wave) via counts of Series #, Sweep #, Trace # (scope channel position), and the Routine name.

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.

If the routine name is left blank, the current routine name is used.

Ex: s[0,0,0,]

The current series, current sweep,

current trace, of the current routine.

- t[#] 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 an input signal with this.

- p[#] n’th paradigm variable
- if[selector ? true-branch : false-branch]

  Conditional processing.

- eq[equation] Result of the given equation.

Undo All changes in the equation editing session are discarded.

(See the Equation Editor for more details.)

- Integrate Display the integral of the data signal. This is equivalent to the signed area under a curve.

  Source 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.

  This feature is only enabled when the Routine includes an output channel with P/N Leak Pulse enabled.

  Source Channel Select an input channel to process.

  Show Leak Displays 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 pulse.

Enable

- LineFreq Remove AC line frequency noise (hum) from the data signal.

Source Channel	Select an input channel to process.	
Line Frequency	60 Hz	Canada, (Caribbean), Central America, (Japan), Mexico, (South America), South Korea, Taiwan, USA. Some (regions) include both 50 Hz and 60 Hz frequencies.
	50 Hz	Most of rest of world.

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.

Note: 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 frequency.

Warning! Do not apply to sweeps of 3 minutes or more, or problems will occur. Either apply offline, or reduce the sweep duration.

- LockIn Measure cell characteristics (such as membrane capacitance) with high signal-to-noise sensitivity, using a dual-phase software lock-in amplifier.

  [for Sutter amplifiers only]

- Smooth Smooth the data with a “moving average” noise-reduction filter.

Source Channel	Select an input channel to smooth.

Smoothing 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 – 99]

  # of points in boxcar sliding window.

  Note: For best performance, only odd values are used.

- Stimulus — Replicate the command waveform.

  Source Channel — Select an input channel – the waveform from its 'Parent Out Chan' is used.

- SweepAverage — Average the input traces.

  Post-analysis can be limited to marked sweeps via the Reanalysis Scope Measurements button / Edit Virtual Signals.

  Source Channel — Select an input channel to average.

  Average Type — Cumulative: Average all processed sweeps together.

  Run Average: Average the last "N" sweeps.

  Number of Sweeps — [for Run Average]

  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.

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.

- SweepSubtract Subtract a sweep from the input trace.

  Post-analysis can be limited to marked sweeps via the Reanalysis Scope Measurements button / Edit Virtual Signals.

Source 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.

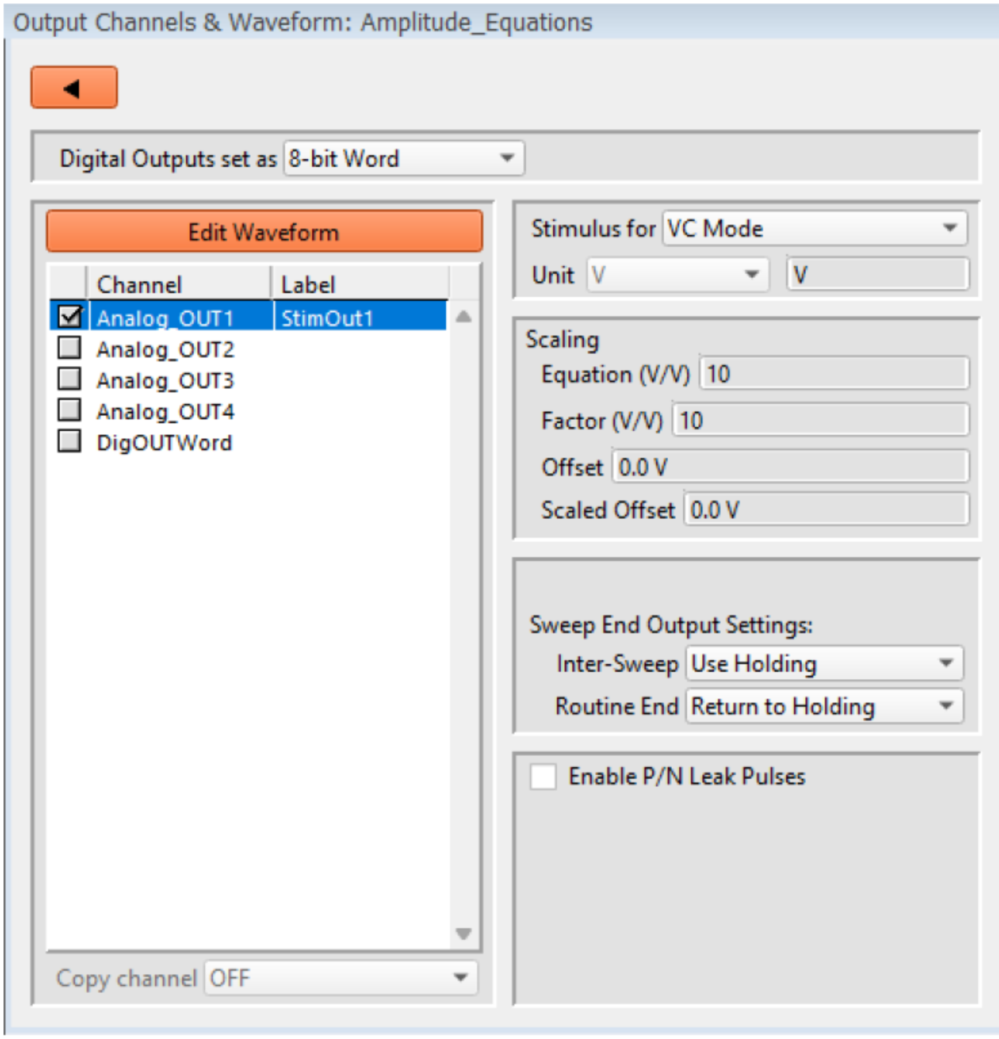


Figure 4-56. Output Channels & Waveform

[Status field] Hardware information displays for the highlighted channel.

Digital Outputs set as

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 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 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 decimal word value for its Y-axis value, i.e., if bits 1 and 3 are 'HIGH', the word 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.

Analog_OUT	The front panel analog output channels can be used to send stimulus or timing waveforms to external instruments (and their headstages).
DigOUT	The digital outputs are available as either a single 8-bit "word", or as 8 individual 1-bit channels, as set in the Acquisition & Parameters section.

Label

A user-defined signal name for the channel.

These are 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 reused for another channel, an underscore and increment number will be appended to the new label.

Copy channel

Copies one channel's waveform to another channel, for output channels of the same type (i.e., "Analog" or "Digital"). 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.

Stimulus for

[for headstage channels only]

Ensures that the matching headstage is in the proper VC/CC mode, else the Routine cannot be activated or executed (or started).

- VC Mode — The Dendrite 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 Dendrite Control Panel matching headstage must be in CC mode to run the Routine.

  "Tag" Recording Mode: 2

However, the Dendrite system 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.

Unit [only editable for non-headstage Analog_OUT 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

Equation ('Unit'/V)

[only editable for non-headstage Analog_OUT channels]

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" headstage channels]

Read-only field of the evaluated Scaling equation.

Offset [only editable for non-headstage Analog_OUT channels]

[±10.000 V]

Applies an amplitude offset to the output channel (before any scaling.)

Tip:	To use 'mV' units, enter:	'#m' or '#e-3'
	To use 'pA' units, enter:	'#p' or '#e-12'

Scaled Offset [only displays for "non-zero Offset" headstage channels]

Read-only field of the amplitude offset, after any scaling. Raw offset values are converted to output units.

Sweep End Output Settings

Control how the amplifier output levels (including I/O Analog and Digital Output levels) are handled when the system is not acquiring data.

Inter-Sweep

This is the time between sweeps - 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

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 changes are only updated when a Routine is activated.

Enable P/N Leak Pulses

Displays the P/N Leak Pulses section.

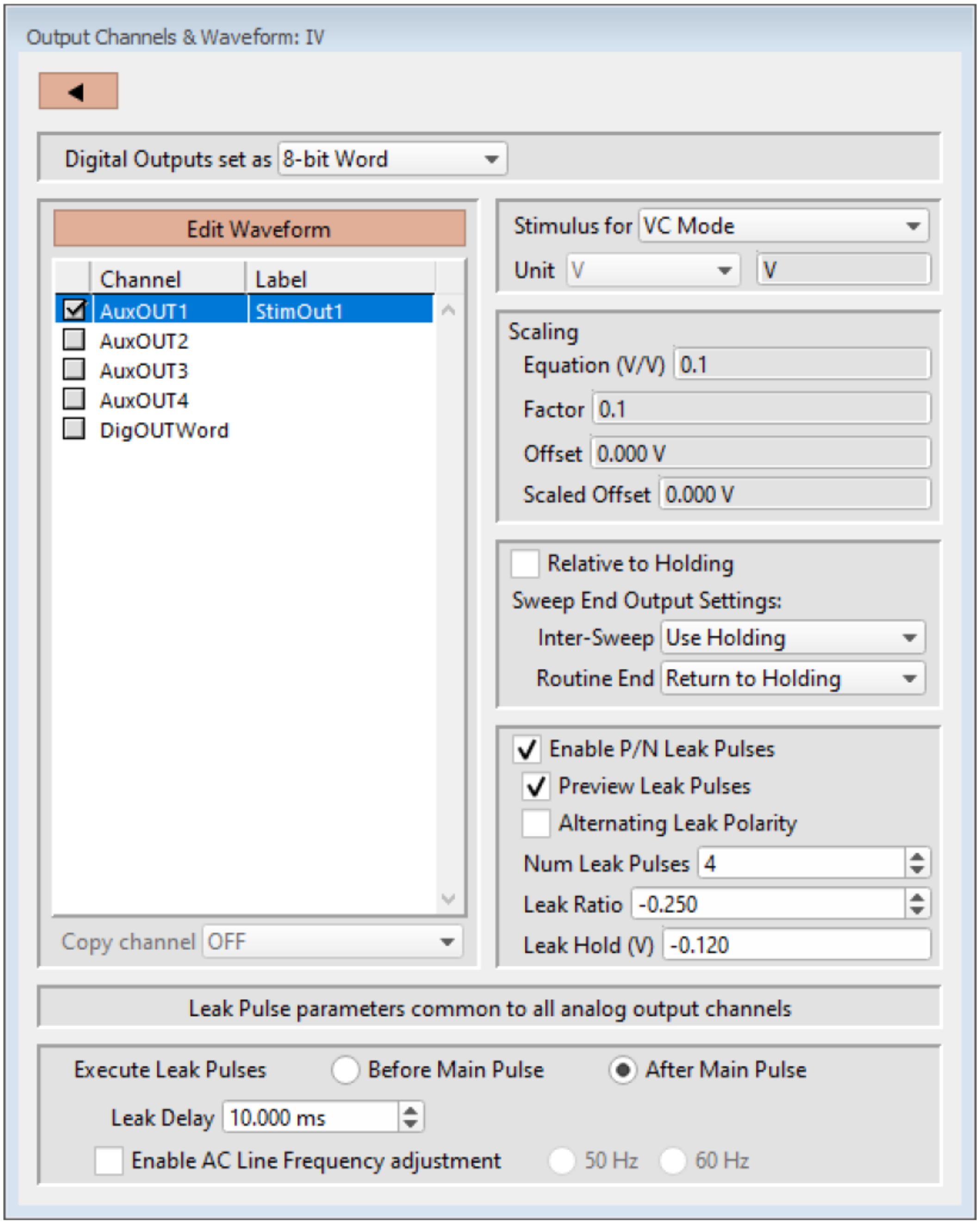


Figure 4-57. Output Channels & Waveform with Leak

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. Online 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 16-bit 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 is 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

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 holding level.

Set to a fixed value, or enter as an equation.
(See the Equation Editor section for more details.)

Check Equations	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.

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 dPatch 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 – 1,000.000 s]

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 Dendrite Holding level; when leak pulses occur after the main pulse, Leak Delay uses the Leak Pulses 'Leak Hold' level.

Enable A/C Line Frequency adjustment

The effect of AC line-frequency noise (hum) can be automatically reduced during P/N leak subtraction recording:

- 60 Hz — Enable the reduction of 60 cycle AC line noise.
- 50 Hz — Enable the reduction of 50 cycle AC line noise.

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.

Waveform Editor

Click the 'Edit Waveform' button to open the Waveform Editor and design a command waveform for the selected output channel.

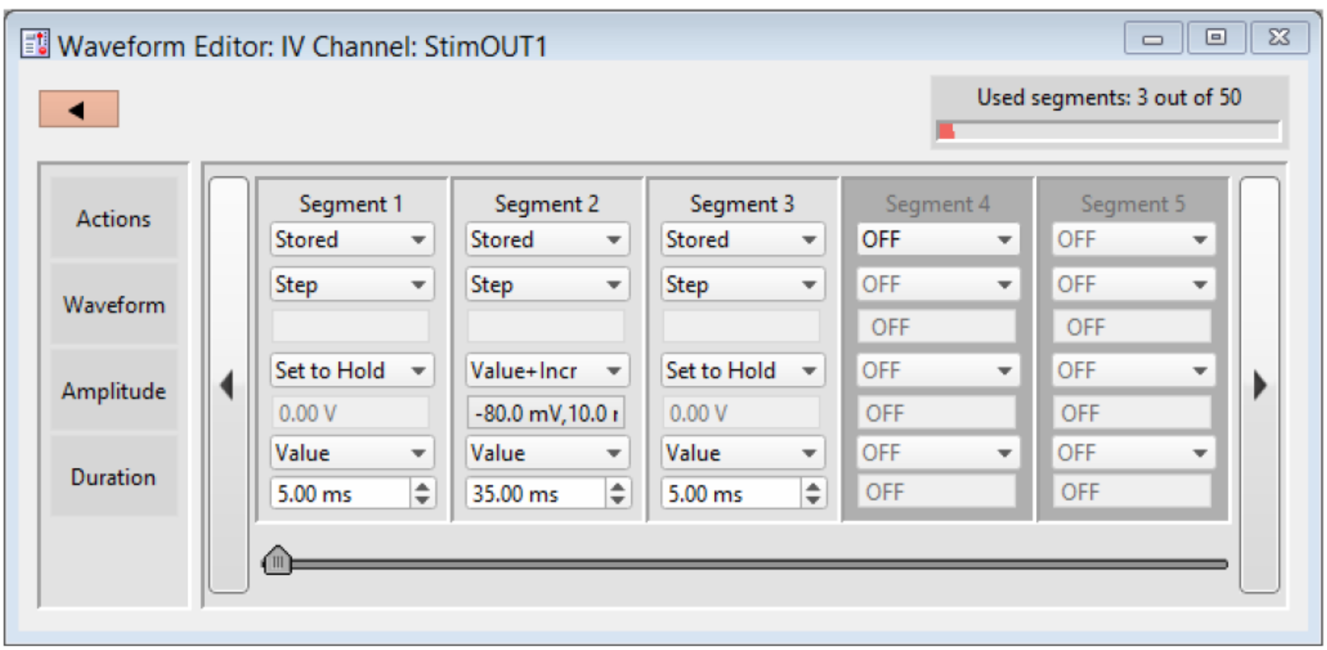
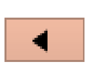


Figure 4-58. Waveform Editor

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

- **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	Select the waveform shape.		
	For Waveform types Sine / Chirp / Squarewave / Template / Triangle, a 'Parameters' field displays below this field, to allow quick access to their parameters.		
Step	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 consists of a Step waveform set to the holding level amplitude (Set to Hold).		
Ramp	The waveform amplitude goes from the previous amplitude to the new amplitude as a smooth straight line - the sloping line looks like a ramp.		
Constant	[for dPatch only]		
	For each sweep, download and repeat a set value for all stimulus points in the last Segment of the output signal. This can help to reduce stimulus loading time.		
Sine	The waveform is a sinusoidal wave.		
	Sine Wave Cycles	Multiple	One or more cycles.
		Single	One cycle, where the Cycle Duration is equal to the Segment Duration.
		LockIn	[for Sutter ampliers only]
	Sine Frequency	[read only]	
	Amplitude	[±1.00 V, ±20.0 nA]	
		Amplitude of the first peak from	

the sine wave baseline.

- Value
- Var_r[1] – [16]

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'.

Cycle Duration — One cycle length (ms).

Ramp Increment — [±1.00 V, ±20.0 nA]

Apply the sine wave onto a ramp "baseline".

[for multiple cycles]

Segment Duration — Sine wave duration (ms).

Square Pulses — The waveform generates a train of rectangular pulses.

Base Amplitude Increment

[±1.00 V, ±20.0 nA]

Increment the baseline amplitude for each succesive pulse.

Step1 Amplitude — [±1.00 V, ±20.0 nA]

Amplitude of first pulse.

- Value
- Var_r[1] – [16]

Step1 Width — Duration of first pulse (ms).

- Value
- Var_r[1] – [16]

Step2 Amplitude — [±1.00 V, ±20.0 nA]

Amplitude of second pulse.

- Value
- Var_r[1] – [16)]

	Step2 Width	Duration of second pulse (ms). • Value • Var_r[1] – [16]	
	Pulse Frequency	[read only]	
	Segment Duration	Square wave duration (ms).	
Chirp	This waveform generates a sinusoidal wave that changes its frequency over time.		
	Chirp 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 of the Start Frequency.
	Amplitude	[±1.00 V, ±20.0 nA]	
	Start Frequency	[1 – 50000 Hz]	
	End Frequency	[1 – 50000 Hz]	
	Segment Duration	Chirp wave duration (ms).	
Template	Assign an arbitrary waveform to a Segment.		

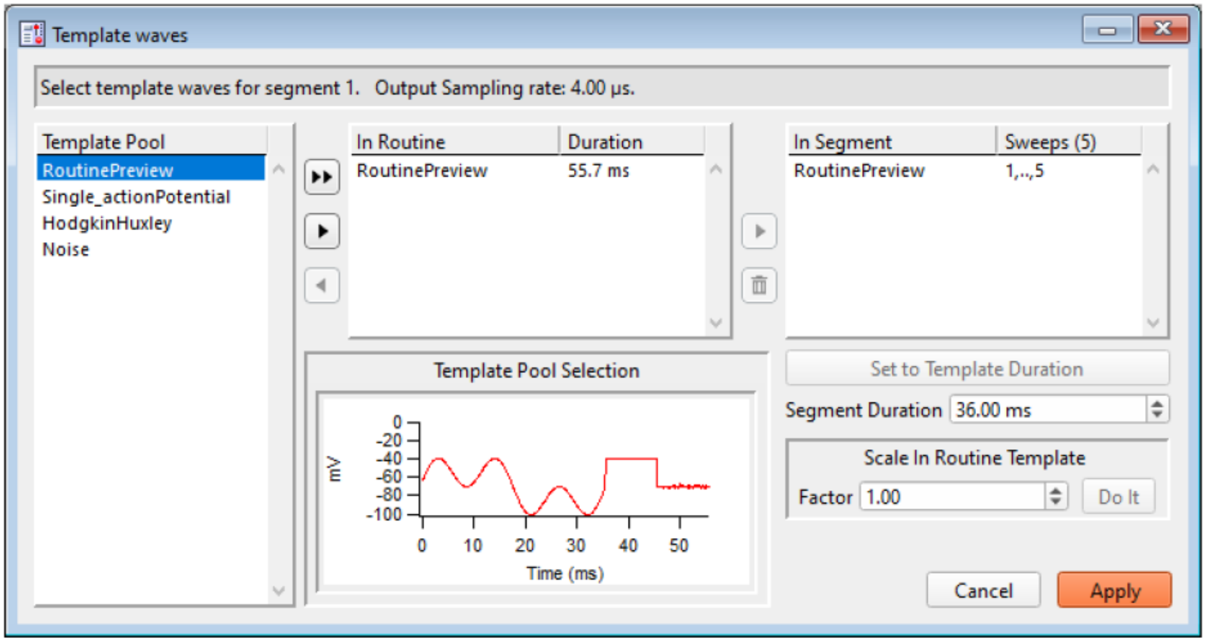


Figure 4-59. Template Waves

[Status field] The Routine Segment # and output sampling rate are displayed.

If the template sampling rate does not match a Routine sampling rate, the template data are interpolated to match the Routine sampling rate.

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 Editor Pool into the 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.

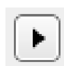
Each output channel can have a maximum of 16 template waves loaded in its Each template can be used in multiple Segments; each Segment can use multiple templates.

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 sizes of the Routine Pool, only include templates that are actually going to be used in a Segment.

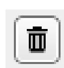
Duration (ms)

The duration of the template trace.



Copy the selected template in the Routine into the Segment.

This button is enabled if the ‘Number of Sweeps’ allows more Segment templates.



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 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.

Template Pool Selection

A preview of the selected template signal.

Set to Template Duration

Set the Segment duration to match the template (sweep) duration.

Segment Duration 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).

Scale In Routine Template

Factor Set a scaling factor for the amplitude of the template signal.

Note: When using templates in Igor Pro 8, close the Scope and Data Navigator windows before saving the Experiment, else the Experiment might not re-open properly.

Triangle Pulses The waveform generates a train of triangular pulses.

Base Amplitude Increment

[±1.00 V, ±20.0 nA]

Increment the baseline amplitude for each succesive pulse.

Peak Amplitude [±1.00 V, ±20.0 nA]

Amplitude of the triangle pulse.

Ramp1 Width Duration of the initial phase.

Ramp2 Width Duration of the secondary phase.

Segment Duration Duration of the triangle train.

Membrane Test The Membrane Test runs in 'Cell' mode.

The waveform applies a predefined negative pulse step (-5 mV) with a 50% duty cycle for Routine-based measurements.

Use with the Real Time Measurements 'Analysis Functions':

- MT Series Resistance

- MT Membrane Capacitance
- MT Membrane Resistance

Warning! For valid results, whole-cell compensation' and series-resistance correction should be disabled on the connected amplifier.

Amplitude (*analog*) Set the waveform amplitude for a Segment.

For the Chirp, Sine, Squarewave and Triangle waveforms, this is used as a baseline offset.

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 the scaling factor in Amplifier Control Panel / Configure Headstage Signals / Command Output / Scaling Factor, then close the window to apply updates.

Set to Hold — Use the Dendrite 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.

[Sweep | Value] — [# | ±1.00 V, ±20.0 nA]

For each numbered sweep, enter a value.

Fill Remaining List — Copy the active value to all remaining sweeps in the list.

	Segment Duration	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.	
	Start Value	• Holding • Value [±1.00 V, ±20.0 nA]
	Increment Value	[±1.00 V, ±20.0 nA]
	Segment Duration	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 field]	[±1.00 V, ±20.0 nA] A free-form text field for writing equations. [ ] Syntax messages are reported here.
	Check Equations	Check the equation syntax. The equation is evaluated for sweep #1, and if valid, it reports "Syntax is ok".
	Insert special identifier	Acquisition and reference settings are available for use in equations. (See list in Equation Editor.)
	Undo	All changes in the equation editing session are discarded.
	(See the Equation Editor for more details.)	

Warning! 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 the Routine Variables table is enabled.

Amplitude *(digital)* Digital settings are displayed if digital outputs are enabled.

Bit	Set a digital level for an individual bit. ▪ LOW = 0 ▪ HIGH = 1
Bit Word	[0 – 256] Value is the decimal number of an 8-bit digital word.

Duration Set the Segment duration.

Value	[0 – 12 ks] Use a single number for the Segment duration. 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 from a list of numbers.

[Sweep | Value]	[# | 0 – 12 ks] For each numbered sweep, enter a value. (Blank lines are removed.)
Fill Remaining List	Copy the active value to all remaining sweeps in the list.
Number of Sweeps	Adjust the number of sweeps in the Routine.

Value+Increment	Increment the Segment duration for each sweep.

Start value	[ms]
Increment value	[ms]
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.
[ ]	Syntax messages are reported here.
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 and reference settings are available for use in equations. (See list in Equation Editor.)
Undo	All changes in the equation editing session are discarded.

(See the Equation Editor for more details.)

Warning! 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 the Routine Variables table is enabled.

Segment Controls

To copy or delete a Segment, click on its background area, and its color turns gold. This enables the additional 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 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

Online analyses are configured in the Real Time Measurements & Graphs dialog. Measurement regions display in the Acquisition: Routine Scope window, and their associated analyses are plotted in an Analysis sub-window during acquisition.

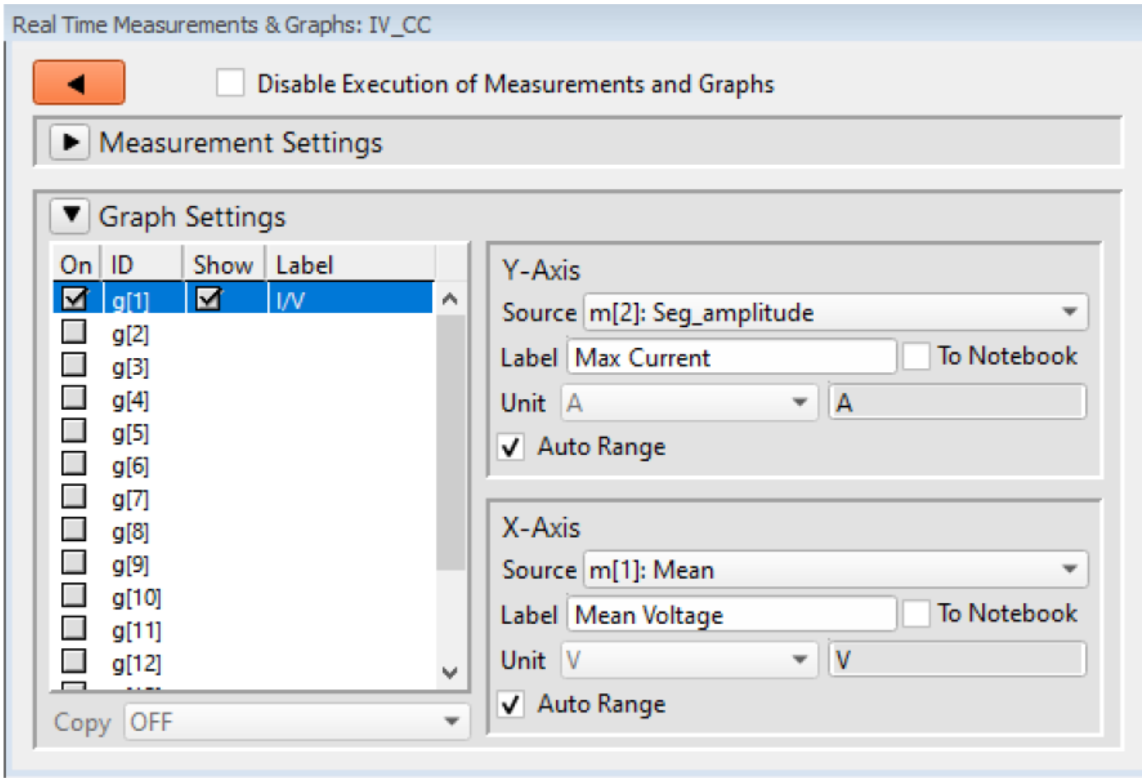


Figure 4-60. Real Time Measurement Settings

Disable Execution of Measurements and Graphs

Block execution of all measurements and analyses with one click.

Measurement Settings

On — Enable an analysis to run.

ID — Measurement regions are identified with an ID number: m[#]

[1 – 16]

Label — These measurement labels display in the Waveform Preview and Scope windows, and can be used in equations. A Label name is automatically generated from the Analysis Function; double-click to manually edit.

Copy — Copy to the selected Measurement another Measurement's settings.

Clear All Measurements

All measurements and their settings are cleared.

Analysis

Be sure to set appropriate Region Timing (below) for the following analyses.

Analysis Function

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 tau	Time constant of 'Decay time'.
Decay time	10 - 90% decay (fall) time of "peak to end".
Frequency	Number of threshold crossings per second (Hz).
Max slope	Maximum slope of simple linear regression fit.
Max value	Value of largest positive sample.
Mean	Arithmetic mean of the samples.
Min value	Value of smallest sample.

[Only available when an output channel segment uses a 'Membrane Test' wave-form.]

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.

Rise tau	Time constant of 'Rise time'.
Rise time	10 - 90% rise time of "start to peak".

RMS noise	Root-Mean-Square noise.
Segment amplitude	Amplitude of the specified Out Channel Segment.
Segment duration	Duration of the specified Out Channel Segment.
Slope	Slope of a simple linear regression fit.
Std deviation	Standard deviation of the samples: $\sqrt{(variance)}$
Stimulus at absolute peak	Stimulus amplitude at time of the largest absolute sample.
Stimulus at max	Stimulus amplitude at time of the largest 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 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.
Variance	Variance of the samples.
Weighted tau	Weighted time constant. Area / Peak - y0 (based on end of measurement).

These 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 defining an Analysis measurement, through the Graph Settings axes source equations.

Note: The first sample point is used for any needed baselines.

[Status field] A short description of the selected Analysis.

Threshold — 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	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.

AP Duration [for AP Duration only]

[20, 30, 40, 50, 60, 70, 80, 90, 100 %]

The action potential amplitude-percentile setting, to calculate the associated AP Duration width.

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>
Sweep	#2	m[#]	<analysis function>	<analysis value>

…

Enable Smoothing

[2 – 200]

Set the number of Gaussian smoothing operations per measurement.

Smoothen noisy data to reduce the effects of high-frequency noise on measurements. Apply averaging to the data sample points with an unweighted sliding average.

Note: Smoothing is not applied to the analyses 'Segment duration' and 'Segment amplitude'. These are fixed values not subject to modification.

Signal to Analyze

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.

Region Timing

Cursors Relative to — Set the measurement boundaries with left / right cursors.

Cursor Start times cannot be greater than their End times.

Warning! 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.

You might need to adjust 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: [ ]

The 'Start Time' or 'End Time' spinners increment by this amount.

The listed time values depend upon the input filter bandwidth.

Reset Times — Set the cursor Start / End Time to the beginning and ending of the sweep.

Start Time — Set the left cursor start time (s).

End Time — Set the right cursor start time (s).

Lock Time step width

Fix the width of the measurement region.

The measurement width is maintained at a constant value when the cursor 'Start Time' is updated.

[ ] The width of the cursors in seconds.

The minimum width size is 2 sample points.

.

- 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 — [Output Channel list] [Segment #]

  Increment by — [0.001, 0.002, 0.005, 0.01, 0.02, 0.05, 0.1, 0.2, 0.5]

  Increment the Start/End Ratios by a relative amount.

  Reset Ratios — [0.0000 / 1.0000]

  Reset the Start / End Ratios to span the entire segment.

  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 — [0 = beginning of Segment]

  Set the left cursor as a ratio of the Segment duration.

  Time [0.0000 s] Cursor start-time read-only field.

  End Ratio — [1 = end of Segment]

  Set the right cursor as a ratio of the Segment duration.

  Time [0.0000 s] Cursor end-time read-only field.

  Note: If the Start / End Ratios extend past the boundary of a Segment, and the measurement is switched to a beginning or ending Segment, the Start / End Ratios are reset to '0' and '1' respectively.

  Cursor Time Width — The width of the measurement region is reported.

Warning! The various input and output sampling rates and time durations might not exactly match up with the measurement region. Please check for Segment boundary issues when performing measurements.

Graph Settings

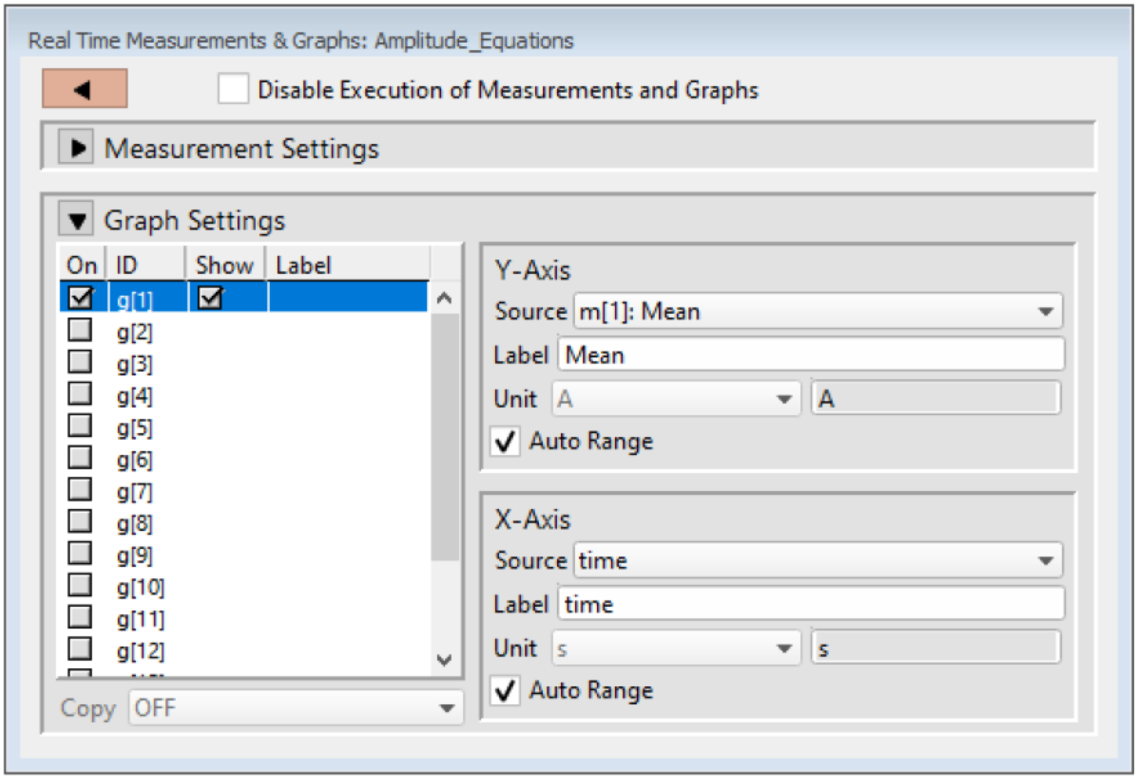


Figure 4-61. Real Time Graph Settings

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.
Copy	Use to transfer graph settings to a new graph. Highlight a Graph ID, then select from the drop-down list of enabled graphs.

Y-Axis

Source — 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 — A Y-axis label is automatically generated from the Measurement label. Directly edit to customize the Y-axis graph label.

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.

Auto Range — Restrict the graph Y-axis range.

Y-min	Lower limit of the Y-axis.
Y-max	Upper limit of the Y-axis.

<u>X-Axis</u>

Source — 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 — Enter a customized name for the X-Axis.

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.

Auto Range — Restrict the graph X-axis range.

X-min	Lower limit of the X-axis.
X-max	Upper limit of the X-axis.

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.

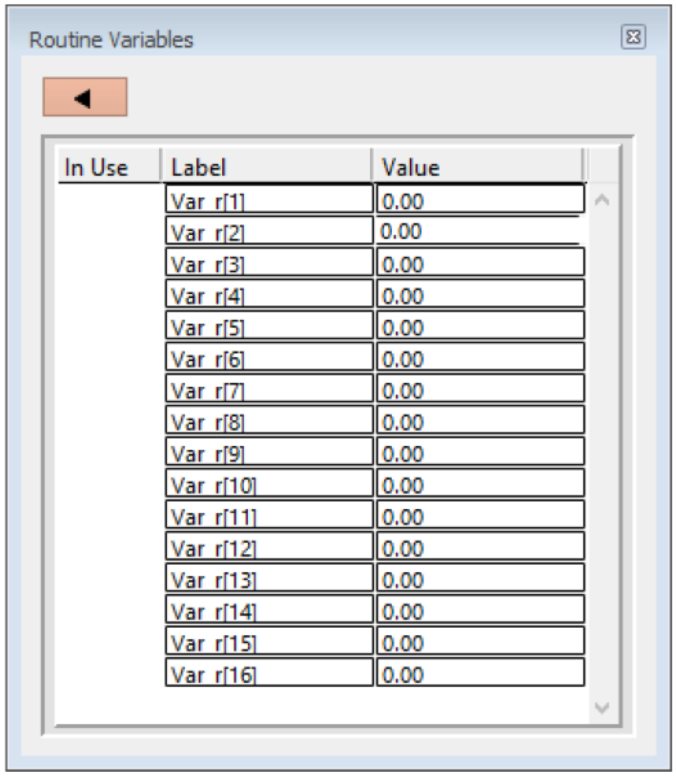


Figure 4-62. Routine Variables

Routine Variables

In Use	A checkmark means this 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

4.1.10 Solution Editor

SutterPatch: Solution Editor

Create a named list of solutions to control physical valves in solution changers and perfusion systems.

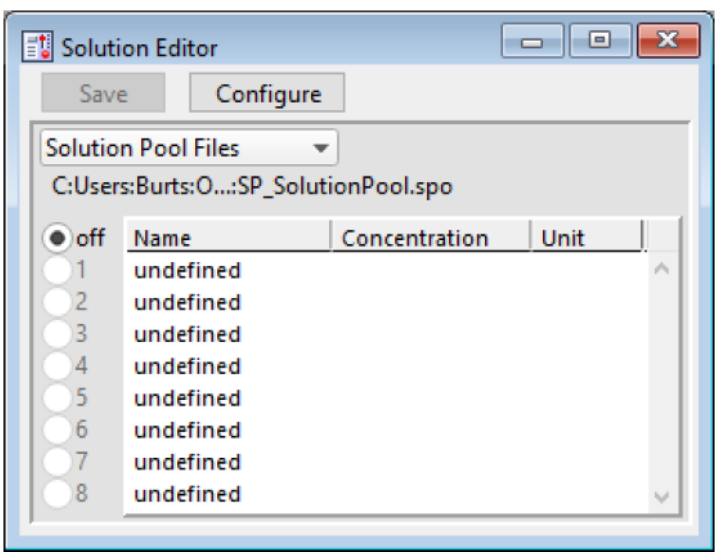


Figure 4-63. Solution Editor

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 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 filepath.
- 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.

[ ] — The pathname of the loaded Solution Pool file is displayed.

[off, 1 – #] — Select a "valve" radio button to open a valve. This activates its corresponding solution configuration. A radio button is 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.

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 the solution.

[Solution Type list] A list of predefined solution types.

- Initial Condition
- Washout
- Control

  Index [1 – 4] Distinguish between different Control solutions.
- Test Compound
- Not a Solution

[Output Channel] Select a physical output channel and set its value.

- No Output
- AuxOUT[1 – 4] [±10.000 V] Analog output voltage.
- DigOUT Word [0 – 255] Decimal value of an 8-bit digital word.
- DigOUT[1 – 8] A single digital bit is set “high”.

4.1.11 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.

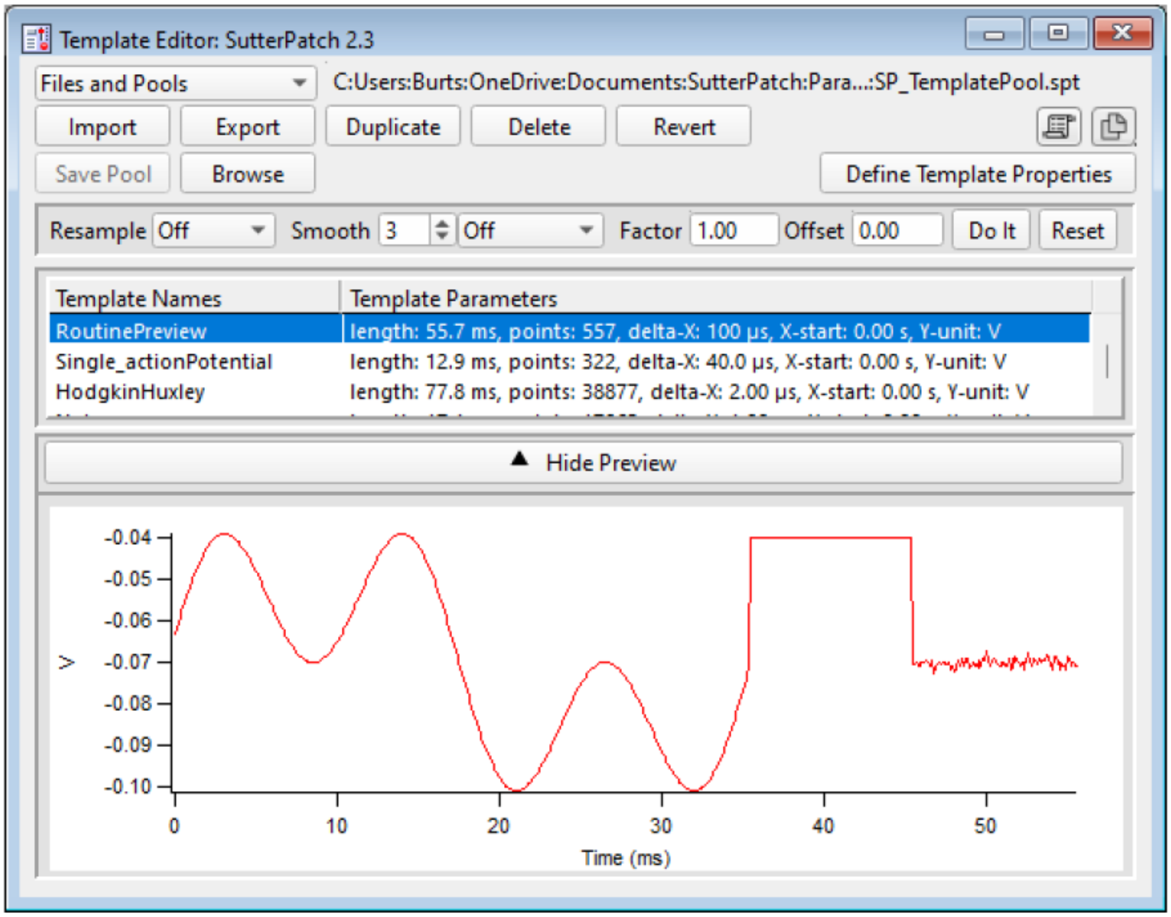


Figure 4-64. Template Editor

Note: Changes made in the Template Editor are only applied to Routines when the Routine Editor / Output Channels / Waveform Editor / 'Template wave' is used to copy the modified template in its Template Editor Pool list into the Routine.

Template Pool Files A Template Pool file (*.spt) can contain multiple defined Templates.

New Template Pool	Create a blank Template Pool.
Load Template Pool	Load the Templates of a previously saved Template Pool.
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.

[ ] The file path and file name of the loaded Template Pool file is displayed.

Import Select a template file (*.ibw).

Alternatively, 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.

Rename Edit the name of the selected template. Allowable characters are A-Z, a-z, 0-9, and "_". Special characters are not allowed; spaces are replaced by an underscore.

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.

Delete — Remove the selected template from the list.

Copy to Layout — Copy the selected template graph into a new Layout window, or append to an existing Layout page.

Copy to Clipboard — Copy the selected template graph to the system clipboard.

Save Pool — Save the template pool using its existing file name.

Browse — Create a template from the Experiment data in the Data Browser.

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	The Y-axis base unit (enclose between 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 — Apply smoothing to the template.

- 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.

Values are displayed with SI unit prefixes.

Offset — Adjust the template offset.

Values are displayed with SI unit prefixes.

Do It — Apply the adjustments to the template parameters.

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.

Template Parameters

Parameter settings description.

Show/Hide Preview — Display / Hide a preview pane with 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.

To measure X-Y data points or set a fitting range, select 'Toggle Cursor Info' from the right-click menu. (See 'Right-Click Menus' for scope windows.)

4.2 Data Analysis

Both online and offline data analyses are configured in these main SutterPatch Editors:

- Routine Editor (Real Time Measurements section)
- Paradigm Editor Note: For extra flexibility in performing data analysis, 'Execute' SutterPatch commands, Igor Pro analyses, or user-defined functions.

Additional online/offline plots can be configured via Scope window 'Measurements':

- Amplitude Histogram
- Color Plot
- Parametric Plot

Fitting can be applied to most displayed data.

Offline data processing is performed in the Analysis Editor:

- Average
- Concatenate
- Normalize

Offline analysis modules are provided via the Data Navigator 'Available actions':

- Action Potential Analysis
- Single-Channel Analysis
- Synaptic Analysis

Igor Pro also offers its own additional analyses in 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.

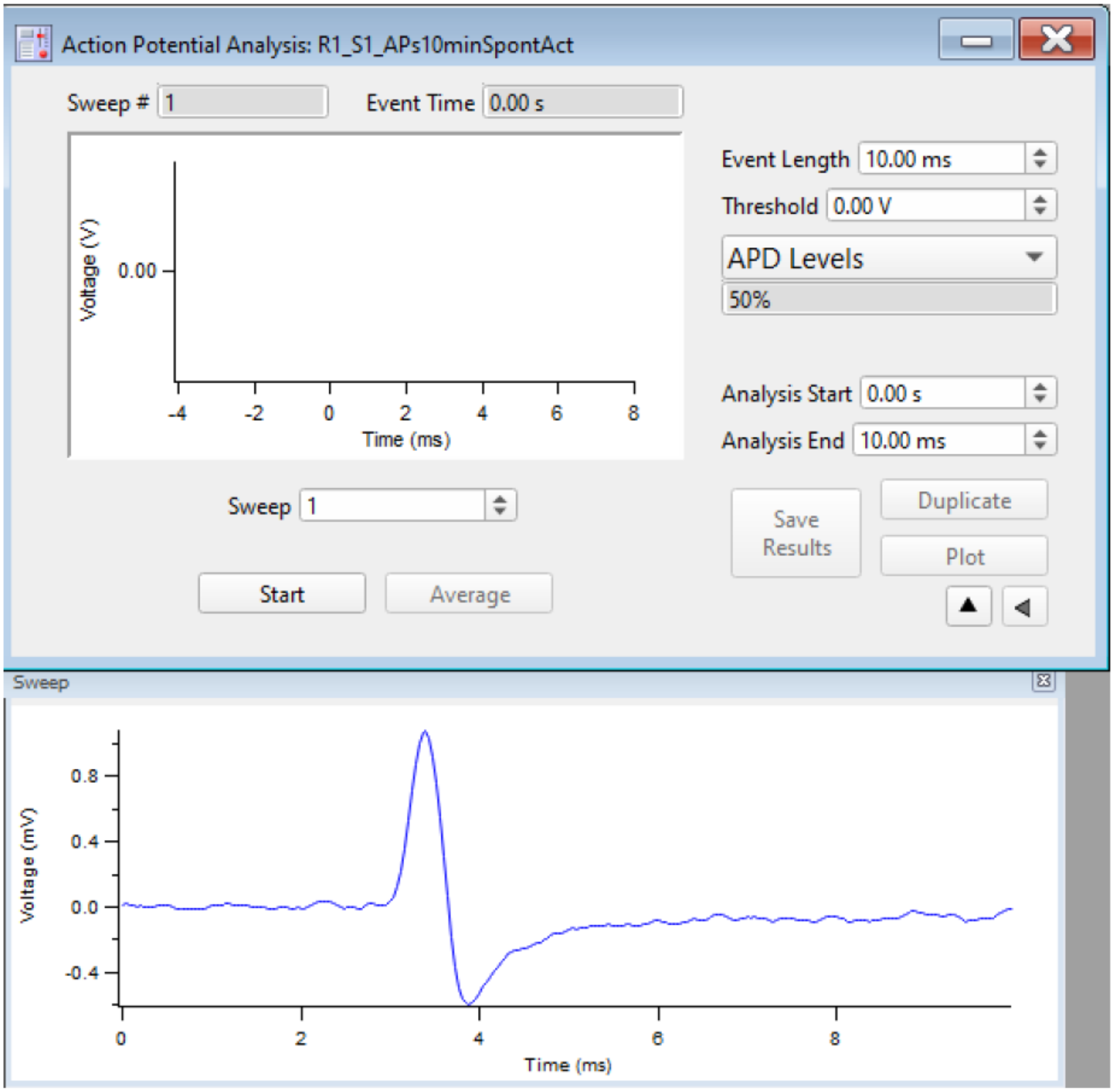


Figure 4-65. Action Potential Analysis

Sweep # — The sweep number of the selected action potential event.

The Sweep # is set to '0' when the Average event is displayed in the Event pane.

Pre-select sweeps for processing by "marking" them in a Scope window or the Data Navigator tree.

Event Time	Time point when the potential of the selected event crosses the threshold.
[Event pane]	A graph of the selected event, with the X-axis zero point reset to the Threshold point. To measure X-Y data points or set a fitting range, select 'Toggle Cursor Info' from the right-click menu. (See 'Right-Click Menus' for Scope windows.)
Event [# of #]	Event number vs. total events. Cycle through the analyzed events in the Event pane, with the event highlighted in red in the 'Sweep' pane,
or Sweep [#]	Cycle through the unanalyzed sweeps in the 'Sweep' pane.
[Sweep pane]	Displays a sweep of data colored in blue, with the selected event colored in red. To measure X-Y data points or set a fitting range, select 'Toggle Cursor Info' from the right-click menu. (See 'Right-Click Menus' for scope windows.)
Start	Click to find and analyze action potentials, and to display the Results pane.
Average	Click to display the averaged event (in Sweep # 0) in the Event pane. The Average Event Amplitude and plot are displayed in the Save Results layout window. Note: While the 'Sweep #' is set to '0' for averaged events, the last displayed Event # is unchanged.
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.
APD Levels:	Set the Action Potential Duration percentile(s). Measures the duration of an Event at percentiles of the event's repolarization amplitude. [20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 %] [Set to Default | Select All Odd | Select All Even]

Analysis Start (s)	[0+] 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.
Save Results	The latest results are displayed in the 'Action Potential Analysis Results' Layout window and a Results table window. Separate 'Average AP' and 'Phase plot' hidden graphs are also created, and can be accessed via menu item Windows / Graphs.

<u>Results table</u>

[ ]	Row number, one row per event.
Sweep Number	Sweep number the event is in.
Event Time (s)	Time point of the event start.
Threshold (V)	Amplitude of the event threshold.
Threshold Time (s)	Time point of the "trigger" threshold time.
Peak (V)	Amplitude of the event peak.
Peak Time (s)	Time point of the event peak.
AP Duration (s)	Duration of the action potential at the AP repolarization percentile.
AHP (V)	Peak amplitude of the 'After Hyper-Polarization' phase.
AHP Time (s)	Time point of 'After Hyper-Polarization'; the event re-crosses the threshold amplitude at this time.
Absolute Event Time	The absolute time of the event from the start of the recording.
Interevent Interval	The time between adjacent events.
Max Slope (V/s)	The maximum slope of the event.
Min Slope (V.s)	The minimum slope of the falling phase.
AP Duration @ n% (s)	The action potential duration at the selected APD level.

'Action Potential Analysis Results' Layout window

Signal Pathname:	The Igor Pro experiment pathname for the analyzed signal.
Analysis Prefix:	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 Sweeps analyzed:	Every sweep was 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.

Duplicate — Results are copied to a new Results table and a new Layout window.

Plot — The 'Plot sweeps' dialog displays to allow events to be plotted as overlapping sweeps in a floating graph window.

Plot sweeps — Enter a list of sweeps separated by a comma "," and/or a range of sweeps separated by a dash "-".

▲ — Show/Hide the Sweep pane (below).

Displays sweep of data colored in blue, with the selected event highlighted in red.

◄ — Show/Hide the Results pane (on the right).

Displays the Action Potential Measurements results.

Results pane Measurement results are displayed for the event selected in the main window.

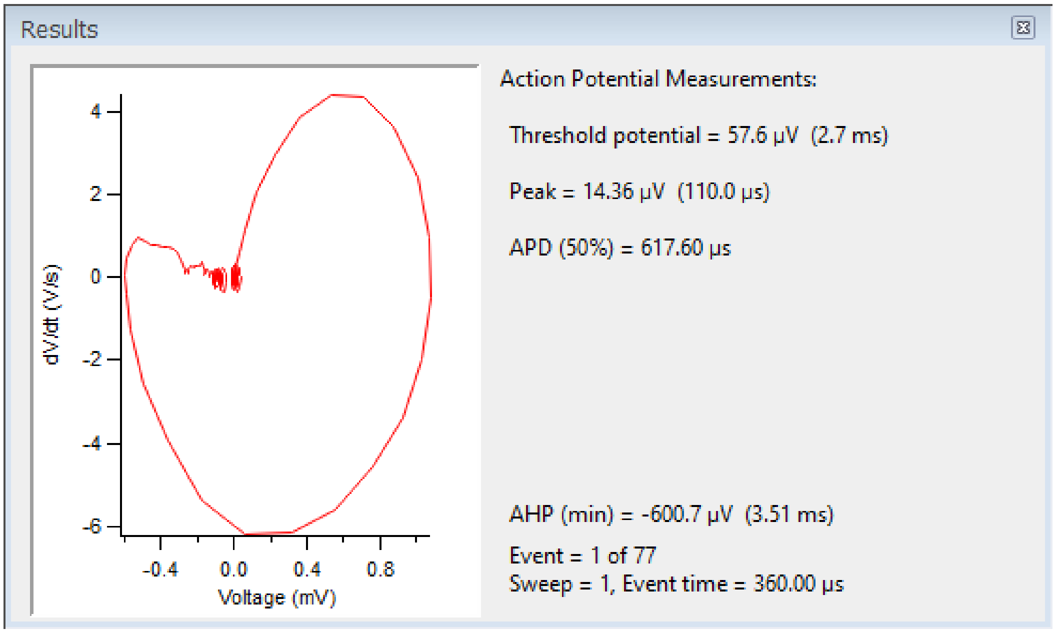


Figure 4-66. Action Potential Measurements

Phase plot A graph of the phase plot for visual inspection of the derivatives.

[dV/dt (V/s) vs. V] Y-axis vs. X-axis.

To measure X-Y data points or set a fitting range, select 'Toggle Cursor Info' from the right-click menu. (See 'Right-Click Menus' for Scope windows.)

Threshold potential = [V (s)]

Event starting amplitude (time from Threshold setting).

The actual start of the selected event (the biological starting amplitude), and its timepoint relative to the 'Threshold' setting timepoint.

See the Algorithms appendix for more information.

Peak = [V (s)]

The largest amplitude excursion of the event (time from 'Threshold' setting).

Two measures of an event's peak amplitude are reported, voltage and time. Time is reported relative to the 'Threshold' timepoint.

APD (%) = [%, s]

Action Potential Duration of the event at (n %) of amplitude repolarization.

AHP (min) = [V (s)]

The largest amplitude excursion of the "After HyperPolarization" phase of the event (time from 'Threshold' setting).

Two measures of the AHP amplitude are reported, voltage and time. AHP is when the action potential repolarization phase drops to its lowest point below the resting membrane potential, i.e., during the hyperpolarized refractory period of the cell.

[displays after 'Start', and when reviewing individual Events]

Event = The analyzed event (of the total number of events) found in the data.

Sweep = The sweep number of the analyzed event.

Event time = The sweep time of the start of the analyzed event.

[displays for 'Average' and 'Save Results']

Events found = The number of averaged events.

Event frequency = The average frequency of the found events.

4.2.2 Analysis Editor

SutterPatch: Analysis Editor

View and manipulate the data in your Experiment's various analyses and graphs.

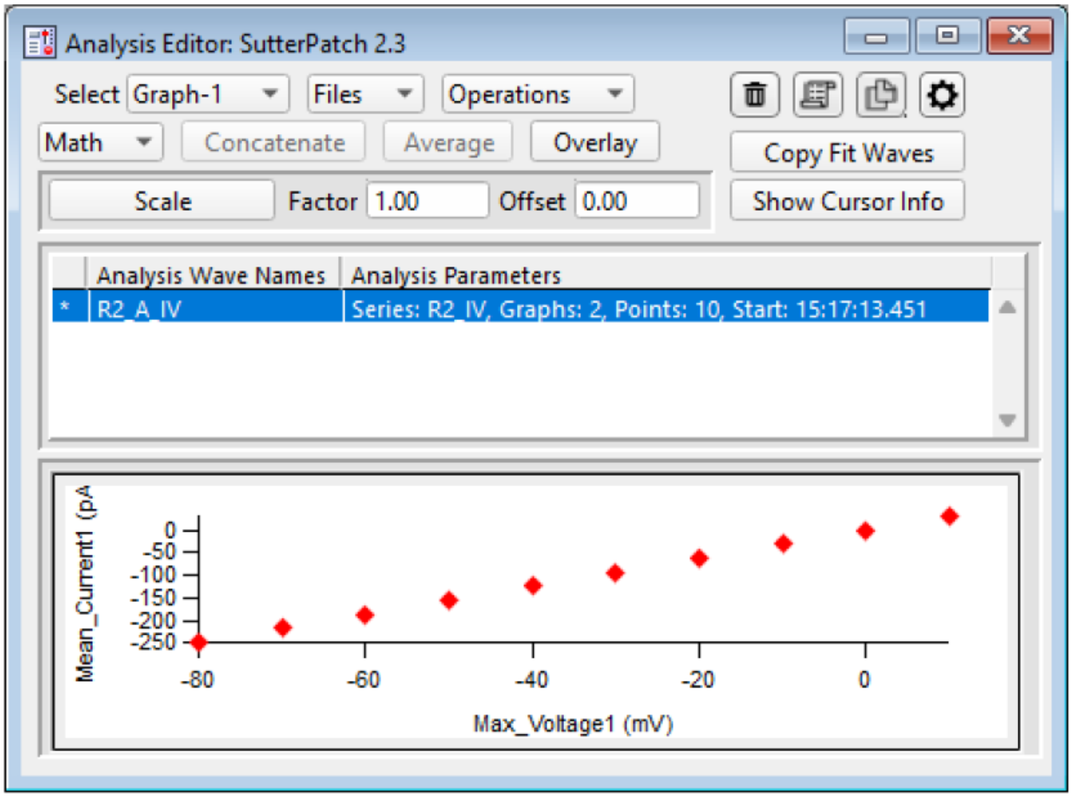


Figure 4-67. Analysis Editor

Select — Choose how to view the data.

Table — View a spreadsheet of the Analysis data

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 deleted later.

Top Row: Row Column numbers and value of the target cell

Source row: Dimension labels:

source routine name and source step number.

Header Row Analysis function measurement name.

Data Rows: Rows [0 – n]

[Columns for time-based graphs]

First Column: Row numbers.

Second Column:

"X \ Y" column label.

[has blank rows]

Column 0: X-data (Time) from the first graph: start times of the measurement sweeps.

Column 1: Y-data from the first graph: amplitudes of the measurements.

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]

First Column: Row numbers.

Second Column:

"Time" column.

Time data from the first graph: start times of the measurement sweeps.

Column 0: Y-data from the first graph: amplitudes of the Y-axis measurements.

Column 1: X-data from the first graph: amplitudes of the X-axis measurements.

Columns m – n:

For each additional X-Y graph, a pair of Y- and X-data columns repeat.

Note: The first data point is in row 0, so the last data point is in row [n – 1].

Row ‘n’ 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 cells, the row ungrays and the next row below is automatically grayed.

Graph-[1 – 8]	Select an Analysis graph for the selected data wave. The graph number refers to its original Analysis window position.

Files 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 wave file (*.ibw).
Export Graph Y-column	Save the Y-column data, including labels, as a one-dimensional 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.

Delete Analysis or Table — Click to delete the selected analysis or table. Hold <Shift> to delete without verification.

Copy to Layout — Copy the selected analysis graph or table into a new Layout window, or append to an existing Layout page.

Copy to Clipboard — Copy the selected analysis graph or table to the system clipboard.

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 the graph.
Show Markers	Display data points with marker symbols.
Show Lines	Display a line between data points.
Include Column Labels	Column labels appear on the first line of an exported table.

Operations

Duplicate	Insert a copy below the highlighted item.
Delete Graph 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.

Math [for Graphs]

Normalize: zero to maximum

Rescale the absolute value data, so the zero point is maintained in, or relative to the data, and the largest absolute point is set to 1.0.

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 1.0.

Tip: Use normalization to compare % of solution block.

Invert — Reverse the Y-axis sign of the data points.

Compute average of respective sweeps in a cycle

More than one full cycle of sweeps is required.

Compute average of all sweeps in a cycle

[for Tables]

Table selection average

Table selection sum

Append — Select an analysis wave for appending with the loaded wave. Time-course data are plotted relative to the loaded analysis wave's "time zero".

Average — Select an analysis wave 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 for the SEM algorithm.)

Overlay — Select multiple analysis waves (Ctrl-Shift in Windows) and plot them in the same graph. When only a single analysis wave is selected, all graphs in the Editor are overlaid.

The initial wave is plotted with standard "diamond" symbols, while the added selections are plotted with smaller "plus" symbols.

Copy Fit Waves

Copy all Quick Fits (from all open SutterPatch windows) into their own analysis waves in the Analysis Editor, so that they persist during the entire experiment, and also are saved with the experiment. Otherwise, uncopied Quick Fits disappear when another Analysis Editor analysis wave is selected, the Cursor pane is hidden, or the window is closed.

Scale and add

Use to combine available analysis waves, with optional scaling and offset applied.

When the Factor is '1.00' and the Offset is '0.00', this operation will simply add the selected wave to the 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 wave, change the Factor to a negative number.

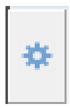
Offset — Set an offset for a data wave that will be added to the displayed data.

Values are displayed with SI unit prefixes.

Show/Hide Cursor Info

Open the Cursor bar to manually measure X-Y data values or to set a fitting range with Igor Pro cursor measurements. Hiding the Cursor Info pane, also hides any cursor symbols in the active pane.

Cursor Info pane

 Options menu

-  One Mover Moves All — Draggable cursor mover tool – move all cursors together with a single control.
- All Styles — Change the cursor symbol style.
- Show Cursor Pairs — Display up to 5 sets of cursor symbol pairs.

Cursor A

	Cursor symbol for data point ‘A’.
A:	Symbol letter (beginning cursor of the pair).
R1_A_IV	(Default) wave name.
	Draggable cursor mover tool for the cursor pair.
pnt:	Data point number (starting from zero).
X:	X-axis value of data point ‘A’.
Y:	Y-axis value of data point ‘A’.
ΔY	Difference of the cursor pair Y values.

Cursor B

	Cursor symbol for data point ‘B’.

B: Symbol letter (ending cursor of the pair).

R1_A_IV (Default) wave name.

 Draggable cursor mover tool for the cursor pair.

pnt: Data point number (starting from zero).

X: X-axis value of data point ‘B’.

Y: Y-axis value of data point ‘B’.

ΔX Difference of the cursor pair X values.

Cursor Instructions

1. Click on symbol A to enable it.
2. Manually drag the highlighted symbol onto a data point in the graph, or enter the data point number in the ‘pnt’ field.
3. Click on symbol B to enable it.
4. Manually drag the highlighted symbol onto a data point in the graph, or enter the data point number in the ‘pnt’ field.

   X- and Y-measurements are displayed for the cursor pair data.
5. Fitting can also be applied to the cursor pair data. Right-click in the graph, and select ‘Quick Fit’ for a list of built-in Igor fitting functions.

   The fit is displayed in the graph, and the fitting information is written to the Command window.

Analysis Wave Names

Loaded analyses available for manipulation.

Analysis 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.
- 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 & Table pane]

Data point markers are plotted, or a numeric table is displayed.

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 'Toggle Cursor Info' from the right-click context menu. (See 'Show/Hide Cursor Info' above.)

4.2.3 Analysis Window

Scope measurements are plotted in an Analysis window docked on the right side of the Scope window. An Analysis window can be resized or closed, but not undocked from the Scope window.

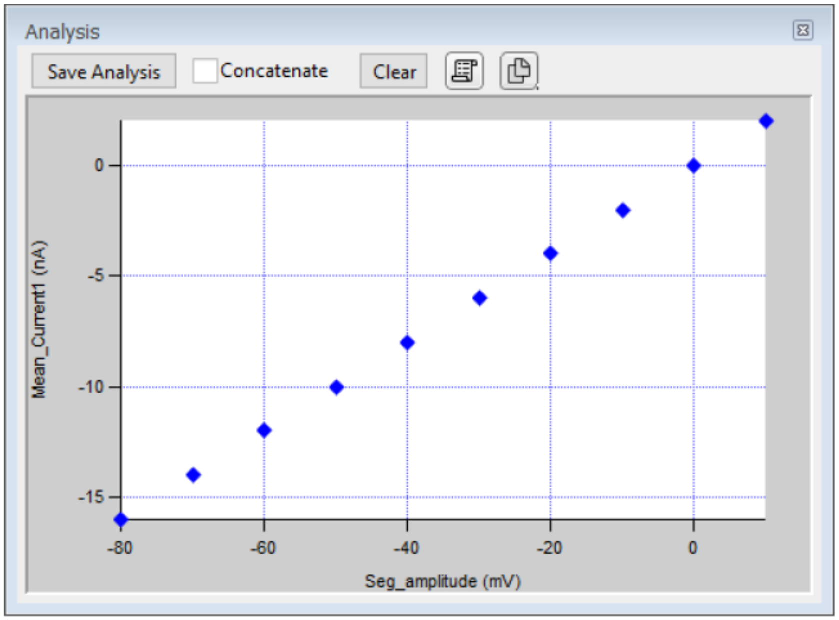


Figure 4-68. Analysis Window

Online measurements are plotted during data acquisition in real-time. Online analysis measurements are 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 offline 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.

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 — Display new measurements along with the previous measurements.

[when docked to a Scope window]

Clear — Erase all measurements from the graph display.

 Copy to Layout — Copy the analysis graphs into a new Layout window, or append to an

existing Layout page.

 Copy to Clipboard Copy the analysis graphs to the system clipboard.

[Graph panes]

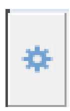
The Graph pane X and Y-axes can be magnified to be larger or smaller. Place the mouse cursor in the axis ticks region (do not include the tick labels or numbers), then scroll the mouse wheel up or down.

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.

To manually measure X-Y data values or to set a fitting range with Igor Pro cursor measurements, right-click in the graph to display a data modification menu and select 'Toggle Cursor Info'. The 'Cursor Info' pane displays.

Select 'Toggle Cursor Info' again to hide the Cursor Info pane, and any cursor symbols in the active pane.

<u>Cursor Info pane</u>

 <u>'Options' menu</u>

-  One Mover Moves All
  Draggable cursor mover tool moves all cursors together with a single control.
- All Styles — Change the cursor symbol style.
- Show Cursor Pairs — Display up to 5 sets of cursor symbol pairs.

Cursor A

 Cursor symbol for data point 'A'.

A: Symbol letter (beginning cursor of the A/B pair).

R1_A_IV (Default) wave name.

 Draggable cursor mover tool for the cursor pair.

pnt: Data point number (starting from zero).

X: X-axis value of data point ‘A’.

Y: Y-axis value of data point ‘A’.

ΔY Difference of the cursor pair ‘Y’ values.

Cursor B

 Cursor symbol for data point ‘B’.

B: Symbol letter (ending cursor of the A/B pair).

R1_A_IV (Default) wave name.

 Draggable cursor mover tool for the cursor pair.

pnt: Data point number (starting from zero).

X: X-axis value of data point ‘B’.

Y: Y-axis value of data point ‘B’.

ΔX Difference of the cursor pair ‘X’ values.

<u>Cursor Instructions</u>

1. Click on symbol A to enable it.
2. Manually drag the highlighted symbol onto a data point in the graph, or enter the data point number in the ‘pnt’ field.
3. Click on symbol B to enable it.
4. Manually drag the highlighted symbol onto a data point in the graph, or enter the data point number in the ‘pnt’ field.

   X- and Y-measurements are displayed for the cursor pair data.
5. Fitting can also be applied to the cursor pair data. Right-click in the graph and select ‘Quick Fit’ for a list of built-in Igor Pro fitting functions.

   The fit is displayed in the graph, and the fitting information is written to the Command windows.

Note: When applied to Analysis windows, the same Quick Fit is applied to all panes selected for fitting.

4.2.4 Data Browser

Data: Data Browser

The Data / 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.

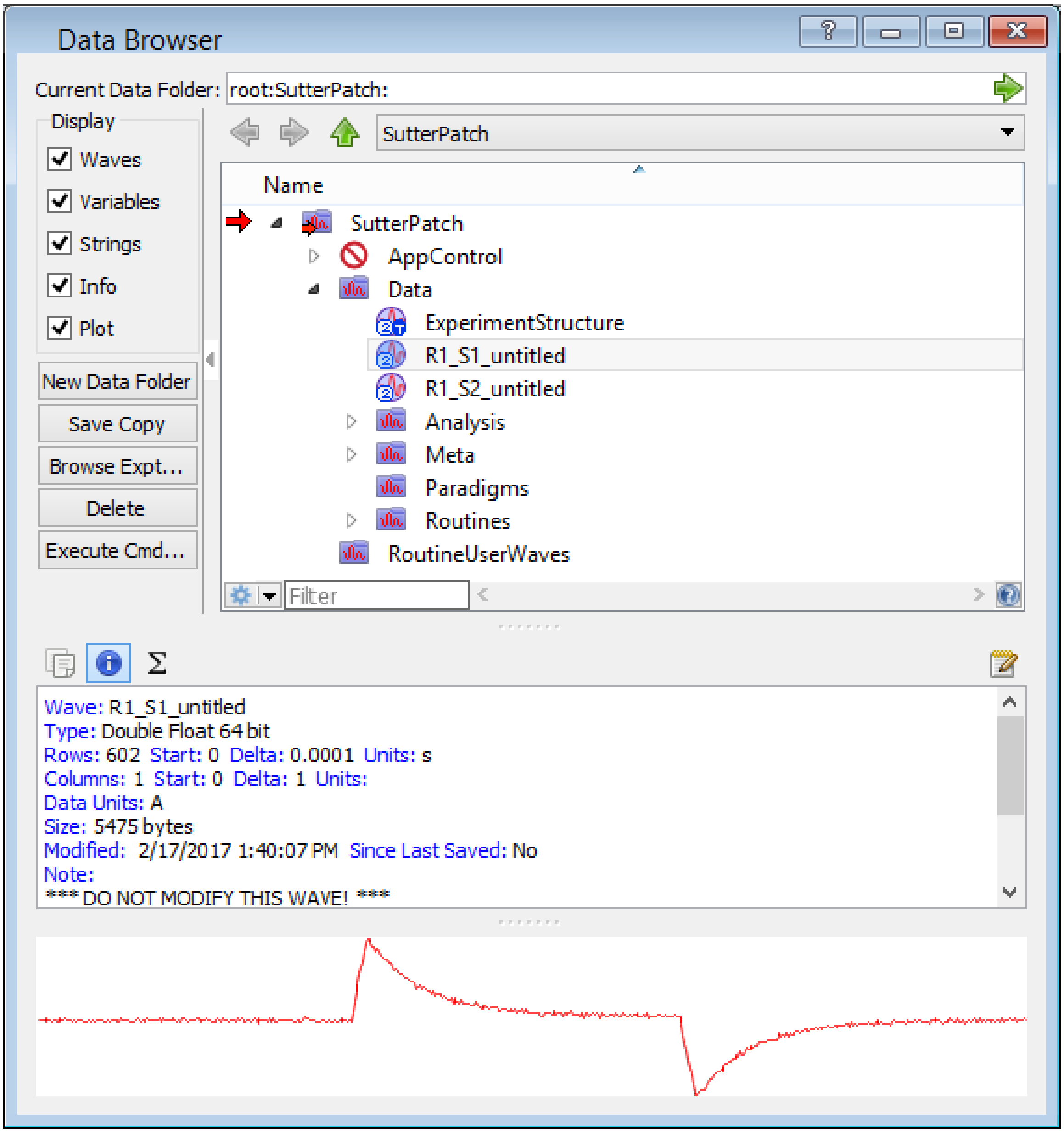


Figure 4-69. Data Browser

Objects are displayed in a tree structure, using a path "root" of 'SutterPatch'.

Warning! If this window is kept open during data acquisition, the Experiment can unexpectedly terminate.

For the macOS: opening and closing windows can take a long time.

The 'Data' subfolder contains recorded data waves, arranged per Signal.

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 is available.

Right-click Menu

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 will permanently alter the raw data. Modify at your own risk!

Copy Full Path Copy the object's path to the clipboard. This is in relation to an internal (hidden) Igor Pro data folder, not the computer's file system. This path 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 current Experiment.

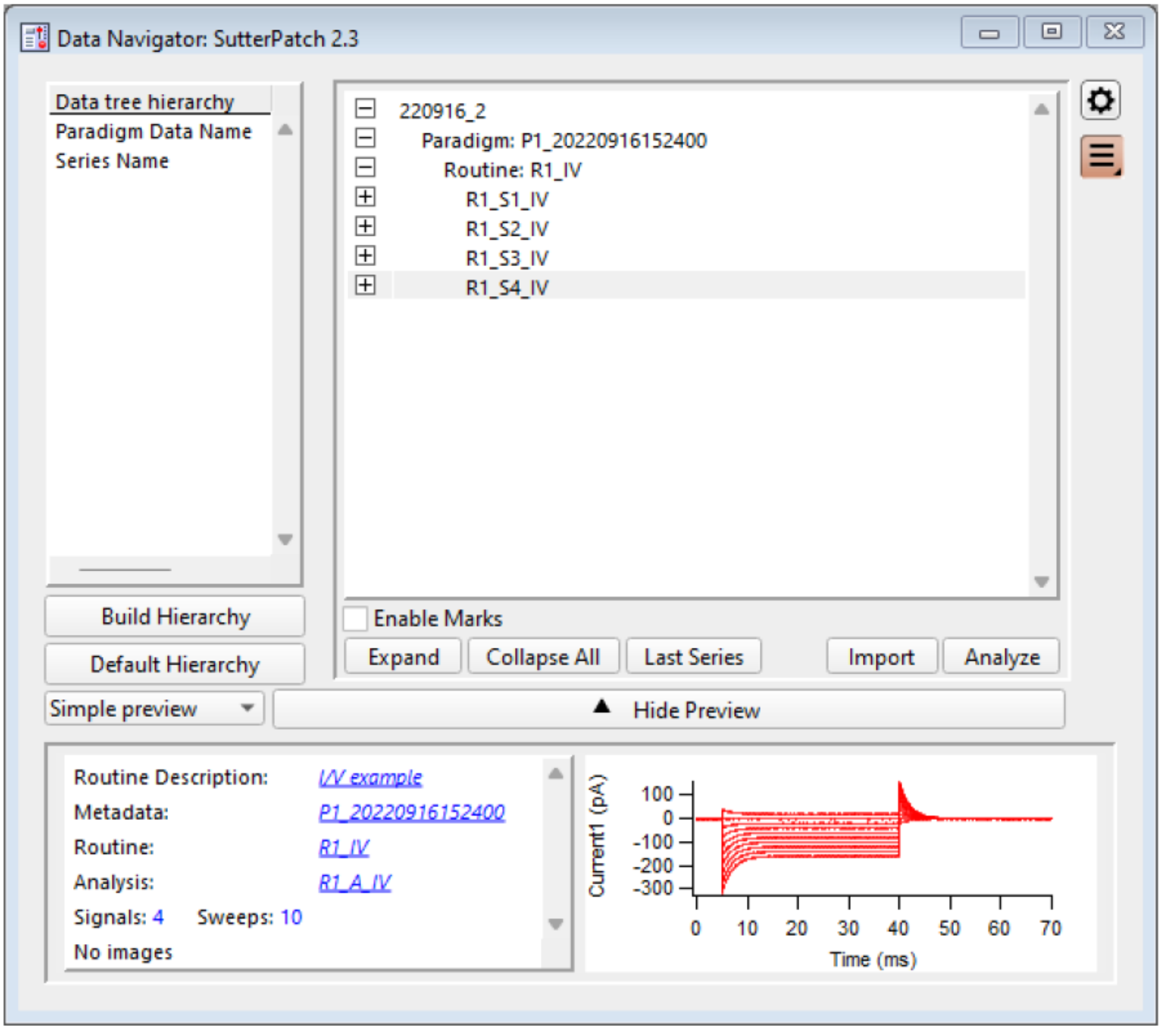


Figure 4-70. Data Navigator

Data tree hierarchy — The hierarchy of sorting levels is displayed in this pane.

Build Hierarchy — Re-organize the data tree using custom settings.

Select parameter group — Organize by metadata parameters:

[Parameter availability depends on the selected 'Set Preferences / Metadata' detail level.]

All Categories

Frequently Used

	Experiment Hierarchy 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	Click on a specific parameter from the selected group.
	Click on the “copy” button to insert the selected parameter above the highlighted level in the Hierarchy pane.
Hierarchy	The Hierarchy pane displays the new sorting hierarchy for the current Experiment.
	Remove the selected parameter from the list.
	The sorting levels can be re-organized by selecting an entry and clicking on the Up/Down keys to reposition it, or using the ‘Del’ key to remove it.
Do It	Click on the ‘Do It’ button to apply these changes to the data tree.
Default Hierarchy	Restore the default experimental hierarchy: Paradigm > Routine (> Signal > Sweeps)

Data Tree Window

The current Experiment's data are arranged in the data tree in five default levels:

Experiment

Paradigm

Routine

Signal

Sweep

Selecting a node in the data tree highlights it in blue.

Enable Marks

Allow data to be marked in the data tree or Available Actions menu for processing.

Marks enabled

- Node selected and marked.

  All levels and nodes below it included for processing.

- Node selected and unmarked.

  Only marked levels and nodes below it included for processing.

Marks disabled

- Node selected.

  All levels and nodes below it included for processing.

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 selection, shift-click on the ending selection.

Clear a range: Highlight an unmarked starting selection, shift-click on the ending selection.

Expand

All nodes of the data tree are expanded down to the Signal level.

To expand a node to the next lower level, with a mouse click on a "+" node, or double-click the node name. With a keyboard, use the up/down arrow keys to select a "+" node and press the space key.

Collapse All — All nodes of the data tree are collapsed up to the Paradigm level.

To collapse the lower levels of a node, with a mouse click on a "-" node, or double-click the node name. With a keyboard, use the up/down arrow keys to select a "-" node and press the space key.

Last Series — The last Routine's first signal is highlighted in the data tree and displayed in the Preview pane.

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 in an Experiment cannot be re-imported. For an Experiment file, only data are imported, i.e., no graphs or layouts.

Note: Imported Routine names are truncated to a maximum length of 28 characters, and special characters are replaced by an underscore.

- Import Igor Experiment File

  The same data set (Experiment) cannot be imported twice.

  When a Series name already exists in the Data Navigator, imported Series are renamed to avoid conflicts.

- Import SutterPatch HDF5 Data File

- Import PatchMaster Data File

  [This option 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.]

  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 pClamp Data File

[This option 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.]

Import pCLAMP ABF version 1 and 2 data files.

Supported pCLAMP acquisition modes are 'Episodic Stimulation' and 'Gap-free' (equivalent to SutterPatch Clock Triggered modes 'Triggered Sweeps' and 'Continuous Sweeps').

- Import Image File

Review [for Paradigms]

Its signals are displayed in a Scope window as continuous data.

Note: This button changes to the Analyze button when a Routine, signal or sweep is selected,

Analyze [for Routines, Signals, Sweeps]

The Routine's signals are displayed in the Reanalysis Scope window and Measurements analysis is run.

Note: This button changes to the Review button when a Paradigm is selected or marked.

Simple preview / Full preview

[for Paradigms and Routines]

A "simple" preview displays a thumbnail sketch of the first signal's first Series (or sweep) of data, to the right of the preview information section.

A "full" preview displays all signals and Series in an attached pane.

Show Preview / Hide Preview

The displayed Preview information items are based upon the selected data tree level.

Note: The Data Navigator Preview pane does not support mouse operations.

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.
Images:	Open any saved images. The image preview window text Note is editable.

Simple preview

[Preview sub-pane]	Displays a thumbnail image of the first signal of the first Routine.

Full preview

Paradigm Preview window	Displays all signals and all Routines in continuous mode in a docked Paradigm Preview window.

Routine

Routine Description:	Displays the Routine description text. Click to edit.

Metadata:	Click to display the Routine's metadata in a docked sub-window.
Routine:	Click to display the 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 any saved images. The image preview window text Note is editable.

<u>Simple preview</u>

[Preview sub-pane]	Displays a thumbnail image of the first signal of the selected Routine.

<u>Full preview</u>

Routine Preview window	Displays all signals in the Routine in continuous mode in a docked window.

<u>Signal</u>

[Preview pane]	Displays a thumbnail image of the selected Signal.

<u>Sweep</u>

[Preview pane]	Displays a thumbnail image of the selected Sweep.

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

Review in Concatenated Display Mode

Review in Time Course Display Mode

 Available Actions button

A menu lists various actions for the marked and highlighted data levels. These actions are also available via a right-click on the selected data level.

<u>Experiment</u>

Copy Signal Data Paths   Copy the Series internal Igor Pro path to the system clipboard:

root:SutterPatch:Data:Series_name

Export Data (See Preferences)

Export all marked data in the Experiment to file(s).

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 older file via the OS file browser.

Analyze All Routines / Analyze All Marked Routines

Run the reanalysis on all [marked] Routines in the Experiment.

[select options to be applied by this Action]

Store Analysis Waves	Append results to the Analysis Editor pool.

Copy Analysis Results to Clipboard

Copy Analysis Graphs to Layout Page

[the following options display when ‘Enable Marks’ is checked]

Mark All Paradigms	All Paradigms in the Experiment are marked.
Unmark All Paradigms	All Paradigms in the Experiment are unmarked.
Mark All Routines	All Routines in the Experiment are marked.
Unmark All Routines	All Routines in the Experiment are unmarked.
Mark All Signals	All signals in the Experiment are marked.
Unmark All Signals	All signals in the Experiment are unmarked.
Mark All Sweeps	All sweeps in the Experiment are marked.
Unmark All Sweeps	All sweeps in the Experiment are unmarked.

Set Routine Marks by Name Match

Opens the ‘Routine Mark: Name Match Editor’ to enter the Routine name to mark.

Set Sweep Marks by Equation

Opens the ‘Sweep Mark: Equation Editor’ to enter an equation for the sweeps to mark or unmark.

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)

Paradigm

Review Paradigm

Display all Series (with all signals and sweeps) in the Paradigm. Each signal displays in a pane in a Paradigm Review window.

Note: This action is not supported with the HDF5 file preference “Keep only one Sweep in Memory”.

Average Marked Sweeps

The average sweep of all marked sweeps is copied to the Analysis Editor.

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 displays if ‘Enable Marks’ is disabled; only executes for “planned” Paradigms]

Display the steps from the selected Paradigm in a ‘Paradigm Steps Review’ window.

The Paradigm steps can be copied to the system clipboard. Hold the <Shift> key when clicking, to remove the line counts and step formatting.

The Paradigm can also be copied to the Paradigm Pool,

Edit Paradigm Description

[only displays if ‘Enable Marks’ is disabled; only executes for “planned” Paradigms]

Add or alter Paradigm Description text in the Preview window. Changes are appended to the metadata as tags.

Copy Signal Data Paths

Copy the Series internal Igor Pro path to the system clipboard:

root:SutterPatch:Data:Series_name

Export Data (See Preferences)

Export the marked Paradigm data to file(s).

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 older file via the OS file browser.

Discard Paradigm

Remove the marked Paradigms and their data from the Experiment.

If the last Paradigm is discarded, 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 Routines / Analyze All Marked Routines

Run the reanalysis on all [marked] Routines in the Paradigm.

[Select options to be applied by this Action]

Store Analysis Waves — Append results to the Analysis Editor pool.

Copy Analysis Results to Clipboard

Copy Analysis Graphs to Layout Page

[the following options display when 'Enable Marks' is checked]

Mark All Routines	All Routines in the Paradigm are marked.
Unmark All Routines	All Routines in the Paradigm are unmarked.
Mark All Sweeps	All sweeps in the Paradigm are marked.
Unmark All Sweeps	All sweeps in the Paradigm are unmarked.

Set Routine Marks by Name Match

Opens the ‘Routine Mark: Name Match Editor’ to enter the Routine name to mark.

Set Sweep Marks by Equation

Opens the ‘Sweep Mark: Equation Editor’ to enter an equation for the sweeps to mark or unmark.

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)

Routine

Analyze Routine	Display the marked sweeps of all signals in the highlighted Series in a Reanalysis scope window.
Review Routine	Display all signals (with all sweeps) from the highlighted Series. Each signal displays in a pane in a Routine Review window. 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 Paradigm Description	[only displays if 'Enable Marks' is disabled; only executes for "planned" Paradigms] Add or alter Paradigm Description text in the Preview window. Changes are appended

	to the metadata as tags.
Copy Signal Data Paths	Copy the Series internal Igor Pro path to the system clipboard: root:SutterPatch:Data:Series_name
Show in Data Browser	Open Igor Pro's Data Browser window to examine the highlighted Series' data waves.
Export Data (See Preferences)	Export the marked Series to file(s). 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 older file via the OS file browser.

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 analysis waves are still open when trying to discard the Routine, an error message will display. To fix, close any associated Graph or Layout windows found in the main menu Windows / Graphs (or Layouts).

Concatenate Sweeps — Combine all sweeps into one sweep.

Restore concatenated Sweeps — Convert the concatenated sweep back to the original sweeps.

[the following options display when ‘Enable Marks’ is checked]

Mark All Signals — All signals in the Series are marked.

Unmark All Signals — All signals in the Series are unmarked.

Mark All Sweeps — All sweeps in the Series are marked.

Unmark All Sweeps — All sweeps in the Series are unmarked.

Set Sweep Marks by Equation

Opens the ‘Sweep Mark: Equation Editor’ to enter an equation for the sweeps to mark or unmark.

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)

Signal

Action Potential Analysis	Analyze action potentials from the marked sweeps of the highlighted signal.
Single Channel Analysis	Analyze single-channel Events from the highlighted signal.
Synaptic Event Analysis	Analyze synaptic Events (EPSPs, minis, etc.) from the marked sweeps of the highlighted signal.

Analyze Routine	Display all signals in the Series and their marked sweeps in a Reanalysis Scope (window.
Edit Signal	Display all sweeps of the highlighted signal as numeric columns in an editable table.
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.
Average Marked Sweeps	Average the marked sweeps from the highlighted signal and display in the Analysis Editor.
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 Data Path	Copy the Series internal Igor path to the system clipboard: root:SutterPatch:Data:Series_name
Show Data in Data Browser	Open Igor's Data Browser window to examine the highlighted signal's data waves.
Export Data (See Preferences)	Highlighted signal: export the marked sweeps in the signal. Marked signal: export all sweeps in the signal, 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 older file via the OS file browser.

[the following options display when 'Enable Marks' is checked]

Mark All Sweeps	All sweeps in the Series are marked.
Unmark All Sweeps	All sweeps in the Series are unmarked.

Sweep

Extract Sweep	Create a graph of the highlighted sweep in the Analysis Editor.
Display Sweep	Display the highlighted sweep in a graph window.
Export Data (See Preferences)	Export the highlighted sweep. (To export a portion of a sweep, use the Template Editor.) 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 older file via the OS file browser.

[the following options display when 'Enable Marks' is checked]

Mark All Sweeps	All sweeps in the Series are marked.
Unmark All Sweeps	All sweeps in the Series are unmarked.

4.2.6 Data Table

The Data Table provides direct access to the sample points in a data Series, using a spreadsheet-style presentation.

Table0:R1_S1_IV

R0 C0 | 5.2332054e-12

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 4-71. Data Table

Warning! Editing data permanently alters the raw data. Modify at your own risk!

Data Tables are accessed from the Data Navigator by highlighting a data Series, and selecting its Action menu ‘Edit’ command, or by right-clicking on it and selecting the ‘Edit’ command. 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.

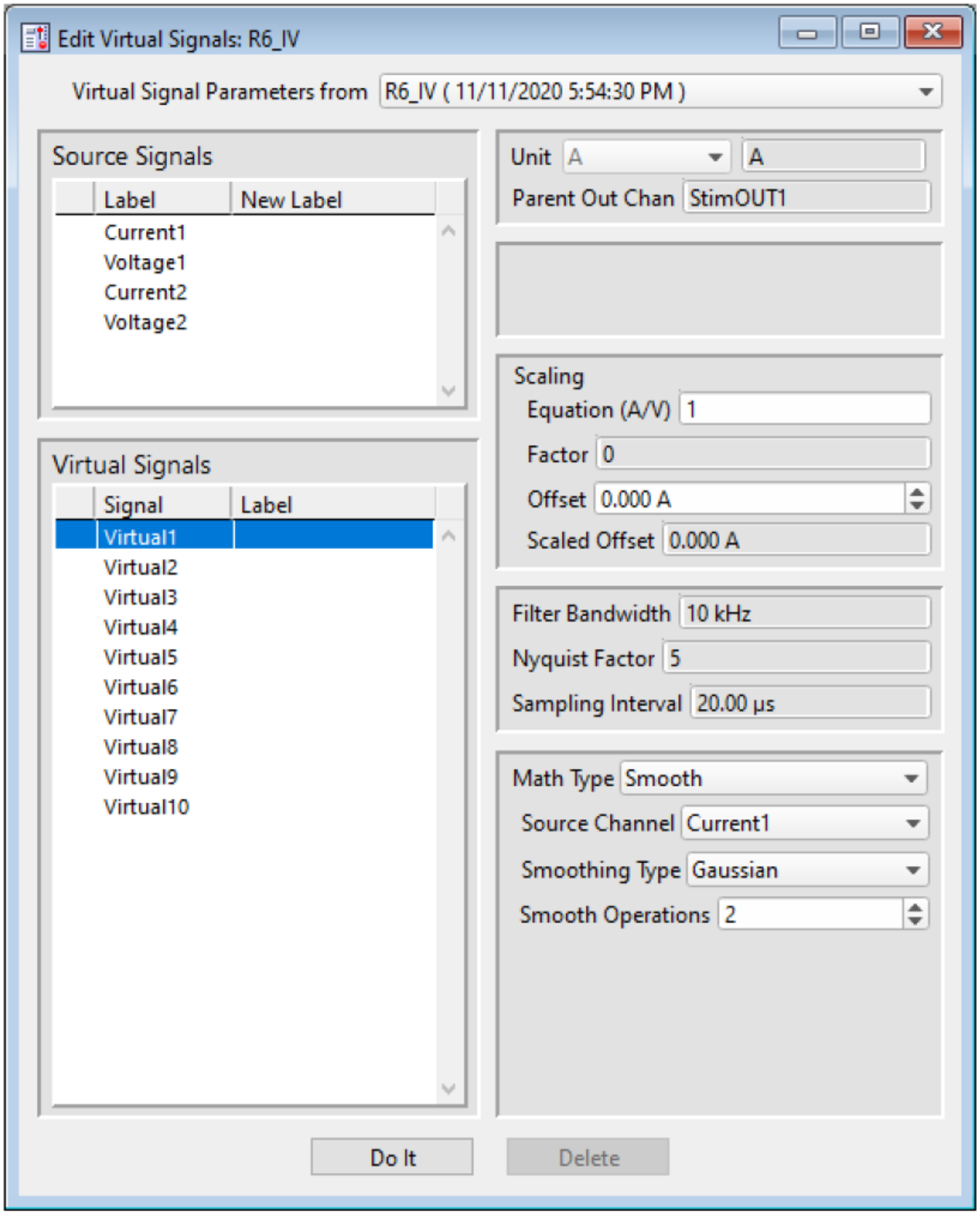


Figure 4-72. Edit Virtual Signals

Virtual Signal Parameters from

- [<Series name> (date/time stamp)]
- Overwrite with Original Routine

<u>Source Signals</u>

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 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.

<u>Virtual Signals</u>

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,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 — The base unit of measurement from its Source signal. The resolution of the unit is automatically adjusted in the signal.

Parent Out Chan

The “Parent Output Channel” shows which output channel is associated with which input channel.

Scope Position

Signal Action

- None
- Show
- Hide
- Move to >> [signal name]

<u>Scaling</u>

Equation — Apply scaling to interpret the input signal data. Specify as a numeric value or an equation for the scaling ratio.

Factor — [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.

Offset — Apply an amplitude offset to the input signal (after any scaling).

For “mV” units, append with ‘m’ or ‘e-3’.

For “pA” units, append with ‘p’ or ‘e-12’.

Example:	5 picoamps using engineering notation:	5p
	or in equivalent scientific E-notation:	5e-12

Scaled Offset — Raw offset values converted to input units.

[for AuxIN channels]

Sampling Interval

The duration of a single data sample.

Math Type 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 an offset or resetting a baseline.

Source Channel Select an input channel to process.

Baseline From 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 Select an input channel to filter.

  Filter Bandwidth Select a frequency range.

  - LowPass 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.

  Filter Order [1, 2, 4, 8]

  Number of “poles” in the filter.

  Cutoff Frequency (Hz)

  [100 to < ½ the sampling rate]

  Restrict frequencies from this boundary point onwards.

  Integrator Reset [for Capacitive Mode]

  - Ignore Capacitive-mode transients are displayed in the data.

  - Blank 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 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]

    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.

  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.

  Source Channel — Select an input channel to process.

  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.

  Errors 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".

  Insert special identifier

  Special references can also be used within commands:

- p[#] n’th Paradigm variable.

- s[series-count, sweep-count, trace-count, routine name]

  Access an arbitrary input trace (data wave) via counts of Series #, Sweep #, Trace # (Scope Position), and the Routine name.

  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.

  If the routine name is left blank, the current routine name is used.

  Ex: s[0,0,0,]

  The current series, current sweep, current trace, of the current routine.

- t[#] 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.

Undo All changes in the equation editing session are discarded.

(See the Equation Editor for more details.)

Limit to Marked Sweeps

Enable to limit this analysis to marked sweeps.

- Integrate — Display the integral of the data signal. This is equivalent to the signed area under a curve.

Source 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.

  This feature is only enabled when the Routine includes an output channel with P/N Leak Pulse enabled.

Source Channel	Select an input signal to process.
Show Leak	Display the accumulated leak currents after the subtracted data in a sweep. Display the average of the leak sub-pulses.
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. 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 current of the main signal.

- LineFreq — Remove AC line frequency noise (hum) from the data signal.

Source Channel	Select an input channel for noise reduction.	
Line Frequency	60 Hz	Canada, (Caribbean), Central America, (Japan), Mexico, (South America), South Korea, Taiwan, USA. Some (regions) include both 50 Hz and 60 Hz frequencies.

50 Hz	Most of rest of world.

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.

- LockIn — Measure cell characteristics (such as membrane capacitance) with high signal-to-noise sensitivity, using a dual-phase software lock-in amplifier.

  Note: This feature is only enabled when the Routine includes 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'.

  Current Channel — Select a (source) input channel with a "current" signal.

  Trace 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 the SutterPatch Algorithms appendix)

- Smooth — Smooth the data with a “moving average” noise-reduction filter.

  Source Channel — Select an input channel to smooth.

  Smoothing 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 – 99]

    # of points in boxcar sliding window.

    Note: For best performance, only odd values are used.

  Integrator Reset [for Capacitive Mode]

  - Ignore — Capacitive-mode transients are displayed in the data.

  - Blank — 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 — 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]

  The default value of 500 μs should be sufficient to encompass the reset transient duration.

- Stimulus — Replicate the command waveform.

  Source Channel — Select an input channel – the waveform from its Parent Out Chan is used.

- SweepAverage

  Average the input traces.

  Source Channel — Select an input channel to average.

  Average Type — Cumulative

  Average all processed sweeps together.

  RunAverage

  Average the last “N” sweeps.

  Number of Sweeps.

  Limit to Marked Sweeps

  Enable to limit this analysis to marked sweeps.

- SweepSubtract

  Subtract a sweep from the input trace.

  Source 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.

Access the Equation Editor from the SutterPatch menu.

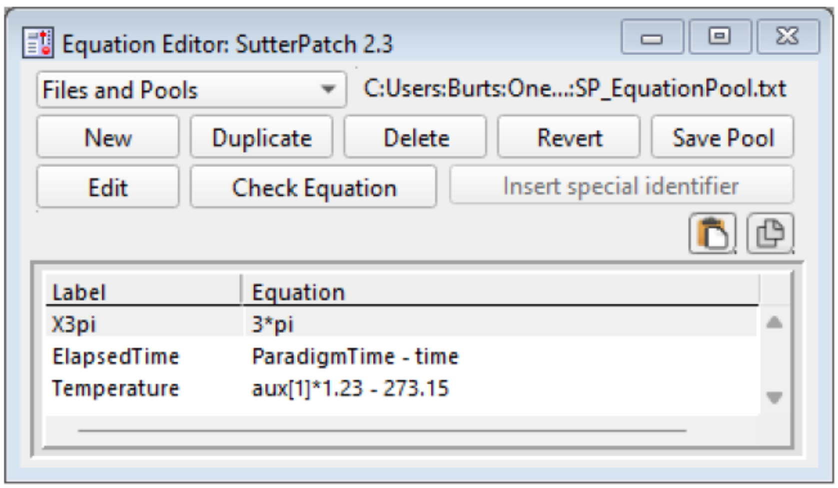


Figure 4-73. Equation Editor

Equation Pool Files	Equations are created and saved in an Equation Pool file.

New Equation Pool	Create a blank Equation Pool file.
Load Equation Pool	Load the Equations of a previously saved Equation Pool file into the Equation Pool.
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 Equation from a previously saved Equation Pool file into the loaded Equation Pool.

Note: Equation Pool files are simple text files (*.txt) that can be directly edited.

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	The equation is evaluated (for sweep #1), and if valid, it reports "Syntax is ok".
Label	Column of editable equation names, for quick usage in place of the equation.
Equation	Column of equations in free-form text fields.

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 numeric equations in free-form text fields, that evaluate as math expressions. Equations are limited to a maximum of 80 characters, including white space.

Special Identifiers List

SutterPatch acquisition, analysis and reference selections are appended to the equation with a "plus" sign.

Timing

Tme	(present date-time, s)
Timer	(timer time, s)
ParadigmTime	(time at start of paradigm, s)
RoutineTime	(time at start of routine, s)

<u>Paradigm Parameters</u>

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: Compare 'sweep' numbers in a ForEachSweep loop in a Paradigm 'If' step:

```
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)

p[1..16] (n'th paradigm variable)

r[1..16] (n'th routine stimulus variable)

<u>Analysis Results</u>

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..8] (analog input, V)

A single-point voltage reading from an Analog Input channel, such as from a slowly changing temperature probe.

Note: This usage does not require setting up a Routine Input channel.

Mean[name or count, start,width]
(mean of given input signal)

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:

<u>Paradigm Editor Steps</u>
Amplifier
Checkbox
Set Variable

Sound
Write Log
If
Else If

<u>Routine Editor</u>
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 operations: Unary Negation, Logical Negation	-, !

<table>
<tr><td>5</td><td>Multiplication, Division, Remainder</td><td>*, /, %</td></tr>
<tr><td>4</td><td>Addition, Subtraction</td><td>+, -</td></tr>
<tr><td>3</td><td>Bitwise operations: And, Or, Nor, Xor</td><td>&, |, nor, %^</td></tr>
<tr><td>2</td><td>Comparison operations: Greater Than, Greater Than or Equal, Less Than, Less Than or Equal, Equal To, Not Equal To</td><td>>, >=, <, <=, ==, !=</td></tr>
<tr><td>1</td><td>Logical operations: And, Or, Conditional</td><td>&&, ||, ? :</td></tr>
<tr><td>0</td><td>All other operations</td><td>abs, acos, asin, atan, ceil, cos, deq, exp, floor, ln, log, mlast, noise, odd, rad, random, round, sin, sqrt, tan, trunc</td></tr>
</table>

Table 4-4. Equation Parser

Comments are 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 two 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.

There are also some differences in operator processing between the SutterPatch equation parser and the Igor Pro command parser:

Comment:

SutterPatch	All characters to the right of a semicolon are ignored.
Igor Pro:	A semicolon separates multiple commands on the same command line. An Igor comment uses a double slash: //

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 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 analyses are also accessible via the "Scope" window 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
  lor
  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, attached Sutter instrumentation, Paradigm and Routine acquisition settings, and tag information.

Metadata parameters can be retrieved several different ways:

Data Navigator

Open a Metadata Review docked sub-window.

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.

- Select a Paradigm or Series and click on 'Metadata' 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'.

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.

To simultaneously display metadata from two different Paradigms, use 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.

To simultaneously display metadata from two different Series, use 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.

Paradigm [ ] Displays the name of the Paradigm.

Routine [ ] Displays the name of the Series.

Signal [ ] Displays the name of the Signal selected in the Data Navigator.

 Copy to Clipboard

Copy the metadata settings to the system clipboard.

Metadata parameters from all detail levels are displayed (see Set Preferences / Metadata).

- By Event — Events are grouped by [time-stamp] [Event #] [Event type]. Highlighted values are editable.
    - Absolute Time — Display the event times in the computer system time.
    - Relative Time — Display the event times relative to the start of the Paradigm.
- By Parameter — Parameters are grouped into major categories. (see below)

  Parameters might also list "Prior" values. These include system and Paradigm parameters written before a Routine starts.

Expand All	All parameter settings 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 by dragging it when the mouse cursor turns into a double-headed arrow.
Collapse All	All parameter settings are hidden and collapsed up to the Event or Parameter level.

'By Parameter' Metadata Categories / Parameters

<u>Tag</u>
Tag Number
Tag Creation Timestamp
Timer Time at Tag Creation
Tag Signals
Tag Source Event

<u>Operator</u>
Login Name

<u>Experiment</u>
Experiment Timestamp

<u>Amplifier</u>
Amplifier Sequence Number
Amplifier Manufacturer
Amplifier Model
Amplifier Serial Number
Amplifier Channel
Number of Available Headstages
Headstage Sequence Number
Headstage Model

<u>Instrumentation and Software</u>
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
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	[for Sutter amplifiers only]
Input Offset Voltage	[for configured headstages]
Input Offset Lock On/Off	[for Sutter amplifiers only]
Input Signal Name	
Input Signal Unit	
Input Scaling Factor	
Input Scaling Offset	
Input Full-scale Minimum	
Input Full-scale Maximum	
Input Sampling Rate	
Auxiliary Input Signal Offset	[for non-headstage ‘Analog_OUT’ 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 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 Sutter amplifiers only]
Virtual Signal Integrator Reset Duration	[for Sutter amplifiers only]
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 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	[for Sutter amplifiers only]
Electrode Fast Time Constant	[for Sutter amplifiers only]
Whole-cell Compensation On/Off	[for Sutter amplifiers only]
Series Resistance Correction On/Off	[for Sutter amplifiers only]
Command Signal Name [1 – 4]	
Command Signal Unit [1 – 4]	
Command Full-scale Minimum [1 – 4]	
Command Full-scale Maximum [1 – 4]	
Command Sampling Rate [1 – 4]	
Command Holding Enabled [1 – 4]	
Command Holding Value [1 – 4]	
Auxiliary Output Signal Name [1 – 4]	[for non-headstage ‘Analog_OUT’ channels]
Auxiliary Output Scaling Factor [1 – 4]	[for non-headstage ‘Analog_OUT’ channels]
Auxiliary Output Offset [1 – 4]	[for non-headstage ‘Analog_OUT’ channels]
Auxiliary Output Holding Value [1 – 4]	[for non-headstage ‘Analog_OUT’ channels]
Digital Holding Pattern (1 → N)	[1 – 8]

<u>Stimulus</u>

Compound Group	[if Solution activated]
Compound Name	[if Solution activated: for Control and Test Compounds]

4.2.11 Paradigm Review

'Paradigm Review' displays data from all Series within the Paradigm, in a modified reanalysis Scope window, in a Time Course or Concatenated view. This view also displays tags that occur between Series.

Access this window from the Data Navigator 'Available actions' menu.

To display the Series_Signal_Routine name of the selected data at the bottom of the window, click on the data.

The state of the Autoscale button (one-time vs. continuous) applies to all 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.)

4.2.12 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 override the loaded Routine for quick interactive control.

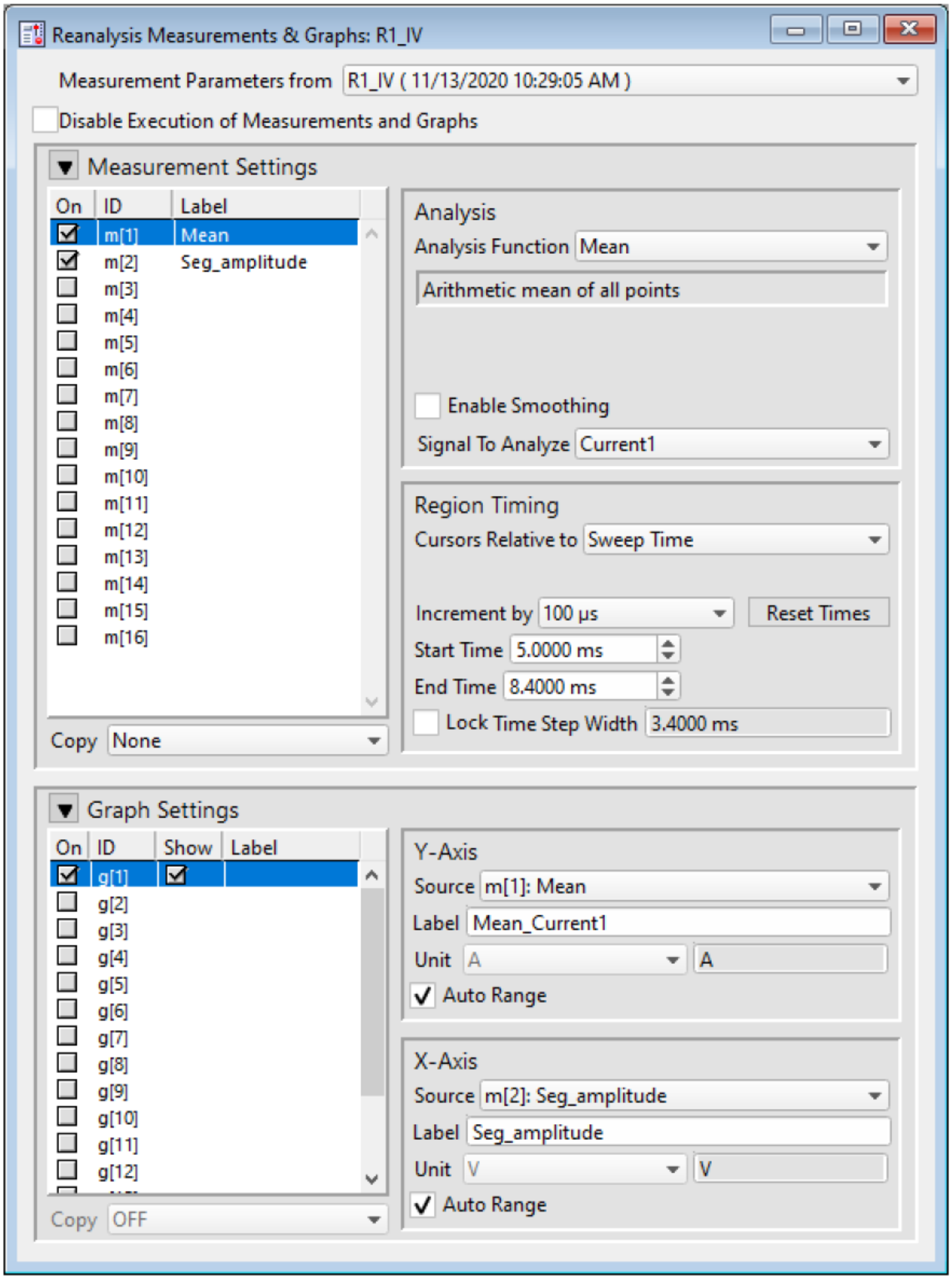


Figure 4-74. Reanalysis Measurements & Graphs

This dialog operates similarly to the Routine Editor: Real Time Measurements & Graphs dialog, with the addition of optional configurations:

Measurement Parameters from

The name of the Series data, and the date/time of the last update to the Measurement parameters.

The current parameters can be optionally overwritten (updated) from these sources:

- Overwrite Measurements from Original Routine
- Overwrite Measurements with Active Values

  The last run analysis values are remembered.
- Overwrite measurements from Saved Default

  [Available when previously saved in the 'Measurements' button drop-down list.]

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 [g5].
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 [g6].
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.

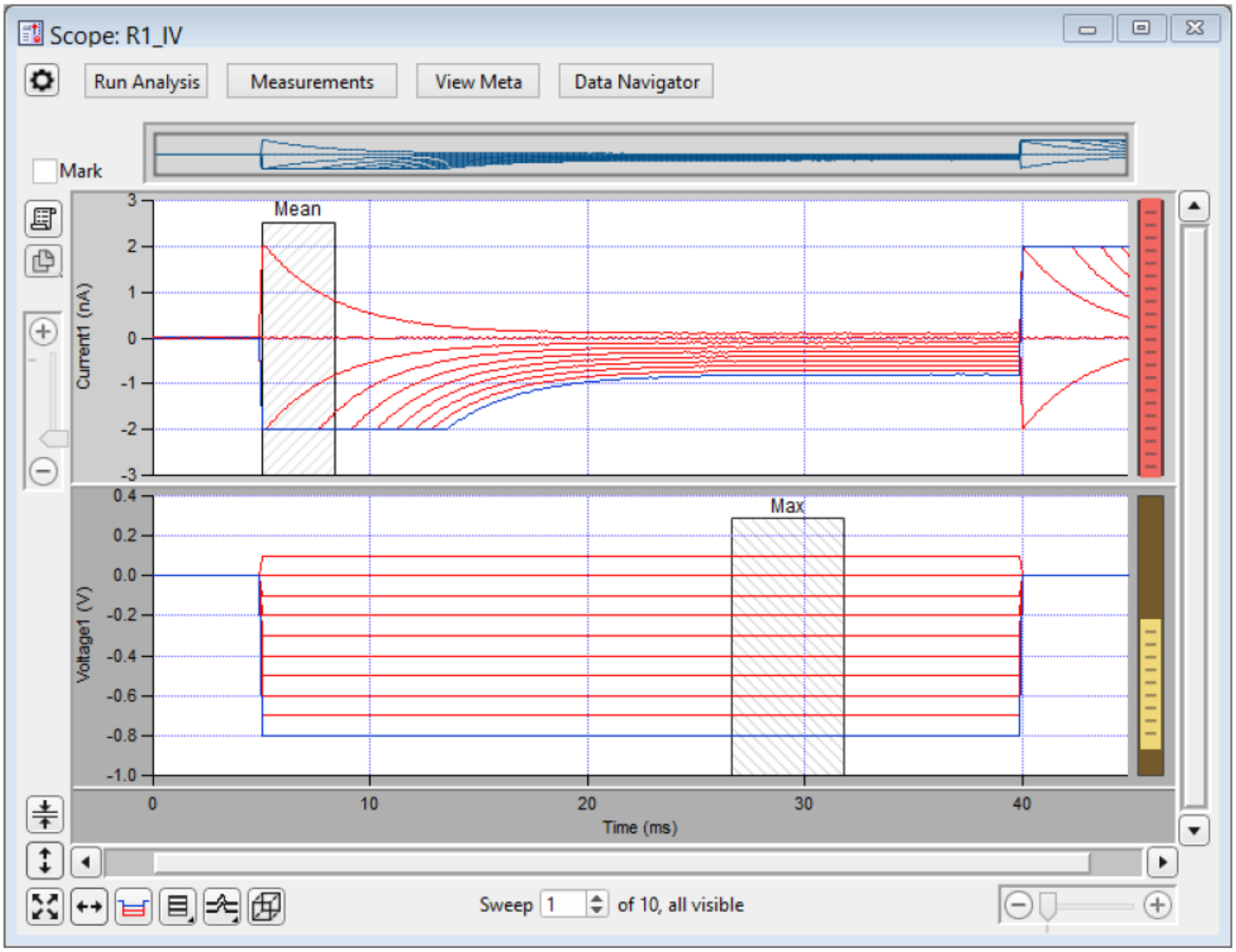


Figure 4-75. Reanalysis Scope Window

Both physical and virtual channels can be displayed and analyzed here.

Many window controls are the same as in the ‘ Routine’ Scope window, however others have slight changes, and new controls were also added:

Navigation pane

The Navigator 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.

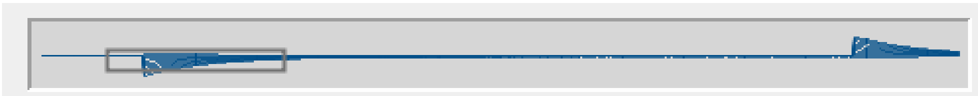
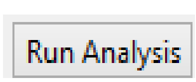


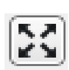
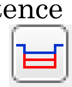
Figure 4-76. Navigator Pane

The Navigator 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

	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.
[ ] 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.
	Run the defined analysis for the displayed sweeps of the active data series, and graph the results in the Analysis window. If this button is grayed out, edit the Measurements to activate analysis. 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. 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)”. --- No Measurements or Graphs Analyze with Active Measurements Analyze with Original Routine Measurements Analyze with Routine Last Executed Measurements --- Analyze with Saved Default Measurements Save as Default 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. Edit Virtual Signals: Open the virtual input signals panel for editing. --- Action Potential Analysis Analyze action potentials. Synaptic Event Analysis Analyze synaptic events (EPSPs, mEPSPs, etc.) Single Channel Analysis Analyze a single ion channel. 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)
	Display any extra information (metadata) associated with the displayed data Series, such as the operator, preparation details, solution information, etc., in a floating window.
	Open a Data Navigator window with all of your Experiment data and metadata available for analysis in a tree structure.
	Show and analyze [Previous / Next] Routine.
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.
Autoscale 	Click to 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. For persistent autoscaling, in “Windows” right-click (or Shift-click or Ctrl-click) the button, or in “macOS” Control-click the button (it turns dark gray). To include the zero amplitude in the Y-ranges, enable “Include zero when autoscaling” in Set Preferences / Scope Window / General.
Persistence Display 	Enable: Display all sweeps (per Marks, and Scope Preferences limits). Disable: Only the active sweep is displayed. Applies to the Scope window, and its right-click graphs: Parametric Plot and Amplitude Histogram Plot.

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.	
Sweeps Display	This button has 3 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,
	Concatenated 	Display sweeps in time sequence on a single time axis. Portions without data are replaced 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.
	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)	
	The 'Sweep #' display at the bottom of the Scope window indicates the 'active sweep' number, the total number of sweeps in the Series,	

Sweep #:	and either “all” or the total number of visible sweeps (per Preferences).

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>

Set all marks in sweeps of active series by equation

Opens the ‘Sweep Mark: Equation Editor’ to enter an equation for the sweeps to mark.

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
Odd(sweep)
Even(sweep)

Do Mark

Evaluate the equation and update the sweep marking.

[Status message]

A value >= 0.1 = 1 (marked)

A value < 0.1 = 0 (unmarked)

Parametric Plot

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

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 — Select an input signal for the Y-axis.

X-signal — Select an input signal for the X-axis.

Plot — Update the plot using the new parameters.

 Copy to Layout — Copy the Parametric Plot graph into a new Layout window, or append to an existing Layout page.

 Copy to Clipboard — Copy the Parametric Plot graph to the system clipboard, or if the 'Shift' key is pressed, the complete scope window.

Time Range — The time range of the data to be plotted.

- Full Trace — Use the entire trace for the time range.
- Sweep Time — Set relative to the start time of a sweep (time zero).

  Start Time — 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 — 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 — [0 = beginning of Segment]

  Set the starting time ratio.

End Ratio [1 = end of Segment]

Set the ending time ratio.

Measurements can be made on the parametric graph using Igor Pro cursors (Ctrl-I). The cursor measurement is written to the SutterPatch Notebook window.

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.

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 Select the input signal to be analyzed.

Time Range The time range of the data to be plotted.

- Full Trace Use the entire trace for the time range.
- Sweep Time Set relative to the start time of a sweep (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 [0 = beginning of Segment]

  Set the starting time ratio.

  End Ratio [1 = end of Segment]

  Set the ending time ratio.

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.

 Copy to Layout

Copy the Amplitude Histogram Plot graph into a new Layout window, or append to an existing Layout page.

 Copy to Clipboard

Copy the Amplitude Histogram Plot graph to the system clipboard.

Cityscape — Display the plot using steps, no interpolation.

Plot — Refresh the plot line for any Time Range settings changes.

[graph pane]

Measurements can be made on the amplitude histogram graph using Igor Pro cursors (Ctrl-I). The cursor measurement is written to the SutterPatch Notebook window.

Color Plot — Plot amplitude data in a false-color graph of Sweep vs. Time. This “heat map” display mode is commonly used in fast-scan cyclic voltammetry.

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.

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

Signal — List of 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.

<u>[range]</u> — Select the Y-range to be used for a Plot.

- Auto Y Range — Use an autoscaled Y-axis range for the data.
- Scope Y Axis min and max

  Use the existing Y-range for the data.
- Given Y min and max

  Set the upper and lower Y-axis boundaries.

Color Table — List of color lookup tables.

Reverse — Reverse the color lookup table.

Plot — Plot the selected signal as a false-color graph using the selected Y-range and color lookup table.

Copy to Layout

Copy the Color Plot graph into a new Layout window, or append to an existing Layout page.

Copy to Clipboard

Copy the Color Plot graph to the system clipboard.

Measurements can be made on the color graph using Igor Pro cursors (Ctrl-I). The cursor measurement is written to the SutterPatch Notebook window. Once set, clicking and dragging a cursor will dynamically update its measurement value in the notebook.

<u>Right-click Menus</u>

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	The minimum X-axis value.
X-max	The 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 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 — The minimum Y-axis value.

Y-max — The maximum Y-axis value.

Copy Y scale of signal

[input signals list]

Apply the Y scaling from another signal.

Axis Properties… — Modify the axis style and components.

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.

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.
Stack All Signals	Display all signals in a single column.

Main Window

Limited data modification menu

Right-click the blank area in a signal pane.

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

This context menu is the same as in the Acquisition: Routine 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	Copy the signal and open in a separate window. Saves to Windows / Graph Macros.
Toggle Cursor Info	Show/Hide the Cursor Info pane to measure X-Y data points or set a fitting range. (See the 'Signal data' section below.) Select 'Toggle Cursor Info' again to hide the Cursor Info pane, and any cursor symbols in the active pane
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

Display only the last [marked] sweep of the selected signal, or

Show All Sweeps of '<name>'

restore the display of all [marked] sweeps in the selected signal.

Stack All Signals	Display all signals in a stacked signal layout.
Show All Sweeps	(with triggered sweeps)
Show Marked Sweeps	(with triggered sweeps)

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

[only in Scope if an Amplitude Histogram is open]

Set Time Range of Analysis

[only in Scope if Single Channel Analysis is open]

Set Time Range of Parametric Plot

[only in Scope 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 menu is the same as in the Acquisition: Routine Scope window (plus a couple of other items):

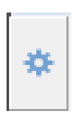
- Hide Sweep_# (with triggered sweeps)
- Show Sweep_# Only (with triggered sweeps)

Tip: To manually measure X-Y data values, or to set a fitting range, open a Cursor Info pane to use Igor measurements:

- Toggle Cursor Info — Select 'Toggle Cursor Info' to show/hide the Cursor Info pane, and any cursor symbols in the active pane.

Note: 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.

Cursor Info pane

 Options menu

-  One Mover Moves All — Draggable cursor mover tool moves all cursors together with a single control.
- All Styles — Change the cursor symbol style.
- Show Cursor Pairs — Display up to 5 sets of cursor symbol pairs.

Cursor A

	Cursor symbol for data point ‘A’.
A:	Symbol letter (beginning cursor of the pair).
R1_A_IV	(Default) wave name.
	Draggable cursor mover tool for the cursor pair.
pnt:	Data point number (starting from zero).
X:	X-axis value of data point ‘A’.
Y:	Y-axis value of data point ‘A’.
ΔY	Difference of the cursor pair Y values.

Cursor B

	Cursor symbol for data point ‘B’.
B:	Symbol letter (ending cursor of the pair).
R1_A_IV	(Default) wave name.
	Draggable cursor mover tool for the cursor pair.
pnt:	Data point number (starting from zero).
X:	X-axis value of data point ‘B’.
Y:	Y-axis value of data point ‘B’.
ΔX	Difference of the cursor pair X values.

Cursor Instructions

1. Click on symbol ‘A’ to enable it.
2. Manually drag the highlighted symbol onto a data point in the scope window, or enter the data point number in the ‘pnt’ field.
3. Click on symbol ‘B’ to enable it.
4. Manually drag the highlighted symbol onto a data point in the scope window, or enter the data point number in the ‘pnt’ field.

X- and Y-measurements are displayed for the cursor pair data.

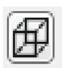
5. Fitting can also be applied to the cursor pair data. Right-click in the graph, and select 'Quick Fit' for a list of built-in Igor Pro fitting functions.

   The fit is displayed in the graph, and the fitting information is written to the Command window.

Channel Timing Delays

The Dendrite system records both command 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 3D representation of your data, color-coded to show amplitude variations.

Note: If the Igor Pro/SutterPatch main window frame is not wider than the Reanalysis Scope window plus its Analysis sub-window, then clicking the 3D button will generate an error message, but the operation will still execute.

The axis definition in 3D View is based on the change of a waveform over the course of successive sweeps. 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. In the default orientation of the 3D View, the Z axis, on which the Sweep Number is plotted, points backward and to the right.

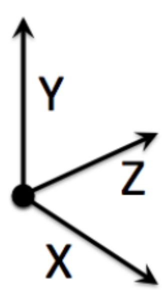


Figure 4-77. 3D Axes Definition

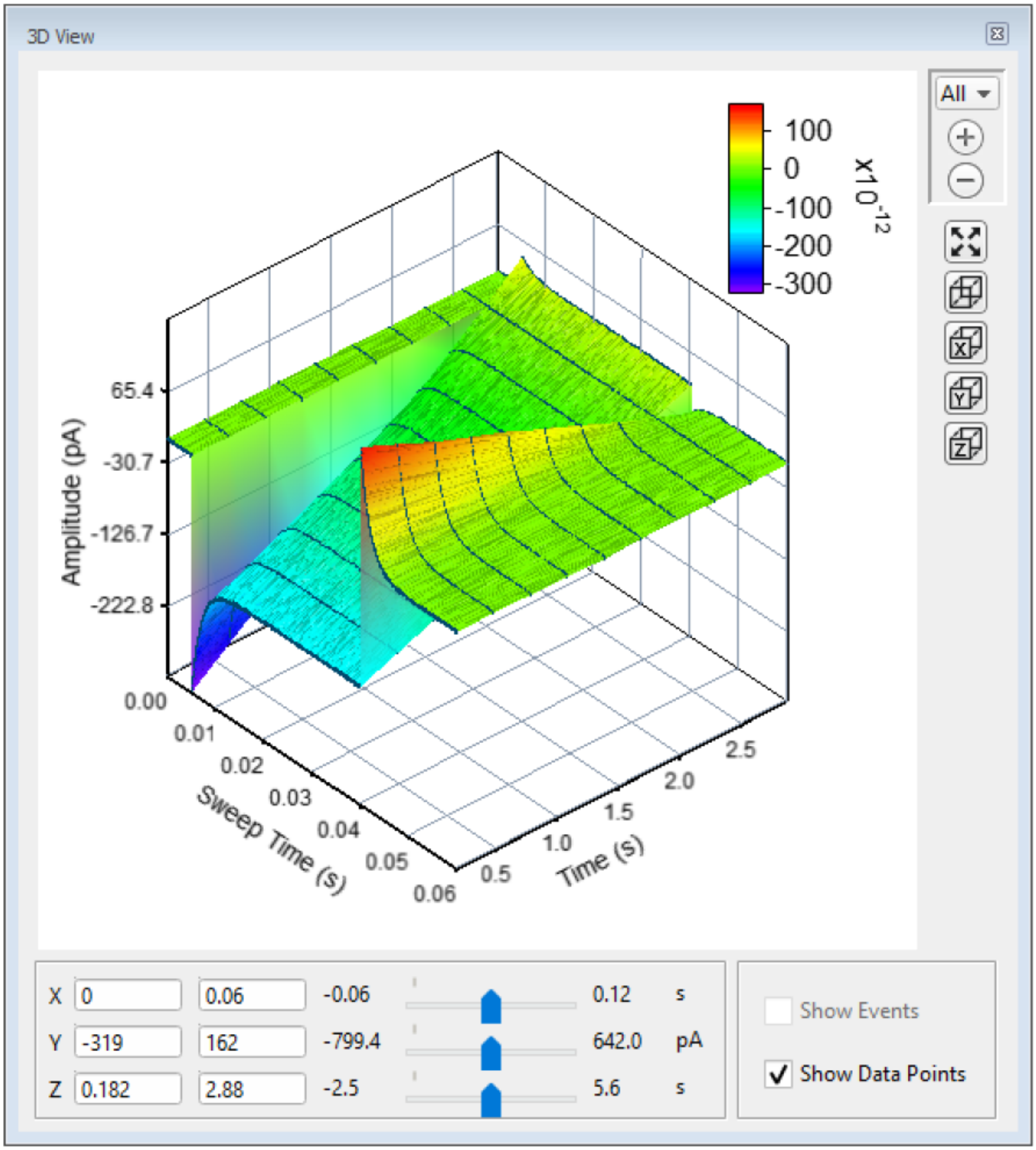


Figure 4-78. 3D View

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:

- All (All 3 axes)
- X (Sweep Time)
- Y (Amplitude)
- Z (Time)

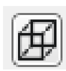
 Zoom in (Magnify)

 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)

 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 Display tagged events in the 3D graph.

Show Data Points Display data points as surface dots in the 3D graph.

4.2.15 Routine Review

'Routine Review' displays the selected Series data in in a modified Reanalysis Scope window defaulted to the 'Time Course' display mode.

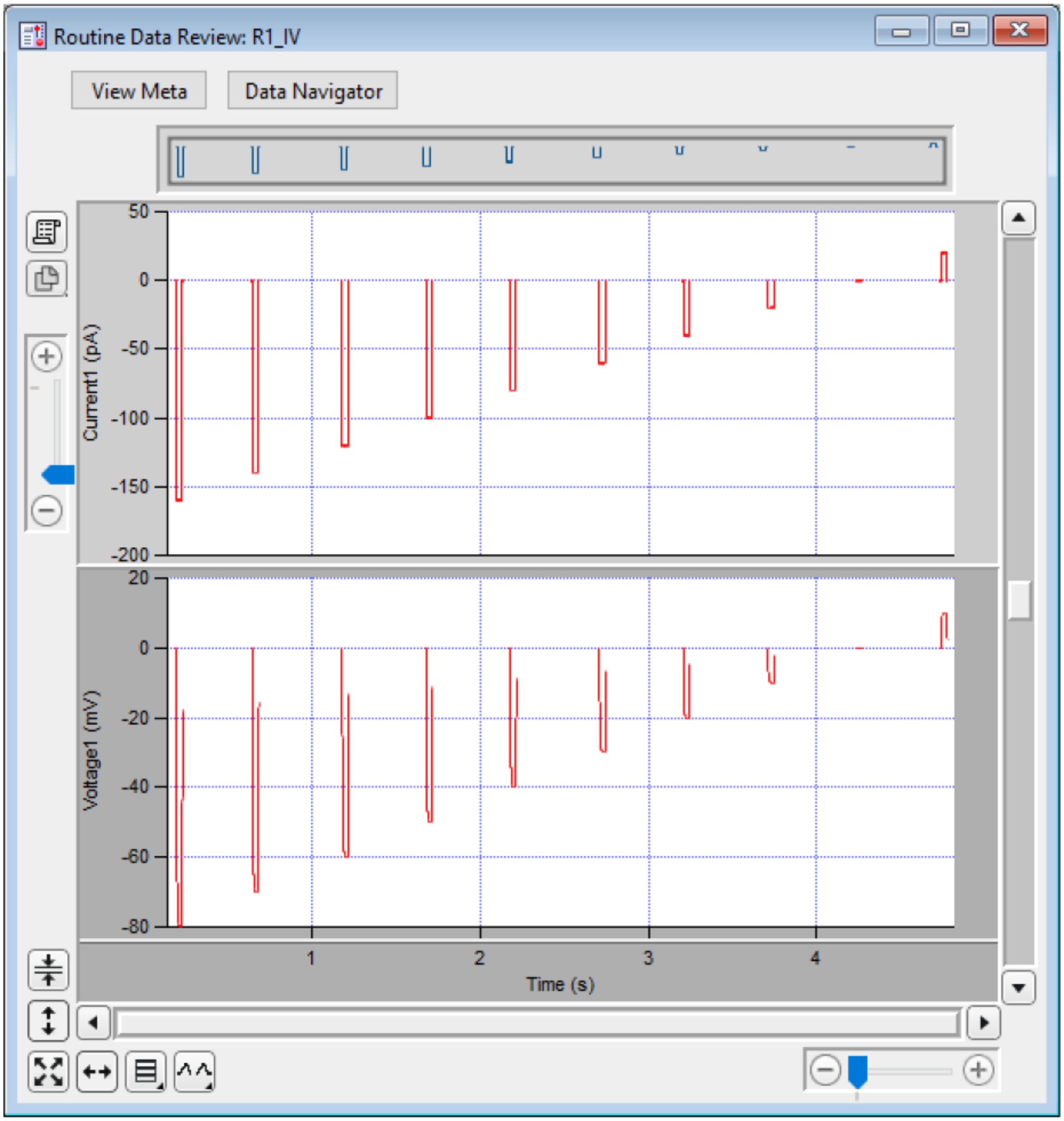


Figure 4-79. Routine Review

Open this window from the Data Navigator by highlighting a Series, and selecting the 'Review Routine' command from a right-click menu or the 'Available actions' button.

The first data point does not display at time = 0 in time course display mode, due to system overhead.

The state of the Autoscale button (one-time vs. continuous) applies to all Routine Review and

Paradigm Review windows.

For more information on the window controls, see the Reanalysis Scope section.

New Controls

Click in a signal pane to display the name of the “Series_Signal_Routine”, or on the data to also include the Sweep #, in a field at the bottom of the window.

- To reopen the Series into a Reanalysis Scope window, right-click in a signal, and select ‘Analyze <Series Name>’ from the menu list.

4.2.16 Routine Settings

The Routine Settings window reports the same settings as would be seen in the Routine Editor / Routine Settings, however its 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.

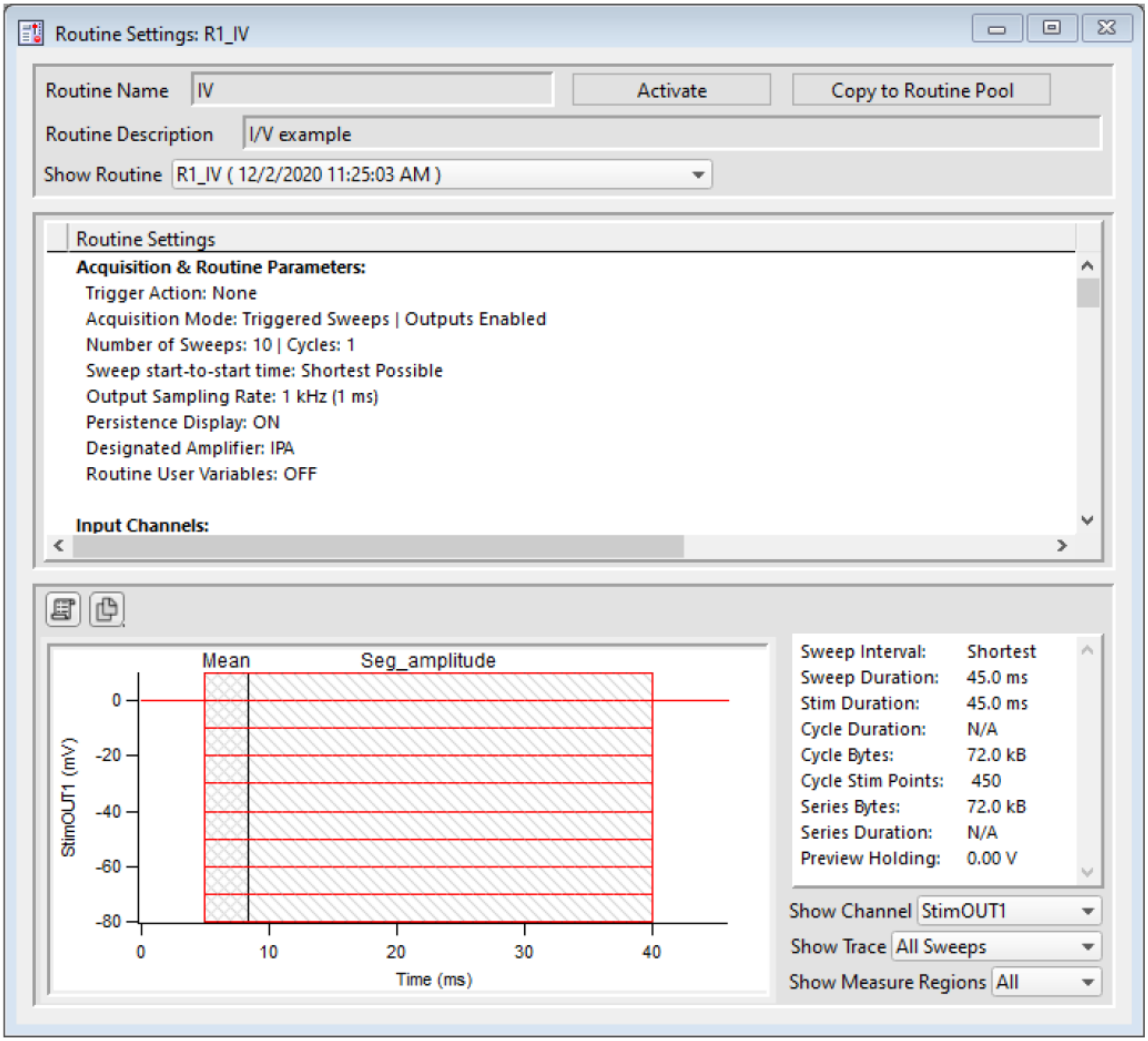


Figure 4-80. Routine Settings

Routine Name	Displays the Routine name.

Activate	Opens the Acquisition: Routine Scope window loaded with these settings.
Copy to Routine Pool	Adds this Routine to the loaded Routine Pool.
Routine Description	Displays the Routine description.
Show Routine Copy	
Routine Settings	Listing of all settings from all sections of the Routine.

Acquisition & Routine Parameters

Input Channels

Output Channels & Waveform

Real Time Measurements & Graphs

Preview panel	Display of the stimulus waveforms.

Copy to Layout	Copy the visible stimulus waveforms into a new Layout window, or append to an existing Layout page.
Copy to Clipboard	Copy the visible stimulus waveforms to the system clipboard.

Some key acquisition settings and display controls are listed on the right of the Preview pane:

Show Channel	Select the output signals to display.
Show Trace	Select the output traces to display.
Show Measure 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.

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	Special addition to the menu.
Set Analysis Time Range	Sets the Single Channel Analysis 'Time Range' to 'Sweep Time', and the 'Start Time' and 'End Time' are set from the marquee range.

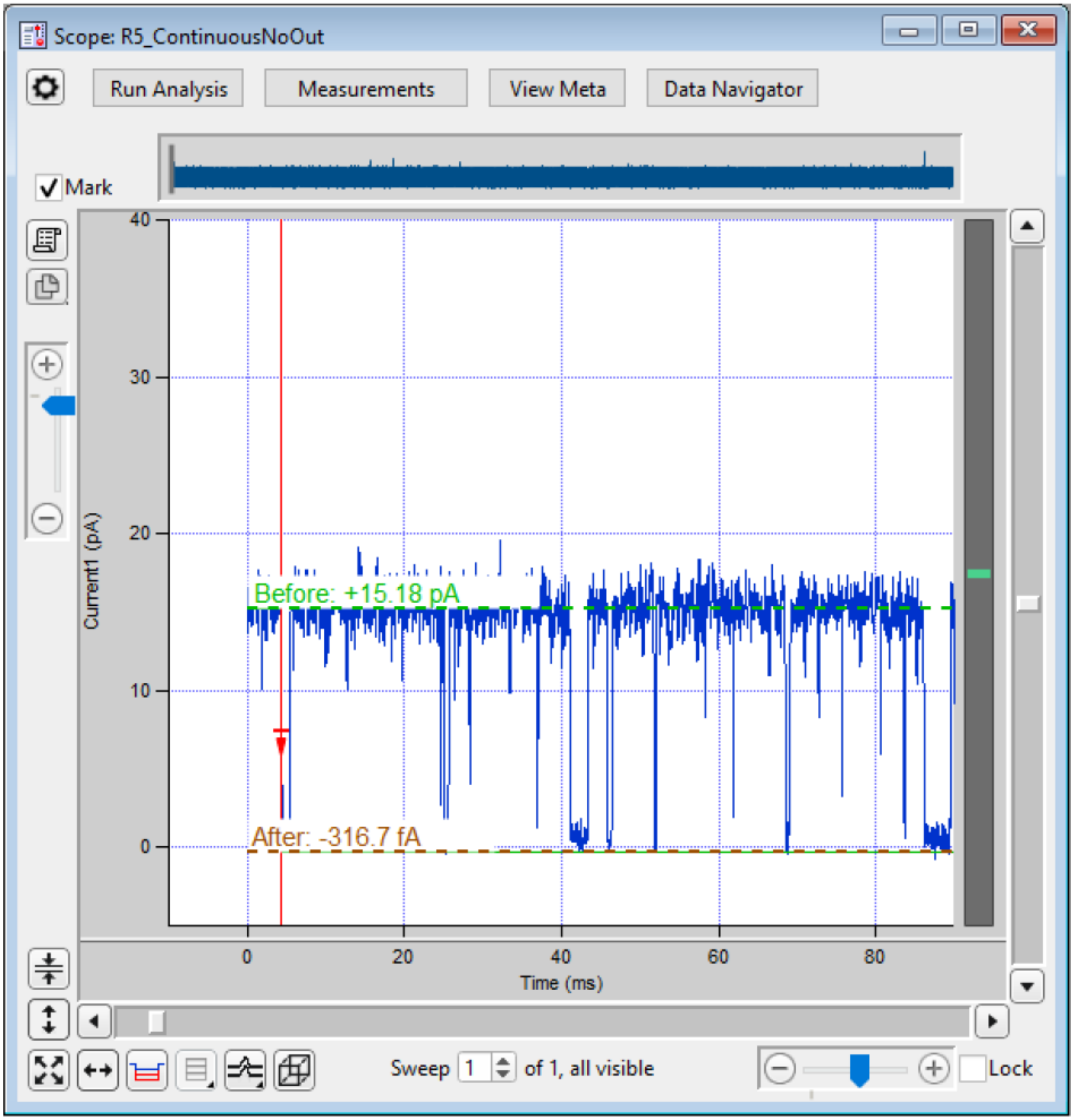


Figure 4-81. Single-Channel Scope

When single channel analysis is activated, a Single Channel Analysis control panel is opened, and the Reanalysis Scope window active signal is overlaid with the transition levels of the first single-channel opening or closing, based upon the settings in the Single Channel Analysis control panel / Current Transition Controls section.

Note: Single-channel analysis only operates in the Scope 'Sweeps' display mode; the Concatenated and Time Course display modes are not supported.

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.

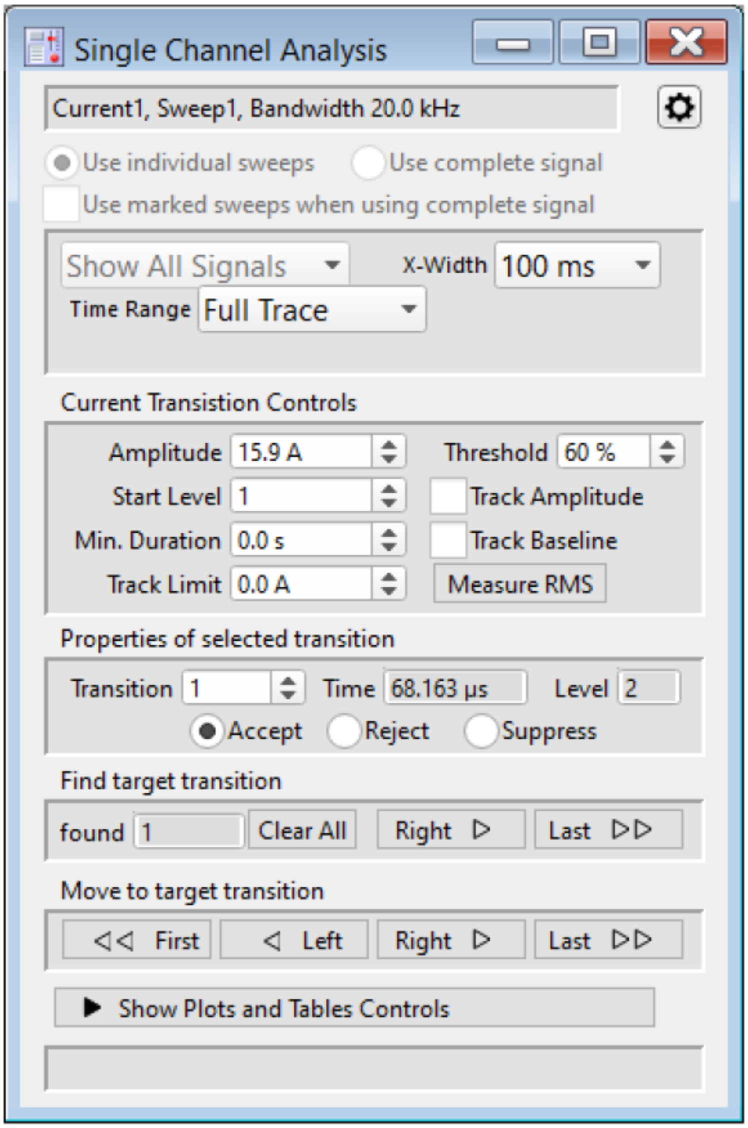


Figure 4-82. Single Channel Analysis

[Descriptive information]

 Single Channel analysis preferences.

Dock to scope

Baseline Average Duration = x.x ms

Calculate the averaged baseline amplitude with the duration of the last baseline data (closed state) before the transition to an open state.

Mean Amplitude Duration = x.x ms

Calculate the mean amplitude using up to the duration of the open state data at that level, after a transition to that level.

Allow display compression

<u>Signal Controls</u>

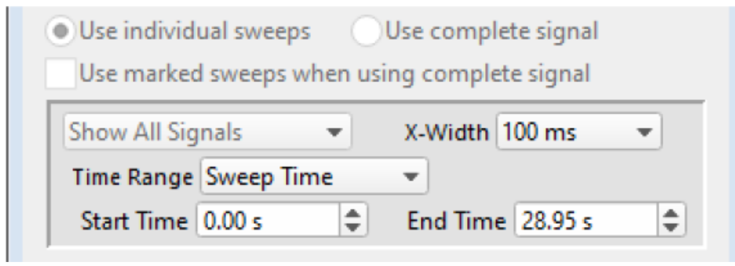


Figure 4-83. Signal Controls

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.

Show All Signals

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 Full Trace

Sweep Time	Start Time (s)	
	End Time (s)	
Segment Time	Start Ratio	Relative to the start of a segment.
	End Ratio	Relative to the end of a segment.

Current Transition Controls

Set up the basic level-detection parameters.

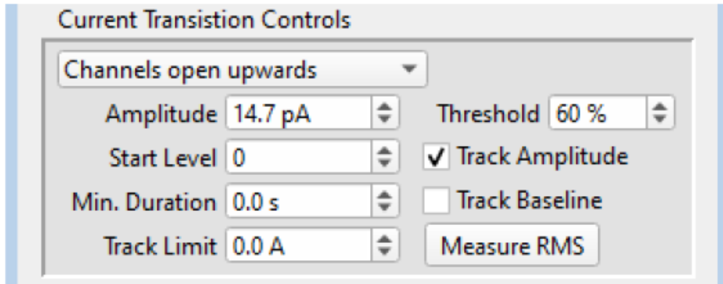


Figure 4-84. Current Transition Controls

Channels open upwards / Channels open downwards

Upwards opening channels only accept positive amplitudes.

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 — 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]

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] 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	[50 – 90%] The percentile of the Amplitude value (open state) that needs to be reached by the raw data to “find” a transition.
Track Amplitude	Store the amplitude of the measured event, instead of the theoretical (short) event, in the event transition table.
Track Baseline	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 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 RMS value is displayed at the bottom of the dialog, and a 3 x RMS value populates the Track Limit field.

<u>Properties of selected transition</u>

View or alter how a transition is processed by the analysis.

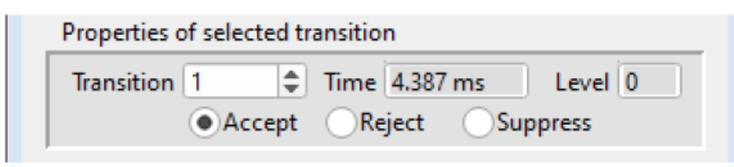


Figure 4-85. Properties of Selected Transition

Transition	The count number of the selected (active) transition.
Time	The start time of the selected transition.
Level	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.

<u>Status</u> The operational status of the selected transition.

- Accept — Terminates the preceding event and starts a new open/close time. The selected transition is included in the idealized trace and all Plots.
- Reject — Terminates the preceding event and starts a new open/close time. However, the selected transition is not included in the idealized trace and all Plots.

  Events that border a rejected transition are also excluded from histograms.
- Suppress — 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 not included in the idealized trace and all Plots.

<u>Find target transition</u>

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.

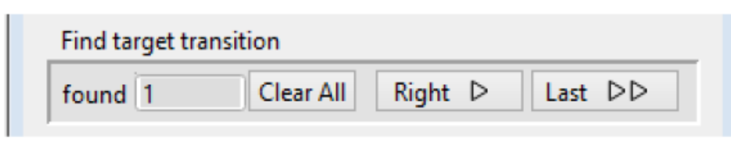


Figure 4-86. Find Target Transition

found — The total number of found transitions (including rejected and suppressed transitions).

Clear All — Reanalyze the data - reset the number of found transitions to zero, and move to the first found transition.

Right > — Find, move to, and process the next transition.

Last >> — Find and process all subsequent transitions, and move to the last transition.

Note: Multiple open levels are handled in a simplistic fashion. It is assumed that there is only one channel open, and that it is open for the same state throughout the duration of the Event.

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.	

<u>Move to target transition</u>

Among the 'found' (processed) transitions, move to an adjacent transition, or jump to the beginning or ending transition.

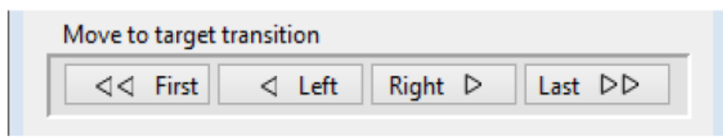


Figure 4-87. Move to Target Transition

<< First	Move to the first found event.
< Left	Move to the prior found event.
Right >	Move to the next found event.
Last >>	Move to the last found event.

Show/Hide Plots and Tables Controls

This button opens/closes the 'Tables and Plots' dialog, docked on the right of this dialog.

[ ] Total events in… Status bar for the number of events in a particular Plot.

Single Channels: Plots and Tables

Note: All plots and histograms support measuring X-Y data points or setting a fitting range via the 'Toggle Cursor Info' right-click menu entry (or Ctrl-I). (See 'Right-Click Menus' for Scope windows.)

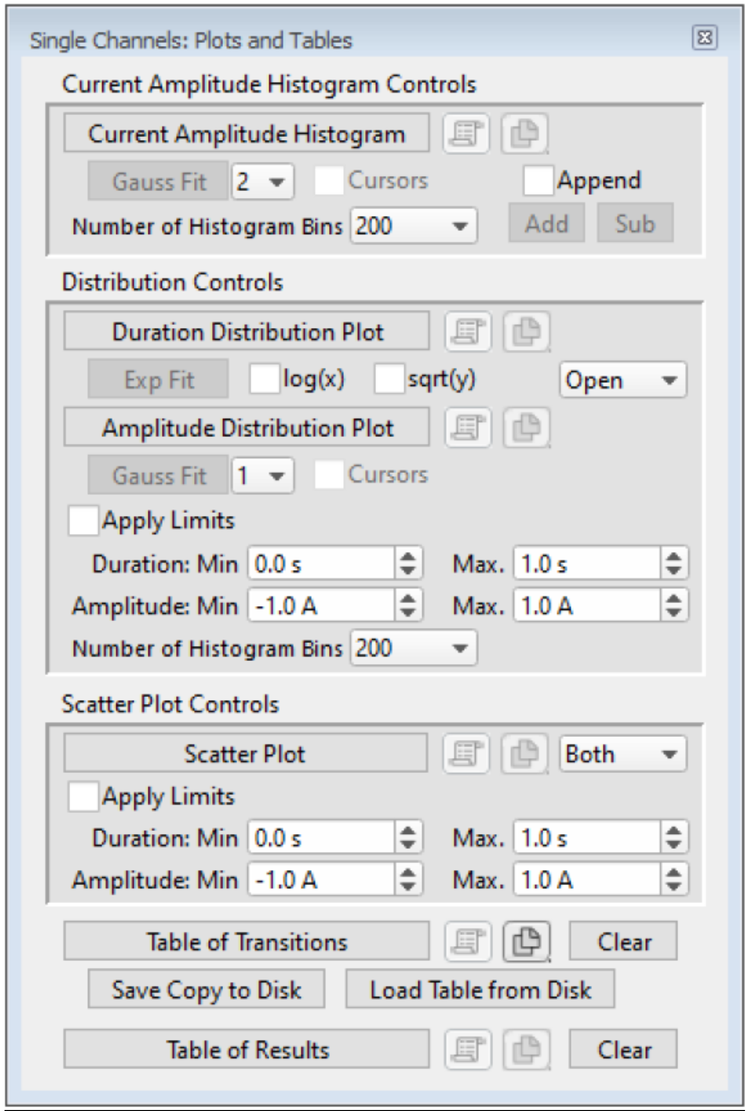


Figure 4-88. Plots and Tables Controls

Current Amplitude Histogram Controls

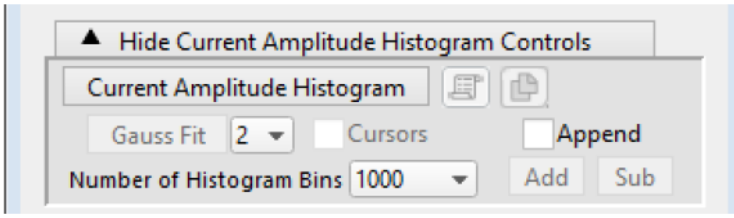


Figure 4-89. Current Amplitude Histogram Controls

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.

 Copy to Layout Page — Copy the 'Current Amplitude Histogram' into a new Layout window, or append to an existing Layout page.

 Copy to Clipboard — Copy the 'Current Amplitude Histogram' to the system clipboard. With the 'Shift' key pressed: as a graph, otherwise as a table.

Gauss Fit — Click button to perform a Gaussian fit on the histogram. SutterPatch will automatically find and fit up to the three largest peaks. You can the fitting ranges as needed with manual cursors.

To fit additional smaller distributions, reposition the cursors and click the Append button.

See the 'Table of Results' for the fitting components.

[1 , 2, 3] — Select the number of peaks (levels) to fit.

When more than one peak is selected, the graph reports amplitudes (in relation to the closed state peak) and P(open) and P(closed) values.

Cursors — Display fitting cursors in the plot window.

To reposition cursors, first create the histogram, and then enable 'Cursors' – this will open a Cursor Bar at the bottom of the plot window. Next, drag the cursor's symbol (labeled "A", "B", etc.) from the cursor bar to the new position (near to the X-axis) on the plot.

Append — Modify the Current Amplitude Histogram.

- Add — Add the current data to the existing 'Current Amplitude Histogram'.
- Sub — Subtract the current data from the existing 'Current Amplitude Histogram'.

Number of Histogram Bins — [4000, 2000, 1000, 500, 200, 100, 50]

<u>Distribution Controls</u>

Create histogram plots of the found Events.

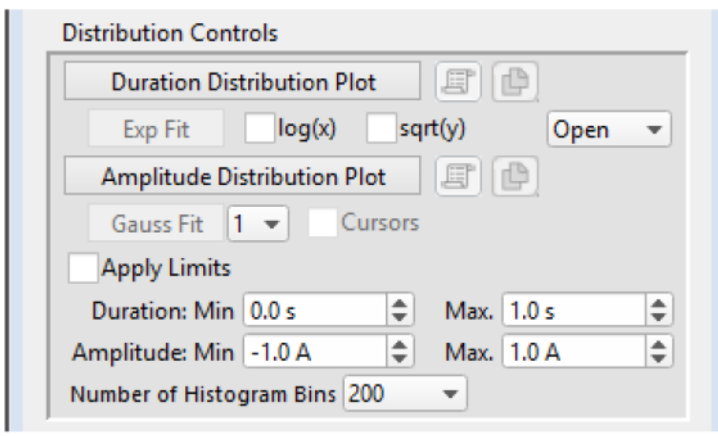


Figure 4-90. Distribution Controls

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.

- Copy to Layout — Copy the 'Duration Distribution Plot' into a new Layout window, or append to an existing Layout page.
- Copy to Clipboard — Copy the 'Duration Distribution Plot' to the system clipboard.
- Exp Fit — Apply an exponential fit to the data.
- log(x) — Set the X-axis to a log scale.
- sqrt(y) — Use the square-root of the Y-axis data.

Open / Closed — Select open or closed state data for the Distribution plots.

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

 Copy to Layout — Copy the 'Amplitude Distribution Plot' into a new Layout window, or append to an existing Layout page.

 Copy to Clipboard — Copy the 'Amplitude Distribution Plot' to the system clipboard.

Gauss Fit [1, 2, 3] — Select the number of components in the fit.

Cursors — When an Amplitude Distribution Plot exists, you can enable draggable fitting cursors in the graph.

To position a cursor, drag its cursor symbol (labeled "A", "B", etc.) from the cursor bar onto the data at the desired position.

Apply Limits — Apply data limits to the events used in distribution 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]

Number of Histogram Bins [1000, 500, 200, 100, 50, 20]

<u>Scatter Plot Controls</u>

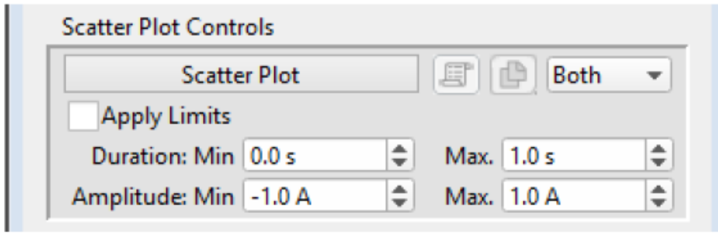


Figure 4-91. Scatter Plot Controls

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.

Events are plotted as colored symbols:

Open = **red**

Closed= **blue**

Selected Event (transition) = **green**

Copy to Layout	Copy the ‘Scatter Plot’ into a new Layout window, or append to an existing Layout page.
Copy to Clipboard	Copy the ‘Scatter Plot’ to the system clipboard.
Open / Closed / Both	Select which states are plotted.

Apply Limits — 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]

Table Controls

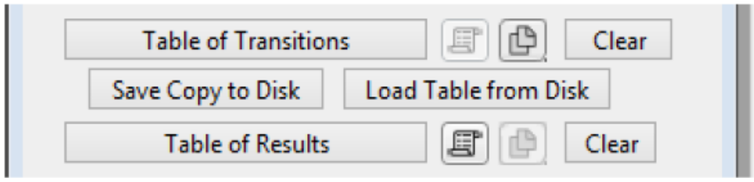


Figure 4-92. Table Controls

Table of Transitions — Click for a listing of all transitions.

<u>Layout of the table</u>

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. Events that border a rejected transition are also excluded from histograms.
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	Not a valid transition.
1	=	Valid	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.

Copy to Layout — Copy the 'Table of Transitions' into a new Layout window, or append to an existing Layout page.

Copy to Clipboard — Copy the 'Table of Transitions' to the system clipboard.

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 listing of all fitting results.

Copy to Layout — Copy the 'Table of Results' into a new Layout window, or append to an existing Layout page.

Copy to Clipboard — Copy the 'Table of Results' to the system clipboard.

Clear — Clear all entries from the table, and reset to the first found transition.

Table Column Labels

Gaussian Fit

Header Row	Row 0
Source	Sweep_#
Analysis	Current Amplitude Histogram Fit, or Amplitude Distribution Fit
Label1	Amplitude
Value1	#
Label2	p(closed)
Value2	#
Label3	p(open)
Value3	#
Label4	Gauss_y0_1
Value4	#
Label5	Gauss_A_1
Value5	#
Label6	Gauss_x0_1
Value6	#
Label7	Gauss_width_1
Value7	#
Label8	Success_1
Value8	#
Label9	Gauss_y0_2
Value9	#
Label10	Gauss_A_2
Value10	#
Label11	Gauss_x0_2
Value11	#
Label12	Gauss_width_2
Value12	#
Label13	Success_2
Value13	#
Label14	Gauss_y0_3
Value14	#

Label15	Gauss_A_3
Value15	#
Label16	Gauss_x0_3
Value16	#
Label17	Gauss_width_3
Value17	#
Label18	Success_3
Value18	#

Linear Exponential Fit

Header Row	Row 0
Source	Sweep_#
Analysis	Duration Distribution Fit
Label1	Exp_y0
Value1	#
Label2	Exp_A
Value2	#
Label3	Exp_Tau
Value3	#
Label4	Exp_0
Value4	#
Label5	Success
Value5	#

Logarithmic Exponential Fit

Header Row	Row 0
Source	Sweep_#
Analysis	Duration Distribution Fit
Label1	LogNormal_k0
Value1	#
Label2	LogNormal_k1
Value2	#
Label3	LogNormal_k2
Value3	#
Label4	LogNormal_k3

Value4	#
Label5	Success
Value5	#

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.

Spontaneous miniature events (mEPSP, etc.), which generate small and often overlapping events, are also detectable with an innovative deconvolution algorithm. This technique finds Events with high temporal fidelity, while also improving the signal-to-noise ratio (SNR).

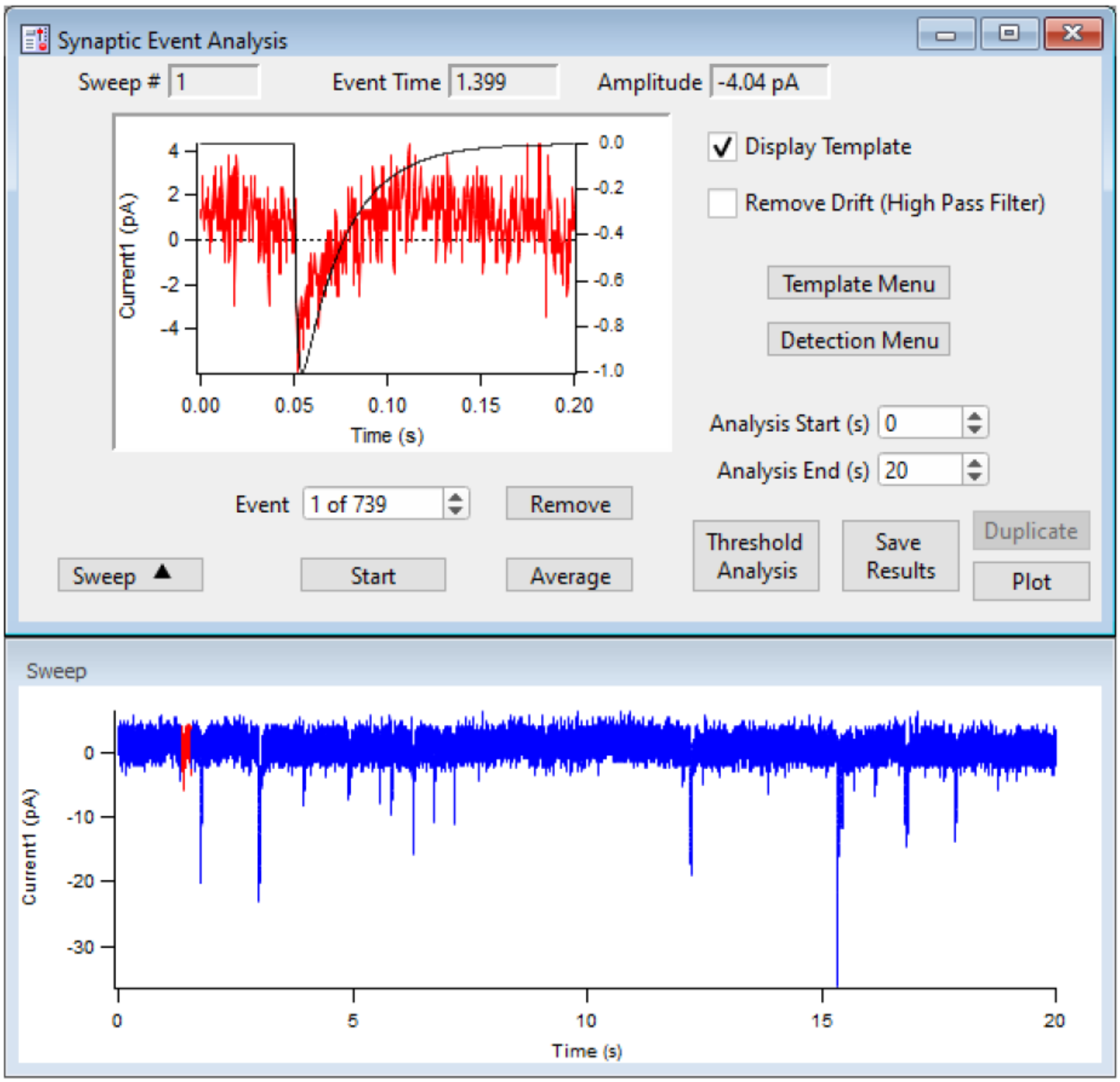


Figure 4-93. Synaptic Event Analysis

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.)

Select arbitrary sweeps for processing by "marking" them in the Data Navigator tree or in a scope window during acquisition or reanalysis.

Event Time	The time(s) of the event threshold crossing relative to the start of the sweep.
Amplitude	The amplitude averaged around the peak by ±1 ms.
[Event pane]	A graph of the selected event overlaid by the template, with the X-axis zero point reset to the template starting point. To measure X-Y data points or set a fitting range, select 'Toggle Cursor Info' from the right-click menu. (See 'Right-Click Menus' for scope windows.)
Display Template	Display the ideal event's template on top of the selected event in the graph - its Y-axis displays on the right edge of the graph. Tip: To match the template to the data, hover the mouse cursor over the right Y-axis, and use the mouse wheel to rescale the template.

Remove Drift (High Pass Filter)

A 1 Hz high-pass filter is applied to the signal to remove baseline drift.

Template Menu — 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	Allow realignment of the 'Use average' template to keep the analysis from drifting	

Detection Menu — Open the Levels sub-panel to configure detection levels.

Threshold (xSD) — A detection threshold representing the "Event Strength". A lower ("weaker") number finds more events, while a higher ("stronger") number finds fewer events. Adjust this threshold based on empirical testing of your data.

[0.1 – 10]	Lower # =	more events	(false-positives)
	Higher # =	less events	(false negatives)

Note: The default threshold is set to 4 times the standard deviation of a Gaussian fit to an all-points histogram of the (Fourier) deconvolved data signal.

Ampl Threshold — [5e-13 – 1e-6]

Set an amplitude threshold for the minimum size of events.

Decay tau (us) — [<, >] [500 – 1,000,000]

Set the decay tau as "less than" or "greater than" the tau value.

Analysis Start (s) — Sweep time to start looking for an event threshold.

Analysis End (s) — Sweep time to stop looking for an event threshold.

Event — The current event number vs. total number of events.

Remove — Delete the current event from the analysis.

Sweep ▲ — Show/Hide the Sweep preview panel.

A right-click menu is available, as well as the click-and-drag marquee for magnification and extraction.

[Sweep pane] — Displays a sweep of data colored in blue, with the selected event colored in red

To measure X-Y data points or set a fitting range, select 'Toggle Cursor Info' from the right-click menu. (See 'Right-Click Menus' for Scope windows.)

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 special menu option 'Add Mini' allows you to manually classify a raw data selection as an event during manual detection, or to include an event missed by the template detection. The new event is highlighted in red, and included in new Results tables.

Note: Manually detected events do not have an 'Event Strength' entry in the Results table, as an algorithm was not used to detect them.

Start — Click to find and analyze synaptic events.

Average	Click to display the averaged event in the Event pane. The Sweep # is set to '0'.
Threshold Analysis	A scatter plot of the Event Strength vs. Current is displayed in a sub-panel. To measure X-Y data points or set a fitting range, select 'Toggle Cursor Info' from the right-click menu. (See 'Right-Click Menus' for Scope windows.)
Save Results	Results are displayed in a Layout page and a table.

Synaptic Event Analysis Results

Results are displayed in their own Layout window, accessible via Windows / Layouts.

Signal Pathname: The path from the Igor Pro internal root directory is displayed (see Data Browser.)

Total time analyzed = (s)

Includes the Start/End times for all sweeps.

Number of events detected =

Total number of Events found.

Event Frequency = (Hz)

Average Event Amplitude = (pA)

±1 ms peak average.

Standard Deviation of Event Amplitude = (pA)

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.

Results Table — A table of columns is created.

[blank]	Row number with 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)	
10-90% Rise Time (s)	
Event Decay Tau (s)	
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)	

Duplicate — Display duplicate copies of the Results table and layout.

Plot — The 'Plot sweeps' dialog displays to allow events to be plotted as overlapping sweeps in a floating graph window.

Plot sweeps — Enter a list of events separated by a comma "," and/or a range of events separated by a dash "-".

(See the SutterPatch Algorithms Appendix for a reference to the synaptic event detection algorithm.)

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, and provides programmatic interaction with SutterPatch. You can manually execute Igor Pro and user-defined assignments, functions and operations in this window.

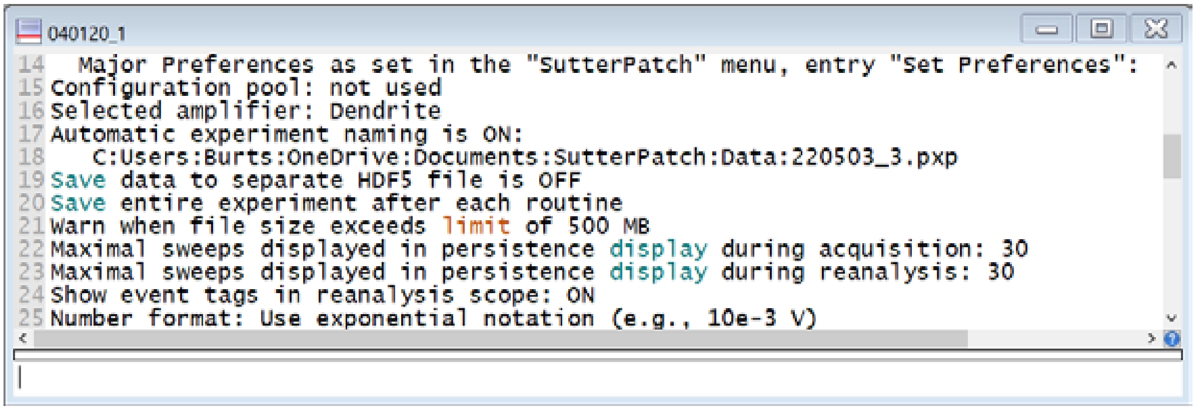


Figure 4-94. Command Window

The Command window is labeled with the current Experiment name, and is accessed from the menu Windows / Command Window.

A history of executed commands and responses displays in the upper section 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

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 placed into the command buffer in multiple ways:

- Manually type (or copy and paste) a line of text into the command line.
- Highlight lines in the history section, and press the Enter key to copy them into the command buffer. To select the entire history, use 'CTRL-A'.
- Use the Paradigm Editor 'Execute' Step Editor 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 Section II-2 of the Igor Pro manual.

4.3.2 Dashboard Panel

SutterPatch: Dashboard

The Dashboard panel provides a convenient gateway to key areas of the SutterPatch program, or to the entire SutterPatch menu.

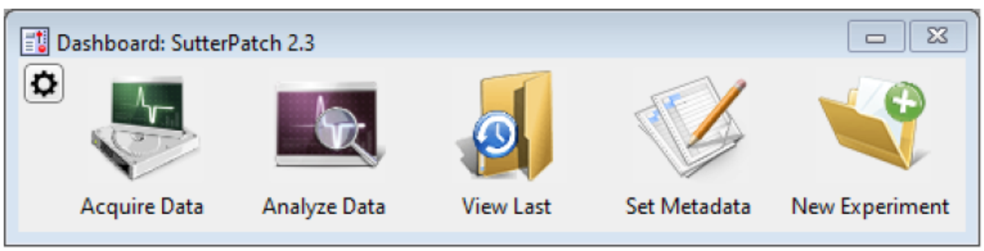


Figure 4-95. Dashboard

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, and dock it to the upper right corner of the computer screen.

Horizontal — Align the toolbar horizontally, and move it to the left-side of the computer screen.

Show Defaults — Amplifier Control Panel
Membrane Test
Free Run (Scope)
Paradigm Editor
Routine Editor
Data Navigator
Set Metadata
View Last
New Experiment / New HDF5 File

Show All Entries

Hide All Entries

Large Icons

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 or unmarked) are visible in the initial display.

Set Metadata

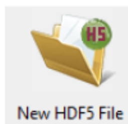
Configure metadata settings and values.

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 (set option in SutterPatch / Set Preferences / Files and Naming)



New HDF5 File

Start a new HDF5 file for the Experiment.

Clicking the Acquire Data icon opens an adjoining secondary pane:

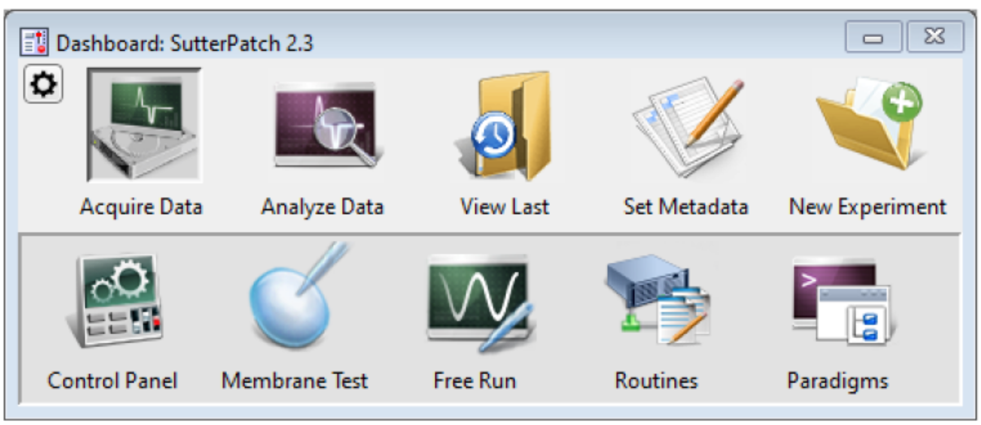


Figure 4-96. Dashboard - Acquisition

Control Panel

Hardware control via the Dendrite Control Panel.

Membrane Test

Monitor seal formation and cell health.

 Free Run

Run an oscilloscope-style signal monitor.

 Routines

Configure Routine acquisition settings.

 Paradigms

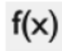
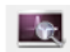
Control the execution of commands.

Small Icons

Display the SutterPatch dashboard as small icons in a floating toolbar.

Select the icons to display in the toolbar:

Icon	Icon Name	Shortcut Key
	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
	New Experiment / New HDF5 File	

4.3.3 Documentation

<u>Help</u>

Help: Help Topics

Full online Help for the SutterPatch software and all models of Sutter Amplifier Systems is available via the Igor Pro ‘Help Browser’.

In the browser’s ‘Help Topics’ tab:

1. Select a Help file starting with “SP_”.

2. Select a Topic to display its Subtopics.

3. Select and click ‘Show Selected Topic’.

Manual

The SutterPatch manual is customized to your Dendrite system, and installed as a PDF file on your computer.

Windows:	C:\ProgramFiles\SutterPatch2\SutterPatch\Documentation\
macOS:	Applications/SutterPatch2/SutterPatch/

To display a PDF Table of Contents with links:

Windows:	In the PDF document, click the ‘Contents’ button on the left side of the PDF Navigation Toolbar, and select the ‘List’ button.
macOS:	In the PDF document, click the ‘Contents’ button on the left side of the PDF Navigation Toolbar, or the ‘Page Thumbnails’ button left of the sidebar, and select ‘Table of Contents’.

QuickStart Guide

A printed “quick” installation guide for your Sutter hardware and software.

Important! Contains your Igor Pro 9 Serial Number and Registration 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:

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

4.3.4 File Import/Export

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 also 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 saving of Experiments that include very large numbers of waves (thousands or more), as existing data waves are not resaved to the Experiment 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/ SutterPatch2/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.

Axon Files

Data can be selected and exported to the Axon Instruments pCLAMP file formats via the Data Navigator 'Available Actions' button or a right-click menu. First select 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.

HDF5 Files

HDF5 is a modern efficient file format for managing and saving 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

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.

The Data Navigator 'Import' option for PatchMaster 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.

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.

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.

Graph, Table and Layout Files

Graphs in the Analysis Editor can be imported or exported as Igor Binary Wave (*.ibw) files, via the dialog's 'File's 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.

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.

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 a '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.

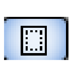
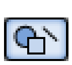
Clicking a Layout button appends its associated items into an existing Layout page (or a new Layout window.) Each signal and analysis graph is appended as an individual object.

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 – the top two buttons reconfigure the toolbar buttons:

-  Operate Mode — Selection tools and object insertion mode.
-  Draw Mode — Drawing tools mode.

The main menu 'Layout' command also displays to 'Show' or 'Delete' the Layout window.

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.

Layout windows can also be saved with the Experiment as Layout Macros - recall them via the Windows / Layout Macros menu.

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 4-97. 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 online help or manual.

Window/Dialog Controls

Keyboard “Return” key	=	‘OK / Yes’ buttons
Keyboard ESC key	=	‘Cancel’ button

File

Data file path defaults:

Windows:	C:\Users\<User Account Name> \Documents\SutterPatch\Data\
macOS:	Applications/ SutterPatch2/SutterPatch/Data/

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: 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.

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: 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 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: [pathname]

- 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.

  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 session is launched, The SutterPatch menu is populated with blank submenus, and the command 'Reactivate SutterPatch' to re-open the Experiment, followed by blank submenus.

Save Experiment

If the current Experiment is already named, it is immediately saved. Otherwise, a 'Save experiment as' file dialog is displayed. If Preferences are enabled for automatic file naming, a default Experiment name is provided.

Stores the Experiment data and temporary (input / output) waves, but does no other cleanup; HDF5 files are not updated to disk.

Save Experiment As

If Preferences are disabled for automatic file naming, the last used Experiment file name or the default name is displayed for renaming and saving. This then stores the Experiment data and temporary (input / output) waves, but does no other cleanup; HDF5 files are not updated to disk.

If Preferences are enabled for automatic file naming, an incrementing Experiment name is displayed for renaming and saving. However, nothing else in the Experiment gets saved.

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.

[The following 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	
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.
Update SutterPatch HDF5 File	[Only ungrays when data has been acquired or loaded.] Update the SutterPatch HDF5 data file without resaving the entire Experiment.
Compact SutterPatch HDF5 File	[Only displays when data has been discarded.] Remove discarded data from a SutterPatch HDF5 data file without resaving the entire Experiment.

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.

Windows

The Windows menu provides access to 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 the menu command.

Layout

The Layout menu only displays when a Layout is the active window. Use it to modify the Layout window objects and display.

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 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 (Scope)	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 Editor	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.
Analysis Editor	Open a window to manage analysis graphs.

Layout Page	Show Layout
	Delete Layout

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.

Action 1 [VHold+10mV|10pA:Right]	
Action 2 [VHold-10mV|10pA:Left]	
Action 3 [VHold+1mV|1pA:Right,shift]	
Action 4 [VHold-1mV|1pA:Left,shift]	
Action 5 [View last]	F2
Action 6 [Stop Acquisition]	F3
Action 7 [Start Routine]	F4
Action 8 [Stop Routine]	F5
Action 9 [Pause Paradigm]	F6
Action 10 [Resume Paradigm]	F7

Available Analysis Modules

- Action Potential Analysis
- Synaptic Event Analysis
- Single Channel Analysis

Help

Igor Help Browser	Igor Pro and SutterPatch Help Topics.
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 To display a limited data modification menu, right-click the blank area in a signal.

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.
- Toggle Cursor Info
- Colors
- Hide Signal '<signal name>'
- Show Signal '<signal name>' Only
- Stack All Signals

Reanalysis Scope main window

To display a limited data modification menu, right-click the blank area in a signal.

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.
- Toggle Cursor Info — Manually measure X-Y data values or set a fitting range.
- Colors
- Hide Signal ‘<signal name>’
- Show Signal ‘<signal name>’ Only
- Stack All Signals
- Show All Sweeps
- Show Marked Sweeps

Signal data

To display the full data modification menu, right-click on or near the data.

- Browse <signal name>
- Edit <signal name>
- Remove Sweep_#
- Hide Sweep_#
- Duplicate Sweep_#
- Replace Wave
- 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
- Toggle Cursor Info
- Hide Signal ‘<signal name>’
- Show Signal ‘<signal name>’ Only
- Stack All Signals
- Show All Sweeps
- Show Marked Sweeps

Scope Marquee window (click-and-drag 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 text-entry lab Notebook, that also receives Igor Pro cursor measurements, and optional system logging information.

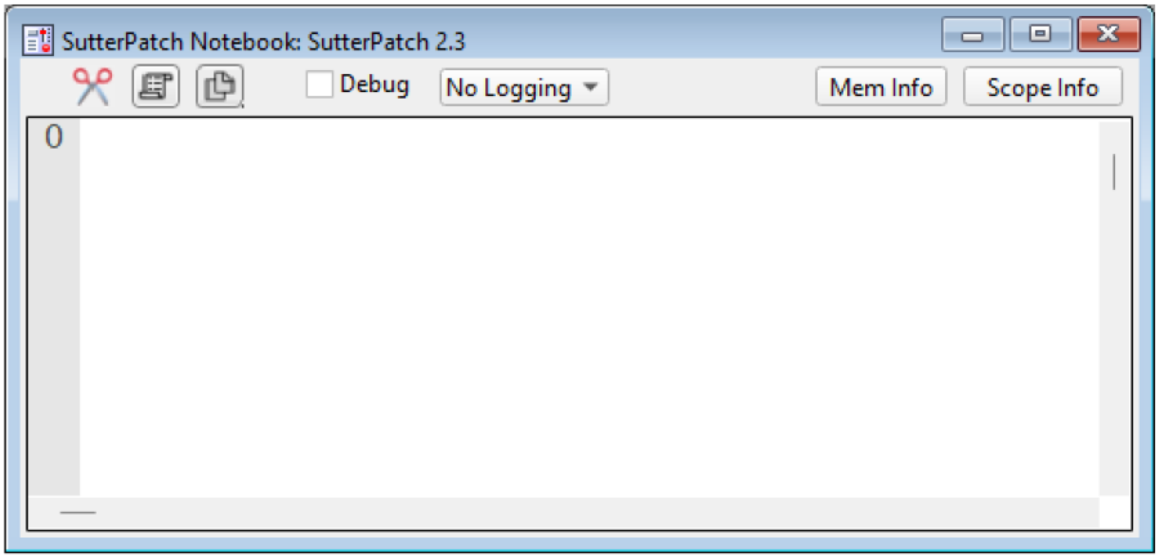


Figure 4-98. Notebook

	Clear	Clear the complete Notebook content.
	Copy to Layout	Click to copy the selected text or the compete (unselected) Notebook into a new Layout window, or append to an existing Layout page, as a text annotation on top of the graph 1 location. Use a Shift-click to copy the text into successive graph locations.
	Copy to Clipboard	Copy the selected text or the compete (unselected) Notebook to the system clipboard.
[Text window]		Each line is numbered, and usually starts with the time in hh:mm:ss.xxx. All entries can be edited or deleted.

4.3.9 Sample Files

Sample settings files (subject to change) are included in the ... / Documents / SutterPatch / Parameters folder:

<u>Compound Pool</u>

SP_CompoundPool.spc

1. undefined — No compounds are configured.

Dynamic Clamp Pool

SP_DynamicClampPool.spd	[for dPatch systems]

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_dPatch.spp	[for dPatch systems]
LockIn / LockIn_IPA.spp	[for D/IPA systems]
SP_ParadigmPool_Dendrite.spp	[for Dendrite systems]

1.	Start_one_Series	Start acquisition of one routine.
2.	Start_two_Series	Start acquisition of two subsequent routines.
3.	Start_ForEachSweep	Start acquisition of a routine, individually triggering each sweep.
4.	Interactive_acquisition_1	Run an interactive acquisition stopping at a given analysis condition.
5.	Interactive_acquisition_2	Run an interactive acquisition loop that selects between 2 routines, and manually stops via a Checkbox.
6.	Toggle_Persistence	Use a Checkbox to toggle Scope window trace persistence while acquiring a routine.
7.	Tuning_with_Keys	Use the keyboard to increment or decrement a Routine’s stimulus output by 10 mV.
8.	Tuning_with_Input	Use the paradigm "Input" control to increment or decrement a Routine’s stimulus output.

SP_ParadigmPool_dPatch.spp	[for dPatch systems]
SP_ParadigmPool_IPA.spp	[for D/IPA systems]

Routine Pools

LockIn / LockIn_DIPA.spr	[for Double IPA systems]
LockIn / LockIn_dPatch.spr	[for dPatch systems]
LockIn / LockIn_IPA.spr	[for IPA systems]
SP_RoutinePool.spr	[for IPA systems]
SP_RoutinePool_Dendrite.spr	Routines for Dendrite systems.

1. Amplitude Equations	Equations for a variety of stimulus waveforms.
2. A_T_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]

SP_RoutinePool_dPatch.spr	[for two-headstage dPatch systems]
SP_RoutinePool_dPatch_1HS.spr	[for one-headstage dPatch systems]

Shortcut Pool

SP_ShortcutPool.sps

1.	VHold + 10mV	Increase the Control Panel V-holding level by 10 mV.
2.	VHold – 10mV	Decrease the Control Panel V-holding level by 10 mV.
3.	VHold + 1mV	Increase the Control Panel V-holding level by 1 mV.
4.	VHold – 1mV	Decrease the Control Panel V-holding level by 1 mV.
5.	View last	Open the last acquired Series into a Reanalysis Scope window.
6.	Stop Acquisition	Stop the acquisition of a Series.
7.	Start Acquisition	Start the acquisition of a Series.
8.	Stop Paradigm	Stop the execution of a Paradigm.
9.	Pause Paradigm	Stop the execution of a Paradigm.
10.	Resume Paradigm	Resume execution of a Paradigm.
11.	Cursor Info	Toggle On/Off
12.	Next Sweep	
13.	Previous Sweep	

Solution Pools

SP_SolutionPool.spl	[for all Sutter amplifier systems from SutterPatch v2.3 onwards]

1. undefined — No solutions are configured.

SP_SolutionPool.spo	[for all Sutter amplifier systems from SutterPatch version 2.2.1 or earlier]

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:

1. ActionPotentials.pxp Action potential data.
2. LargeAPs.pxp Large action potentials data.
3. MiniExample.pxp Spontaneous miniature synaptic potential data.

4.3.10 Set Metadata

SutterPatch: Set Metadata

A variety of optional experimental parameters (preparation, electrode, etc.) can be associated with an Experiment, Paradigm, or Routine as user-configurable "metadata".

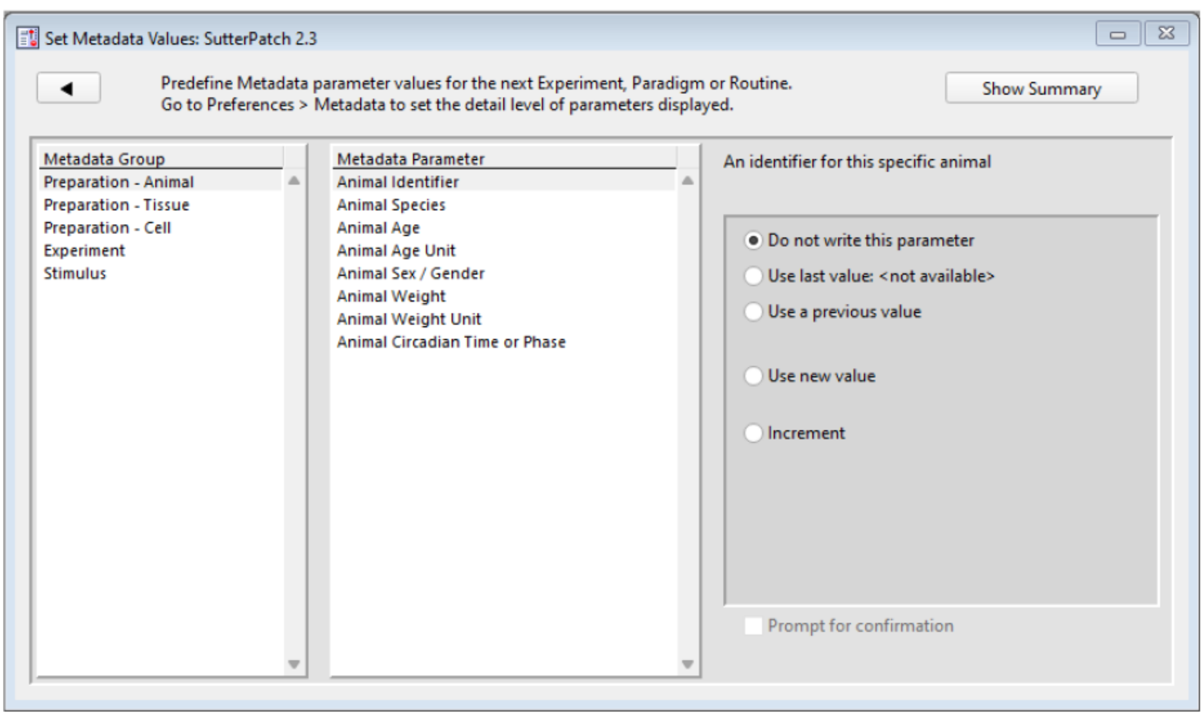


Figure 4-99. Set Metadata Values

Predefine the Metadata parameter values here.

Show Summary An overview of the user-defined metadata parameters.

Metadata Summary dialog

This list summarizes all Metadata parameters (from all Metadata detail levels) 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'.

Basic Level 1 (default metadata groups)

Preparation – Animal
Preparation – Tissue
Preparation – Cell
Experiment
Stimulus

Extended Level 2 (plus two more metadata groups)

Electrode
Recording Solution

Full Level 3 (plus four more metadata groups)

Operator
Paradigm
Cell Health / Quality Control
Series (= Routine Data)

Metadata Parameter The available metadata parameters are displayed by detail level, as set in SutterPatch > Set Preferences > Metadata.

[Parameter description]

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 stored.

  If this parameter was previously written in this Experiment, then its Previous Value is displayed.
- Use last value — The parameter used in the previous acquisition is written.
- Use a previous value — Select from a drop-down list of the previous 20 metadata values used for acquisition in the experiment.
- 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 (before):

- 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 — This dialog displays whenever an Experiment, Paradigm or Routine is started with prompts enabled.

Write	Enable to write the selected metadata parameter with the Experiment, Paradigm or Routine.
Metadata Parameter	The name of the selected metadata parameter.
Next 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'.

BASIC	EXTENDED	FULL	GROUP / Parameters	NOTES
		F	**OPERATOR**	
		F	Full Operator Name	
B	E	F	**PREPARATION - ANIMAL**	
B	E	F	Animal Identifier	
B	E	F	Animal Species	Binomial species name
	E	F	Animal Strain	Strain, breed or variety characterizing the animal
	E	F	Animal Genotype	
B	E	F	Animal Age	
B	E	F	Animal Age Unit	Ex.: h, d, m
B	E	F	Animal Sex / Gender	Ex.: 1: F, 2: M, 3: Undeter-mined
B	E	F	Animal Weight	
B	E	F	Animal Weight Unit	
B	E	F	Annual Circadian Time or Phase	
	E	F	Animal Preparation Date	ISO Date, Format: YYYY-MM-DD
	E	F	Animal Preparation Time	Time of Day, Format: hh:mm[:ss.000]
	E	F	Animal User Parameter 1 Name	
	E	F	Animal User Parameter 1	
	E	F	Animal User Parameter 2 Name	
	E	F	Animal User Parameter 2	
	E	F	Animal User Parameter 3 Name	
	E	F	Animal User Parameter 3	
	E	F	Animal User Parameter 4 Name	
	E	F	Animal User Parameter 4	
	E	F	Animal User Parameter 5 Name	
	E	F	Animal User Parameter 5	
B	E	F	**PREPARATION - TISSUE**	
B	E	F	Tissue Preparation Identifier	
B	E	F	Organ	
	E	F	Organ Region	
	E	F	Preparation Method	
	E	F	Tissue Preparation Date	ISO Date, Format: YYY-MM-DD
	E	F	Tissue Preparation Time	Time of Day, Format: hh:mm[:ss.000]
	E	F	Tissue Incubation Duration	
	E	F	Tissue Incubation Duration Unit	
	E	F	Tissue Incubation Temperature	
	E	F	Tissue Incubation Temperature Unit	
	E	F	Tissue Incubation Solution	
	E	F	Tissue User Parameter 1 Name	
	E	F	Tissue User Parameter 1	
	E	F	Tissue User Parameter 2 Name	
	E	F	Tissue User Parameter 2	

	E	F	Tissue User Parameter 3 Name	
	E	F	Tissue User Parameter 3	
	E	F	Tissue User Parameter 4 Name	
	E	F	Tissue User Parameter 4	
	E	F	Tissue User Parameter 5 Name	
	E	F	Tissue User Parameter 5	
B	E	F	**PREPARATION - CELL**	
B	E	F	Cell Preparation Identifier	
	E	F	Acutely Dissociated Cells	
	E	F	Cell Line	
	E	F	Slice Preparation	
	E	F	Whole-organ Preparation	
	E	F	In-situ Recording	
	E	F	Stem Cell Preparation	
	E	F	User-defined Preparation	
B	E	F	Cell Type	
B	E	F	Cell Identifier	
B	E	F	Cell Preparation Date	ISO Date, Format: YYY-MM-DD
B	E	F	Cell Preparation Time	Time of Day, Format: hh:mm[:ss.000]
	E	F	Cell Dissociation Solution	
	E	F	Cell Preparation Dissociation Temperature	
	E	F	Cell Prep. Dissociation Temperature Unit	
B	E	F	Cell Preparation Incubation Duration	
B	E	F	Cell Prep. Incubation Duration Unit	
B	E	F	Cell Preparation Incubation Temperature	
B	E	F	Cell Prep. Incubation Temperature Unit	
B	E	F	Cell Preparation Incubation Solution	
B	E	F	Ion Channel	
	E	F	Cell Fluorescent Marker	
	E	F	Cell Diameter	
	E	F	Cell User Parameter 1 Name	
	E	F	Cell User Parameter 1	
	E	F	Cell User Parameter 2 Name	
	E	F	Cell User Parameter 2	
	E	F	Cell User Parameter 3 Name	
	E	F	Cell User Parameter 3	
	E	F	Cell User Parameter 4 Name	
	E	F	Cell User Parameter 4	
	E	F	Cell User Parameter 5 Name	
	E	F	Cell User Parameter 5	
B	E	F	**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	E	F	Experiment User Parameter 1 Name	
B	E	F	Experiment User Parameter 1	
B	E	F	Experiment User Parameter 2 Name	
B	E	F	Experiment User Parameter 2	
B	E	F	Experiment User Parameter 3 Name	
B	E	F	Experiment User Parameter 3	
B	E	F	Experiment User Parameter 4 Name	
B	E	F	Experiment User Parameter 4	
B	E	F	Experiment User Parameter 5 Name	
B	E	F	Experiment User Parameter 5	
	E	F	**ELECTRODE**	
	E	F	Electrode Identifier	
	E	F	Electrode Glass Manufacturer	
	E	F	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	F	Electrode Glass Ramp Test Value	
	E	F	Pipette Puller Manufacturer	
	E	F	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	F	Electrode User Parameter 1 Name	
	E	F	Electrode User Parameter 1	
	E	F	Electrode User Parameter 2 Name	
	E	F	Electrode User Parameter 2	
	E	F	Electrode User Parameter 3 Name	
	E	F	Electrode User Parameter 3	
	E	F	Electrode User Parameter 4 Name	
	E	F	Electrode User Parameter 4	
	E	F	Electrode User Parameter 5 Name	
	E	F	Electrode User Parameter 5	
	E	F	RECORDING SOLUTIONS	
	E	F	Solution Pair Identifier	
	E	F	Solution Pair Name	
	E	F	Bath Solution Identifier	
	E	F	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	
			Bath Solution Preparer	
	E	F	Pipette Solution Identifier	
	E	F	Pipette Solution Name	
		F	Pipette Solution Batch	
		F	Pipette Solution Composition	
		F	Pipette Solution Preparation Date	
		F	Pipette Solution Preparation Time	
	E	F	Pipette Solution pH	
		F	Pipette Solution pH Adjustment Agent	
	E	F	Pipette Solution Osmolarity	
		F	Pipette Solution Osmolarity Adj. Agent	
		F	Pipette Solution Preparer	
		F	Liquid Junction Potential, computed	
		F	Liquid Junction Potential, measured	
		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	E	F	**STIMULUS**	
	E	F	Key Stimulus	
	E	F	Stimulus Duration	
	E	F	Compound Group	
	E	F	Compound Group Index	
B	E	F	Compound Identifier	
B	E	F	Compound Name	
B	E	F	Compound Concentration	
B	E	F	Compound Concentration Unit	
	E	F	Compound Batch	
	E	F	Compound Lot	
	E	F	Compound Salt Code	
	E	F	Compound Solution	
	E	F	Compound Vehicle / Solubility Enhancer	
	E	F	Compound Vehicle Concentration	
	E	F	Compound Vehicle Concentration Unit	
	E	F	Compound Reservoir Identifier	
	E	F	Application Tip Identifier	
	E	F	Compound Plate Identifier	
	E	F	Compound Plate Row	
	E	F	Compound Plate Column	
	E	F	Chem. Stimulus User Parameter 1 Name	
	E	F	Chem. Stimulus User Parameter 1	
	E	F	Chem. Stimulus User Parameter 2 Name	
	E	F	Chem. Stimulus User Parameter 2	
	E	F	Chem. Stimulus User Parameter 3 Name	
	E	F	Chem. Stimulus User Parameter 3	
	E	F	Chem. Stimulus User Parameter 4 Name	
	E	F	Chem. Stimulus User Parameter 4	
	E	F	Chem. Stimulus User Parameter 5 Name	
	E	F	Chem. Stimulus User Parameter 5	
B	E	F	Light Stimulus Wavelength	
B	E	F	Light Stimulus Intensity	
B	E	F	Light Stimulus Intensity Unit	
	E	F	Light Stimulus User Parameter 1 Name	
	E	F	Light Stimulus User Parameter 1	
	E	F	Light Stimulus User Parameter 2 Name	
	E	F	Light Stimulus User Parameter 2	
	E	F	Light Stimulus User Parameter 3 Name	
	E	F	Light Stimulus User Parameter 3	
	E	F	Light Stimulus User Parameter 4 Name	
	E	F	Light Stimulus User Parameter 4	
	E	F	Light Stimulus User Parameter 5 Name	

	E	F	Light Stimulus User Parameter 5	
B	E	F	Mechanical Stimulus Intensity	
B	E	F	Mechanical Stimulus Intensity Unit	
	E	F	Mechanical Stimulus User Parameter 1 Name	
	E	F	Mechanical Stimulus User Parameter 1	
	E	F	Mechanical Stimulus User Parameter 2 Name	
	E	F	Mechanical Stimulus User Parameter 2	
	E	F	Mechanical Stimulus User Parameter 3 Name	
	E	F	Mechanical Stimulus User Parameter 3	
	E	F	Mechanical Stimulus User Parameter 4 Name	
	E	F	Mechanical Stimulus User Parameter 4	
	E	F	Mechanical Stimulus User Parameter 5 Name	
	E	F	Mechanical Stimulus User Parameter 5	
B	E	F	Acoustic Stimulus Frequency	
B	E	F	Acoustic Stimulus Intensity	
B	E	F	Acoustic Stimulus Intensity Unit	
	E	F	Acoust. Stimulus User Parameter 1 Name	
	E	F	Acoust. Stimulus User Parameter 1	
	E	F	Acoust. Stimulus User Parameter 2 Name	
	E	F	Acoust. Stimulus User Parameter 2	
	E	F	Acoust. Stimulus User Parameter 3 Name	
	E	F	Acoust. Stimulus User Parameter 3	
	E	F	Acoust. Stimulus User Parameter 4 Name	
	E	F	Acoust. Stimulus User Parameter 4	
	E	F	Acoust. Stimulus User Parameter 5 Name	
	E	F	Acoust. Stimulus User Parameter 5	
B	E	F	Thermal Stimulus Temperature	
B	E	F	Thermal Stimulus Temperature Unit	°C, °F or K
	E	F	Thermal Stimulus User Parameter 1 Name	
	E	F	Thermal Stimulus User Parameter 1	
	E	F	Thermal Stimulus User Parameter 2 Name	
	E	F	Thermal Stimulus User Parameter 2	
	E	F	Thermal Stimulus User Parameter 3 Name	
	E	F	Thermal Stimulus User Parameter 3	
	E	F	Thermal Stimulus User Parameter 4 Name	
	E	F	Thermal Stimulus User Parameter 4	
	E	F	Thermal Stimulus User Parameter 5 Name	
	E	F	Thermal Stimulus User Parameter 5	
B	E	F	Electrical Stimulus Frequency	The frequency of an external electrical stimulus

B	E	F	Electrical Stimulus Intensity	The intensity of an external electrical stimulus
B	E	F	Electrical Stimulus Intensity Unit	The intensity unit of an external electrical stimulus
	E	F	Electrical Stimulus User Parameter 1 Name	
	E	F	Electrical Stimulus User Parameter 1	
	E	F	Electrical Stimulus User Parameter 2 Name	
	E	F	Electrical Stimulus User Parameter 2	
	E	F	Electrical Stimulus User Parameter 3 Name	
	E	F	Electrical Stimulus User Parameter 3	
	E	F	Electrical Stimulus User Parameter 4 Name	
	E	F	Electrical Stimulus User Parameter 4	
	E	F	Electrical Stimulus User Parameter 5 Name	
	E	F	Electrical Stimulus User Parameter 5	
	E	F	Other Stimulus User Parameter 1 Name	
	E	F	Other Stimulus User Parameter 1	
	E	F	Other Stimulus User Parameter 2 Name	
	E	F	Other Stimulus User Parameter 2	
	E	F	Other Stimulus User Parameter 3 Name	
	E	F	Other Stimulus User Parameter 3	
	E	F	Other Stimulus User Parameter 4 Name	
	E	F	Other Stimulus User Parameter 4	
	E	F	Other Stimulus User Parameter 5 Name	
	E	F	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.

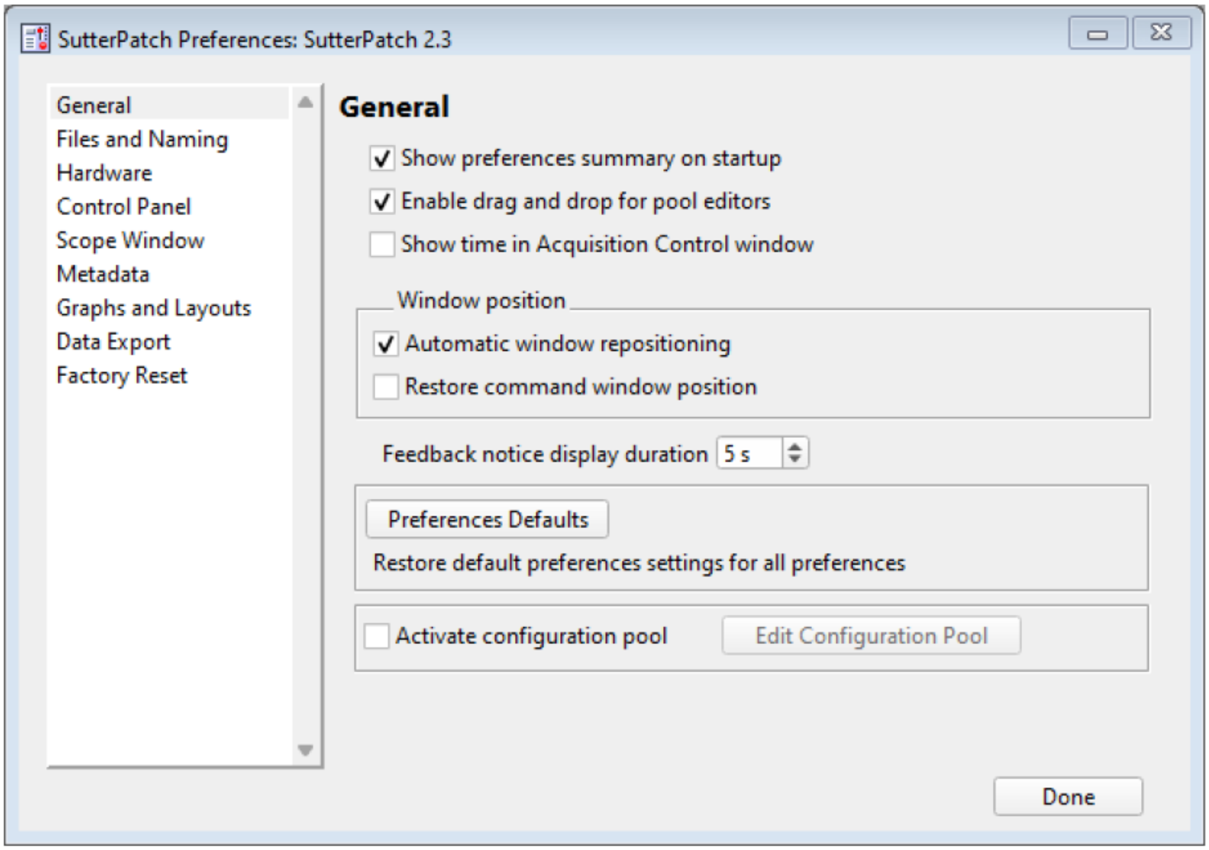


Figure 4-100. Preferences Settings

i. General

Don’t wait at Startup Panel

Skip the “Welcome” screen during startup and directly launch SutterPatch with a new Experiment. The options to startup just ‘Igor Pro’ or to re-open a saved Experiment are bypassed.

Show preferences summary on startup

Display the ‘Summary of Major Preferences’ window when SutterPatch s a new Experiment.

Configuration pool: <name> | not used

Selected amplifier: Dendrite

Automatic experiment naming is ON|OFF

<experiment file pathname>

Save data to separate HDF5 file is ON|OFF

Save entire experiment | (Don't) Save to temp file after each routine

Warn when file size exceeds limit of 500 MB|OFF

Maximal sweeps displayed in persistence display during acquisition:

| all

Maximal sweeps displayed in persistence display during reanalysis: #

| all

Show event tags in reanalysis scope: ON|OFF

Number format: Use exponential | engineering

and also display this summary in the startup 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.

Dual-monitor option	[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.

Note: You can also bring all unminimized windows into view with the Windows > Control > Retrieve All Windows menu command.

Feedback notice display duration

[1 – 30 s]

Control how long SutterPatch messages display for reading, before automatically closing.

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 .

Delete Configuration — Remove the named Configuration from the list.

Add New Configuration — Create a new Preferences Configuration for the existing Preferences settings.

Description — Enter the name of the new Preferences Configuration.

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 ”.

ii. Files and Naming

Data file path: Browse to select a folder.

The data folder should reside on a local disk drive. We do not recommend using a mapped network drive, as speed/throughput bottlenecks can occur, including delays when saving experiments.

Default file paths

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

macOS: Applications/SutterPatch2/SutterPatch/Data/

Enable automatic naming for experiment

Experiment file name example: (Maximum 34 characters)

[ ]

Text:	[ ] Include user text at the start of the file name. At least one character is required. Valid characters are A-Z, a-z, 0-9 and "_".
Separator	Separate the user text from the rest of the file name with an underscore.
Date: YYMMDD	Include the date in the file name.
Separator	Separate the date from the rest of the file name with an underscore.
Time: hhmmss	Include the time in the file name.

Save 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: This setting is disabled by a Factory Reset.

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, this can result in delays when saving new data, as the entire experiment is re-saved with each additional recording. (See HDF5 file below.)

Enable the HDF5 file option to avoid such delays. A new setting becomes active after starting a New Experiment or a new SutterPatch session.

Then, 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".

Keep only one Sweep in Memory

[only displays when "Save data to HDF5" is enabled]

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 online, such as subtracting the data of a "reference" sweep from other sweeps.

Update HDF5 file after each routine

[only displays when "Save data to HDF5" is enabled]

For efficient processing, while the raw signal data are written to the HDF5 file after each sweep during acquisition, the other SutterPatch Data folder information (metadata, Experiment structure, analysis results, Routines, Log, images, Dynamic Clamp conductances) is separately written to the HDF5 file.

The non-data information are automatically written to the HDF5 file at the end of an Experiment. However, if this option is enabled, the information is also automatically written to the HDF5 file at the end of each Series.

[save options] [displays when “Save data to HDF5” is enabled]

- Save data as double precision, 8-byte reals

The raw data are saved as reals instead of floats. This can help to reduce file sizes for large Experiments.

- Save data as single precision, 4-byte reals

The raw data are saved as reals instead of floats. This can help to file sizes for large Experiments.

[save options] [displays when “Save data to HDF5” is disabled]

- 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.

- Save entire experiment after each routine

This default option re-saves the entire Experiment after each recording (all data and Experiment information). 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 limit.

Note: It is advised to disable the Igor Pro 9 'Autosave' feature to prevent delays during data acquisition. See Misc / Miscellaneous Settings / Autosave.

iii. 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, emulate:
  - IPA — Integrated Patch Amplifier system.
  - Double IPA — Dual-headstage IPA system.
  - dPatch — Digital Patch-clamp system.
  - Dendrite — Data Acquisition system.

  When a new Experiment is started, if Sutter electrophysiology hardware is not connected to the computer and turned on, then automatically start up in the selected hardware emulation mode.

iv. Control Panel

Customize the active headstage tab's color in the Control Panel.

Headstage background color

Headstage 1	Color palette displays.
Headstage2	Color palette displays.

v. 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:

- 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.

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.

Acquisition

Maximal sweeps displayed in persistence display

[2 – 100] (30 = default value)

The last 'N' sweeps are displayed.

[All] All sweeps are displayed.

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 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.

Reanalysis

Persistence — On

Off

Keep current setting

Maximal sweeps displayed in persistence display

[2 – 100]

All

Improve data readability and system performance by restricting the number of sweeps displayed, which reduces 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.

Show event tags — Display tag lines in the Reanalysis Scope window; also display tag text boxes in the Continuous and Concatenated display modes.

Tag Position

- Frozen
- Movable

Tag types to show

- User

- Input-triggered
- System

<u>Tag text box</u>

■ Relative Time	Time from beginning of Series. [hours to milliseconds]
■ Absolute Time	Clock time. [hours to milliseconds]
■ Description	User Comment, from ‘Set Tag’.

<u>Tag appearance</u>

- Color by type
- Transparent

Appearance Use a color palette to choose colors.

Active signal panel color	[light gray]
Inactive signal panel color	[dark gray]
Active sweep color	[dark blue]
Inactive sweep color	[red]
Event tag line color	[blue]
Drop-down color palette	Click on a color square to set it as the active color.
Other	Use a color dialog with more options.
Opaque	< unused >
[Preview Pane]	The selected signal and sweep colors are displayed in a preview pane.

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

- Windows: In the Control Panel / Appearance / Personalization window, scroll down and select the High Contrast Black theme, or use the Windows Magnifier tool with option ‘Turn on color inversion’ enabled.

- 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

Metadata setup detail level:

Select levels for metadata setup categorization complexity.

Select which metadata groups and parameters are visible for configuration in 'Set Metadata' and in Data Navigator / 'Build Hierarchy'.

Basic	Show only the most essential parameters.
Extended	Show additional detail.
Full	Expose all available metadata parameters.

Note: This setting does not affect the Metadata Review dialog - all user-defined metadata are displayed irrespective of the metadata detail level.

This setting does not affect data acquisition metadata prompts – all configured prompts are always executed.

vii. Graphs and Layouts

These settings apply to Layout windows and stand-alone graph windows (not graph files).

Copy "To Clipboard" graph 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.

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

left (the Y-axis)

Tick location:

- Outside
- Crossing
- Inside
- None

Labels:

- On
- Axis only Text labels only.
- Off

Grid:

- Off
- On
- Major only

bottom (the X-axis)

Tick location:

- Outside
- Crossing
- Inside
- None

Labels:

- On
- Axis only
- Off

Grid:

- Off
- On
- Major only

viii. Data Export

File Export

- Igor Binary Format — Save the signal formatted as an "Igor Binary Wave" file (*.ibw).
    - 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 each signal of the routine formatted as an "Axon Binary File" v.1.8 (*.abf).
    - 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 signal formatted as an "Axon Text File" (*.atf).

  Uses the table formatting preferences below.

Table Formatting: Copy to Clipboard, Text Table Export

Cell separator

- Tab
- Comma

- Semicolon

New line

- <CR> (Igor Pro, macos)
- <CR> <LF> (Windows)

Invalid value

- Use NaN
- Use empty string
- Use zero

Digits in table entries [3 – 15]

Numeric format

- Use exponential notation (e.g., 10e-3 V)
- Use engineering prefix (e.g., mV)

  This uses "powers of 3" to determine the decimal prefix symbol (e.g., µ, m, n, p) for a non-zero number to the left of the decimal point with 1 – 3 digits.

ix. Factory Reset

[Factory Reset] Click this button to reset all SutterPatch preferences and settings to their defaults. SutterPatch will need to be exited and restarted to complete the factory reset.

Warning! When you do a factory reset, you will lose ALL your configuration data (including Metadata, Scope, Preferences, etc.)

4.3.12 Shortcut Editor

SutterPatch: Shortcuts: Shortcut Editor

Keyboard control of SutterPatch is available by configuring keyboard shortcuts.

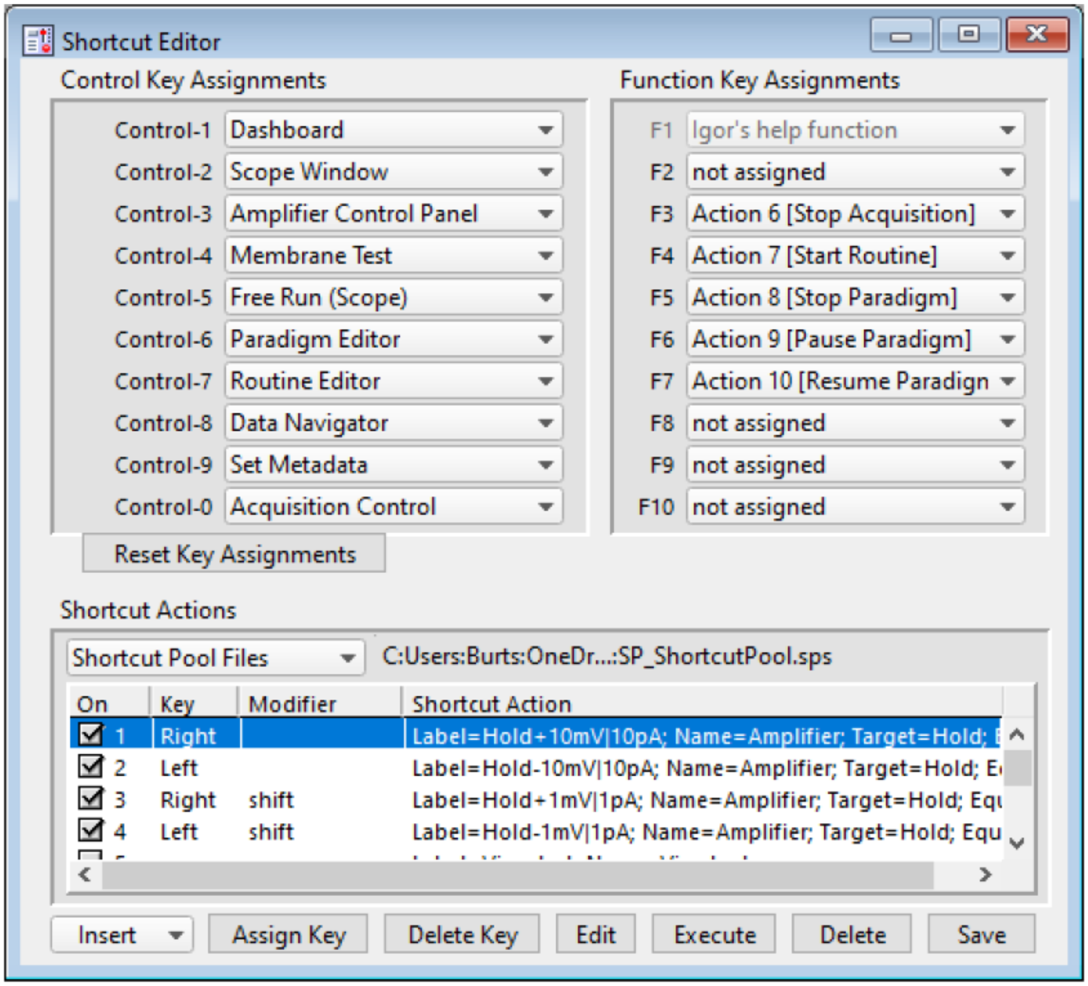


Figure 4-101. Shortcuts Editor

All assigned Control (Command), 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 items 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 / Command 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 a Control key by holding down:

- Windows: Control key: Ctrl
- macOS: Command key: ⌘

and clicking its assigned number key.

Control keys and their default SutterPatch menu assignments:

Control-1	Dashboard	
Control-2	Scope Window	[Scope window must be open.]
Control-3	Amplifier Control Panel	
Control-4	Membrane Test	
Control-5	Free Run (Scope)	
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:

Analysis Editor
Camera Module
Equation Editor
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 other 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.

Function Key F1 is not available for assignment, as it is reserved for Igor Pro’s Help function.

Default Functions

F1		Igor Pro’s Help function	
F2	Action 5	View last]	
F3	Action 6	Stop Acquisition	
F4	Action 7	Start Routine	
F5	Action 8	Stop Routine	
F6	Action 9	Pause Paradigm	
F7	Action 10	Resume Paradigm	
F10	Action 11	Cursor Info	[Target window must be open.]

Reset Key Assignments

Reset all Control keys to their default settings. Function key “menu” items are reset to ‘not assigned’, while ‘Action’ items are unaffected.

Shortcut Actions

Up to 10 additional custom keyboard Actions can be created, managed and stored in a file.

[ ] Displays the last executed shortcut Action.

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.

[ ] Shortcut Pool file path.

Shortcut Actions Table

Columns

On	Enable/disable the Shortcut Action.
Key	The assigned keyboard key.
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.
- ctrl — Keys '0 – 2' reserved by Igor Pro for File / Recent Experiments.
- Caps Lock — Ignored.

Shortcut 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 Actions

1	[Hold+10mV | 10 pA: Right]	(keyboard arrow key)
2	[Hold-10mV | 10pA: Left]	(keyboard arrow key)
3	[Hold+1mV | 1pA: Right,shift]	(keyboard arrow key)
4	[Hold-1mV | 1pA: Left,shift]	(keyboard arrow key)
5	[View last]	F2
6	[Stop Acquisition]	F3
7	[Start Routine]	F4
8	[Stop Routine]	F5
9	[Pause Paradigm]	F6
10	[Resume Paradigm]	F7
11	[Cursor Info]	F10
12	[Next Sweep]]	In Reanalysis Scope.
13	[Previous Sweep]	In 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 the Dendrite 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	Display 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	Set Paradigm or Routine variables.
Start Acquisition	In an open Acquisition Scope window.
Stop Acquisition	In an open Acquisition Scope window.
View Last	Display the last recording in a Reanalysis scope window.
Write Log	Write a note to the Log window.

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.

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 9' icon to launch SutterPatch: 

   Igor Pro opens with an Igor Pro "splash" screen displaying while Igor Pro files are compiled, 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.

   Don't wait at Startup

   Optionally skip this screen and automatically launch a new session of SutterPatch at startup.

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

4. Next, if no Sutter hardware 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, the Dendrite Control Panel and Acquisition 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 the Dashboard panel, Acquisition Control panel, and SP_Notebook and Command windows display, and additional SutterPatch windows display if they were open in the prior experiment.

   A 'Summary of Major Preferences' window opens:

   Major Preferences as set in the "SutterPatch" menu, entry "Set Preferences":

Configuration pool: not used
Selected amplifier: Dendrite
Automatic experiment naming is ON: <pathname>
Save data to separate HDF5 file is OFF
Save entire experiment after each routine is OFF
Warn when file size exceeds limit of 500 MB
Maximal sweeps displayed in persistence display during acquisition: 30
Maximal sweeps displayed in persistence display during reanalysis: 30
Show event tags in reanalysis scope: ON
Number format: Use exponential notation (e.g., 10e-3 V)

Show on startup	Enable display of the “Preferences Summary” window at startup. This window is only created at startup. If this window is closed, a copy of the “Preferences Summary” can be found in the Command window history.

5. PROGRAMMING

5.1 Data Format

SutterPatch data are written in a 64-bit double-precision binary 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 will be available for streaming data acquisition without resaving the experiment at the end of a recording.

5.2 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.

5.3 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.

5.4 User Functions

SutterPatch functionality can be extended 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 Help topics on Programming / User-Defined Functions, and Procedure Windows.

Warning! 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
E-mail:	info@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 the Start splash screen during program loading, or in the Log Window Startup events.

For issues regarding Igor Pro features (all non-SutterPatch menu items), please contact Wavemetrics, Inc. for technical support.

6.2 Manual

The Dendrite manual is installed as a PDF file along with the SutterPatch software. The latest version of the manual can 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, accessed via the Bookmarks tab on the left side of the PDF screen.

6.3 Online Help

Online help is available via the main Help menu, under 'Igor Help Browser' or 'Help Topics'. The SutterPatch Help Topics / Help File names start with "SP_". The online Help includes the same information as found in the PDF manual.

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, and automatically close after several seconds, and then write to a "History" window. To review such messages, see the Command window (menu item Windows / Command Window).

6.4 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 (except Japanese) has been added. If foreign language versions still cause problems, please contact Sutter Technical Support.

6.4.2 Startup Compiler Errors

Problem: The SutterPatch 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'.

6.4.3 Saved Experiment Not Opening

Problem: In Igor Pro 8, the Experiment does not open due to a 'Macro Recreation Error'.

Solution: When using templates in a Routine, close the Scope and Data Navigator windows before saving the Experiment.

6.4.4 Startup EEPROM Errors

Problem: Starting up SutterPatch and simultaneously powering on the Dendrite instrument generates an EEPROM error. Attached hardware might use incorrect settings.

Solution: Close SutterPatch, power cycle the Dendrite instrument, and relaunch SutterPatch

6.4.5 Startup Odd Errors

Problem: When starting up or running SutterPatch, odd program errors display.

Solution: If after a SutterPatch update, close and re-open SutterPatch.

If after an OS update, roll back the OS software update.

6.4.6 USB Communication Fails

Problem: When starting up SutterPatch in Windows, there is no USB communication with the computer.

Solution: Power off the Dendrite instrument, then reseat the USB cable on both ends, and then power on the Dendrite instrument.

Or, the Windows "power plan" might have disabled the USB ports:

1) Go to the Windows Start screen, and enter "edit power plan" in the Windows Search box.
2) Click on "Change advanced power settings".
3) Scroll down to "USB settings" and click on its [+] box.
4) Click on the "USB selective suspend setting" [+] box.
5) Change the "On battery" and "Plugged in" settings from 'enabled' to 'disabled', and click "OK".

Or, a Windows 10 update can sometimes disable the computer's USB ports. Either browse the web to find a Device Manager driver solution to the problem, or restore the OS to an earlier version of Windows 10, until a Windows 10 update fix is released.

6.4.7 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.

6.4.8 Igor Pro Crashes on Wake Up

Problem: When a computer with external monitors wakes up from sleep, Igor Pro crashes.

Solution: Close Igor Pro before letting the computer go to sleep, or disconnect the external monitors. This is an OS issue we have no control over.

6.5 Acquisition Issues

6.5.1 Routine Loading Delays I

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 sweeps to display, the Preview pane can take a long time to redraw, and the program becomes temporarily unresponsive.

6.5.1 Routine Loading Delays II

Problem: Starting a pre-loaded Routine takes the same amount of time to load into the SutterPatch program.

Solution: Any changes made to the Amplifier Control Panel 'Offset', 'Holding' or 'Compensation controls will invalidate a pre-loaded Routine, and reload the Routine.

6.5.2 Acquisition Does Not Restart

Problem: Unable to start an acquisition because SutterPatch thinks prior acquisition is still in progress.

Solution: Use the menu command SutterPatch / Reset Acquisition to clear the acquisition status.

6.5.3 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.

6.5.4 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.

6.5.5 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.

6.5.6 Headstage Noise

Problem: The noise levels of the instrument suddenly and erratically increase.

Solution: If any attached headstages are touched, the noise level will greatly increase. Make sure all headstages are grounded and in a Faraday cage.

6.5.7 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.

6.5.8 Post-Acquisition Delay

Problem: Every time acquisition completes, there is a delay with the program operations, as the entire *.pxp Experiment file is resaved when a recording stops.

Solution: 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.

6.5.9 Sluggish Acquisition

Problem: Data acquisition is sluggish.

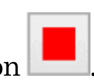
Solution: The computer's available resources need to be increased to handle the system load.

A combination of SutterPatch-related and computer-related issues can contribute to your system's performance. Here are some suggestions to improve it:

Close:	Data Browser window – in Igor Pro 8, it consumes a lot of CPU time.
Disable:	Computer screen saver, and 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.

6.5.10 USB Errors

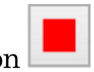
Problem: A USB communications error occurs.

Solution: In the Control Panel, click the Reset USB button . If the button does not turn from red to green, then try to isolate the problem.

a) Unplug and re-plug both ends of the USB cable from the amplifier to the computer.
b) Try another USB cable.
c) Try another USB port.
d) Remove any USB hubs.

6.5.11 System Freezes

Problem: The system hangs up after changing the filter setting or VC/CC mode selection.

Solution: Reset the USB port via the Dendrite Control Panel USB Reset button  or the SutterPatch / Hardware Control menu.

6.6 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 to see the object. Right-click it to modify with Igor Pro options.

6.7 General Issues

6.7.1 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.

Solution: You may need to click the button more than once or hold it down longer than usual.

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 above.

6.7.2 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.

6.7.3 Window Maximizing

Problem: Maximizing a window only maximizes the title bar.

Solution: Certain fixed-size windows and panels will not maximize (Action Potential Analysis, Amplifier Control Panel, Dashboard, Synaptic Event Analysis, Log, Paradigm Editor, Set Metadata, Set Preferences.) This is a reported Igor Pro issue.

Also, if the active window is maximized, creating a new window might automatically "maximize" the new window.

6.7.4 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.

6.7.5 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

c) Reduce the Windows option Start / Settings / System / Display / 'Scale and layout' to 100%.

6.7.6 Command Window Frozen

Problem: The Command Window is blank and/or unresponsive.

Solution: Use Ctrl-J, or click on the instrument Control Panel, and the Command window is redrawn as an active window. This is a reported Igor Pro issue.

6.7.7 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.

6.7.8 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.

6.7.9 Font Size Too Large

Problem: The font size is too large when using the display scaling in 'Scale and Layout'.

Solution: This can occur on high-resolution monitors running on older versions of Windows 10. Upgrade to the current version of Windows 10.

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 Weird Behavior

Problem: There is weird or buggy behavior with the SutterPatch program.

Solution: Reset the SutterPatch program settings to their factory defaults via the SutterPatch / Set Preferences menu command, by performing a Factory Reset.

6.7.12 Igor Pro Features

Problem: There are a large number of standard features in Igor Pro that can be used in conjunction with the SutterPatch application.

Solution: Refer to the Igor Help browser, or to Wavemetrics, Inc., regarding issues with Igor Pro features.

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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.

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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.

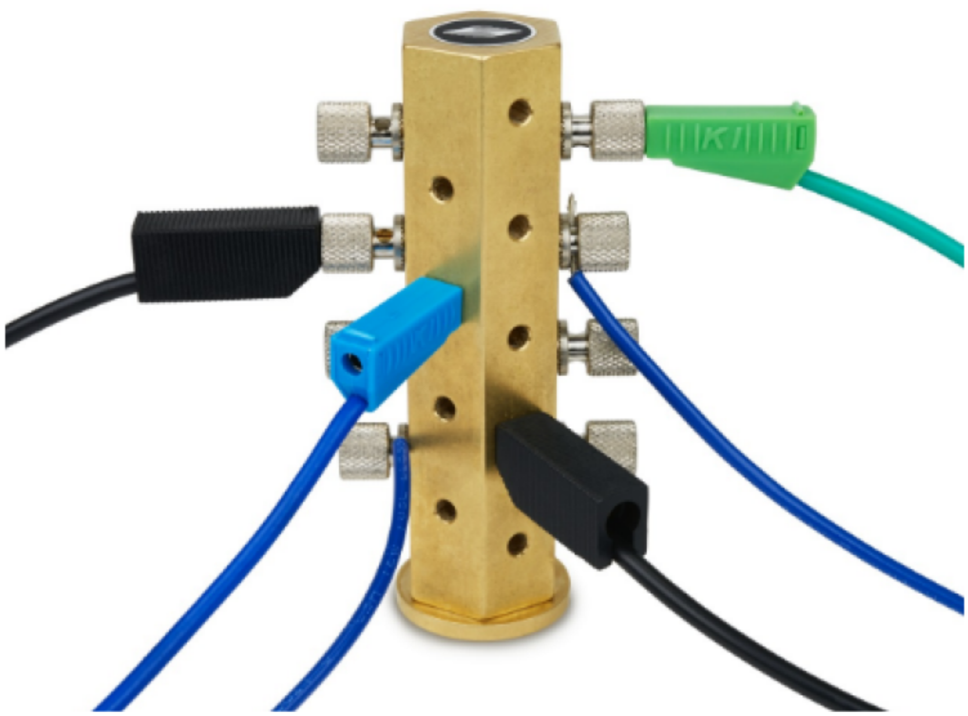
Section 10.11. Any amendments or addenda to this Agreement, may be executed in counterparts, each of which will be considered an original, but all counterparts together will constitute one agreement. A facsimile of a signed copy of this Agreement, or an electronic or other digital signature imprinted on this Agreement, may be relied upon as an original.

APPENDIX C: Accessories

- Ground Point Grounding point hardware,

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.



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.

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 (see below).
5. Replace the fuse holder in the power entry module and reconnect the power cord.

Mains Power Source	Fuses (5 mm x 20 mm, glass tube)	
	Fuse Rating	Manufacturer Examples
100 – 240 VAC	T2.0 A, 250 V (Time Delay)	Bussmann: GMC-2-R, S506-2A, Littelfuse: 239.002.P

Table D-1. dPatch Fuses

APPENDIX E. Technical Specifications

General Specifications

Dendrite Digitizer – Physical	
Dimensions (in.) (includes handles & connectors)	18.8 (W) x 11.8 (D) x 1.8 (H)
Dimensions (cm) (includes handles & connectors)	48.25 (W) x 30.0 (D) x 4.5 (H)
Weight (lb) (with headstages)	9.05
Weight (kg) (with headstages)	4.1
Case	Steel
Computer Communications	USB 2.0 port
BNC Channels	4 Auxiliary analog outputs (current sourcing: ±30 mA) 8 Auxiliary analog inputs (impedance: 10 kΩ) 8 Digital outputs (current sourcing: 20 mA) 1 Digital output trigger (current sourcing: 20 mA) 1 Digital input trigger (impedance: 1 MΩ)
Rack use	19” rack-mount (1U)
Benchtop use	4 Rubber feet
Earth Ground	4 mm Banana socket
Safety Signage	CE marking (Conformité Européenne)
Pin numbering	Right to left, top to bottom.

Table E-1. Dendrite Amplifier - Physical

Dendrite 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 bits
Analog In Sample Rates	0.1 - 50 kHz
Analog Out Sample Rates	0.1 - 10 kHz
Analog Out Current (max)	20 mA
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 Sample Rates	0.1 – 50 kHz
Digital Out Sample Rates	0.1 – 10 kHz
Digital In Trigger Width	Edge triggered (ns)
Digital Out Trigger Width	100 µs
Digital Out Current (max)	20 mA

Table E-2. Dendrite Data Acquisition

Dendrite 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-3. Dendrite Electrical

Dendrite System Components

Carefully remove all components from the shipping container. The following are included:

• (1) Dendrite Instrument	DENDRITE
• (1) Rack Mount Kit	RACK-PK
• (1) Power Cord	
• (1) USB 2.0 Cable	
• (1) Quick Start Guide	(with Igor Pro Serial #)
• (1) USB Flash Drive	SutterPatch and Igor Pro software.

APPENDIX F. SutterPatch Algorithms

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.

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.

<u>Fitting</u>

Capacitive decay transients (current response) 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.

<u>Tau</u>

The fitted curve decay time constant (tau) is calculated.

<u>Peak</u>

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

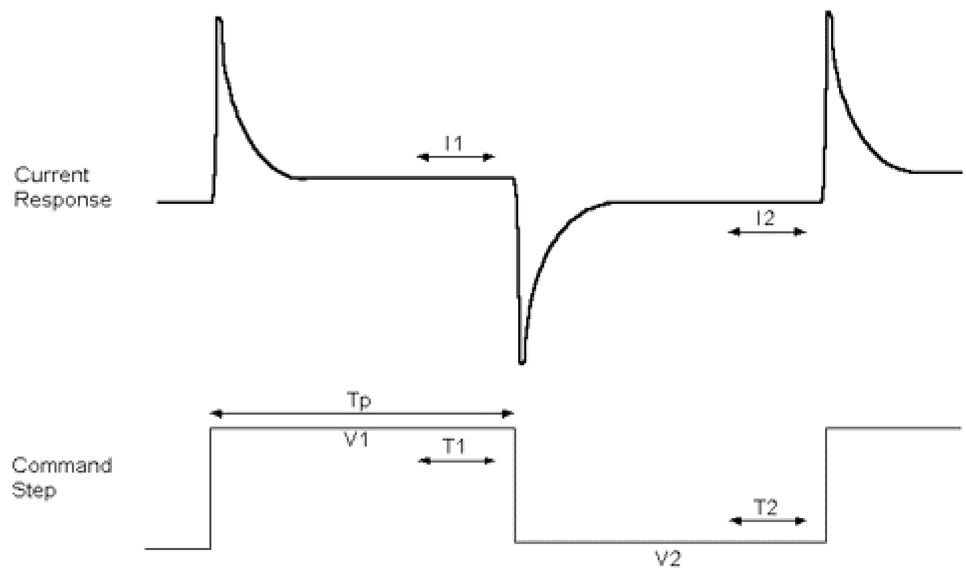


Figure 0-1. MT Command Pulse & Response

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,

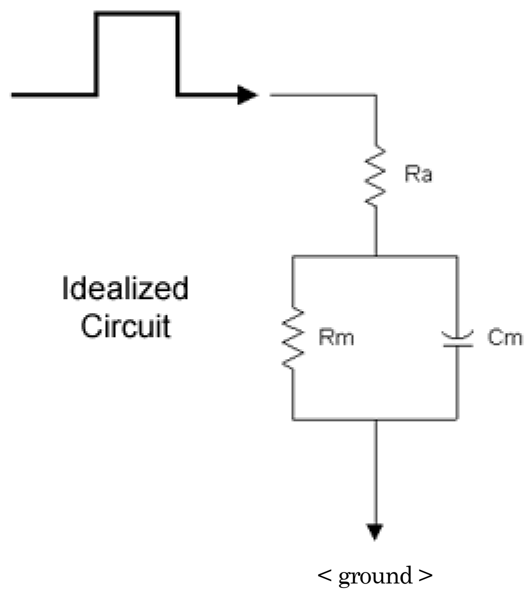


Figure 0-2. Idealized Membrane Circuit

as:

$$Tau / Cm = (Ra * Rm) / (Ra + Rm)$$

or:

$$(Ra + Rm) * (Tau/Cm) = Ra * Rm$$

Substituting in above for resistance terms:

$$Rt = Ra + Rm$$

$$Rm = Rt - Ra$$

$$\begin{aligned} Rt * (Tau/Cm) &= Ra * (Rt - Ra) \\ &= (Ra * Rt) - Ra^2 \end{aligned}$$

and:

$$\begin{aligned} (Rt * (Tau / Cm)) - ((Ra * Rt) - Ra^2) &= 0 \\ (Rt * (Tau / Cm)) - (Ra * Rt) + Ra^2 &= 0 \\ Ra^2 - (Ra * Rt) + (Rt * (Tau/Cm)) &= 0 \end{aligned}$$

Solve iteratively using the Newton-Raphson method.

<u>Rm</u>

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:

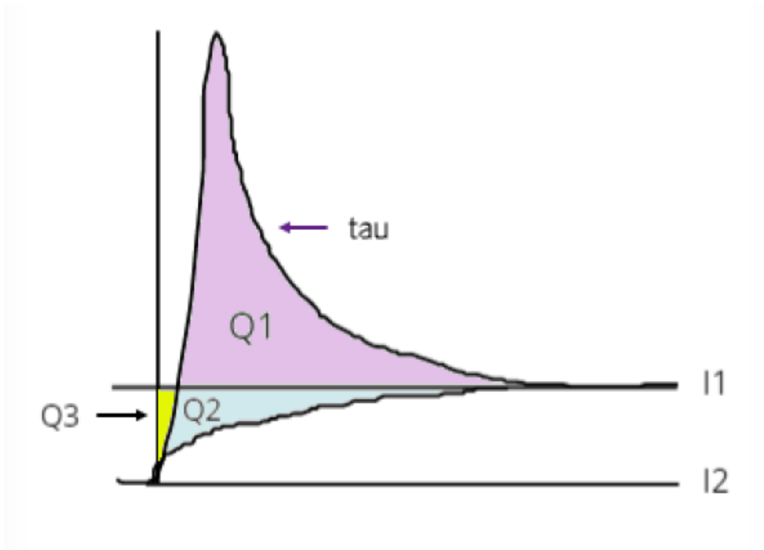


Figure 0-3. Membrane Charge

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:

$$Qt = Cm * \Delta V, \qquad \Delta V = V1 - V2$$

$$Cm = Qt / \Delta V$$

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 = √2 * σ

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)

Standard Error of the Mean (SEM) Algorithm

[for Analysis Editor Error Bars]

'Standard Error of the Mean' computation:

SEM = √ (SumSq – Mean^2 * 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'.

Synaptic Event Detection Reference

[for Synaptic Event Analysis]

Deconvolution paper:

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.