Dendrite™

Data Acquisition, Management and Analysis System

ELECTROPHYSIOLOGY
DATA ACQUISITION SYSTEM

WITH

SutterPatch® SOFTWARE

Operation Manual

The Dendrite system has two international safety certifications.

1) The CE mark is for compliance to health, safety and environmental protection standards for products sold within the European Economic Area:

$$C \in$$

2) The RoHS (Restriction of Hazardous Substances) Directive 2002/95/EC restricts the use of hazardous substances for electronic equipment sold within the European Union:

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**

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- ⚠ **Always use the grounded power cord provided to connect the 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 set 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, fast, low-noise 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 each preparation recorded from.

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.
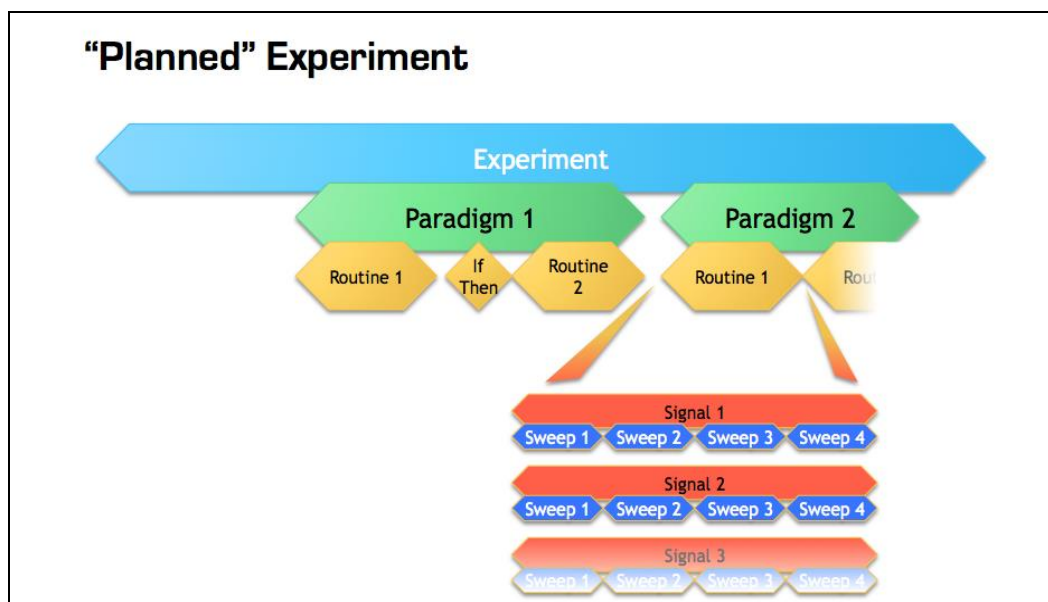
Figure 1-1. Data Structure - Planned Paradigms

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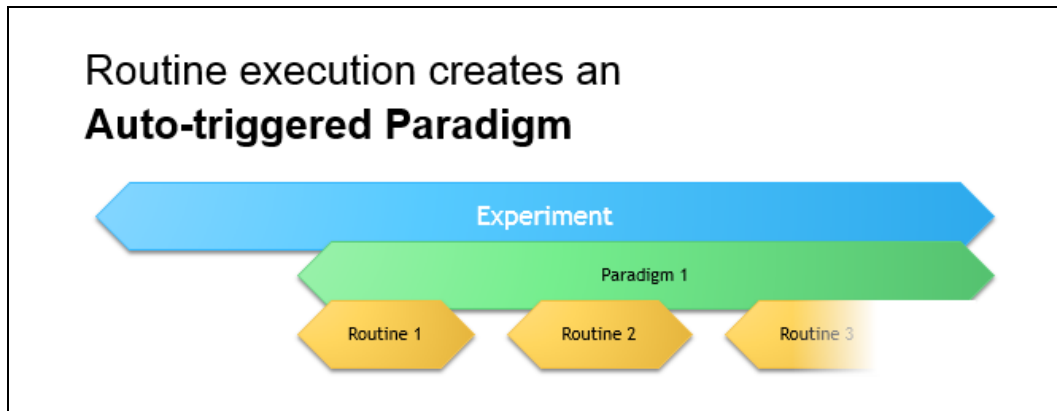
Figure 1-2. Data Structure – Auto-triggered Paradigms

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 data, even though they are not predetermined. (See the Data Browser.)

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 (D/A) or a physical or virtual input (A/D) of the Dendrite system.

Analog input channels are used to record data from external instruments, and are displayed in their own panes in the Scope window. Virtual input channels allow creative processing of the physical 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 single 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. A command waveform can be composed of up to 50 Segments.

SutterPatch Metadata:

Metadata are additional information associated with stored data. These can include information about the preparation (cell, tissue, animal), instrumentation (hardware, software), environmental parameters (temperature, atmospheric composition, etc.), stimuli (chemical compounds, light, acoustic, etc.), 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

<u>Minimum Configuration</u>

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

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

External USB hubs are not supported.

<u>Recommended Configuration (for Bandwidths > 50 kHz)</u>

Operating System:	< same >
CPU:	< same >
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,

Computer Ports: < same >

2.2 SutterPatch System Environment

The SutterPatch software runs in the Igor Pro 8 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

SutterPatch 2.1 requires a 64-bit version of Igor Pro to run. The SutterPatch 2.1 full installer automatically installs Igor Pro 8.0.4 (64-bit English version) and SutterPatch 2.1, while the SutterPatch 2.1 Updater only updates SutterPatch.

Igor Pro 8.0.4 has a 30-day trial period where it is fully functional and fully supports SutterPatch 2.1. After 30-days, if the Igor Pro 8 license has not been activated, Igor Pro 8 runs in a demo mode with limited functionality that does not support the SutterPatch application.

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

Although Igor Pro 8.0.4 (64-bit) is strongly recommended for full support, SutterPatch 2.1 can still be run in Igor Pro 7 (64-bit), but only if the newly introduced SutterPatch 2 features (long names) are avoided.

For third-party applications that need a 32-bit version of Igor Pro 8:

Windows: A 32-bit version of Igor Pro 8 is available in the installer.

macOS: There is no 32-bit version of Igor Pro 8; run Igor Pro 7.

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

Typical AC Power: 60 Hz, 120 V

                       50 Hz, 240V

The Dendrite instrument can also run on power from 100 to 250 VAC - no switches need 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

Power on the computer.

A: It is strongly recommended to use the latest SutterPatch software version available.

Download the latest version of SutterPatch installer software from:

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

and choose the "Download" tab. Navigate your file browser to the download file and run it.

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

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

   ▪ Windows: sutterpatch_win_full

   ▪ Macintosh: sutterpatch_mac_full

2. Follow the installer prompts:

   • If an existing version of Igor Pro 7 is found, we recommend to replace it with Igor Pro 8. However, first make a backup copy of all user files and parameter files in the program folder and its sub-folders.

   • However, older versions of Igor Pro can be retained if desired, as different versions of Igor Pro can coexist on the same computer.

   • If an existing version of Igor Pro 8 is found, SutterPatch sample files are overwritten.

   • The new install uses the Preferences from prior SutterPatch installations.

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

   • Dendrite QuickStart Guide (PDF)   (Includes Igor Pro 8 Serial Number and

                                          Key.)

   • Release Notes (PDF)

   • Dendrite-SutterPatch manual (PDF)

- SutterPatch2 / SutterPatch folder   (Includes sample Routine Pool, Paradigm

   Pool, and Experiment data files).

- SutterPatch2 / SP_Code folder

- SutterPatch2 / SP_Drivers folder   (XOP)

4. Launch Igor Pro 8 and activate its license as instructed.

   You will need to enter the Igor Pro 8 Serial Number and Activation Key found in your Dendrite Quick Start Guide.

5. "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 Igor Pro (SutterPatch) application by clicking on the 'Igor Pro 8' icon.

   A SutterPatch splash screen displays while opening files.

Figure 2-3. Splash Screen

Then the Welcome to SutterPatch "start" window displays.

Figure 2-4. Welcome Screen

3. Click on the 'Start' button in the 'Welcome to SutterPatch' window, and the application begins compiling. This process may take several seconds.

4. Specify the Experiment file name and storage location when prompted.

5. If the Dendrite instrument is OFF, or disconnected from the computer, this dialog displays:
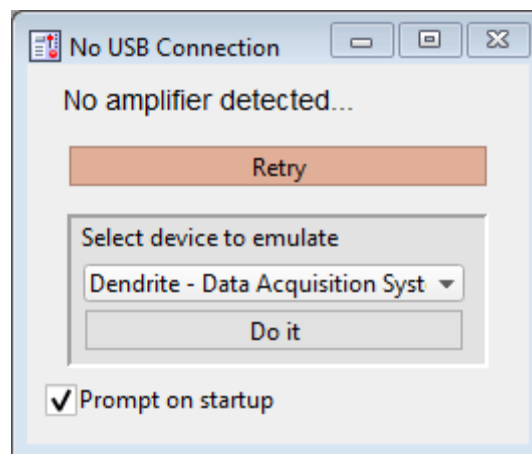
Figure 2-5. Emulation Modes

    a. Turn on and/or reconnect the Dendrite instrument and click 'Retry', or

    b. Click in 'Select device to emulate' and select 'Dendrite'.

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

6. The Dashboard panel is displayed.
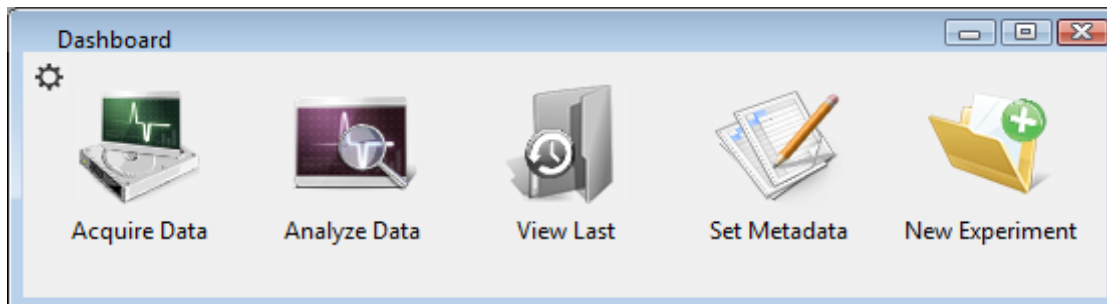
Figure 2-6. Dashboard.

7. Click on the 'Acquire Data' icon, and a second level of the Dashboard is displayed.
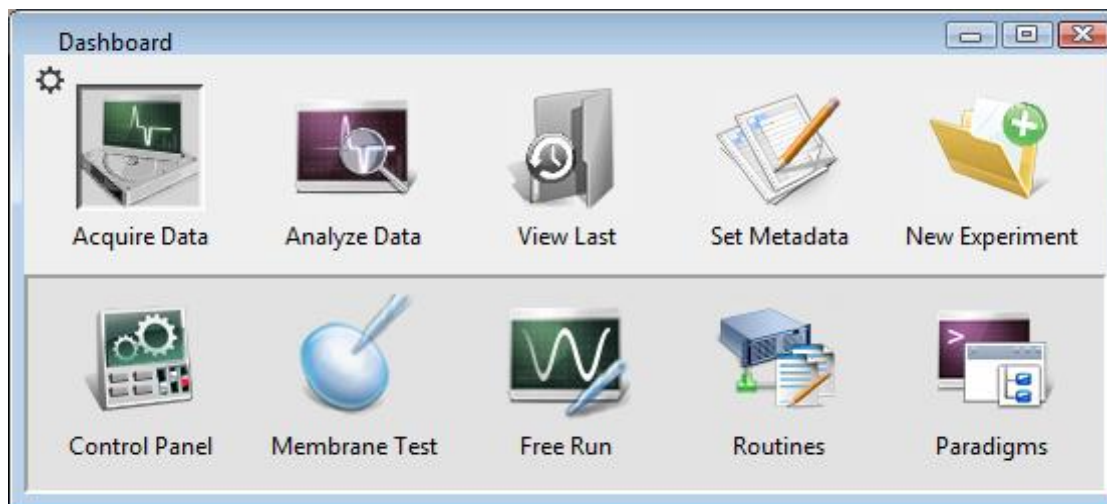
Figure 2-7. Acquisition Dashboard.

8. Click on the 'Control Panel' icon, and the Dendrite Control Panel is displayed.
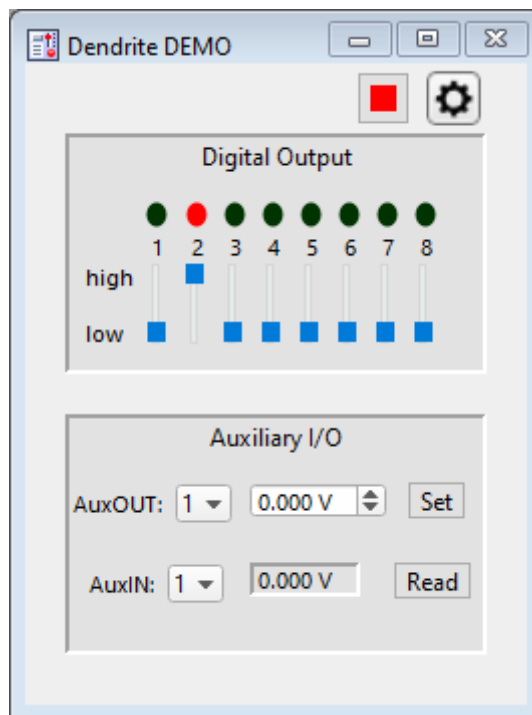
Figure 2-8. Dendrite Control Panel

a. If "DEMO" is displayed in the 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 connected, 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.
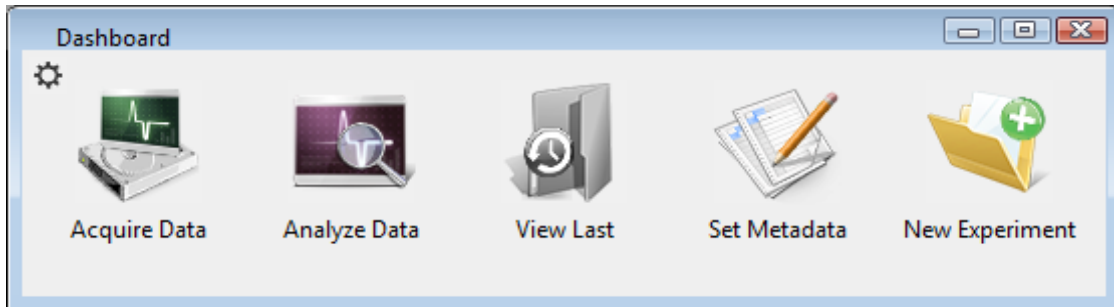
Figure 2-9. Dashboard

2.   Click on the 'Free Run' icon.
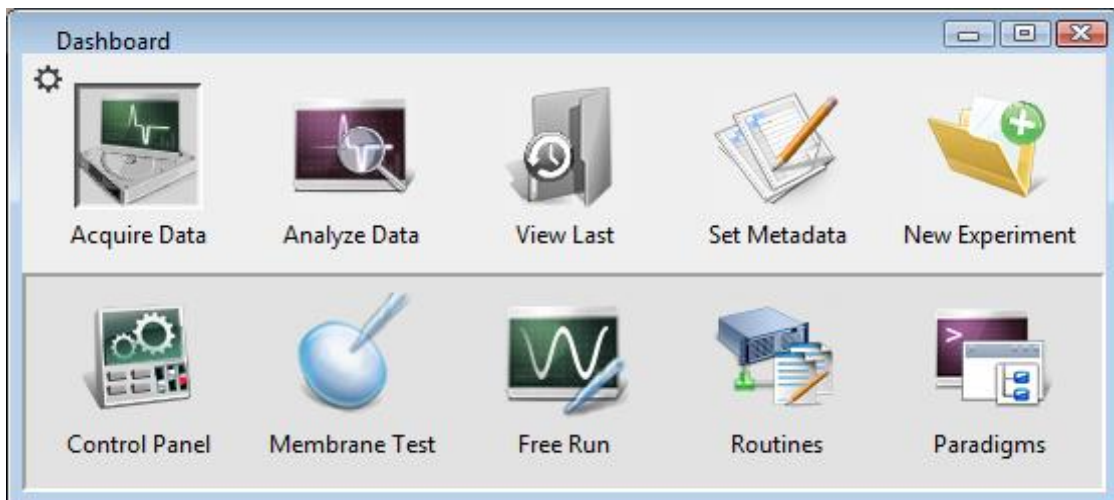
Figure 2-10. Acquisition Dashboard.

3.   A noise signal should display in the Free Run Scope channel AuxIN1.
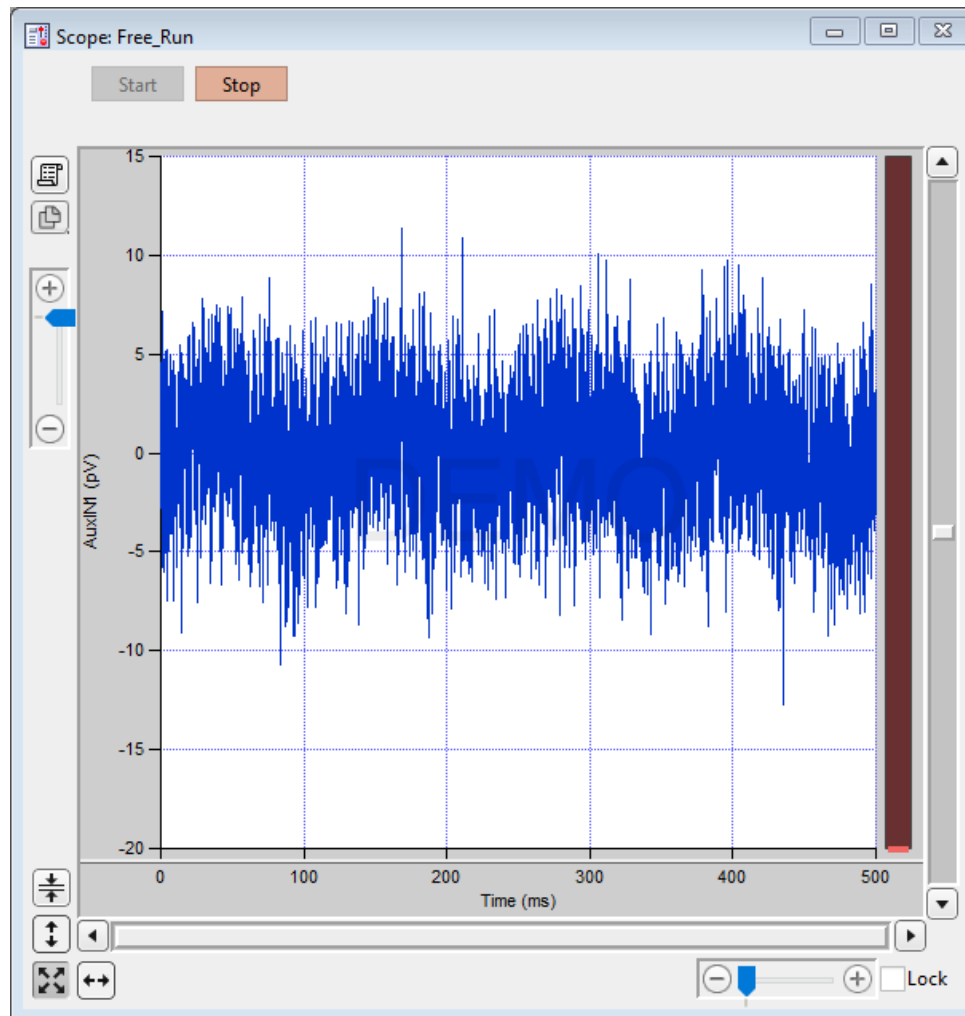
Figure 2-11. Free Run Noise

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 dPatch 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
		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

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

These settings can also be programmatically controlled in a Paradigm.
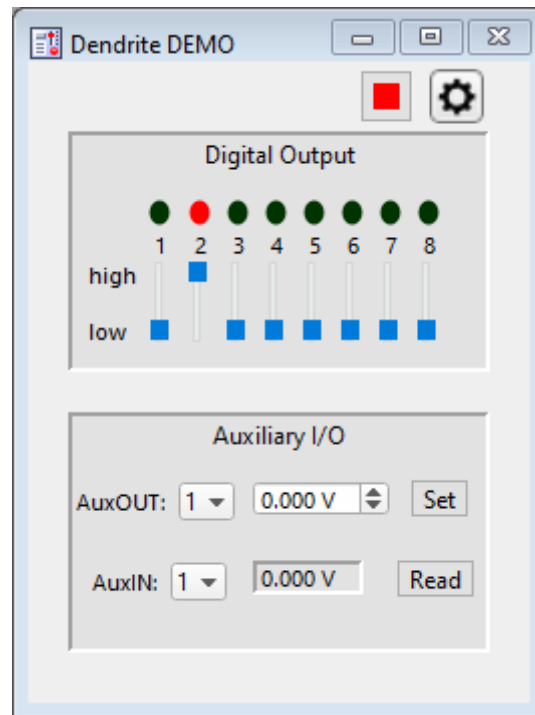
Figure 3-3. Dendrite Control Panel

Reset USB   Shift-click to re-establish the USB connection to the data acquisition system.

⚙   Configure Headstage Signals   Setup the Dendrite system to support external amplifier headstages.

(see System Integration: Using Non-Sutter Amplifiers section)

Digital Output   [1 – 8]

This section controls the holding bit pattern generated by the Digital Outs of the instrument. Eight TTL-compatible digital channels are displayed. Switch between digital states with the slider buttons:

- On   (red dot)   high   (+3.3 V)
- Off   (black dot)   low   (0 V)

Auxiliary I/O

General purpose "auxiliary" analog channels are available.

AuxOUT 1 - 4   [±10.000 V]

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

button to apply the value.

AuxIN 1 - 8   [±10.000 V]

Select an auxiliary analog input channel and read its voltage level.

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

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 can interface to external non-Sutter amplifiers via front panel BNC connections:

ANALOG IN 1 – 8	"Auxiliary" analog input channels to digitize signals from non-Sutter amplifiers.
ANALOG OUT 1- 4	"Auxiliary" 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 signals for non-Sutter headstages via the Dendrite Control Panel gear button.

⚙ Configure Headstage Signals Setup the Dendrite system to support external amplifiers.

HS1 / HS 2 / HS 3 / HS 4	Up to four external headstages can be configured.
Enable	Enable or disable the selected headstage.
Current Input	[AuxIN1 – AuxIN8] Select the analog input channel for Current readings from the external headstage #.
Label	Enter a signal name for the channel.
Unit	Enter the unit designation for the signal amplitude. (A) for Ampere.
Scaling	
Offset	Enter an offset for the external input signal. [Current offset value or equation] [corresponding value]
Factor	Enter the scaling factor for the

headstage.

[Factor value or equation]
[corresponding value]

(A/V)

Voltage Input   [AuxIN1 – AuxIN8]

Select the analog input channel for Voltage readings from the external headstage #.

Label   Enter a signal name for the channel.

Unit   Enter the unit designation for the signal amplitude.

(V) for Voltage.

Scaling

Offset   Enter an offset for the external input signal.

[Voltage offset value or equation]
[corresponding value]

Factor   Enter the scaling factor for the headstage.

[Factor value or equation]
[corresponding value]

(V/V)

Command Output   [AuxIN1 – AuxIN8]

Select the analog output channel to the external headstage #.

Recording Mode   [Voltage Clamp, Current Clamp]

Label   Enter a signal name for the channel.

Unit   Enter the unit designation for the signal amplitude.

(V) in Voltage Clamp mode.

(A) in Current Clamp mode.

Scaling

Offset   Enter an offset for the external output signal.

[Voltage or Current value or equation]
[corresponding value]

Factor   Enter the scaling factor for the headstage.

 [Factor value or equation]
[corresponding value]

(V/V) in Voltage Clamp mode.

(A/V) in Current Clamp mode.

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: HEKA amplifier signal levels into Sutter systems attenuate by 0%.
         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

The interactive acquisition controls for both Routines and Paradigms are grouped into this control panel.
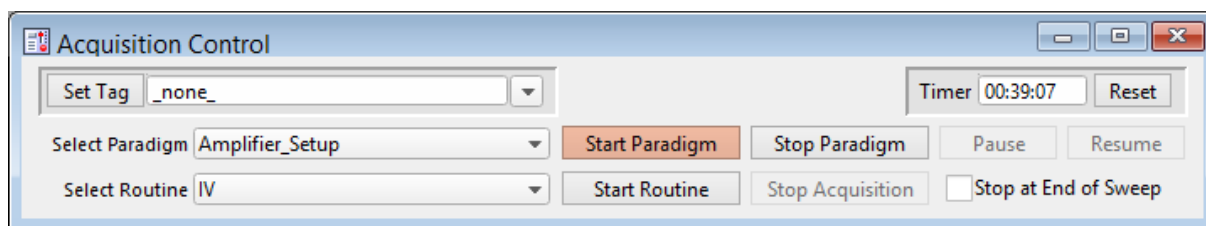
Figure 4-1. Acquisition Control

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

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.

Enter the comment text into the field, or select text from a drop-down list of recently used entries.

Note: In emulation mode, tag timing is not accurate, and tags are not set in the first sweep.

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 existing acquisition

in the Scope window is stopped, and a "planned" (user named) Paradigm is created.

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	Pause a running Paradigm.

Resume	Resume running the active Paradigm.

Select Routine	The active Routine is selected from the loaded 'Routine Pool' list. See the Routine Editor to load a different Routine Pool.

Start Routine	Manually run the selected Routine - start recording and displaying data in the Scope window.

When you click the 'Start' button, the Scope 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	Stop recording Routine data.

When you click the 'Stop Acquisition' button, data acquisition is immediately halted for the Series, even if this occurs in the middle of a sweep. In this case, any partial sweep that was in progress is not saved with the data.

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 partial sweep completes before data acquisition is halted; otherwise, when disabled, the partial sweep is discarded when acquisition stops.

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 Scope (acquisition) window button 'Measurements / Edit Measurements'.
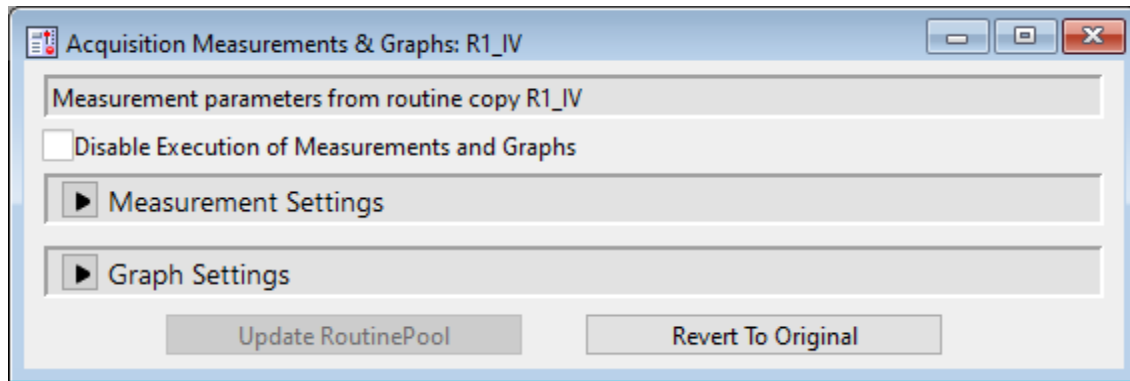
Figure 4-2. Acquisition Measurements & Graphs

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

Update Routine Pool   Save your edits to the Routine.

Revert to Original   Discard any edits.

4.1.3 Camera Module

The SP_Camera window displays:

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.

[video screen]

All pictures are stored in the current Experiment. To review pictures, go to:

        Data Navigator   Select a Paradigm or Routine. Any associated images are

listed in the Preview pane. Click on an image name to display the image.

Data Browser   Navigate to the Data / Images folder. Right-click on an image name, and select 'New Image'.

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

4.1.4 Free Run

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

It operates similarly to the Scope acquisition window, with unsupported controls removed or disabled.

Settings Window

Signal Parameters

Channel:	Select an input channel to monitor:
	AuxIN1 - 8
Duration:	The duration of the data sweep.
	[100, 200 ms, 0.5 , 1 , 2 s]
Sampling rate:	[5, 10, 20, 50 kHz]

4.1.5 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.

Scope (Membrane Test)

This Scope (Membrane Test) window operates similarly to the Scope (acquisition) window. The default Scope window 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).

- 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 any acquisition.

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 4-3. Membrane Test Settings

Show   Monitor Only

                         Monitor + Test Pulse

                         All Settings

⚙   Open the Membrane Test 'Preferences' settings dialog.

Membrane Test Preferences

Second Membrane Test channel

> MT analysis on second channel

ZAP controls

Sound controls

Line Frequency Reduction options

> A/C Line Frequency   50 Hz
>
>   60 Hz

Enable Holding with Seal mode selection

Running Average Trace	The average of the last "N" traces, as set in 'Measure Parameters'.
Line Thickness	[0.25, 0.50, 0.75, 1 – 10]
Color	Open a color selection panel.
Average Traces	The last "N" traces used in the running average.
Line Thickness	[0.25, 0.50, 0.75, 1 – 10]
Color	Open a color selection panel.
Capture Trace	Set which trace is used by the "push pin" snapshot control in the Signal Parameters section.
Source	

- Signal   Use the raw Membrane Test trace.
- Average   Use the running average trace.

Line Thickness	[0.25, 0.50, 0.75, 1 – 10]
Color	Open a color selection panel.

The Membrane Test Analysis panel contains 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.

This configuration is used for single-channel recordings, as well as inside-out and outside-out patches.

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. These values can be periodically checked to monitor the health of the cell.

The Membrane Test calculations are displayed in real-time numeric fields:

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]	

These values should be periodically checked to monitor the health of the cell. In particular, monitoring the Series Resistance is helpful, as if it increases by more than 5%, the electrode tip might be clogged.

Warning!   In Cell mode, disable the amplifier's Capacitance Compensation and Series Resistance Correction so that uncompensated capacitance spikes can be generated for the calculation of the Series Resistance and Membrane Capacitance values. Otherwise, these fields are reported as "OFF".

Tip: 'Series Resistance' and 'Access Resistance' are equivalent terms. It is helpful to monitor the Series Resistance, as if it increases by more than 5%, the electrode tip might be clogged.

Note: Reported values are dependent upon experimental variables and settings, such as cell and pipette size, solution conductivity, test pulse duration, etc.

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.

Test Pulse Parameters

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   A train of 5 symmetrical bipolar triangular pulses.

    [dPatch only]

- Sine   A train of 5 sine wave pulses.

    [dPatch only]

- RMS Noise   No pulse – the holding level is output.

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.

Zap Parameters

After a gigaohm patch has been achieved, use Zap in the Seal mode, as an alternative to suction, to create a whole-cell patch. The Zap electrical pulse disrupts the cell membrane, which should reconstitute as 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 to disrupt the cell mem-
                       brane.

Signal Parameters

A/C Line Reduction   Off

                       50 Hz

                       60 Hz

Sampling rate   10 kHz

                       20 kHz

                       50 kHz

4.1.6 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.
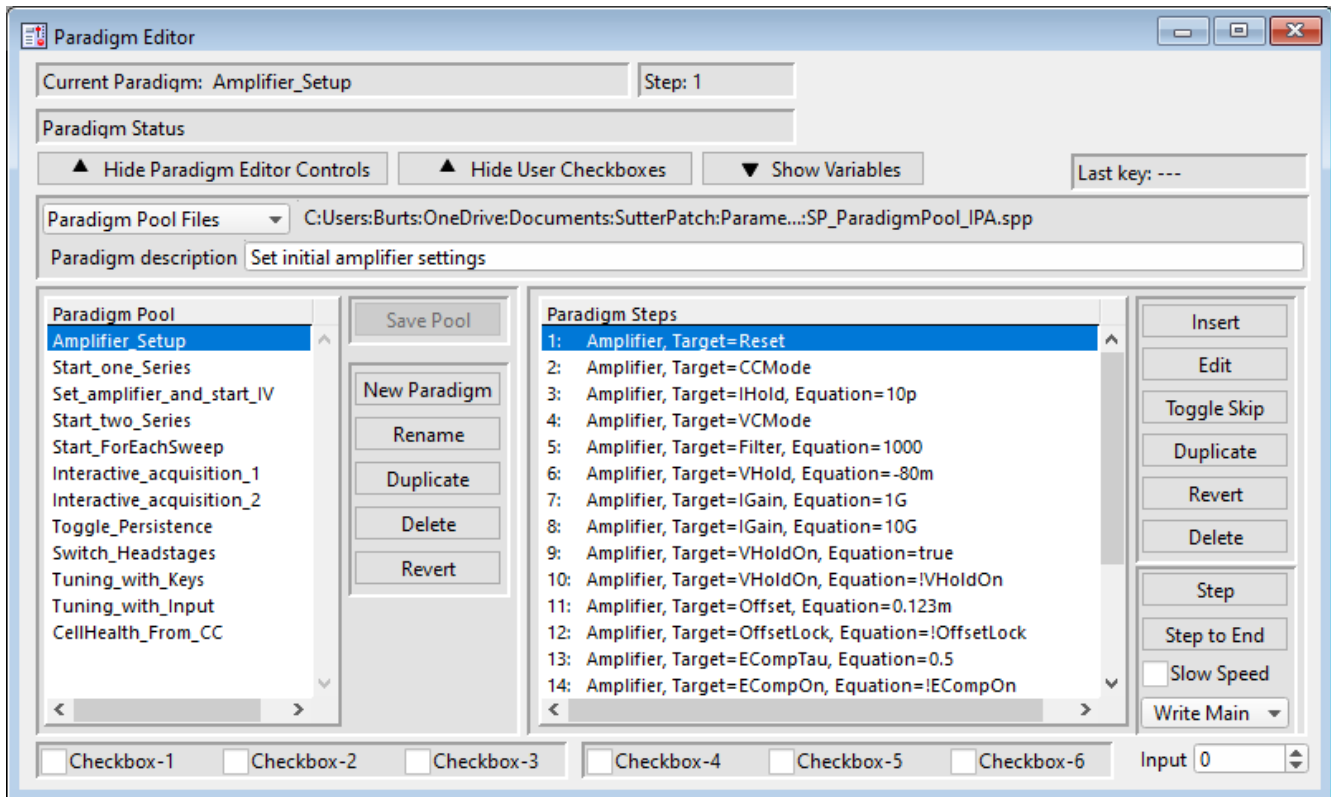
Figure 4-4. Paradigm Editor

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

Controls

Start/Stop, 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.

Paradigm Pool Files These operations affect the entire "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.

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

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.

[The file path and file name of the loaded Paradigm Pool file are displayed.]

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 A-Z, a-z, 0-9, and "_".
- Special characters are not allowed.
- Spaces are replaced by an underscore.
- The name cannot start with a number – such entries will have an 'X' prepended 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>

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 Write Steps

Set Solution

Set Tag

Update Inputs

Set Variable

Sound

View Last

Write to Log

Alert

Beep

Comment

Wait

Pause

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.
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.
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 entire 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.)

Insertable Steps

Amplifier

Control the Dendrite hardware.
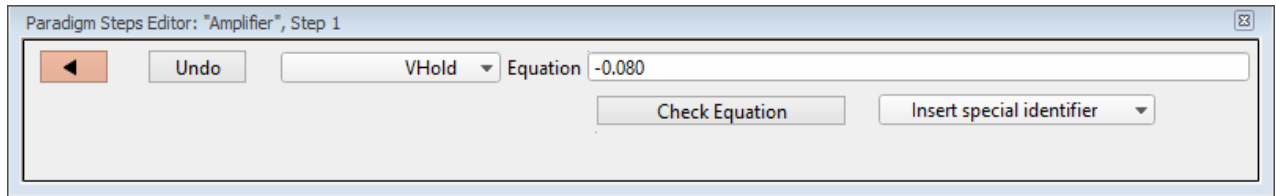
Figure 4-5. Step: Amplifier

Default Setting:	*Amplifier, Target=VHold, Equation=-0.080*
◄	Close the 'Paradigm Steps Editor'.
Undo	Remove any unsaved edits to this step.
[drop-down list]	Amplifier options

AuxOUT1   (Auxiliary Output-1, V)

AuxOUT2   (Auxiliary Output-2, V)

AuxOUT3   (Auxiliary Output-3, V)

AuxOUT4   (Auxiliary Output-4, V)

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.]

Note: Values in the Equation field are rounded to whole numbers.

While Amplifier steps are configured in standard units (Amperes, Volts), the Amplifier Control Panel displays values in scaled units.

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 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.

Paradigm Steps Editor: "EachSweep", Step 2

◄   Undo   IV   ▼
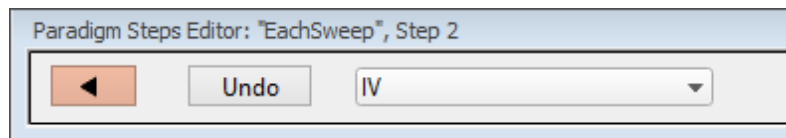
Figure 4-6. Step: Each Sweep

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. For faster execution times, use the 'Routine' step.

Routine

Record data from a Routine.
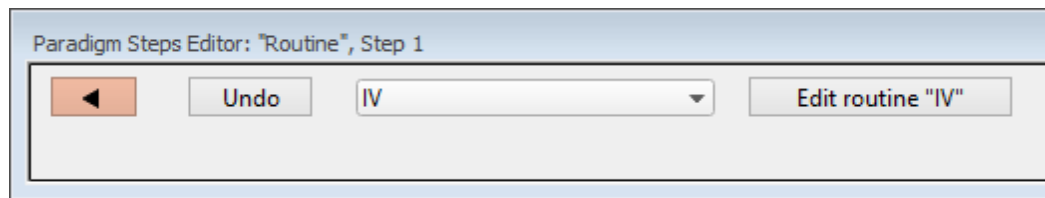
Figure 4-7. Step: Routine

Default Setting:	*Routine, Target=untitled*
◄	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.

Membrane Test

Repeats	[1 – 999]
Indefinitely	Repeat an "infinite" number of times.

Write to Metadata

Configuration

- No change
- Bath
- Seal
- Cell

Free Run

      Duration   [100 ms – 999.9 s / inf]

        Indefinitely   Acquire for an "infinite" duration.

      Add Channel   Clear

                        List of input channels.

     [selected channels]

List of Routine names from Routine Pool

     [selected Routines]

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

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

"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.
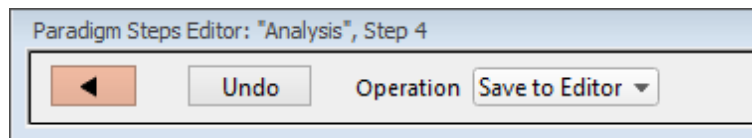
Figure 4-8. Step: Analysis

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.

- Show Table   Display analysis as numeric table.

- Show Graph (1 – 8)   Display analysis as visual graph.

Camera

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

Paradigm Steps Editor: "Camera", Step 1	
◀	Undo Camera HD User Facing ▼ ✓ Capture Live view: No change ▼
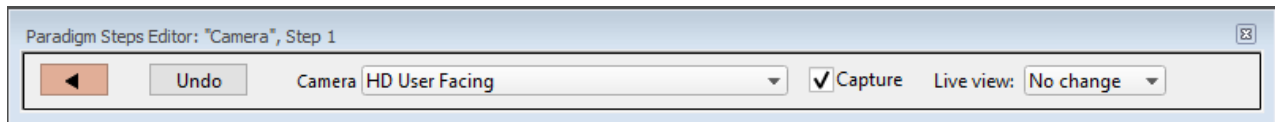
Figure 4-9. Step: Camera

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 command.

Paradigm Steps Editor: "Execute", Step 11

◀	Undo	Command	Beep

Insert special identifier ▼   Copy to Command Line   Expand to Command Line
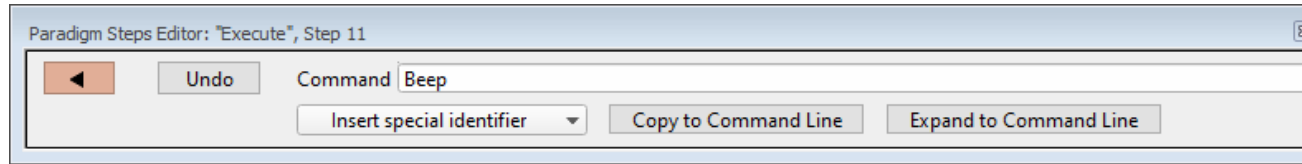
Figure 4-10. Step: Execute

Default Setting: *Execute, Command=Beep*

◀   Close the 'Paradigm Steps Editor'.

Undo   Remove any unsaved edits to this step.

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

Note: Igor 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:

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

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

                         (trace of specified series)

                         Reference an 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[#]   (trace of current sweep of current series)

Reference the input trace (data wave) in Scope signal position "n", for the last sweep of the current Series.

- 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 Volt- age1_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 'FFT' command is run, and "t[2]" retrieves the Scope's second input trace.

<u>Export</u>

Export data graphs into a <u>Layout</u> window.
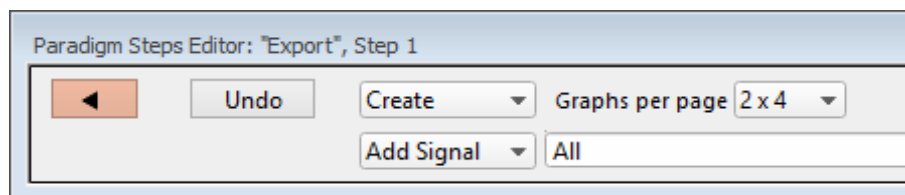
Figure 4-11. Step: Export

Default Setting: *Export, Signal=Layout*

◄   Close the 'Paradigm Steps Editor'.

Undo   Remove any unsaved edits to this step.

[drop-down list]   Select the operation to perform.

     Append   Append graphs to an open Layout window, or into a new Layout window.

     Create   Create a new Layout window.

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.

[drop-down 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.
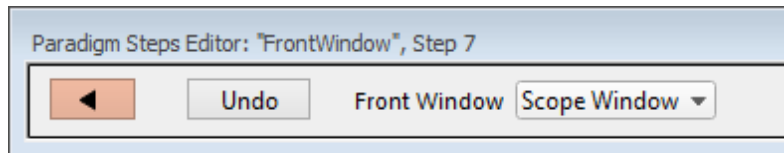
Figure 4-12. Step: Front Window

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.
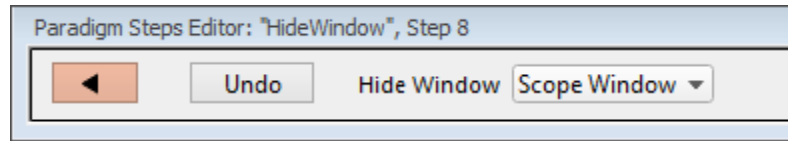
Figure 4-13. Step: Hide Window

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.
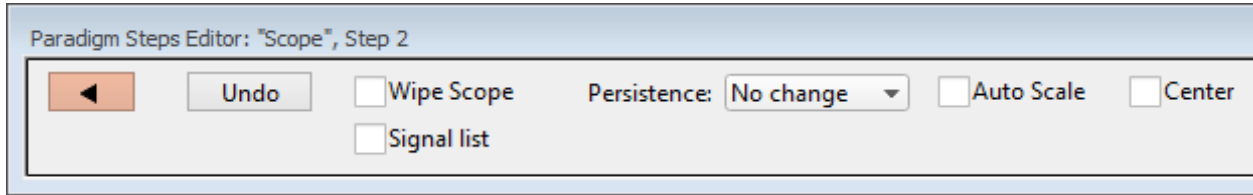
Figure 4-14. Step: Scope Operation

Default Setting:	*S*cope, 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 a signal.
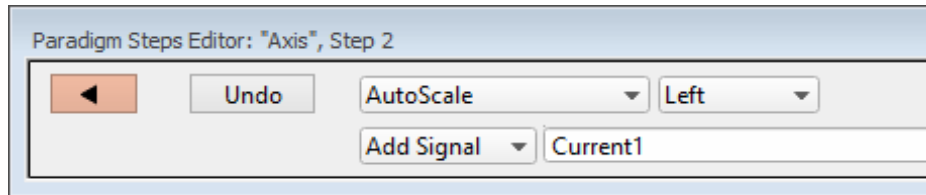
Figure 4-15. Step: Set Axis

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]	Select the operation to perform

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.
Use last	Keep using the last-used settings.

[drop-down list]	Select the axis orientation.

Left	Apply to the Y-axes on the signal list.
Bottom	Apply to the X-axes for all signals.

Add Signal

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

[list of selected signals]	Select an input signal to modify from the list, or enter user-defined signal labels.

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".
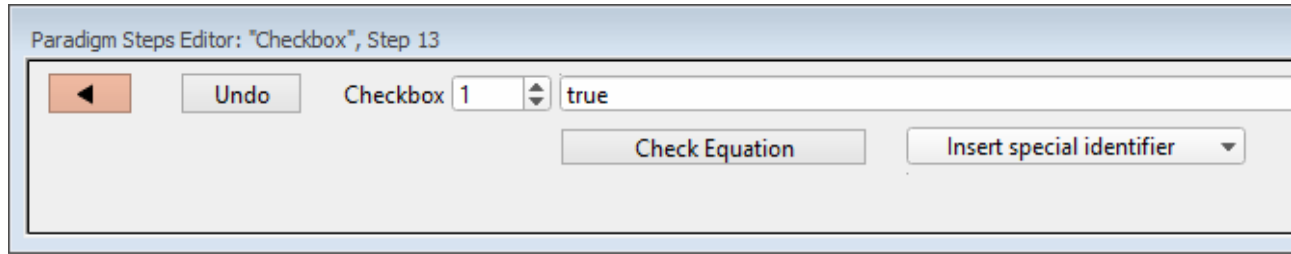
Figure 4-16. Step: Checkbox

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: they are not automatically cleared, so 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 | Acquisition and reference settings are available for use in equations. (See list below.) |

Set Mark

The 'Set Mark' step marks (or unmarks) a sweep for later processing.

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.
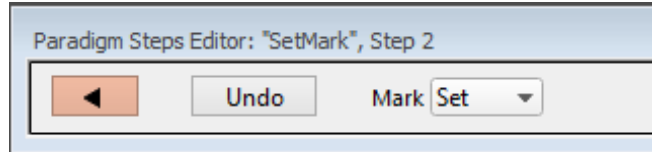
Figure 4-17. Step: Set Mark

Default Setting:	*SetMark, Value=Set*
◀	Close the 'Paradigm Steps Editor'.
Undo	Remove any unsaved edits to this step.
Mark	Set
	Clear

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

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.

Go to Preferences > Metadata to change the detail level.

Default Setting: *Metadata, Value=*

The 'Set Metadata Paradigm Step Value' dialog opens:
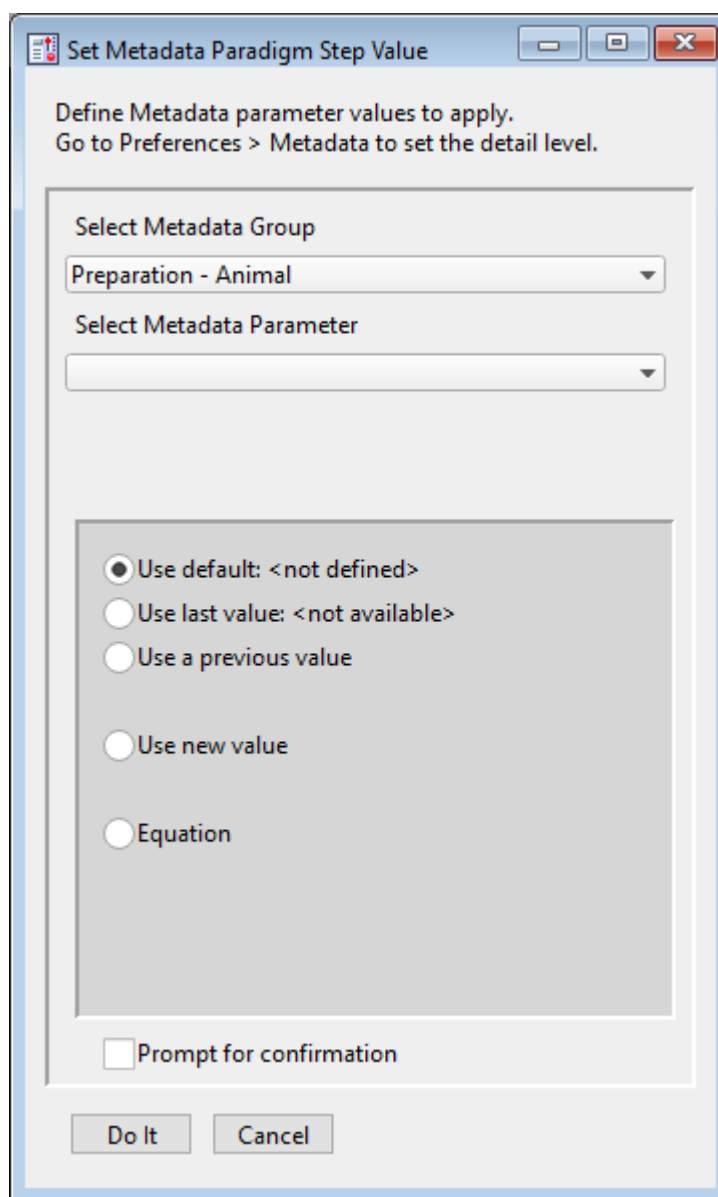
Figure 4-18. Step: Select Metadata Group

Select Metadata Group

- 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.
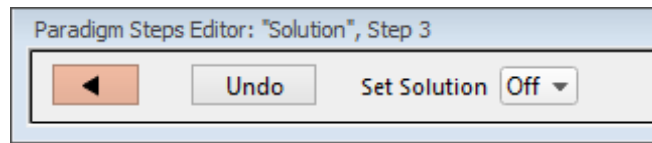
Figure 4-19. Step: Set Solution

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.

<u>Set Tag</u>

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.
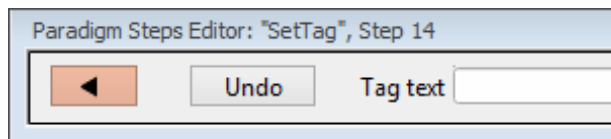
Figure 4-20. Step: Set Tag

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 'Set Tag' button text.

Update Inputs

>Takes a single "live" reading from the Auxiliary Inputs.

>Use for slowly changing variables, such as temperature.

Set Variable

>Variables allow flexible control of any operation that uses equations.
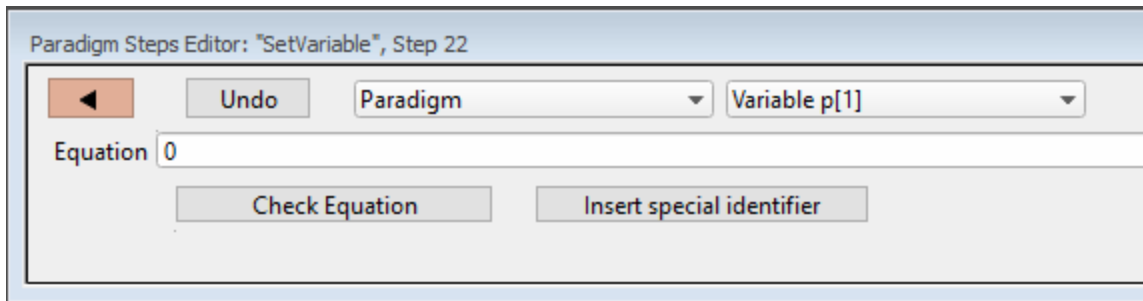
Figure 4-21. Step: Set Variable

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

Set Write Steps

Configure the level of logging Paradigm metadata.
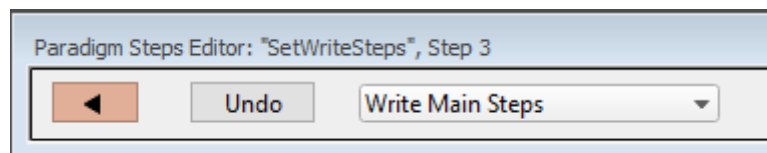
Default Setting: *SetWriteSteps, Value=Main*

  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.
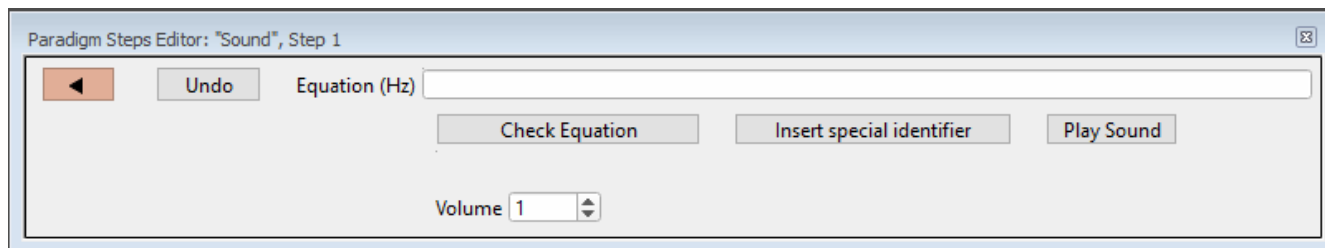
Figure 4-22. Step: Sound

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, else:
	< 250 Hz two clicks
	> 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	Acquisition 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 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 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)

View Last

Display the data from the last recording in a Scope (analysis) window.

Write to Log

Enter text to be written to the Log window.
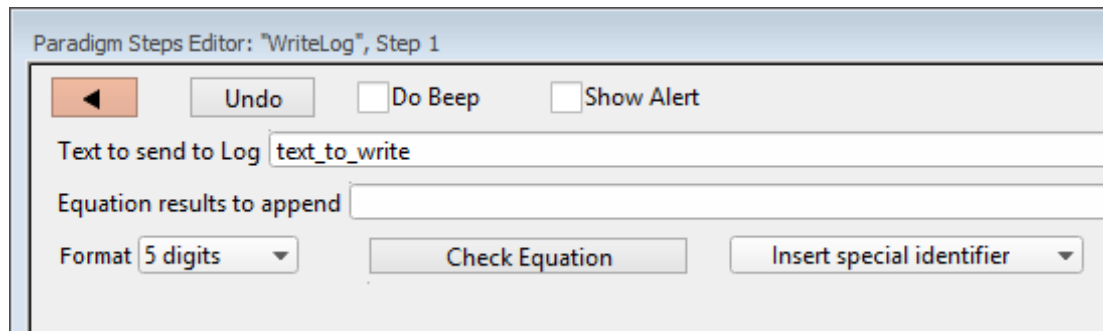
Figure 4-23. Step: Write to Log

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

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

Run-time dialog: Write to log
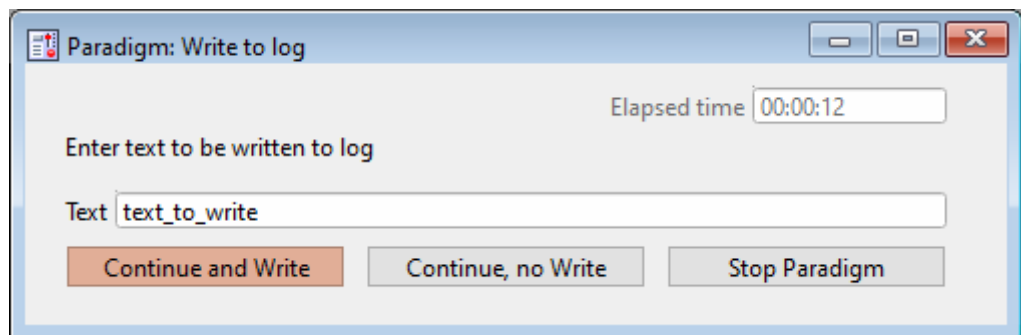
Figure 4-24. Step: Write to Log Run Time Window

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.
Stop Paradigm	Stop the Paradigm.

Alert

Display an "Alert" dialog box that pauses Paradigm execution until manually dismissed.

Figure 4-25. 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.
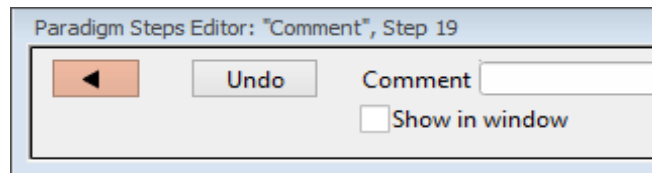
Figure 4-26. Step: Comment

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.

Wait

Temporarily pause execution of the Paradigm for a defined duration.

Paradigm Steps Editor: "Wait", Step 28

◄   Undo   Use Given value ▼   Seconds to Wait 1.0 s 🔼
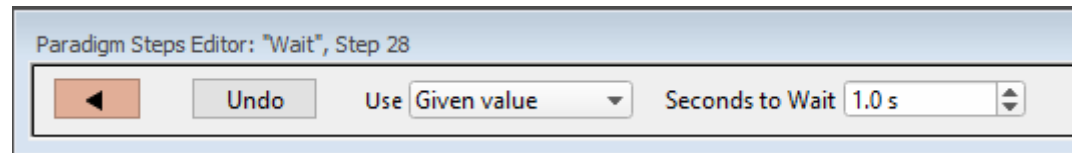
Figure 4-27. Step: Wait

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.

Pause

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

Break

Use a Break step to stop the execution of a Paradigm, or to interrupt For Loop and For Each Sweep loops.

Paradigm Steps Editor: "Break", Step 21

◄   Undo   Break Kind   Paradigm ▼
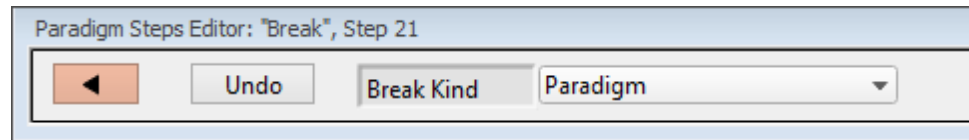
Figure 4-28. Step: Break

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

Chain

Use to link step execution to another Paradigm.

Paradigm Steps Editor: "Chain", Step 30

◄   Undo   ✓ Return to calling Paradigm   Paradigm to chain to undefined_paradigm ▼
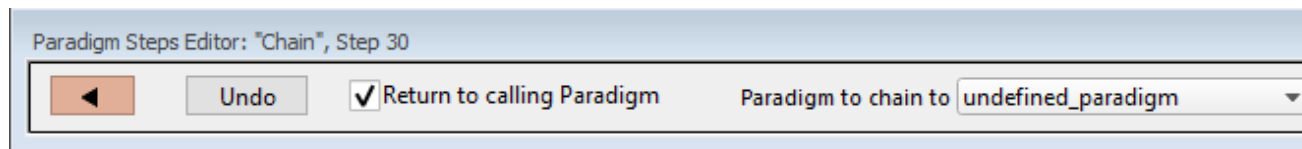
Figure 4-29. Step: Chain

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.

For Loop

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

Note: A "For loop" is processed as one step.
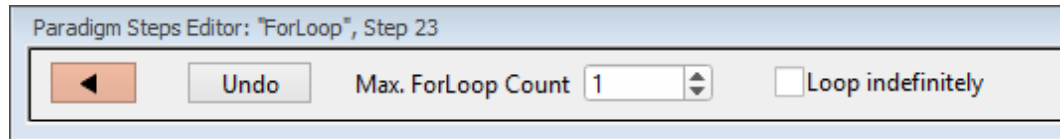
Figure 4-30. Step: For Loop

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".

Jump

Shift the Paradigm sequence to an arbitrary step. When executed, a jump occurs to the step after the target Label.
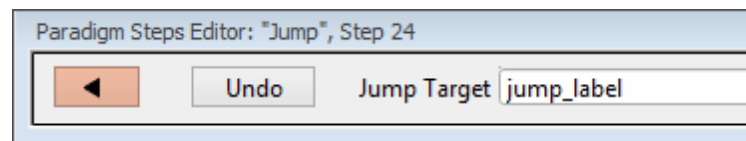
Figure 4-31. Step: Jump

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.

Label

Create a Label for a Jump step.

Paradigm Steps Editor: "Label", Step 25

◄ | Undo | Label name | jump_label
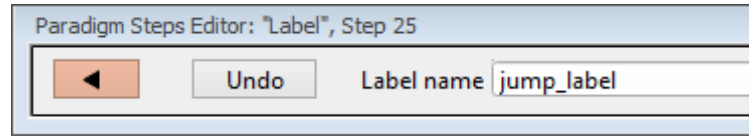
Figure 4-32. Step: Label

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.

If

This step allows conditional Paradigm flow control between multiple choices.

Paradigm Steps Editor: "If", Step 26

◄ | Undo | Compare 2 equations ▼
Left Equation
Check Equation | Insert special identifier ▼
Operation: ">" ▼
Right Equation |
Check Equation | Insert special identifier ▼
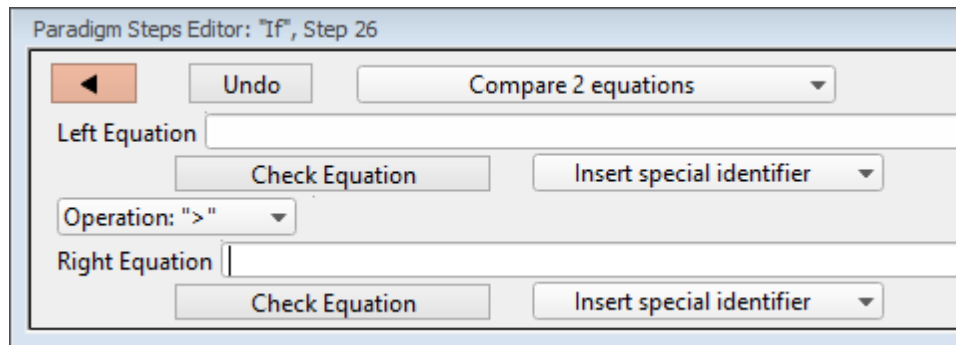
Figure 4-33. Step: If

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

- Check for key pressed   "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.

     o Space

        o   Return

        o   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.	

ElseIf

Allow conditional Paradigm flow control between multiple choices.
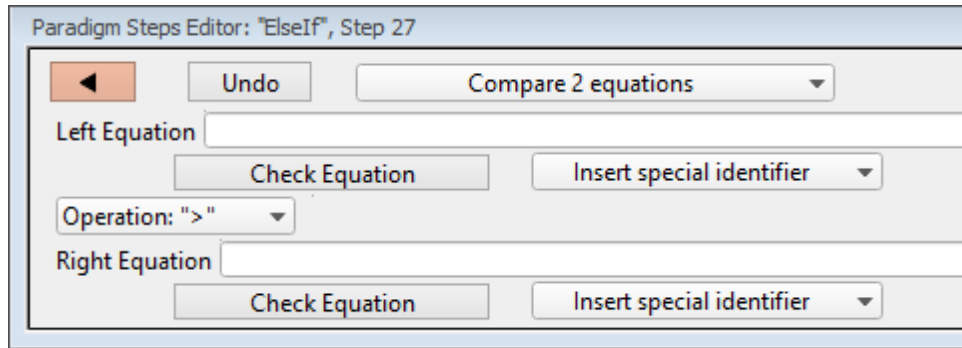
Figure 4-34. Step: Else If

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   Acquisition 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	Acquisition, amplifier and reference settings are available for use in equations. (See list below.)

- Check for key pressed — "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.	

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.
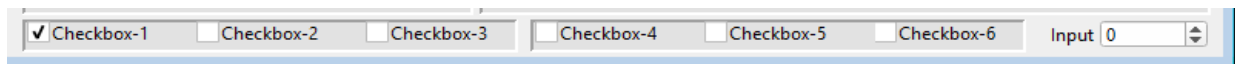
Figure 4-35. Checkboxes

[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'.

[-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 Pane   The Paradigm Variables table displays at the bottom of the Paradigm Editor.
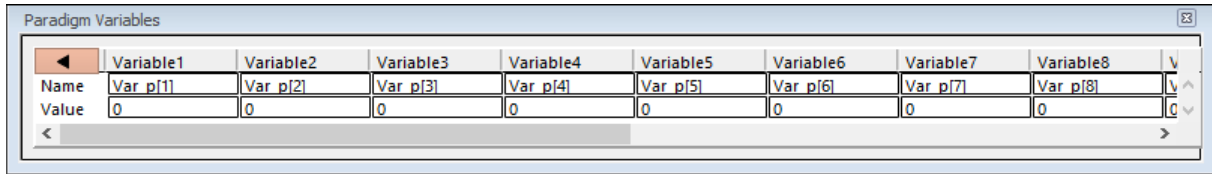
Figure 4-36. Paradigm Variables

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: The following acquisition, amplifier and reference settings are available for use in equations.

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)

Analysis Results

m[1..16]   (n'th analysis measurement value)

gx[1..16]   (n'th analysis graph x value)

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

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

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

Signal Readings

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

A single-point reading, such as from a slowly changing temperature probe.

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)

4.1.7 Reanalysis Measurements & Graphs

Make changes to the offline measurements and graphs with this dialog.

To access this dialog, click on the Scope (analysis) window button 'Measurements / Edit Measurements'.
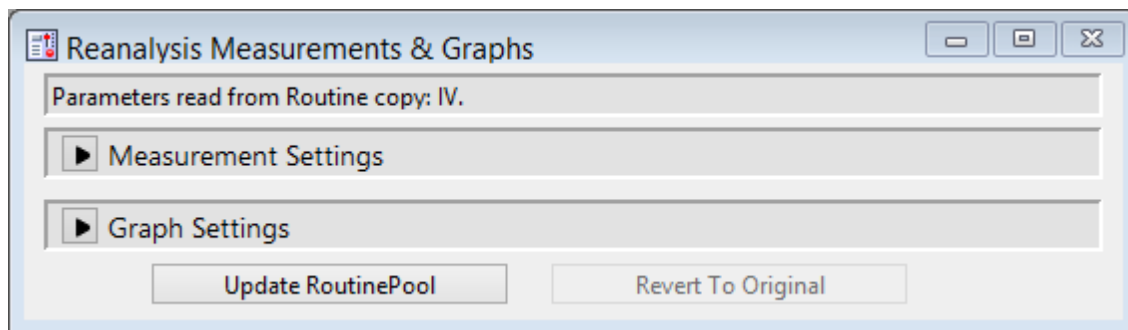
Figure 4-37. Reanalysis Measurements & Graphs

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

Measurement parameters from: The Routine name and date/time stamp.

4.1.8 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.
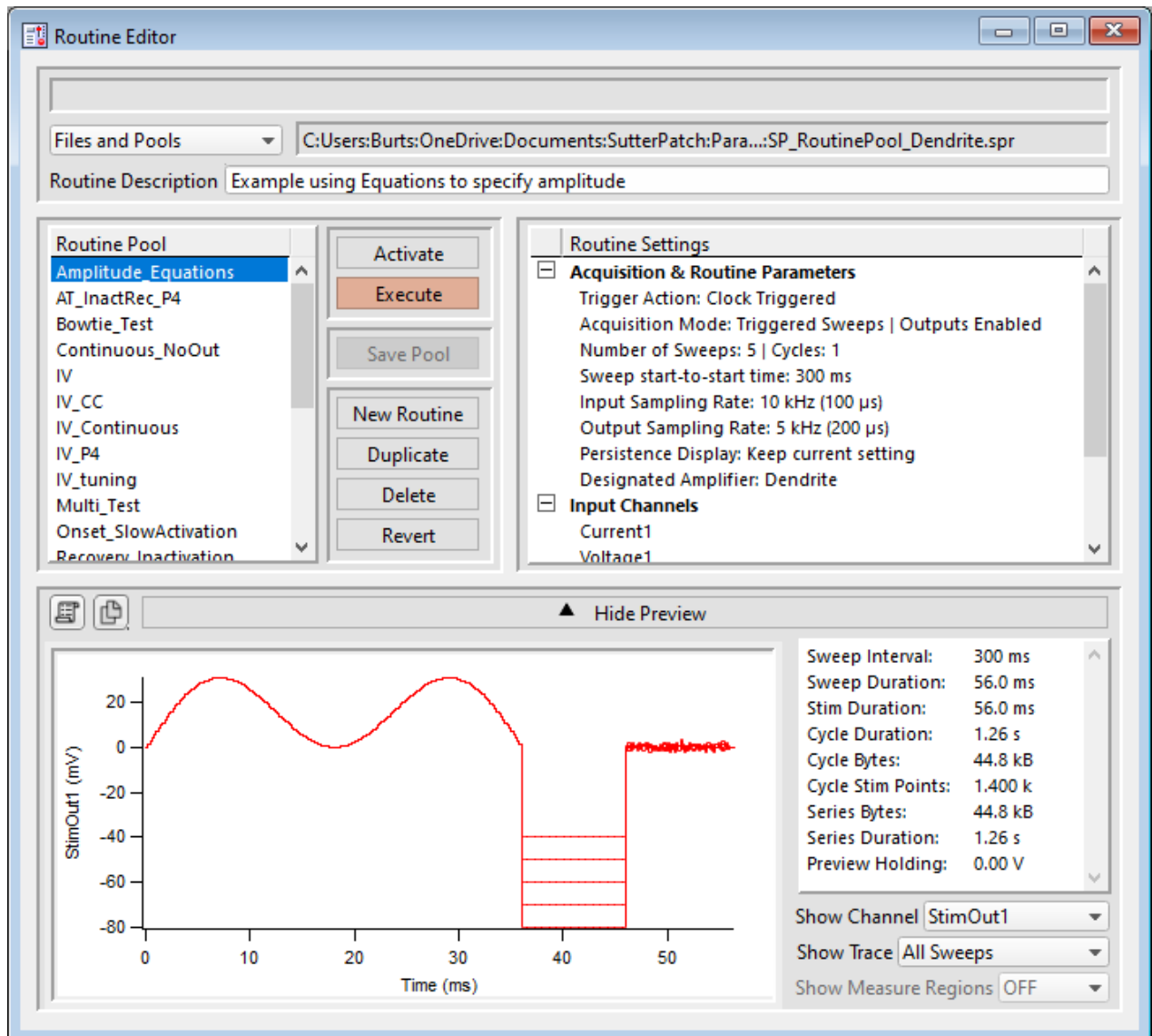
Figure 4-38. Routine Editor

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.

Status Field	Notifications on edits and Routine names are displayed here.	
Files and Pools	[drop-down list …]	
	Most recently used list of the last 5 Routine Pool files	
	Load Routine Pool	Load the Routines of a previously saved Routine Pool file into the Routine Pool
	New Default Routine Pool	Create a new blank Routine Pool.
	New Routine Pool	Create a new Routine Pool optionally populated with Routines from the currently loaded Routine Pool.
	Get Default Sample Routine Pool	Load the Routines from the default Dendrite 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 file name and path.
	Save Routine Pool As	Save the Routine Pool to a new file, and switch to the new file. The default file name has an increment number appended to the original file name.
	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.
	Convert Routine Pool	Convert the loaded Routines to be compatible with the attached amplifier or emulation mode.
	Send Last Used List to History	Copy the pathname of the last used Routine and paste it into the Command window history.

Table 4-1. Routine Files and Pools

New Routine Pool dialog:
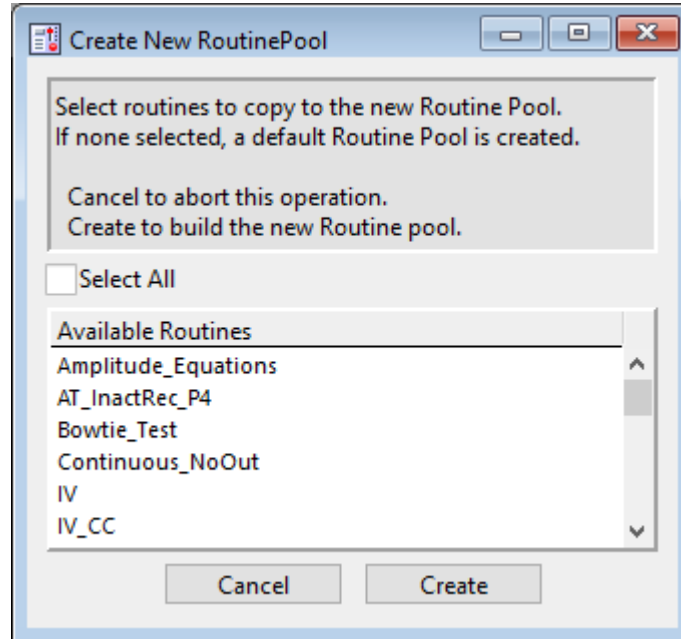
Figure 4-39. New Routine Pool

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

[File Path field]

The file path of the current Routine Pool displays on the right of the 'Files and Pools' list. If the Routine Pool has not been previously saved, this field is blank.

Routine Description

A Routine Description text comment can be edited and saved with the Routine.

Routine Pool

The Routine Pool section lists the names of all currently loaded Routines. Selecting a Routine name loads it into the Routine Settings section for editing and activation. As the Routine Pool contents are held in memory, the switching times between Routines are very fast.

Double click a Routine name to edit it.

- Allowable characters are A-Z, a-z, 0-9, and "_".
- Special characters and spaces are not allowed.
- The maximum length of a Routine name is 22 characters.

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.

Note: When a Routine is selected, if it was created for a different system (i.e., IPA or Double IPA), and the Preferences / Hardware / Routine Conversion is set to 'Prompt user', then a Routine Conversion dialog displays.

Activate	Open or refresh the Scope window with the latest Routine settings, but do not start acquisition. This button is re-named to "In Progress" during a recording.
Execute	Open or refresh the Scope window and immediately start recording. The latest Routine settings are applied to the Scope window. This button is renamed to "Convert" if a routine designed for a different amplifier type is selected and the Hardware Preferences do not automatically convert it.
Save Pool	Save the Routine Pool using its existing file name.
New Routine	Add a blank 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 4-2. Routine Editor Buttons

Waveform Preview

The stimulus waveform is graphically displayed at the bottom of the Routine Editor.
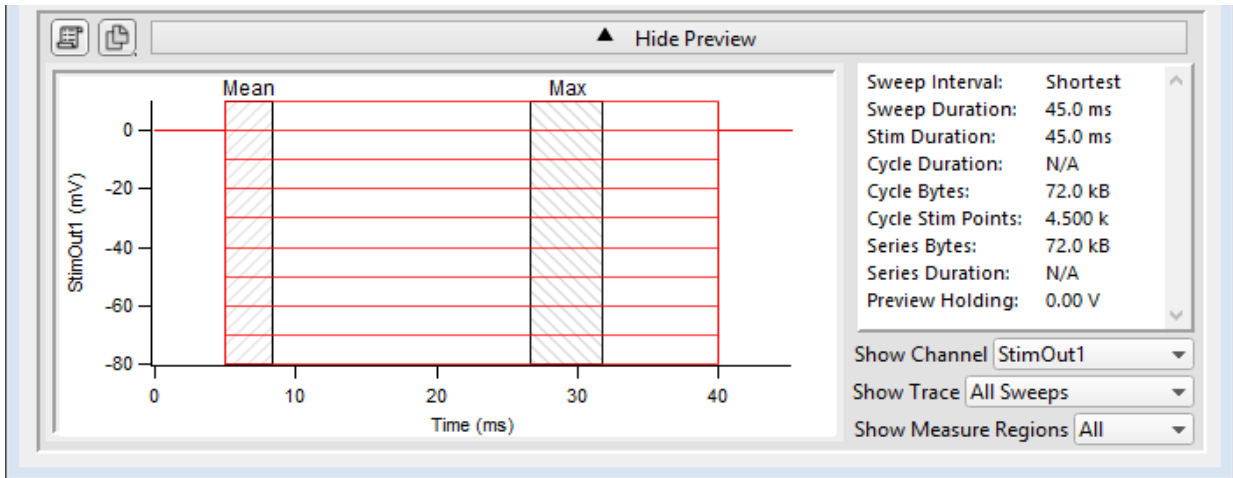
Figure 4-40. Waveform Preview Pane

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.

X- and Y-axis Control

- Hover the mouse cursor over an axis line until the cursor turns into a double-headed arrow, then scroll up or down to contract/expand the axis.

- In the preview pane, click and drag the mouse cursor to surround a region of interest with a bounding box (the "marquee"). Right-click in the box and select one of the expand/shrink options.

Some key settings and display controls are listed on the right of the Preview pane.

Units are in 's', or if < 1 s., then in 'ms'.

Sweep Interval:	The interval of time between the starts of consecutive triggered sweeps (Sweep Start-to-Start Time) in the active Routine.
Sweep Duration:	The amount of time in a sweep during which signal recording occurs with the active Routine.
Stim. Duration:	The maximum amount of time during which output stimulation occurs in a sweep.
	Set in Output Channels & Waveform / Waveform Editor / Duration.
Cycle Duration:	The amount of time for a cycle.
	Set in Acquisition & Routine Parameters.
Cycle Bytes:	The number of bytes of data in a cycle.
Cycle Stim Points:	The number of points in which output stimulation occurs in a cycle.
Series Bytes:	The number of bytes of data in the Series.
Series Duration:	The amount of time for the Series.
Preview Holding:	The holding level in the Dendrite Control Panel.
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[#]   **S**elect 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.
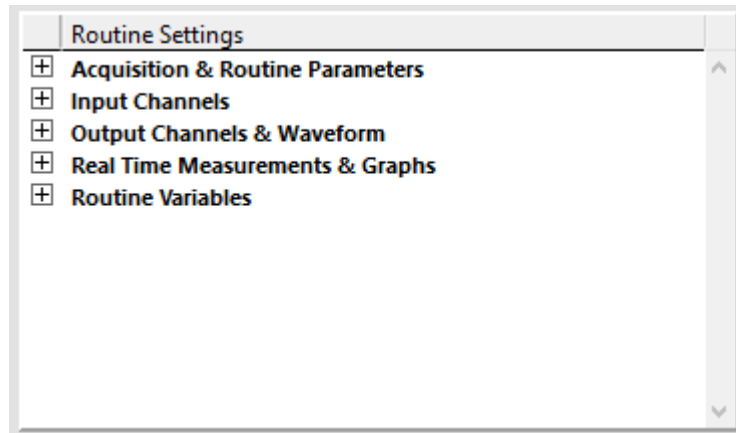
Figure 4-41. Routine Settings

Routine Editor: 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.
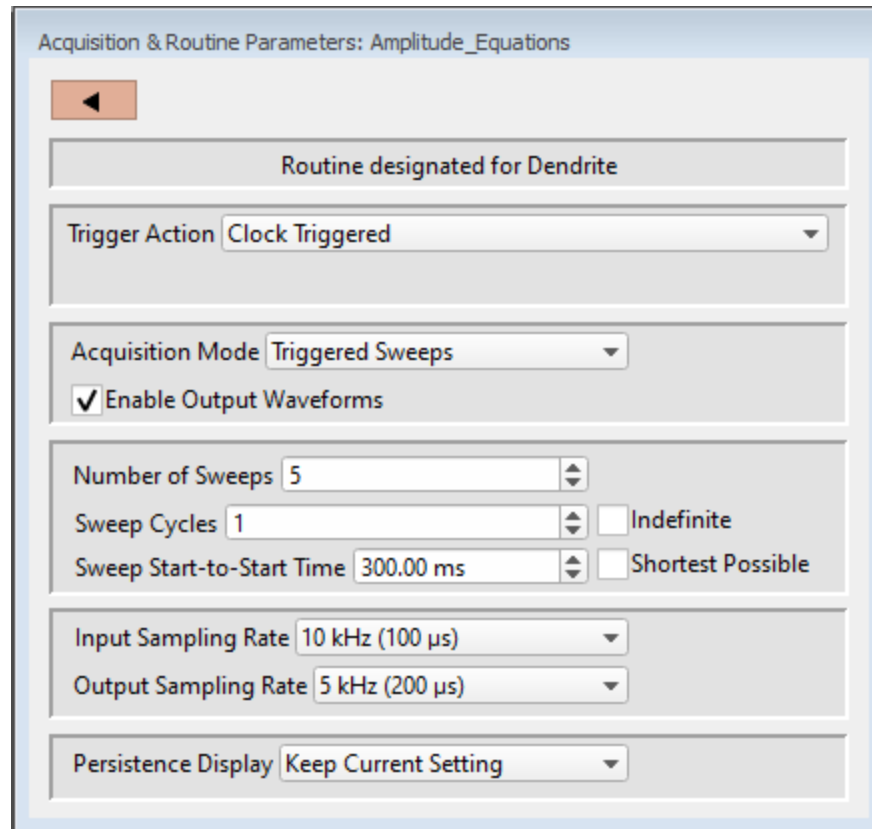
Figure 4-42. Acquisition & Routine Parameters

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 within a Paradigm 'Each Sweep' step, then the hardware trigger is substituted by

software trigger generated by the Paradigm.

- **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 for a set length of time.

  This functionality is useful to reduce extraneous data when infrequent events occur during long recordings, or to align random events within sweeps.

  The Acquisition Mode is set to 'Continuous Sweeps', to continuously monitor the signal for a trigger event.

  Event Triggered Settings   Click on the 'Event Triggered' field to open this dialog.

  Input Channel To Scan

  Pre-Trigger Duration   [0 – 0.06 s]

  Trigger Threshold   [±20.000 nA] current input

                               [±0.75 V]   voltage input

  Trigger Polarity   Rising Edge

                               Trailing Edge

  Minimum Trigger Duration   [0.0001 – 0.045 s]

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 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. When outputs are disabled, the sweep and segment durations (for analysis measurements) can be controlled via the Input Channels / Edit Signal / Waveform Editor.

Number of Sweeps   [0, 1 – 65000]

The number of sweeps to record.

Sweep Cycles   [0, 1 – 65000]

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

A value of zero is replaced by "indefinite", and the Indefinite checkbox is automatically enabled.

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

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

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

The largest file size that SutterPatch can record is 2.5 G samples.

Sweep Start-to-Start Time ['s', or if < 1 s, then in 'ms']

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

Shortest Possible   [for 'Triggered Sweeps']

Accomodates 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.

[Outputs enabled]   As set in Output Channels & Waveform / Waveform Editor.

[Outputs disabled]   As set in Input Channels / Edit Signals / Waveform Editor.

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

Input Sampling Rate: Applies to all input channels.

Sampling Rate	Sampling Interval
100 Hz	(10 ms)
200 Hz	(5 ms)
400 Hz	(2.5 ms)
800 Hz	(2 ms)
1 kHz	(1 ms)
2 kHz	(500 µs)
4 kHz	(250 µs)
5 kHz	(200 µs)
8 kHz	(125 µs)
10 kHz	(100 µs)
20 kHz	(50 µs)
25 kHz	(40 µs)
40 kHz	(25 µs)

50 kHz	(20 μs)
100 kHz	(10 μs)
200 kHz	(5 μs)

Note: 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.

Output Sampling Rate: Applies to all output channels.

Sampling Rate	Sampling Interval
100 Hz	(10 ms)
200 Hz	(5 ms)
400 Hz	(2.5 ms)
800 Hz	(2 ms)
1 kHz	(1 ms)
2 kHz	(500 μs)
4 kHz	(250 μs)
5 kHz	(200 μs)
8 kHz	(125 μs)
10 kHz	(100 μs)
20 kHz	(50 μs)
25 kHz	(40 μs)
40 kHz	(25 μs)
50 kHz	(20 μs)
100 kHz	(10 μs)
200 kHz	(5 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.

Persistence Display

For a recording, display each new sweep without erasing any previous sweeps.

- Off Set the Scope window into non-persistence display mode.

- On Set the Scope window into persistence display mode.

- Keep current setting Do not change the Scope window's prior setting.

Routine Editor: Input Channels

Configure the input channels.
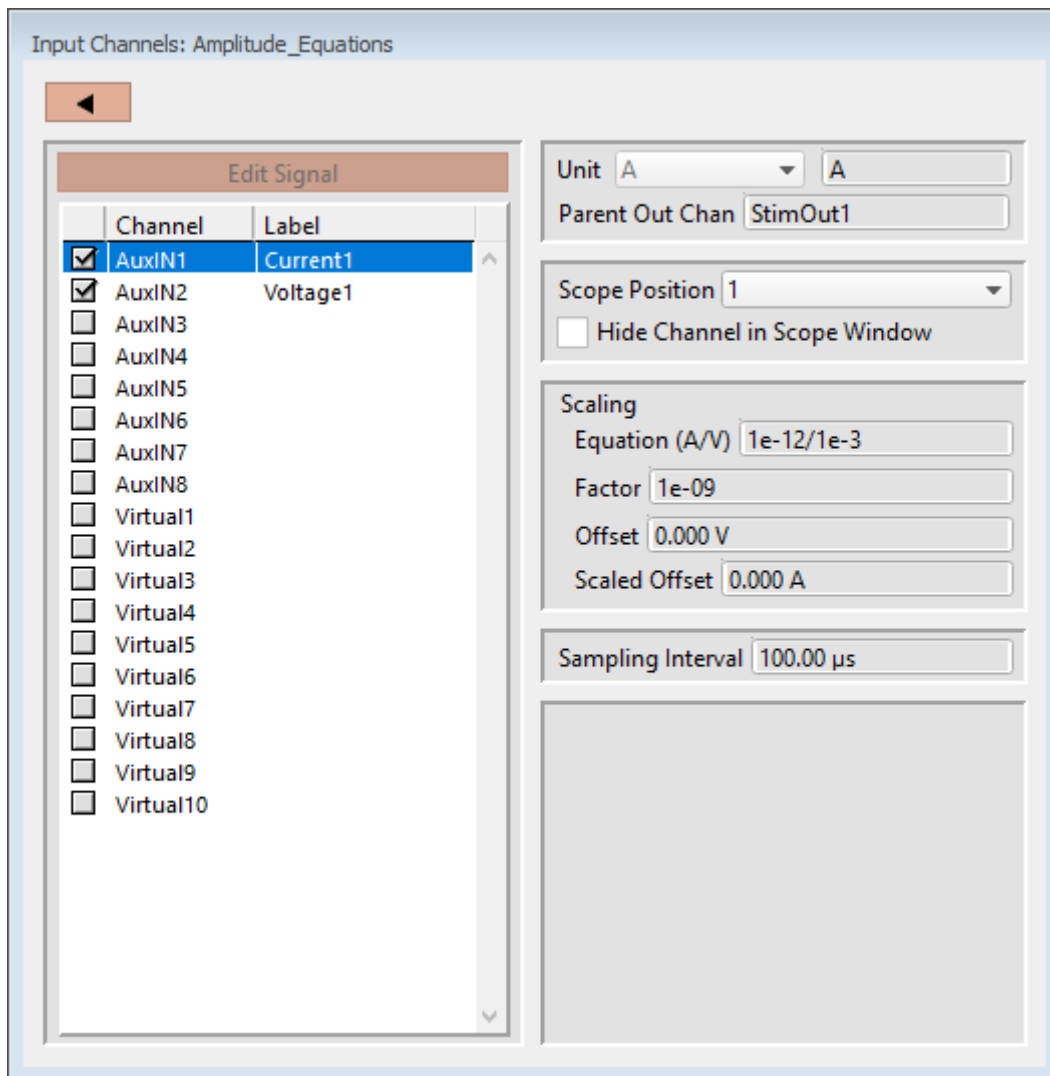
Figure 4-43. Input Channels

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 is a "timing only" version of the Waveform Editor, which controls the duration of segments to facilitate segment-based measurements.

Channel

Enable up to 16 Input Channels for recording data:

AuxIN[1 – 8]   Eight auxiliary analog input channels allow you to directly

digitize and record input signals from connected non-Suttter external equipment.

Note: In Emulation mode, the AuxIN channels display a ±20 mV sine wave.

Virtual[1 – 10]   Ten virtual channels are available.

Virtual channel data are mathematically transformed data from another input channel, or are entirely computed from an equation.

Label

A user-editable signal name for a channel.

These labels are 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 it 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.

- 'AuxIN' Channels   Default is 'V', but is editable.

- 'Virtual' Channels   Same as its Source channel; is only editable for virtual Math Type 'Equation'.

Note: The resolution of the signal units are automatically set.

Parent Out Chan   The "Parent Output Channel" shows which output channel is associated with which input channel. The ouput channel timing is also used for measurements with 'Cursors Relative to Segments'.

Auxiliary Input channels allow you to change the 'Parent Out Chan'.

However, Virtual channels cannot directly select Parent Output channels. Instead, they utilize their Source channel's Parent channels.

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   [for AuxIN and Virtual Input channels]

Equation   Enter a fixed value or equation for the input channel scaling factor of the external signal.

Factor   [read-only field]

The input channel scaling factor (converted from an equation).

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 (after any scaling).

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

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

Scaled Offset [read-only field]

Raw offset values are converted to input units.

Sampling Interval   [read-only field]

The duration of a single data sample.

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, its configuration fields are ungrayed.

Math Type   Apply a data transformation to a virtual input channel.

Baseline Subtract

Bessel Filter

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 for 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.

        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.

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

Restrict frequencies from this boundary point onwards.

- 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.

- 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.

    <u>Specify math equation for virtual signal</u>

     [<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 that the 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[#]   n'th 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.)

- 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.

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

Source Channel	Select an input channel to process.	
Line Frequency	50 Hz	Most of rest of world.
	60 Hz	Canada, (Carribean), Central America, (Japan), Mexico, (South America), South Korea, Taiwan, USA.

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.

  [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.

  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

- 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.

Routine Editor: Output Channels & Waveform

Configure the output channels and command waveform.
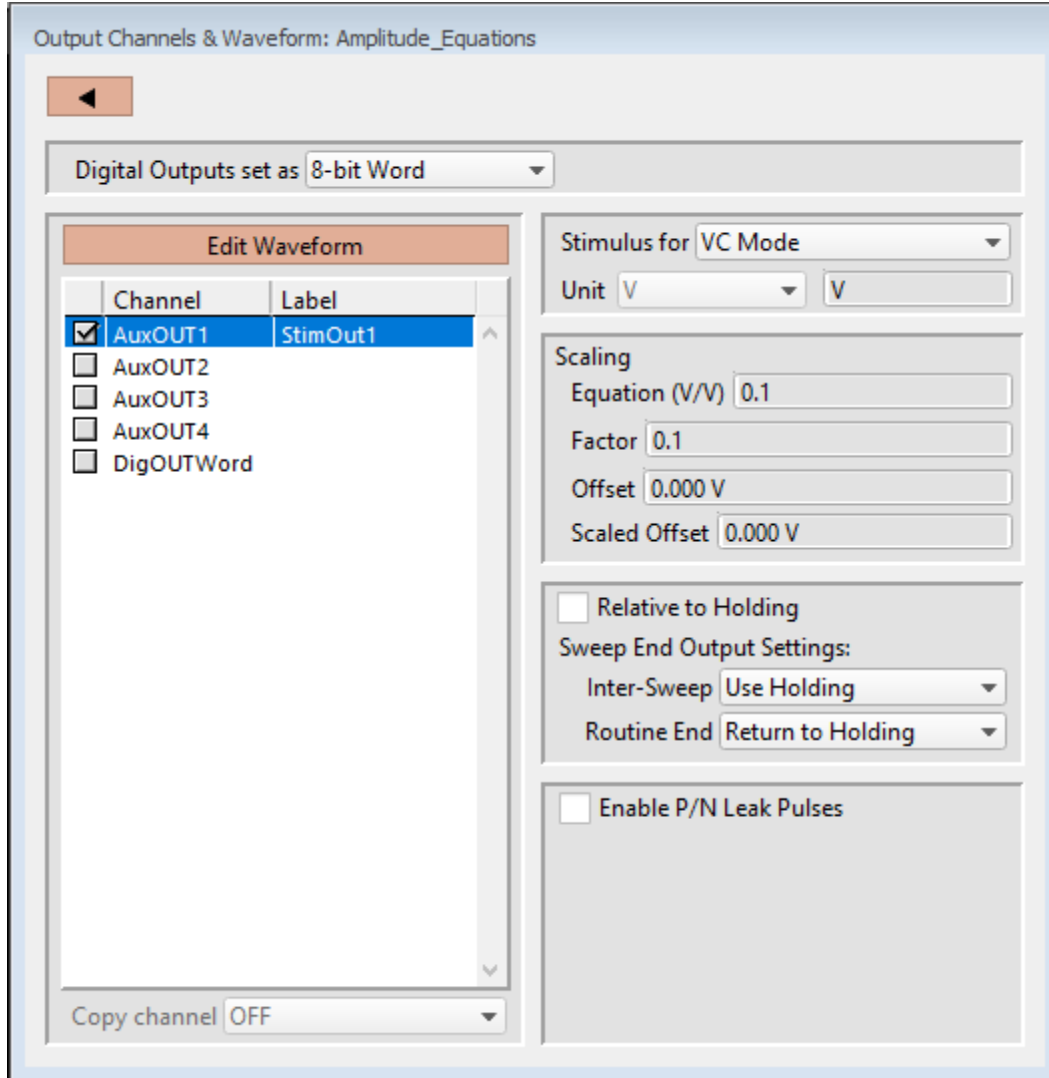
Figure 4-44. Output Channels & Waveform

[HW Status field]   Hardware information on the selected channel is displayed.

Digital Outputs set as

The digital output channels (bits) can be set individually or as a group.

- Individual bits   Each DigOUT(1 − 8) 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   The 8-bit digital output pattern is controlled by a single decimal number (0 – 256), which is also the waveform preview amplitude value.

     The waveform preview uses the binary bit pattern word value for its Y-axis value, i.e., if bits '1' and '3' are 'HIGH', 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. Or alternatively, double-click on an Output Channel name. (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 a channel name to highlight and select it – the channel output parameters are displayed for configuration.

   The front panel (auxiliary) analog output channels (-can be used to send stimulus waveforms to external instruments.

   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.

   To rename any of the Output Channels, double-click on the respective name and enter a new one.

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 it 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., "Aux" 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

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

- 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.

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

Note: The Dendrite system can be switched into any mode (VC or CC) while a recording is in progress. However, it is your own responsibility to correctly interpret data with mixed recording modes.

Unit

Enter the base unit of measurement. The signal unit resolution is automatically adjusted.

- AuxOUT Channels

  Can be edited to any setting.

Scaling   [for AuxOUT channels]

Offset   Apply an offset to the output channel (after any scaling.)

Equation   Enter a fixed value or equation for the output channel scaling factor of the stimulus signal.

Factor   [read-only field]

  The Output channel scaling factor (converted from the Equation).

Offset (V)   Apply an amplitude offset to the output signal (after any scaling).

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

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

Scaled Offset [read-only field]

  Raw offset values are converted to output units.

Relative to Holding

If 'Relative to Holding' is enabled, the headstage output signal is the command waveform summed with the "-holding" level in the Dendrite Control Panel. If the holding level is set to '0', this setting has no effect.

For the Auxiliary channels, the command waveform is summed with the Dendrite Control Panel Auxiliary Output settings.

For digital channels, the command waveform is relative to the Dendrite Control Panel Digital Output settings.

Note: When enabled, this setting is updated live by holding level changes in the Dendrite Control Panel.

Sweep End Output Settings

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

Inter-Sweep

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, after changing the holding levels, if 'Relative to Holding' is enabled, then the 'Return to Holding' levels are updated immediately, otherwise they are only updated when a Routine is activated.

Enable P/N Leak Pulses

[The P/N Leak Pulses section is only displayed if this field is enabled.]
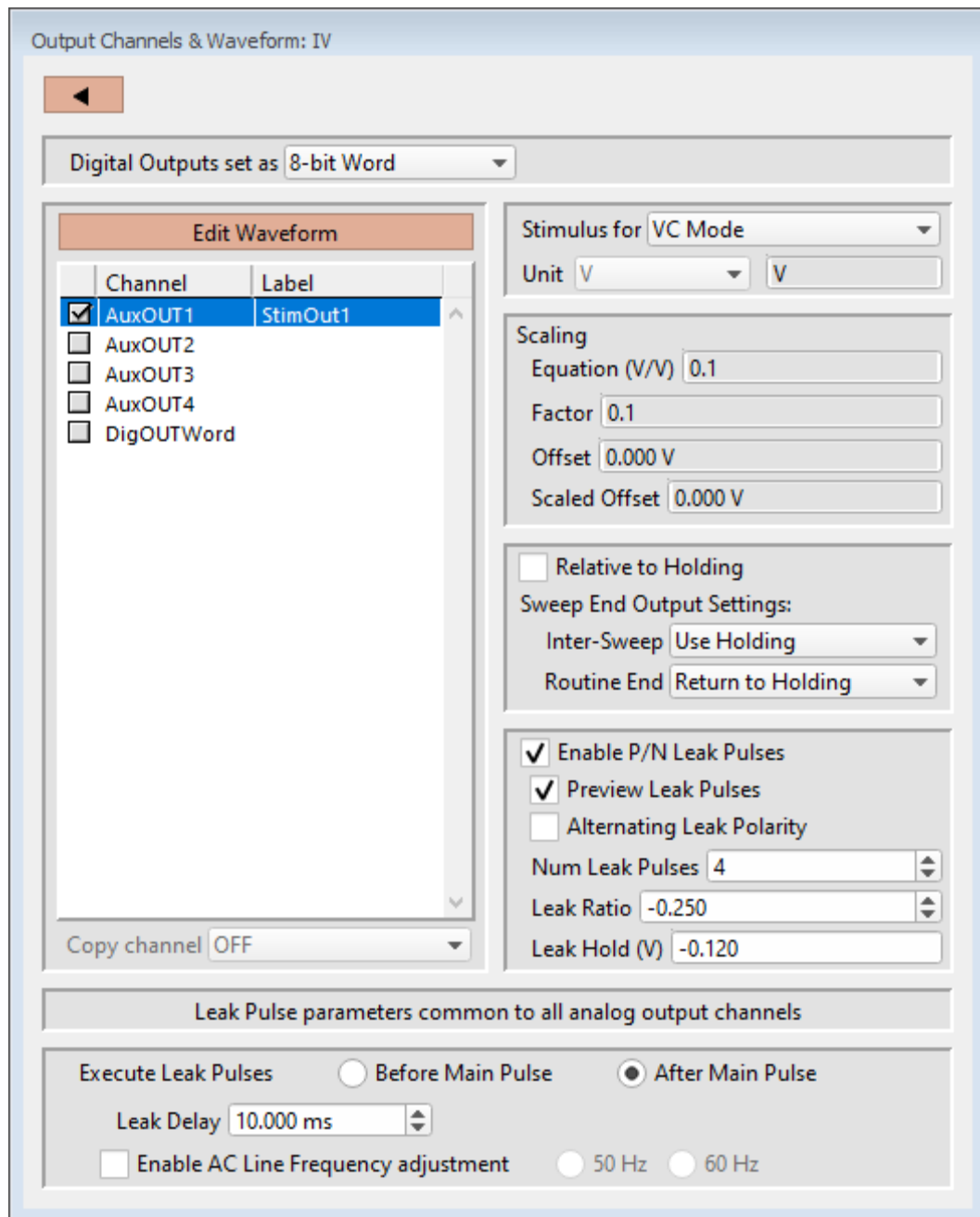
Figure 4-45. Output Channels & Waveform with Leak

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. With the high precision of modern 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 that the 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:

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

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

This Line Frequency adjustment automatically calculates the proper interpulse interval for the P/N sub-pulses, so that they are counter-phased to the line frequency of the output signal, which reduces hum without filtering the signal.

Routine Editor: Waveform Editor

Click the 'Edit Waveform' button to open the Waveform Editor and design a command waveform for the selected output channel.
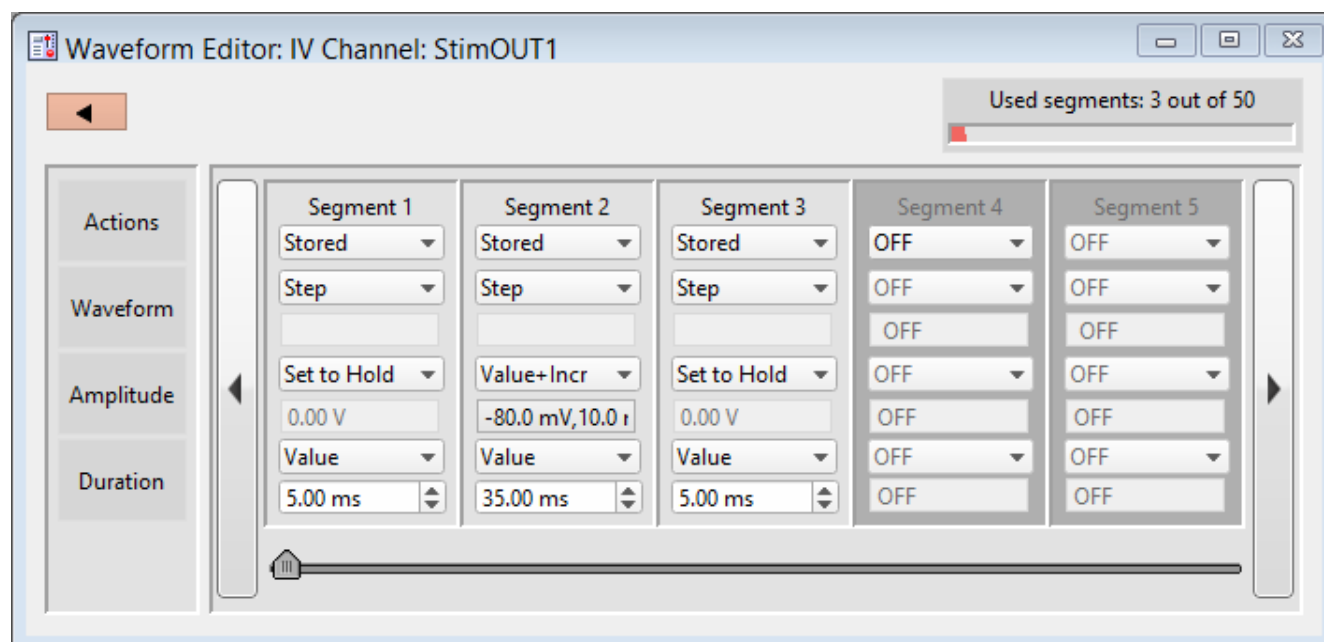
Figure 4-46. Waveform Editor

Close button ◀   Use this button to close the Waveform Editor window.

Used segments [# out of 50] Up to 50 contiguous segments can be configured in a

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.

    Note: 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.

    Tip: 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.

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]

Cycle Amplitude   Amplitude of the first peak from the sine wave baseline. [±1000.00 mV, ±20 nA]

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).

Segment Duration   Sine wave duration (ms).

Squarewave   The waveform generates a train of rectangular pulses.

Base Amplitude Increment
                    Increment the baseline amplitude

	for each succesive pulse.		
	[±1.00 V, ±20.000 nA]		
Step1 Amplitude	Amplitude of first pulse.		
	Value [±1.00 V, ±20.000 nA]		
	Var_r[1 – 16]		
Step1 Width	Duration of first pulse (ms).		
	Value [ ]		
	Var_r[1 – 16]		
Step2 Amplitude	Amplitude of second pulse.		
	Value [±1.00 V, ±20.000 nA]		
	Var_r[1 – 16]		
Step2 Width	Duration of second pulse (ms).		
	Value [ ]		
	Var_r[1 – 16]		
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	[±1000.00 mv, ±20000 pA]	
	Start Frequency	[1 – 50000 Hz]	
	End Frequency	[1 – 50000 Hz]	

Segment Duration   Chirp wave duration (ms).

Template   Assign an arbitrary waveform to a segment.
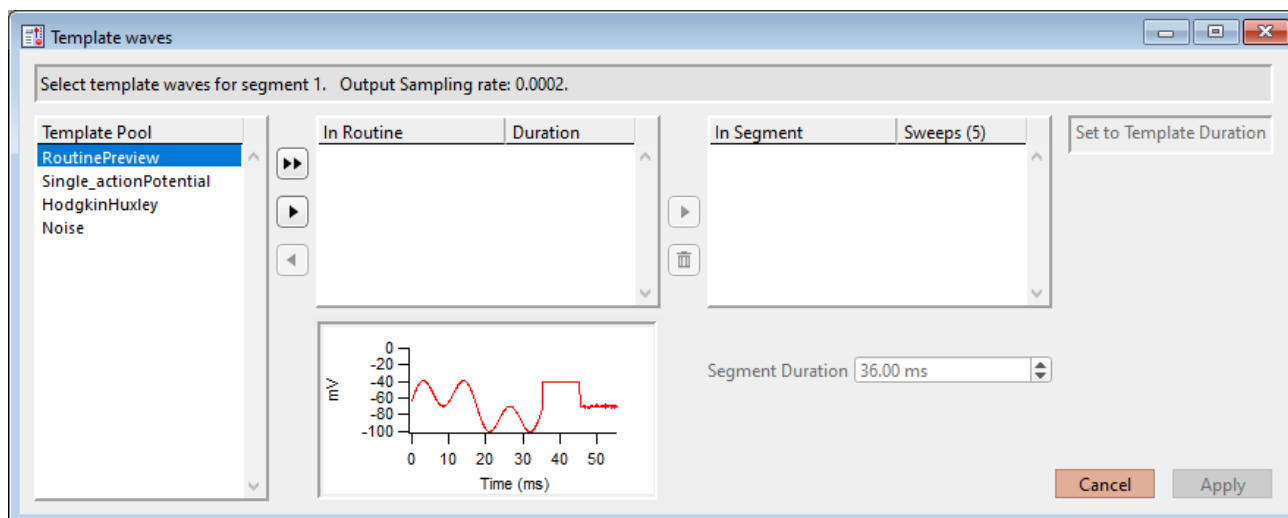
Figure 4-47. Template Waves

[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.

Template Pool	Templates loaded in the Template Editor Pool plus extracted templates.
▶▶	Copy the selected template wave from the Template Pool into a Routine and Segment.
▶	Copy the selected template wave from the Template Pool into the Routine.
◀	Copy the selected template wave from the Routine into the Template Pool.
In Routine	Templates stored in the Routine.

Each output channel can have a maximum of 16 template waves stored in its routine. The same template can be used in multiple segments. Each segment can have one or multiple templates assigned to it.

Probably the most used case will simply be a single template paired with a single segment, but the possibilities are endless.

Note: To avoid unnecessary increase in the sizes of routines and Routine Pool files, only include templates that are actually used by segments.

Duration (ms)   The duration of the template trace.

▶   Copy the selected template from a Routine to a Segment.

🗑   Delete the template wave from a Segment or an unused Routine

In Segment   Each segment can have one or multiple templates assigned to it.

If only one template is listed, then for any number of sweeps, the segment output wave will be the same for all sweeps.

If more than one template is assigned to a segment, and the number of sweeps is greater than 1, then an output wave is created as:

    1st sweep with the 1st template on the list.
    2nd sweep with the 2nd template.
    Etc.

If there are more sweeps than templates, then the templates are reused (round robin) for each subsequent sweep.

In Segment

Sweeps   Number of sweeps in the Routine.

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).

Set to Template Duration

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

Triangle   The waveform generates a train of triangular pulses.

Base Amplitude Increment

Increment the baseline amplitude for each succesive pulse.

Peak Amplitude   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 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.	
Tip:	Record an initial baseline in Segment 1 to help intepret your data (or set in the last segment.)	
	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 can be recorded, such as from tail currents.	
Value	Use a single number for the segment amplitude.	
	[±1000.00 mV, ±20000 pA]	
Value List	Set an arbitrary segment amplitude for each sweep.	
	[Sweep | Value]	For each sweep, enter a number. [±1000.00 mV, ±20000 pA]
	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

[±1000.00 mV, ±20000 pA]

	Increment Value	[±1000.00 mV, ±20000 pA]
	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]   A free-form text field.

                                                  [±1000.00 mV, ±20000 nA]

                                                  Errors are reported under this field.

    Check Equations   Check the equation syntax. The equation is evaluated for sweep #1, and if valid, it reports that the 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.)

      Note: Computing an equation for an output wave 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.

  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 = O
        ▪   HIGH = 1

    Bit Word   Values are the decimal number of a 8-bit word (0 – 256), also displayed as a bit pattern.

Duration   Set the segment duration.

    Value   Use a single number for the segment duration.
                        [0 – 12 ks]

When typing in a value, if no unit type is entered, the unit type defaults to seconds (s).   If you enter a number followed by an 'm' or 'ms', the unit type is milliseconds (ms).

Value List   Set an arbitrary segment duration for each sweep from a list of numbers.

             [Sweep | Value]   For each sweep, enter a number. [0 – 12 ks]

                                              (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.

        [Equation field]   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 that the 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.)

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.

Routine Editor: Real Time Measurements & Graphs

Online analyses are configured in the Real Time Measurements & Graphs dialog. Measurement regions display in the Scope window, and their associated analyses are plotted in an Analysis sub-window during acquisition.
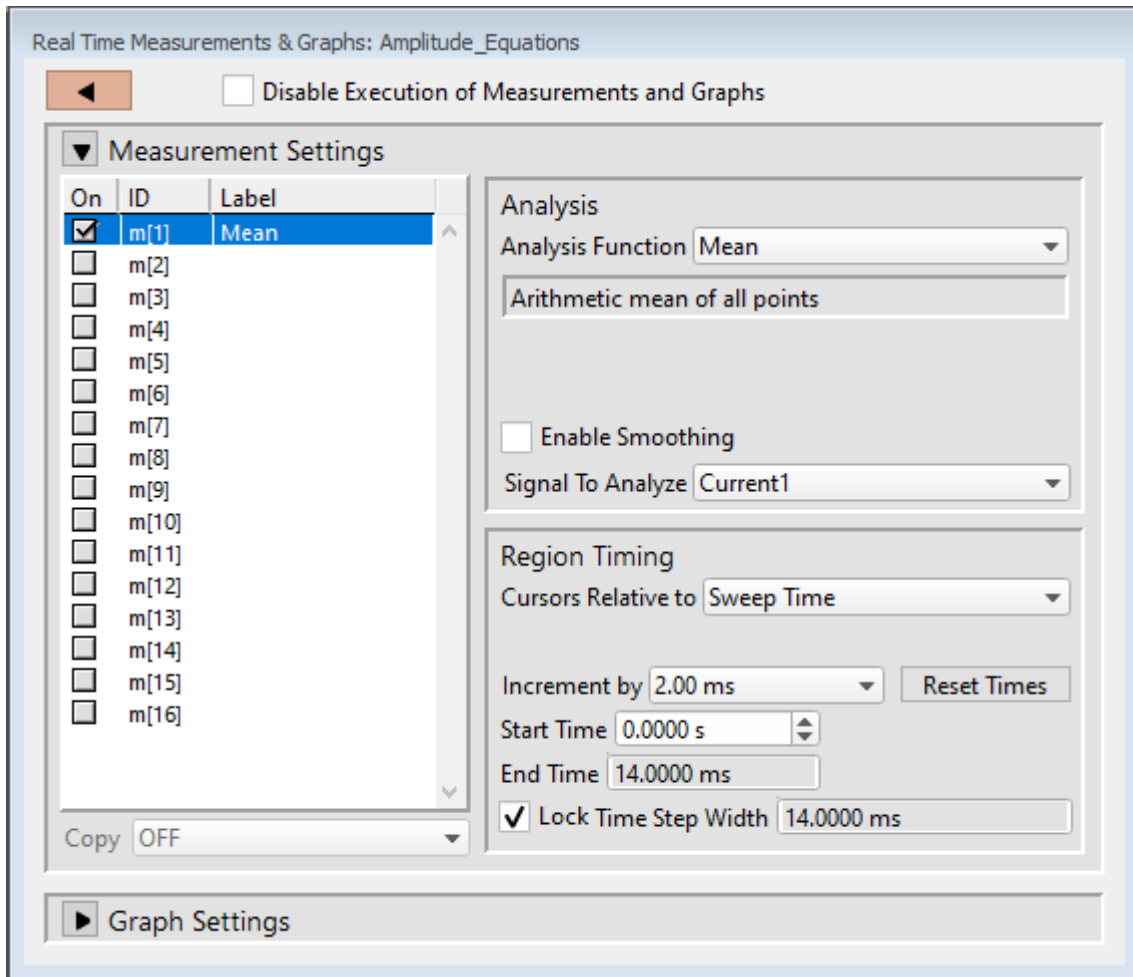
Figure 4-48. Real Time Measurement Settings

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.

<u>Analysis</u>

Analysis Function Choose from 23 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.

Area Signed area - negative values negate positive values.

Decay tau Time constant of 'Decay time'.

Decay time 0 - 100% decay (fall) time, "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 sample.

Mean Arithmetic mean of the samples.

Min value Value of smallest sample.

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 0 - 100% rise time, "start to peak".

RMS noise Root-Mean-Square noise.

Segment amplitude Maximum amplitude of the selected segment.

Segment duration Duration of the selected segment.

Slope Slope of a simple linear regression fit.

Std deviation Standard deviation of the samples: $\sqrt{\text{(variance)}}$

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 with end-of-measurement y0 subtracted.)

These analyses can be directly plotted, or used in more complex equations. (See the Equation Editor section for more details.)

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

Threshold   This amplitude level needs to be crossed by the data to trigger measurements for:

- 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.

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 the signal to be measured from the list of Input Channels. A measurement is only made on one input channel, but it can be used in multiple graphs.

Region Timing

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

Note: Cursor Start times cannot be greater than their End times.

- 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 occur 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
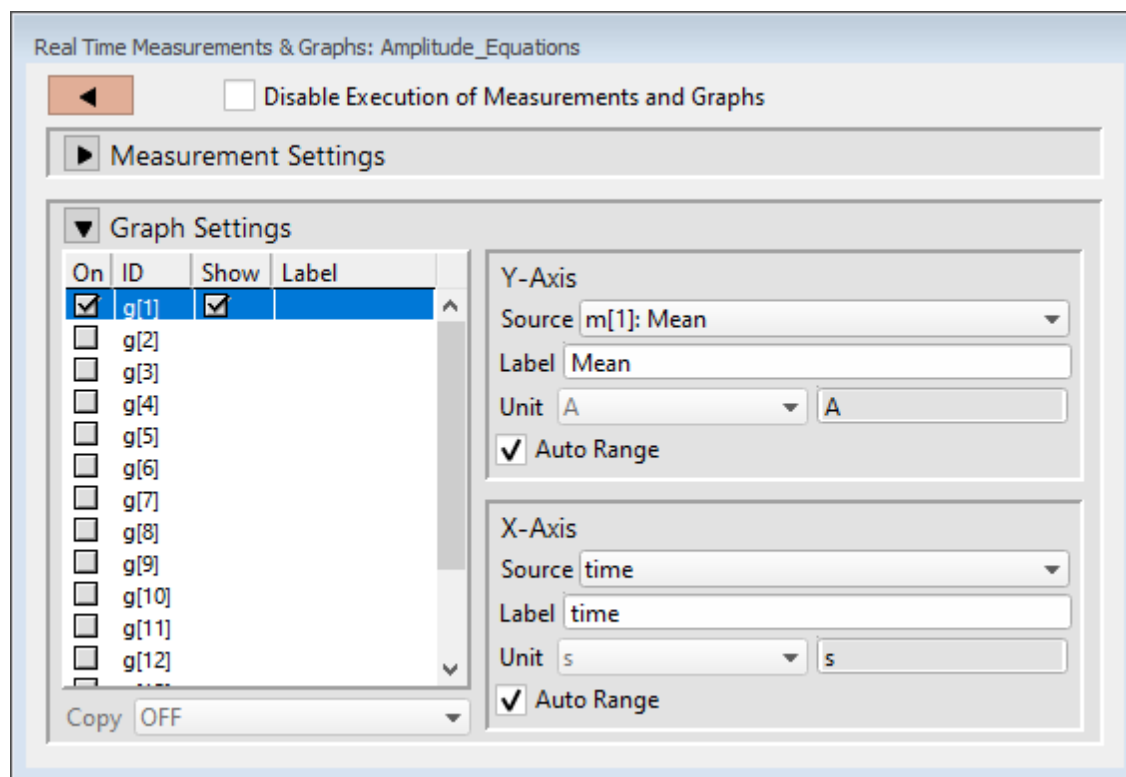
Figure 4-49. Real Time Graph Settings

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.

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   Select a Measurement ID for the graph Y-Axis, or use an equation for a custom-
            ized Y-axis plot.

            Source   Select a Measurement, or enter an equation

                            (see the Equation Editor for more details.)

                                    For example, track cell changes sweep-by-sweep by run-
                                    ning a planned Paradigm with a Routine step inside a
                                    'For Each' step.

Label   A Y-axis label is automatically generated from the Measurement label; directly edit to customize the 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>   Display the graph X-axis with a standard time-base, or select a Measurement ID for the X-axis, or use an equation for a customized X-axis plot.

Source   Select a Measurement, or enter an equation.

        (See the Equation Editor for details.)

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 Editor: Routine Variables

Up to 16 Routine Variables can be configured for stimulus control. These variables allow interactive manual control of the waveform amplitude and duration, or automatically via Paradigms.
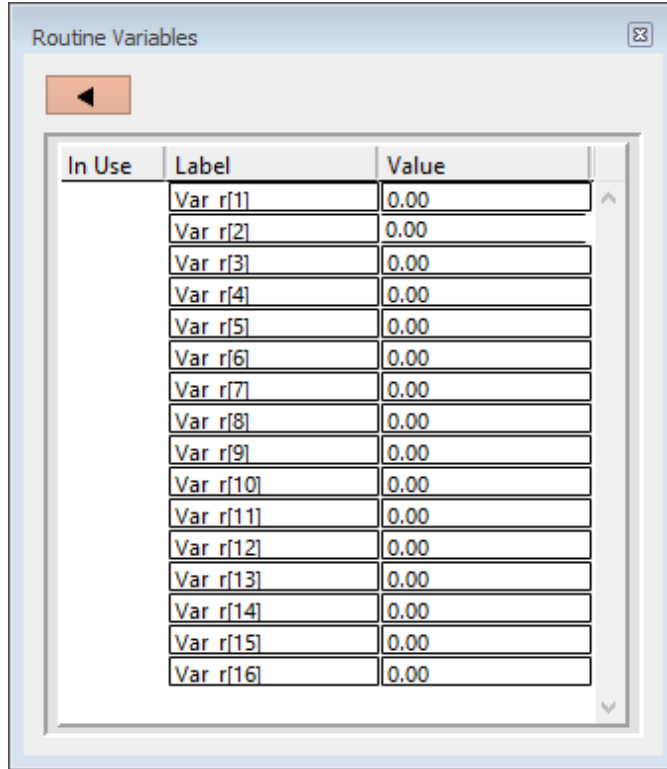
Figure 4-50. Routine Variables

Routine Variables

| In Use | A checkmark means this Routine Variable is in use by the Waveform Editor. |

| Label | Var_r[1 - 16] | Edit the default variable name if desired. |

| Value | Numeric values can be manually entered or set by a Paradigm. |

| Note: | If Routine Variables are enabled and then disabled, the Waveform Editor converts its 'Var_r' settings to 'Value' settings using the last enabled values. |

4.1.9 Scope (Acquisition)

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

Note: Only one Scope window can be open at a time. For example, if a Scope window is open for data acquisition, then opening the Membrane Test, Free-Run, or data for reanalysis, will close the acquisition Scope window, and re-open it as the new type of Scope window.
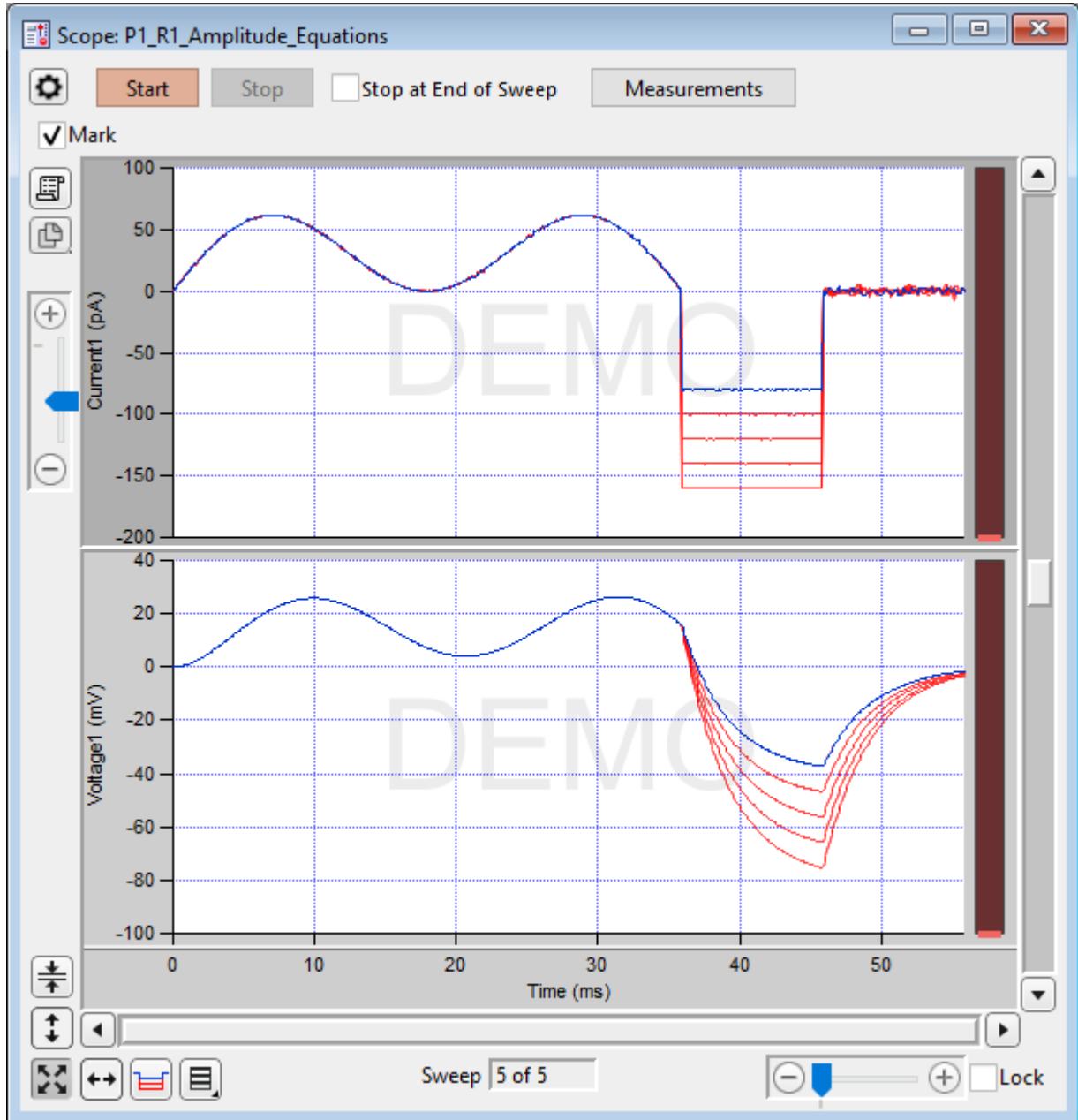
Figure 4-51. Scope (Acquisition) Window

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

Controls

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.

Signal Display Mode
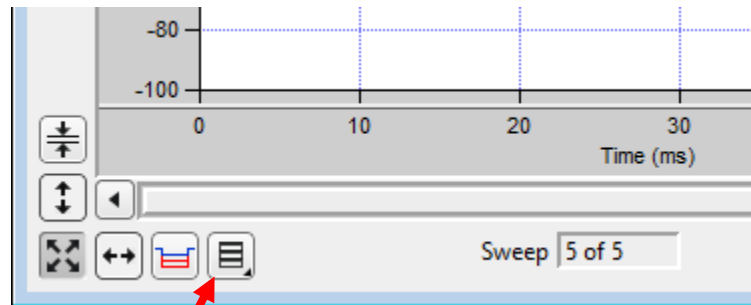
Figure 4-52. Signal Layout

Signal pane arrangements are set by the 'Select signal layout' button ⊞ in the lower left corner of the Scope window. Select 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.

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.)

Magnification and Scrolling

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

- 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
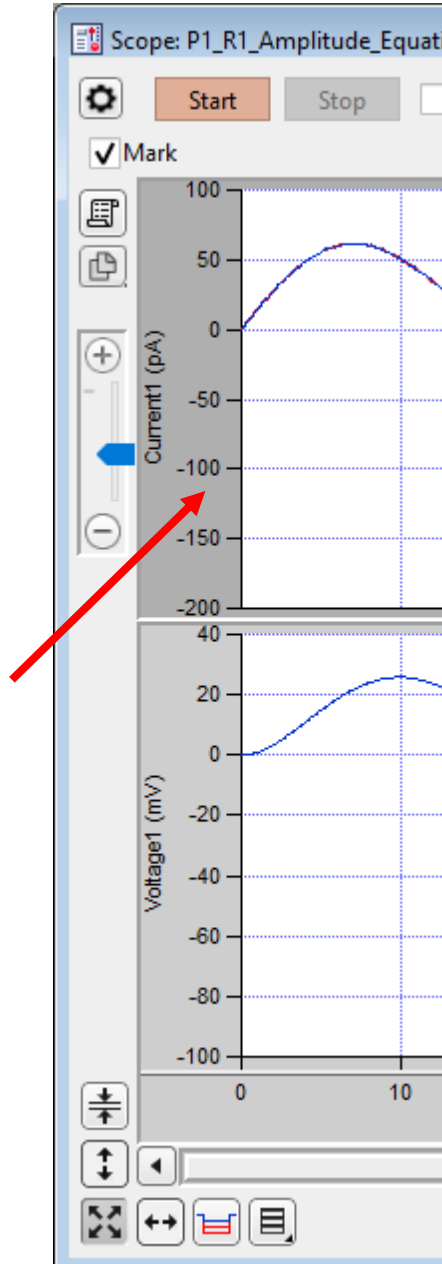
Figure 4-53. Axis Magnification

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
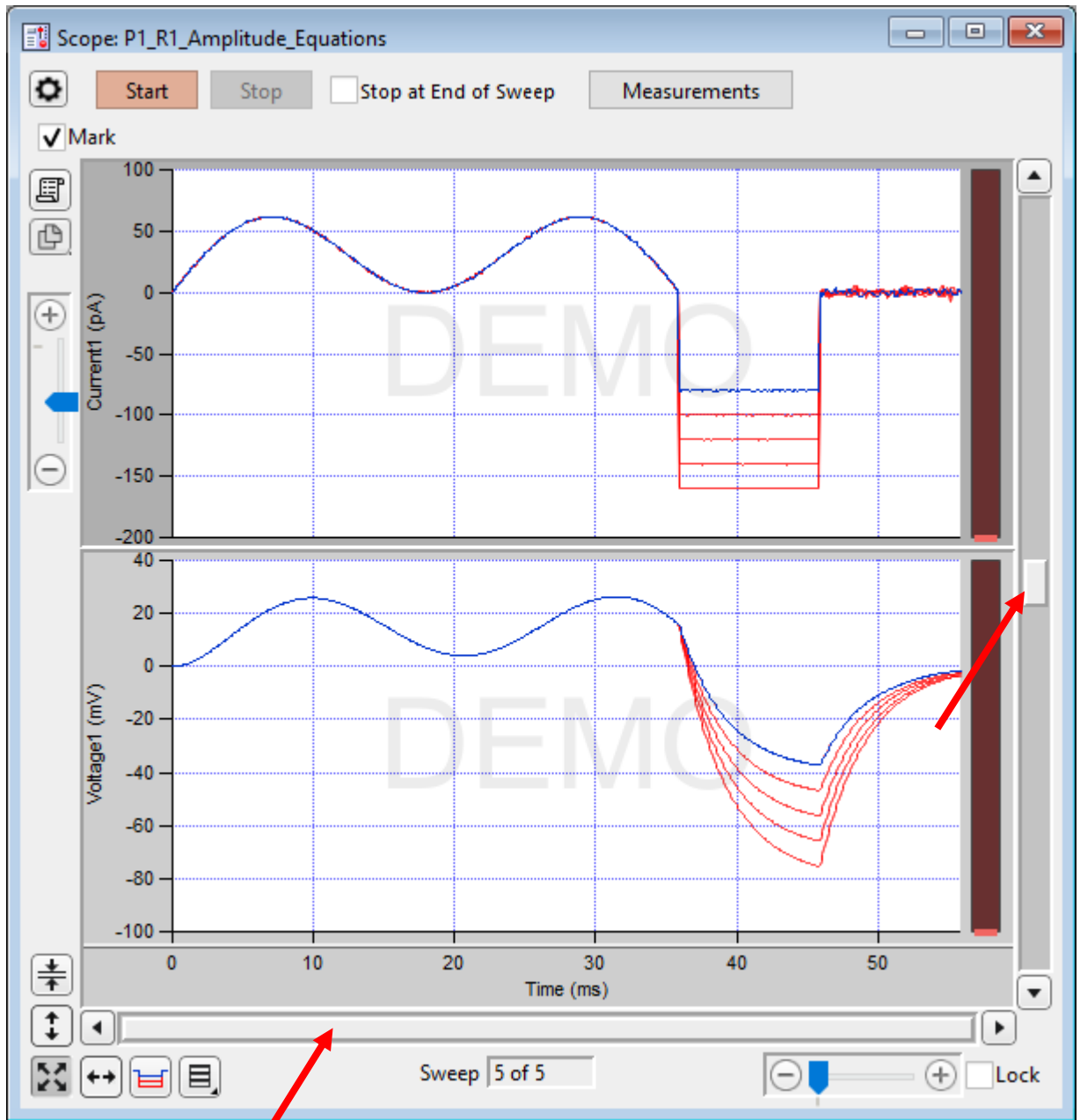
Figure 4-54. Axis Scroll Bars

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:
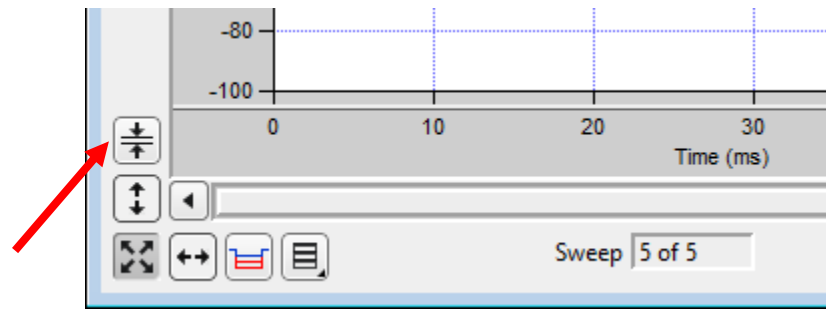
Figure 4-55. Center Button

Center the active signal. Vertically off-center or off-screen data is reposi-
tioned so for the active sweep, the mean of the Y-axis data is vertically cen-
tered in the signal pane. The Y-axis offset is adjusted, while the Y-axis scal-
ing is kept unchanged; the X-axis remains unchanged.

To center all signals, shift-click the button.

▪ Autoscale Axes
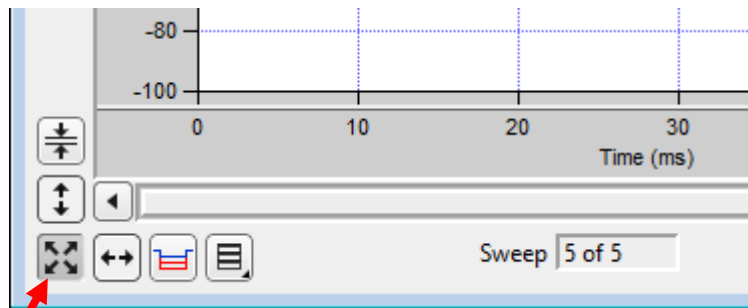
Figure 4-56. Autoscale Axes

Autoscale.

Click to autoscale once the Y-axes of all visible signals to their
visible sweeps data limits, and toreset all X-axes to their full
sweep duration.

To include the zero amplitude in the Y-ranges, configure
"Continuous autoscale from zero" in the Set Preferences / Scope
Window / Acquisiton / Y axis initial settings.

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;
also all X-axes are reset to their full sweep duration. The

Autoscale button remains depressed in this state.

⬍ Click to autoscale once the Y-axis of the active signal to its visible sweeps data limits.

To include the zero amplitude in the Y-range, configure "Continuous autoscale from zero" in the Set Preferences / Scope Window / Acquisition / Y axis initial settings.

To autoscale the Y-axes of all visible signals, in Windows right-click (or Shift-click or Ctrl-click) the button, or in macOS Control-click the button

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.

- X-Scale

↔ Full-scale all X-axes.

All signals X-axes are reset to their full-scale setting

- 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.
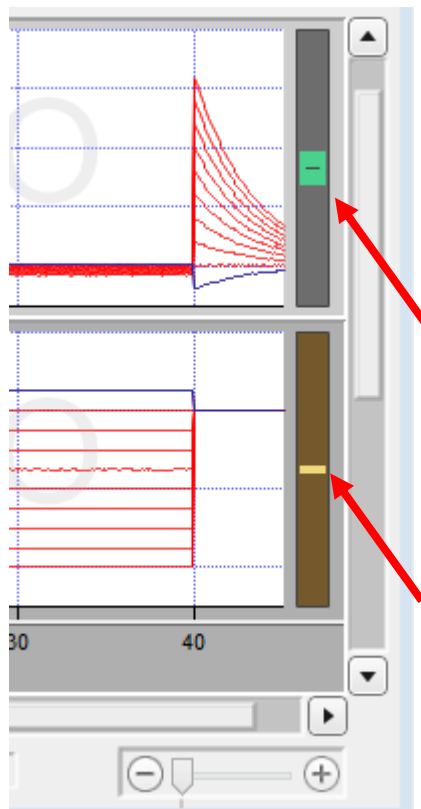
Figure 4-57. Amplitude Meters

For the Triggered Sweeps acquisition mode, each displayed signal has its own Y-axis amplitude meter on the inner right-side of the associated Scope 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: Set all marks in sweeps of active series Clear all marks in sweeps of active series ------ Begin with all marks set (in sweeps of active series) Begin with all marks cleared (in sweeps of active series)
	Start recording and displaying digitized analog data in the Scope window input channels.

Start	When you click the 'Start' button, the Scope 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 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, any partial sweep in progress is not saved with the data.
	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 Current Measurements
	Analyze with Original Routine Measurements
	Analyze with Routine Last Executed Measurements

	Load 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.
	Edit Virtual Signals Open the virtual input signals panel for editing.
Mark	Enable to "mark" the current (or upcoming) sweep. See the Data Navigator to process marked sweeps.
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 graph to the system clipboard or, if the 'Shift' key is pressed, the complete Scope window.
Persistence Display	Enabled: Data from all acquired sweeps of the Series are displayed, i.e., multiple sweeps are displayed. Disabled: Previous sweeps are cleared, and the newest acquired sweep is displayed.
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 4-3. Other Scope Buttons

Right-click Menus

X-Axis

	Autoscale All Axes	Scale all signals Y-axes to their data, and set all signals X-axes to their full-scale range.
	Full scale X Axis	Set all signals X-axes to their full-scale range.
	Axis Properties…	Modify the axis style and components.
Y-Axis		
	Autoscale All Axes	Scale all signals Y-axes to their data, and set all signals X-axes to their full-scale range.
	Continuous Autoscale Axis	Continuously scale the signal's Y-axis to its data.
	Autoscale Axis	Scale a signal's Y-axis to its data.
	Full scale Y Axis	Set the signal's Y-axis to its full-scale range.
	Axis Properties…	Modify the axis style and components.
	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 area

> To display a limited data modification menu, right-click in the blank area of a signal pane.

Note: If you click too close to the signal 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	Scale all signals Y-axes to their data, and set all signals X-axes to their full-scale range.
	Add Annotation	Add a floating text box label to the signal.
		To edit or delete an annotation, double-click on it.
	Parametric Plot	Open a separate graph window of X vs. Y input signals.
	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 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.

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.)'

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.

Show Signal '<name>' Only   Show the selected signal in the Scope, and hide all other signals.

Stack All Signals   Display all signals in a stacked signal layout.

Signal Data   A full data modification menu displays with numerous options to modify sweeps and data points, such as marker symbols and lines.

The entries include most of those from the right-click main window menu (see above), such as:

Toggle Cursor Info   Show/Hide the Cursor Info pane to manually measure X-Y data values, or to set a fitting range.

 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

$\oplus$	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

$\boxtimes$	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 a 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 fitting functions.

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

Marquee

Click and drag the mouse to surround a region of interest:

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.

4.1.10 Solution Editor

Control perfusion systems with named solution control settings.
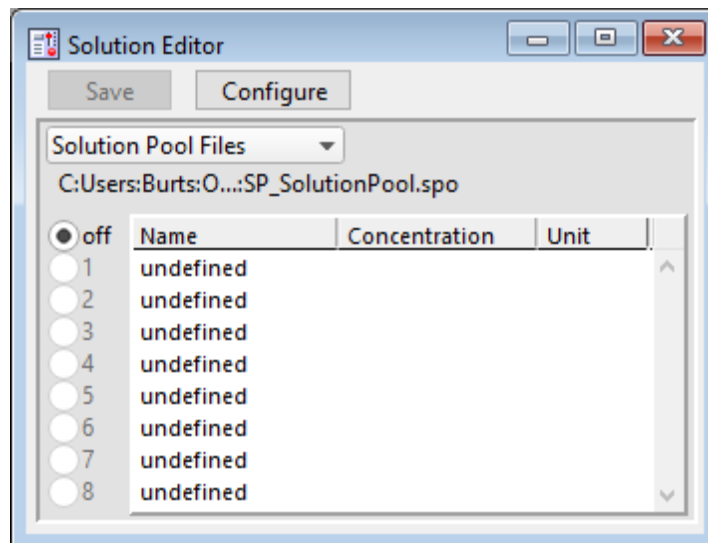
Figure 4-58. Solution Editor

You can create a named list of solution control "valves" to manage your analog and digital commands to physical valves and solution changers.

Save
: Save Solution Editor changes to the current Solution Pool file (*.spo). This button becomes active once a Solution is selected for editing

Configure
: Opens 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 blank Solution Pool.

Load Solution Pool
: Load the Solutions of a previously saved Solution Pool file into the Solution Pool.

Revert to Last Saved
: Undo any unsaved changes to the Solution Pool.

Save Solution Pool
: Save the Solution Pool using its existing file name and path.

Save Solution Pool As
: Save the Solution Pool to a new file, and switch to the new file.

Save Solution Pool Copy
: Save the Solution Pool to a new file, but do not switch to the new file.

Note: Default file names are auto-incremented from the previously loaded Solution Pool name.

The file path and file name of the loaded Solution Pool file is displayed.

[off, 1 – #]   Manually select a "valve" radio button to activate its corresponding Solution configuration. A radio button is available for selection (ungrayed) when its name is changed from 'undefined'.

The number of radio buttons is set by the number of "Configured" solutions with outputs. Only one "valve" can be active at a time.

Name   Double-click on a field to edit it; click-and-drag to move it up or down in the table.

Concentration   Enter a concentration value for the solution.

Tip: You can access the concentration value from the last-used 'Test Compound' solution valve in SutterPatch fields that accept "Special IDs", using 'Solutions'.

Unit   The unit type of the concentration.

Configure Solutions

◀   Close Dialog button.

[# Solutions]   Set the number of Solutions to configure. Changing this number creates a new solution pool.

[4, 8, 12, 16, 20, 24]

Loading other Solution Pool files allows a virtually 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
- Test Compound
- Not a Solution

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

- No Output

- AuxOUT1 - 4   [±10.000 V]   Analog output voltage.

- DigOUT Word   [0 – 255]   Decimal value of an 8-bit digital word.

- DigOUT1 – 8   [Low / High] A single digital bit is set "high".

4.1.11 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.
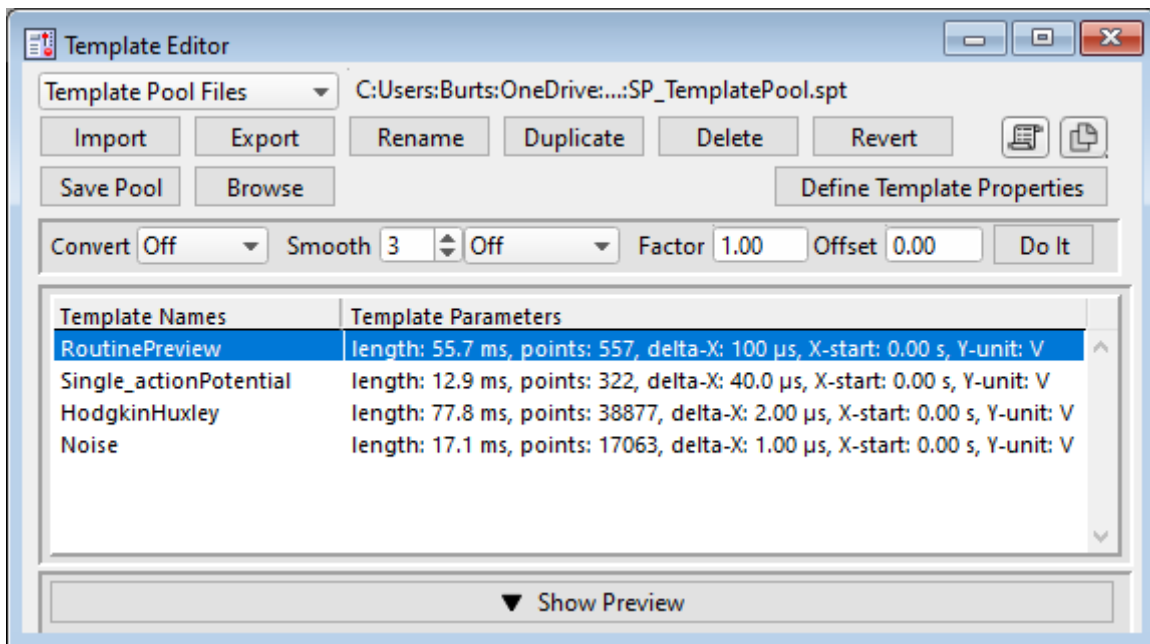
Figure 4-59. Template Editor

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:

- Scope window (Acquisition): Last sweep.

- Scope window (Analysis):   Selected sweep.

- Preview pane: Last or selected sweep.

Note: 'Extract Template' is not implemented for graphs or the Data Navigator preview pane. Also, it is only valid with monotonically increasing or decreasing X-axes.

Export	Export the selected template to a 1-D Igor 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.
Delete	Remove the selected template from the list.
Revert	Discard any unsaved changes to the selected template.
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.)
Convert		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

Online data analysis is configured in the Routine Editor with measurement settings. These same settings are also available during offline data reanalysis.

For complete flexibility in controlling how analyses are performed, use a Paradigm Execute step to run virtually any SutterPatch command, Igor analysis or user-defined function.

General analyses include:

- Analysis Editor

- Equation Editor

- Igor Analyses

- Metadata Review

- Paradigm Editor

- Routine Editor

- Scope / Reanalysis Measurements

Specialized analyses are available via the reanalysis Scope or the Data Navigator:

- Action Potential Analysis

- Single-Channel Analysis

- Synaptic Analysis

4.2.1 Action Potential Analysis

Action potentials (APs) are analyzed with this offline dialog. Access via the Scope analysis window 'Measurements' button or the Data Navigator (signal) 'Available actions' menu.
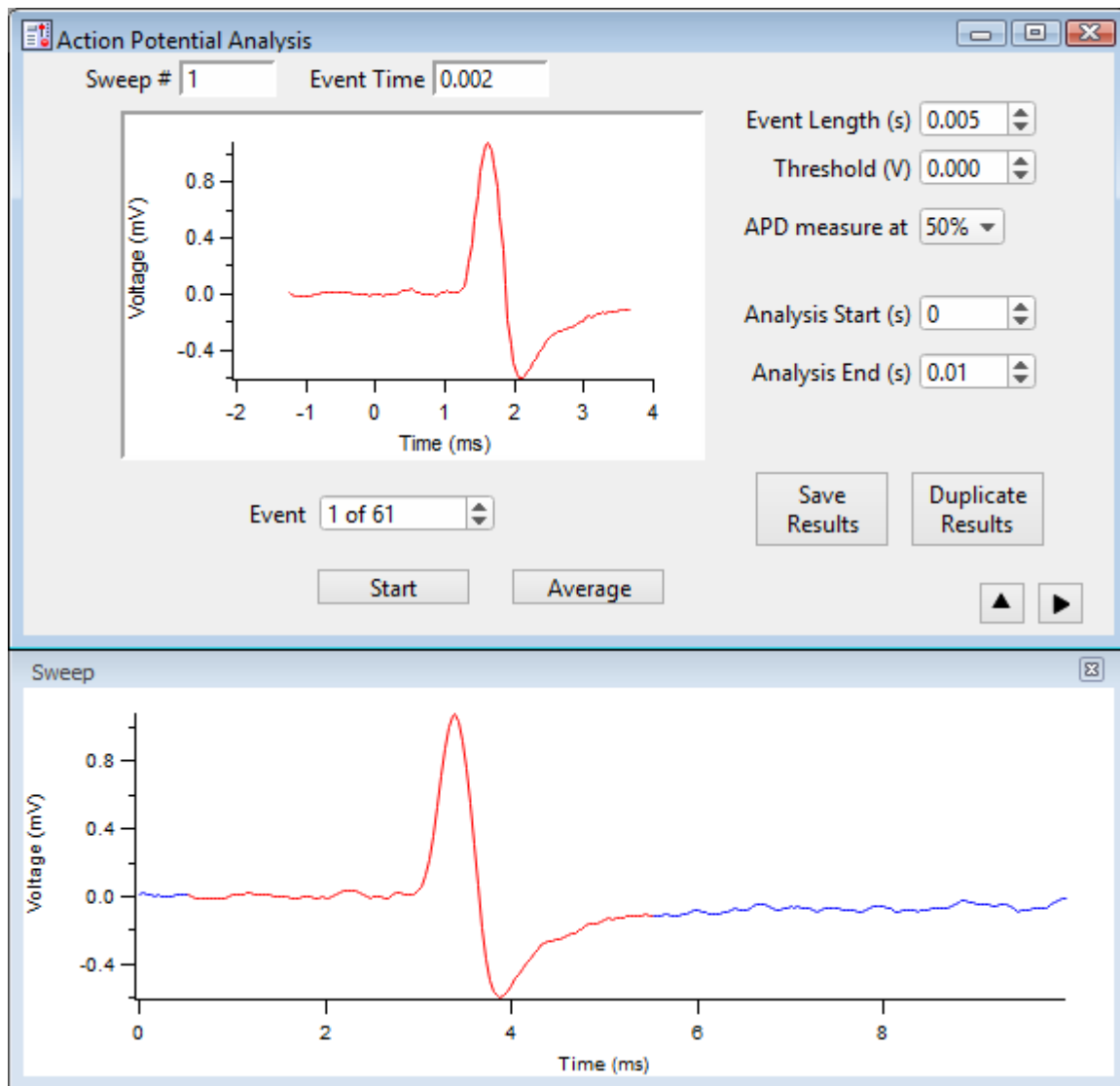
Figure 4-60. Action Potential Analysis

Sweep #   The sweep number of the selected action potential Event.

       When set to '0', this indicates that averaged Results measurements are being displayed.

       Select sweeps for processing by "marking" them in the Data Navigator tree (or during Scope acquisition or reanalysis.)

Event Time   Time point when the potential of the selected Event crosses the threshold.

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.)

Note: Cursors are available for all AP graph panes/windows.

[Event pane]	A graph of the selected Event, with the X-axis zero point reset to the Threshold point.
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]	The graph of a selected sweep, or a sweep containing a selected Event (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	Run the Action Potential Analysis and display the Results pane.
Average	Display the averaged Event in the Event pane, and its measurements in the Results panel. The 'Sweep #' is set to '0'.
Event Length (s)	The Event duration in the Event pane; displays 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 measure at:	Set the Action Potential Duration percentile Measures the duration of an Event at a percentile of the Event's repolarization amplitude. [20 / 30 / 40 / 50 / 60 / 70 / 80 / 90 / 100 %]
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   Results are displayed in a table and a Layout window; prior results are overwritten.

A 'Results' table of all Events automatically opens:

[ ]	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.

An 'Action Potential Analysis Results' report automatically opens in a special 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 =	Includes the Start/ End times for all analyzed sweeps. [s]
Number of events detected =	Total number of Events found.
Event Frequency =	The average frequency of the found Events. [Hz]
All Sweeps analyzed	Every sweep was analyzed.

<div style="margin-left:2em">

or

Sweeps analyzed:	[list of analyzed sweep #s]
[Event graph]	A graph of the averaged Event.
	[V vs. s]
[Phase plot]	A graph of the phase plot for visual inspection of the derivatives.
	[dV/dt (V/s) vs. V]

</div>

Duplicate Results	Results are copied to a new Results table and a new Layout window.
▲	Show / Hide the Sweep pane (below).
	Display a graph of the sweep containing the selected Event.
◄	Show/Hide the Results pane (on the right).
	Display the Action Potential Measurements results.
Results pane	Measurement results are displayed for the Event selected in the main window.
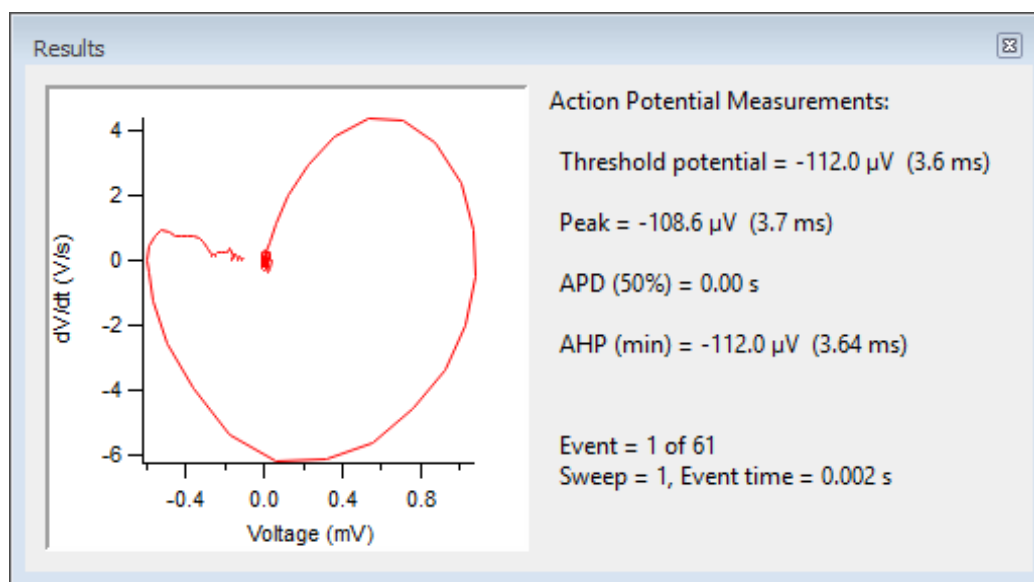
Figure 4-61. Action Potential Measurements

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 biological start of the selected Event - the Event's actual 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.

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.

Events found =   The number of averaged Events.

Event frequency =   The average frequency of the found Events.

4.2.2 Analysis Editor

View and manipulate the data in your Experiment's various analyses and graphs.
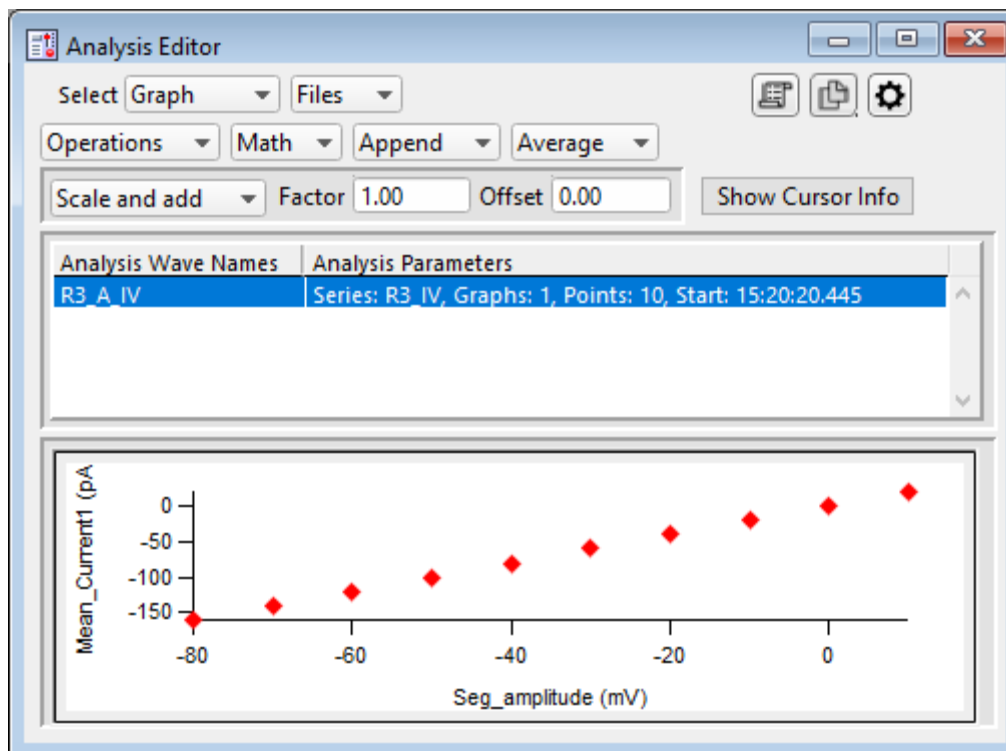
Figure 4-62. Analysis Editor

Select   Choose how to view the data.

Table   View a spreadsheet of the Analysis data.

Column 1:   Row number.

Column 2:   X-data for the first graph.

Column 3:   Y-data for the first graph.

Column m – n:

Pairs of X- and Y-data columns
repeat for each additional graph.

The first graph (X-Y-pair) that uses X-axis time
units populates its X-data column with time
values; subsequent graphs that use X-axis time

units have blank X-data columns, as they use the first time-column created.

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 blank (gray) row is automatically moved to the row beneath it.

Warning! Editing the table will permanently alter its data.

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 Graphs   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 Graphs   Open and display a saved graph.

Note: Import of one-dimensional Igor Binary Wave files (*.ibw) is not supported.

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 Axes Color   Display a background color for the axes.

Show Grid   Display X & Y grid lines in the graph.

Show Error Bars   Display SEM error bars for averaged data.

Show Markers   Display data points with marker symbols.

Show Lines   Display a line between data points.

(Toggle between 'markers' and 'lines', or both).

	Cell Separator: Tab	Use tab separators when exporting a table (e.g. to Excel).
	Cell Separator: Comma	Use comma separators when exporting a table (e.g. to MS-Works).
	Include Column Labels	Column labels appear on the first line of an exported table.
	Digits in table entries:	Digits = (3, 5, 7, 9, 11, 13, 15)

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	Normalize: zero to maximum	
		Rescale the data whereby the largest absolute point is set to 1.0 (or -1.0), while the zero point is maintained in, or relative to, the data range.
	Normalize: minimum to maximum	
		Rescale the data whereby the smallest point is set to zero and the largest point is set to 1.0.
	Invert	Reverse the Y-axis sign of the data points.

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.)

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.

 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#_   Name of the Series.
- Graphs: #   Number of graphs in the analysis wave.
- Points: #   Number of data points in the graph.
- Start: #   Start time of analysis 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 'ToggleCursor 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.
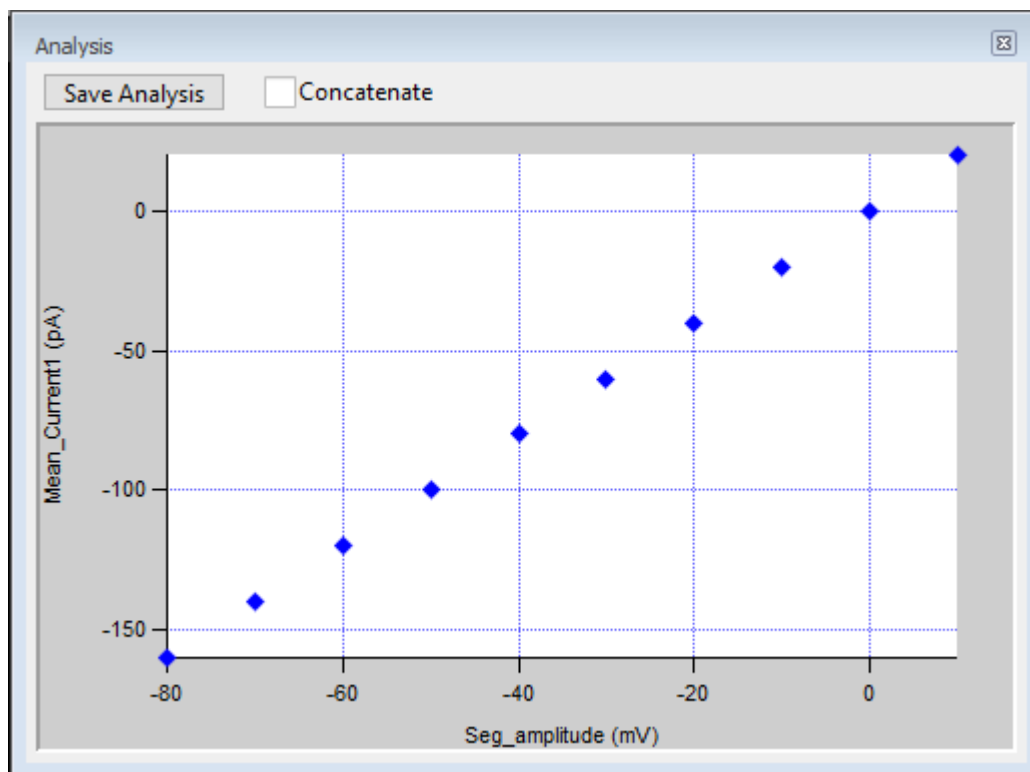
Figure 4-63. Analysis Window

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 selected for offline review or analysis via the Data Navigator (or 'View Last' Dashboard button.) 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.

Concatenate   Display new measurements along with the previous measurements.

       [when docked to the "acquisition" Scope]

Clear   Erase all measurements from the graph display.

[Graph panes]   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.

Tto manually measure X-Y data values, or to set a fitting range, right-click in the graph to display a data modiication menu and select 'Toggle Cursor Info'. The 'Cursor Info' pane displays:

       '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

$\oplus$ 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.

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 windows.

4.2.4 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.
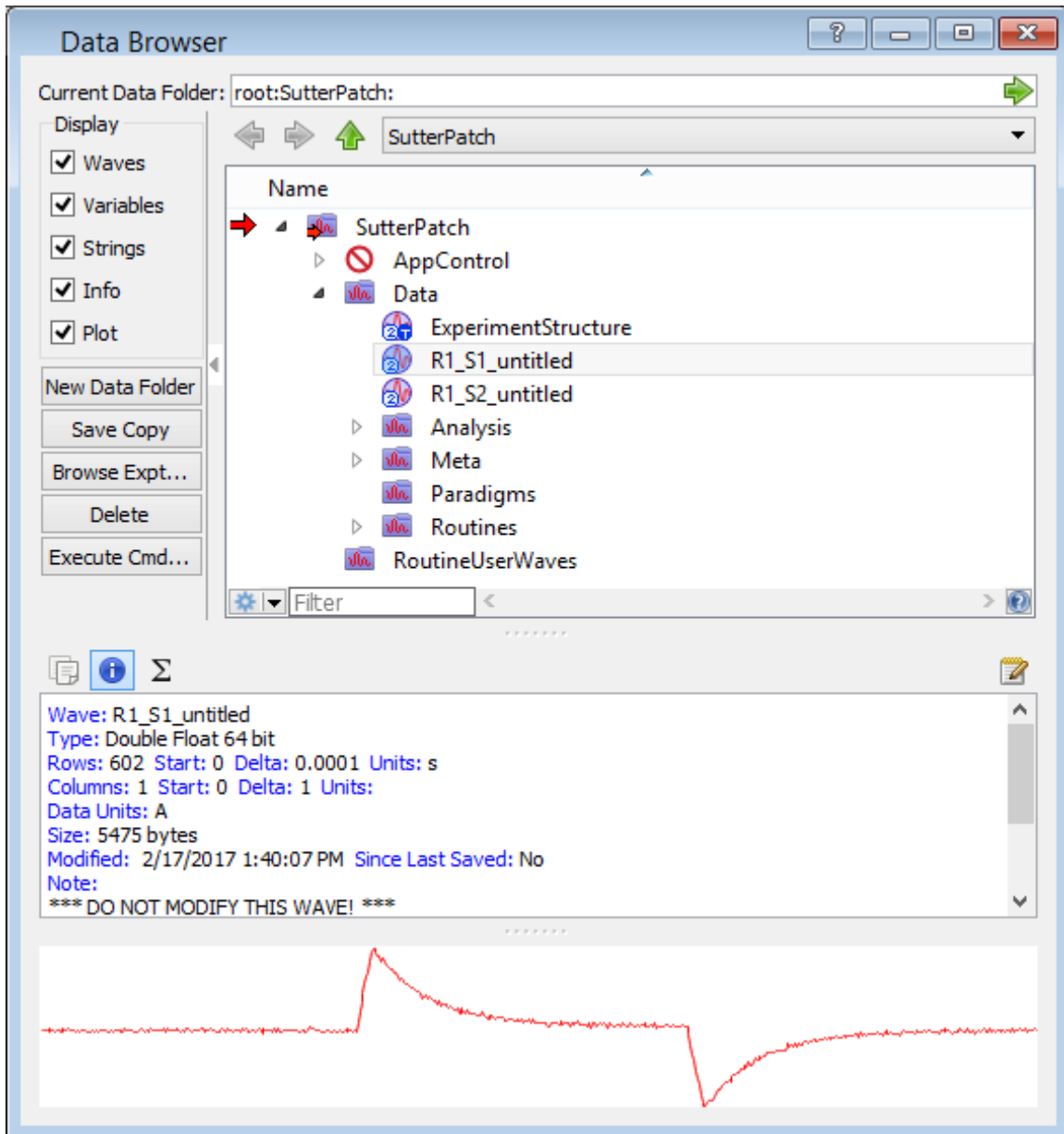
Figure 4-64. Data Browser

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.

Also, 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.

<u>Right-click Menu</u>

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 data folder, not the computer's file system. This path can be used by advanced Igor users in user functions and executable commands.

4.2.5 Data Navigator

The Data Navigator window organizes and displays all levels of data for the current Experiment.
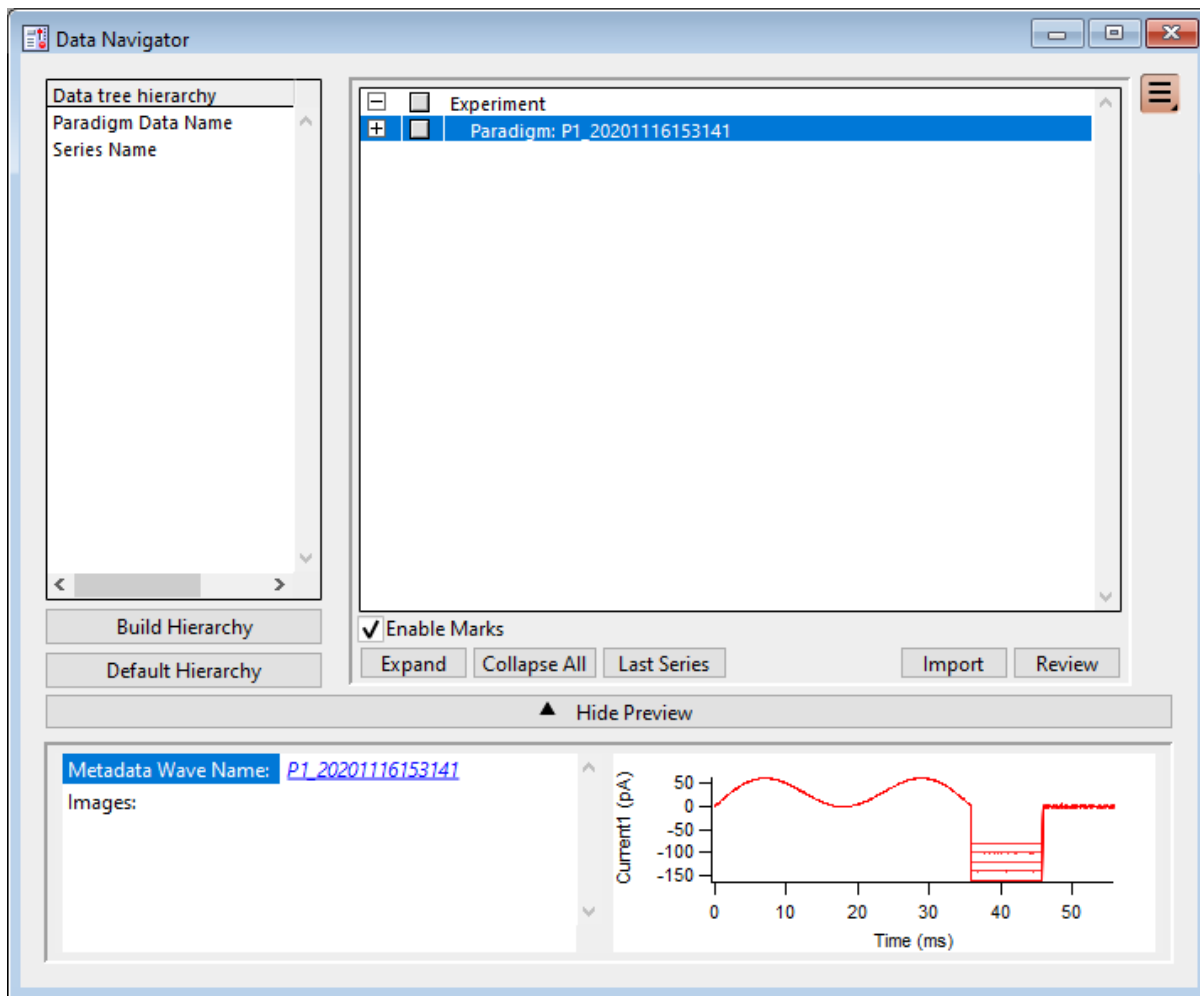
Figure 4-65. Data Navigator

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.
Del ▲ ▼	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)

<u>Data Tree Window</u>

The current Experiment's data are arranged in the data tree (down to the Sweep level.)

Enable Marks	Allow multiple items to be marked for processing by the Available Actions menu:

        Action Potential Analysis (sweeps)

        Synaptic Event Analysis (sweeps)

        Average Selected Sweeps

        Display (signals)

        Export Data (all levels)

        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 SutterPatch experiment to incorporate into the current experiment.

        The same data set cannot be imported twice.

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

Review	Paradigm:	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	Routine, Signal, Sweep:	
		The Routine's signals are displayed in the Scope (analysis) window and Measurements analysis is run.
	Note:	This button changes to the Review button when a Paradigm is selected or marked.

Show Preview / Hide Preview

The displayed Preview pane items are based upon the selected hierarchy level.

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

<u>Experiment</u>

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 data wave bytes:	Combined size of all data waves in the Experiment.

<u>Paradigm</u>

Metadata Wave Name:	Click to display the Paradigm's metadata.
Images:	Open any saved images.

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

Routine

	Metadata Wave Name:	Click to display the Routine metadata.
	Signals:	Number of signals in the Routine.
	Sweeps:	Number of sweeps in the Routine.
	Routine Data Name:	Click to display the Routine parameters.
	Analysis:	Click an analysis name to open it into the Analysis Editor.
	Images:	Open any saved images.
	[Preview sub-pane]	Displays the first signal of the selected Routine.

Signal

	[Preview pane]	Displays the selected Signal.

Sweep

	[Preview pane]	Displays the selected Sweep.

▤ 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.

Experiment

	Copy Signal Data Paths	Copy the Series internal Igor 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.

	Mark All Sweeps	Mark all sweeps in the Experiment.
	Unmark All Sweeps	Unmark all sweeps in the Experiment.

Paradigm

	Review Paradigm Data	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".
	View Metadata	Display the Paradigm metadata in the Metadata Review sub-window, docked to the right of the Data Navigator window.
	Copy Signal Data Paths	Copy the Series internal Igor path to the system clipboard. (root:SutterPatch:Data:Series_na me)

Export Data (See Preferences)

Export the marked Paradigm data to file(s).

Uses the 'Set Preferences / Data Export' options.

Discard Paradigm Data   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.

	Mark All Sweeps	All sweeps in the Paradigm are marked.
	Unmark All Sweeps	Marks are removed from all sweeps in the Paradigm.
<u>Routine</u>		
	Analyze Routine Data	Display the marked sweeps of all signals in the highlighted Series in a Scope (analysis) window.
	Review Routine Data	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.
	Copy Signal Data Paths	Copy the Series internal Igor path to the system clipboard. (root:SutterPatch:Data:Series_na me)
	Show in Data Browser	Open Igor'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.

	Discard Routine Data	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.

Mark All Sweeps	All sweeps in the Series are marked.
Unmark All Sweeps	Marks are removed from all sweeps in the Series.

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 Data	Display all signals in the Series and their marked sweeps in a Scope (analysis) 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_na me)
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.

Mark All Sweeps	All sweeps in the Series are marked.
Unmark All Sweeps	Marks are removed from all sweeps in the Series.

<u>Sweep</u>

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.

Mark All Sweeps	All sweeps in the Series are marked.
Unmark All Sweeps	Marks are removed from all sweeps in the Series.

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 4-66. 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 Scope (Analysis) 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.
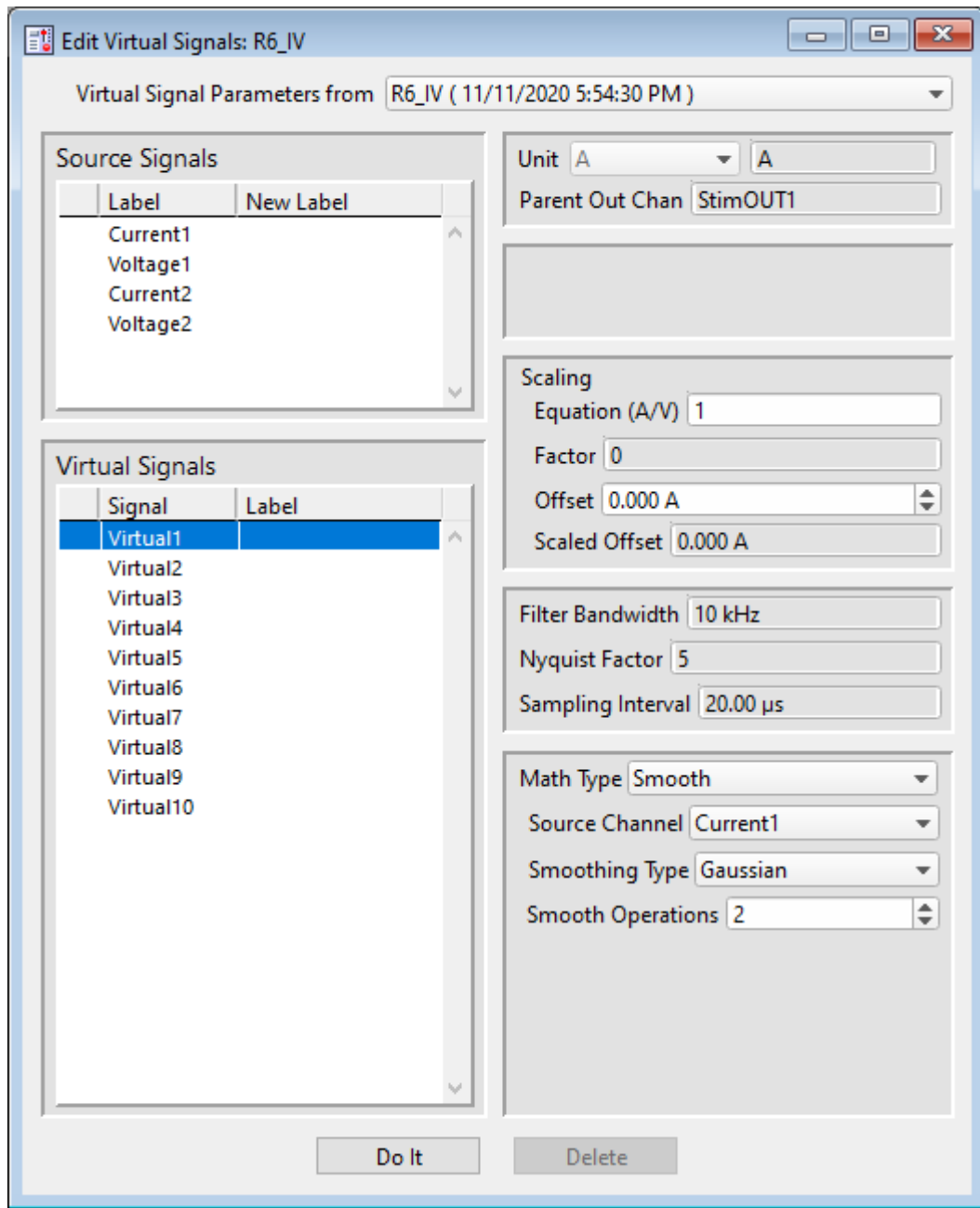
Figure 4-67. Edit Virtual Signals

Virtual Signal Parameters from   [<Series name> (date/time stamp)]

                                          Overwrite with Original Routine

Source Signals

          Label

          New Label

<u>Virtual Signals</u>

Signal

Label

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

Parent Out Chan

<u>Scaling</u>

Equation   Use a value or an equation for the scaling ratio.

Factor   Apply scaling to interpret the input signal data. Specify as a
               numeric value or an equation.

       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

Filter Bandwidth

Nyquist Factor

Sampling Interval

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 for 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]

- 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 us – 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 us – 1 s]

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

- 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.

<u>Specify math equation for virtual signal</u>

[<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[#]   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.)

- 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.
	Note:	The mean of the second half of the specified segment is used to compute an averaged leak current, which is then used to correct the P/N leak average. This option reduces the influence of a constant leak-current, which is otherwise included in the 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	50 Hz	Most of rest of world.
		60 Hz	Canada, (Carribean), Central America, (Japan), Mexico, (South America), South Korea, Taiwan, USA.

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.

Note: See the SutterPatch Algorithms appendix for the math used in the LockIn computation.

- 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 us – 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 us – 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

- 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.

4.2.8 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.
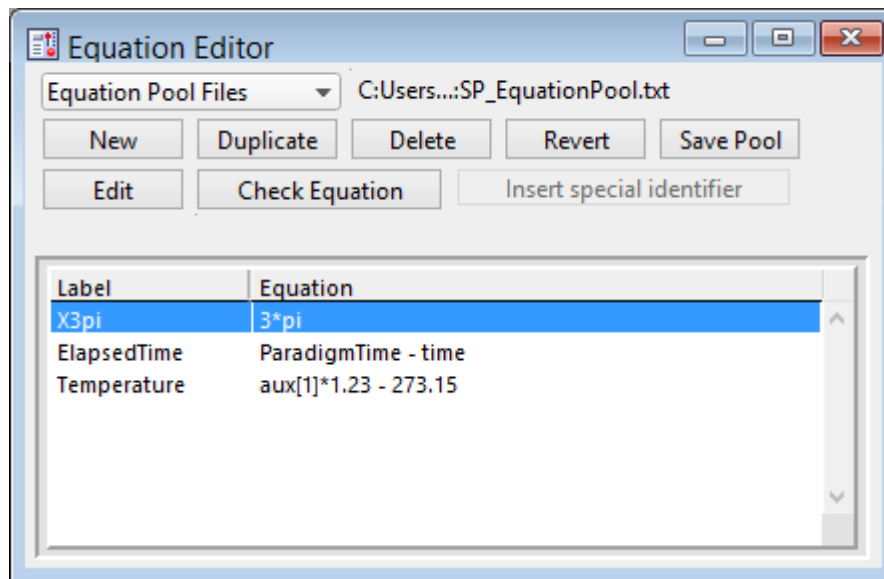
Figure 4-68. Equation Editor

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 re-set 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 that the 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

    Acquisition, amplifier and reference settings are available for use in equations. (See list below.)

Table

 Label   Column of editable equation names, for quick usage in place of the equation.

 Equation   Column of equations in free-form text fields.

Special Identifiers

 Timing

   Tme   (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)

	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)

Analysis Results

m[1..16]		(n'th analysis measurement value)
gx[1..16]		(n'th analysis graph x value)
gy[1..16]		(n'th analysis graph y value)

Signal Readings

AuxIN[1..8]		(reading of auxiliary input, V)

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

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

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

Other identifiers are forwarded to Igor Pro's 'Execute' command.

<u>Equation Extras</u>

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)

Parsing and Operators

Equation parsing is executed from left to right, processing the highest prece-
dence 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	-, !
5	Multiplication, Division, Remainder	*, /, %
4	Addition, Subtraction	+, -
3	Bitwise operations: And, Or, Nor, Xor	&, |, nor, %^
2	Comparison operations: Greater Than, Greater Than or Equal, Less Than, Less Than or Equal, Equal To, Not Equal To	>, >=, <, <=, ==, !=
1	Logical operations: And, Or, Conditional	&&, ||, ? :
0	All other operations	round, trunc, ceil, floor, exp, sqrt, ln, log, sin, cos, tan, asin, acos, atan, abs, rad, deq, noise, random

Table 4-4. Equation Parser

For expressions using Comparison and Logical operators, it is recommended to
use parentheses to explicitly define the order of execution.

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 semi-colon are ignored.
Igor Pro:	A semi-colon separates multiple commands on the same command line. An Igor comment uses a double slash: //

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.

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

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(5)". This 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".

The following areas have a simplified version of the Equation Editor that 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: Computing an equation for a data wave 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 Analyses

Additional mathematical operations are located in the Analysis main menu. These built-in Igor analyses are documented in the Igor Pro Help:

- Curve Fitting   Create your own fitting equation.

- Quick Fit   Use a pre-defined equation:

  line
  poly [3 – 10]
  poly_XOffset [3 – 10]
  gauss
  Ior
  Voight
  exp_XOffset
  dblexp_XOffset
  exp
  dblexp
  dblexp_peak
  sin
  HillEquation
  Sigmoid
  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. In the Data Navigator, select the sweep, and use the 'Extract Sweep' command on it.

2. In the Analysis Editor, click the 'To Layout' button.

3. In the Layout window, right-click for the "Show Window" command.

4. With the Graph window active, select the main menu item Graph > Show Info.

5. In the Graph window cursor pane, drag cursors 'A' and 'B' onto the data.

6. Select main menu Analysis / Quick Fit and the fit of your choice.

Built-in Igor analyses are documented in the Igor Pro Help:

- 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 Layout Window

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 , such as found in Scope windows. The Layout window can also be created by running a Paradigm 'Export' step.

Note: A new Layout window is sometimes created hidden behind other windows. Clicking a Layout button appends its associated items into an existing Layout page (or a new Layout window.) When a Scope window is exported to the 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.

When a Layout window is the active window, the main menu "Layout" command also displays to customize the layout. The 'Append to Layout' command allows you to append additional objects into the Layout window.

4.2.11 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

- Select a Paradigm or Routine, and click its 'Metadata Wave Name' in the Preview pane.

- Select a Paradigm or Routine, then click the 'Available actions' button and select 'View Metadata'.

- Right-click a Paradigm or Routine and select 'View Metadata'.

    Once the Metadata Review sub-window is open, new Paradigm or Routine selections also update the Metadata Review.

Scope (analysis)

    For Routines from the Dashboard 'View Last' button or the Data Navigator 'Analyze' button, use the 'View Metadata' button in their Scope windows to open a Metadata Review floating window.

To display metadata from two different Paradigms, display the first Paradigm's metadata as described above. Then from the Data Navigator, select the second Paradigm and the Action 'Review Paradigm Data', and in the Paradigm Review window click the 'View Metadata' button to open its docked Metadata Review sub-window.

To display metadata from two different Routines, display the first Routine's

metadata as listed above. Then from the Data Navigator, select the second Routine and the Action 'Review Routine Data', and in the Routine Review window or Scope (analysis) window click the 'View Metadata' button to open its Metadata Review window.

Paradigm Data   [   ]   Displays the name of the Paradigm.

Routine Data   [   ]   Displays the name of the Routine.

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

- By Event   Events are grouped by [time-stamp] [Event #] [Event type]. Highlighted fields are editable.

- By Parameter   Parameters are grouped into major categories. (see below)

                     Routine parameters that are set by their higher-level Paradigm are labeled as 'Prior value', as those time stamps are set at the time of the Paradigm, not the Routine; prior non-Routine tags are also labeled as 'Prior value'.

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, collapsed up to the Event or Parameter level.

'By Parameter' Metadata Categories / Parameters

          Tag
          Tag Number
          Tag Creation Timestamp
          Timer Time at Tag Creation
          Tag Signals
          Tag Source Event

          Operator
          Login Name

          Experiment
          Experiment Timestamp

          Amplifier
          Amplifier Sequence Number   [for Sutter amplifiers only]

Amplifier Manufacturer [for Sutter amplifiers only]
Amplifier Model [for Sutter amplifiers only]
Amplifier Serial Number [for Sutter amplifiers only]
Amplifier Channel [for Sutter amplifiers only]
 Number of Available Headstages
Headstage Sequence Number [for Sutter amplifiers only]
Headstage Model

Instrumentation and Software
Interface Sequence Number
Interface Manufacturer
Interface Model
Interface Firmware Version
Interface Serial Number
Interface Input Channel (physical)
Interface Out. Ch. (physical or logical)
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

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

<u>Data Acquisition Settings</u>
Active Headstage
Recording Mode   [VC or CC mode]
Current Gain   [for Sutter amplifiers only]
Voltage Gain   [for Sutter amplifiers only]
Headstage Gain   [for Sutter amplifiers only]
Headstage Feedback Mode   [for Sutter amplifiers only]
Filter Cutoff Frequency   [for Sutter amplifiers only]
Filter Type   [for Sutter amplifiers only]
Input Offset Voltage   [for configured headstages]
Input Offset Lock On/Off   [for Sutter amplifiers only]
Input Liquid Junction Potential
Input Signal Name
Input Signal Units
Input Scaling Factor
Input Full-scale Minimum
Input Full-scale Maximum
Input Sampling Rate
Auxiliary Input Signal Offset
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
Command Signal Units 1
Command Full-scale Minimum 1
Command Full-scale Maximum 1
Command Sampling Rate 1
Command Holding Enabled 1   [for Sutter amplifiers only]
Command Holding Value 1   [for Sutter amplifiers only]

Auxiliary Output Signal Name [1 – 4]
Auxiliary Output Scaling Factor [1 – 4]
Auxiliary Output Offset [1 – 4]
Auxiliary Output Holding Value [1 – 4]
Command Signal Name 2
Command Signal Units 2
Command Full-scale Minimum 2   [for Sutter amplifiers only]
Command Full-scale Maximum 2   [for Sutter amplifiers only]
Command Sampling Rate 2   [for Sutter amplifiers only]
Command Holding Enabled 2   [for Sutter amplifiers only]
Command Holding Value 2   [for Sutter amplifiers only]
Digital Holding Pattern (1 → N)   [1 – 8]

4.2.12 Paradigm Review

'Paradigm Review' displays data from all Series within the Paradigm, in a Time Course or Concatenated view in a modified Scope window. (For more information on the window controls, see the Scope (Analysis) section below.)

This view also displays the tags that occur between Series.

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

To open a Series into a Scope (Analysis window), right-click on the Series data and select Analyze <Series Name> from the menu list.

4.2.13 Reanalysis Measurements & Graphs

The Scope (Analysis) window Measurements button provides access to the 'Reanalysis Measurements & Graphs' dialog. Use it to apply different analysis scenarios to recorded data, by configuring measurements on input channels and analysis graphs.
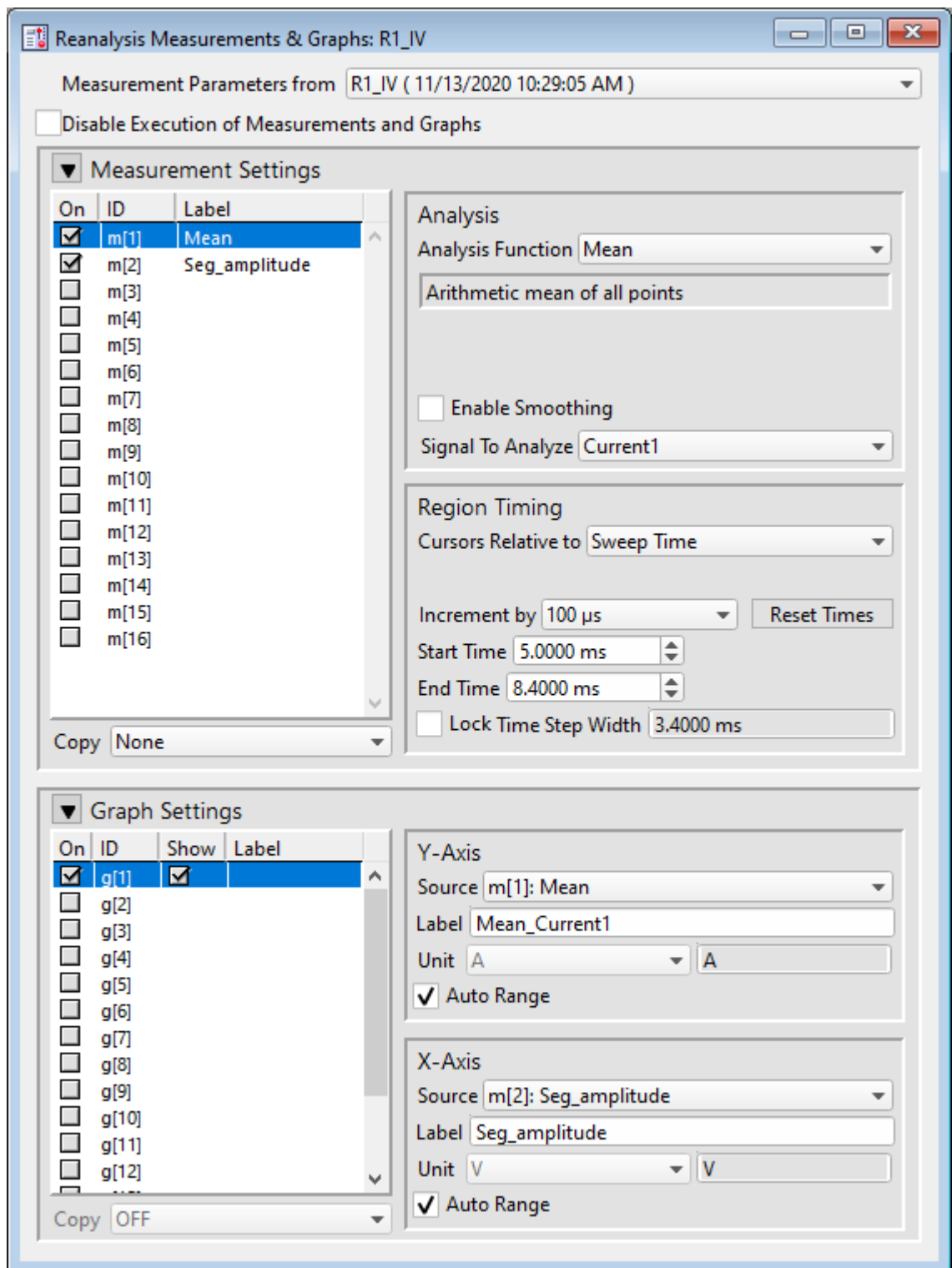
Figure 4-69. Reanalysis Measurements & Graphs

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

Measurement parameters from	Select which Routine settings to record with:

- Current Settings   (newly modified settings)
- Last Executed   (last used version)
- Original Routine   (original loaded version)

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.

4.2.14 Routine Data Review

'Routine Data Review' displays the selected Series data in a Time Course or Concatenated view in a modified Scope window.
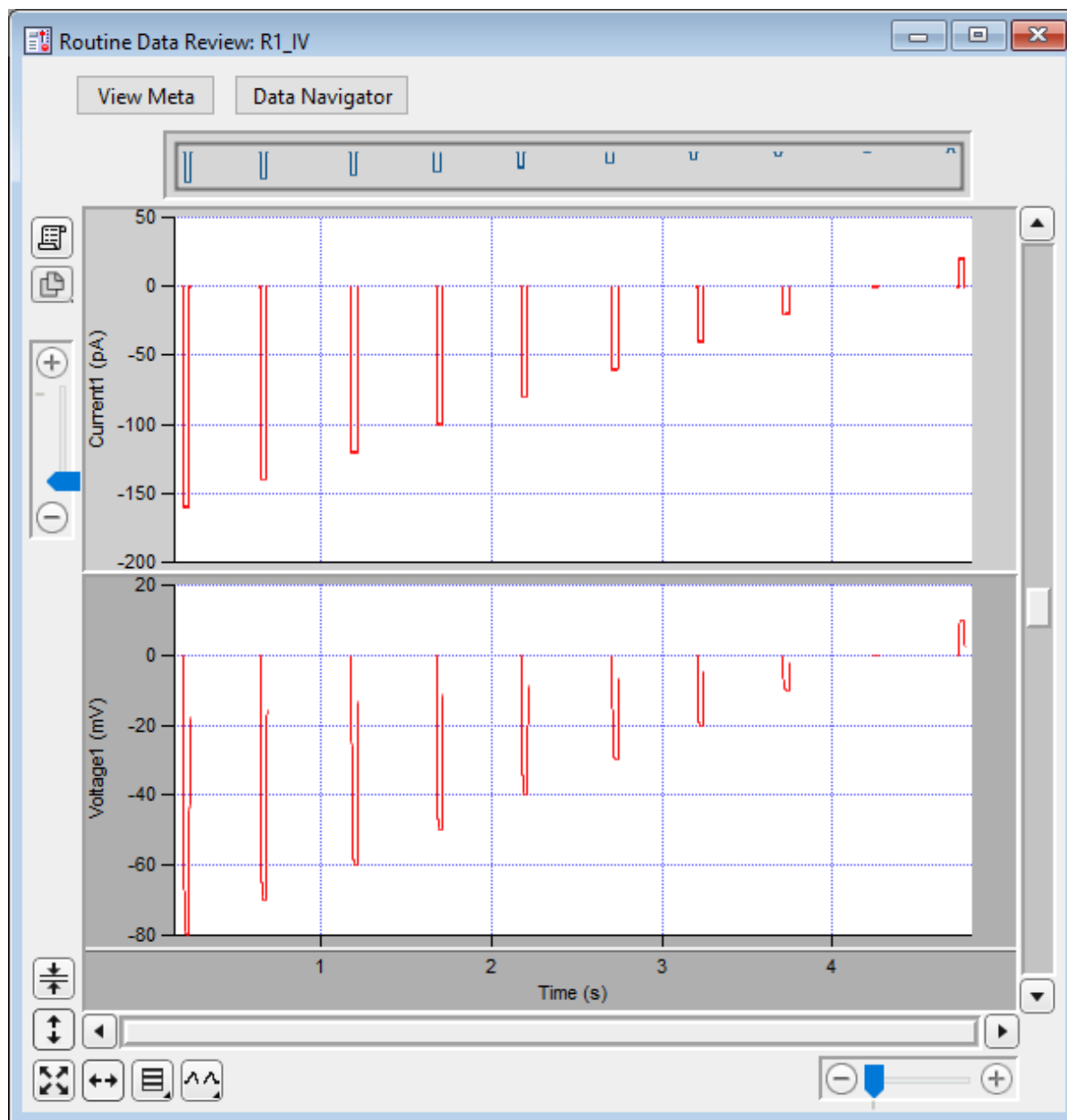
Figure 4-70. Routine Data Review

For more information on the window controls, see the Scope (Analysis) section below.

Open this window from the Data Navigator by highlighting a Series, and selecting the 'Review Routine Data' command from a right-click menu or the 'Available actions' button.

To display a signal name at the bottom of the window, click on the signal.

To open the Series into a Scope (Analysis) window, right-click in a signal, and select 'Analyze <Series Name>' from the menu list.

4.2.15 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 'Routine Data Name' in the Data Navigator preview pane.
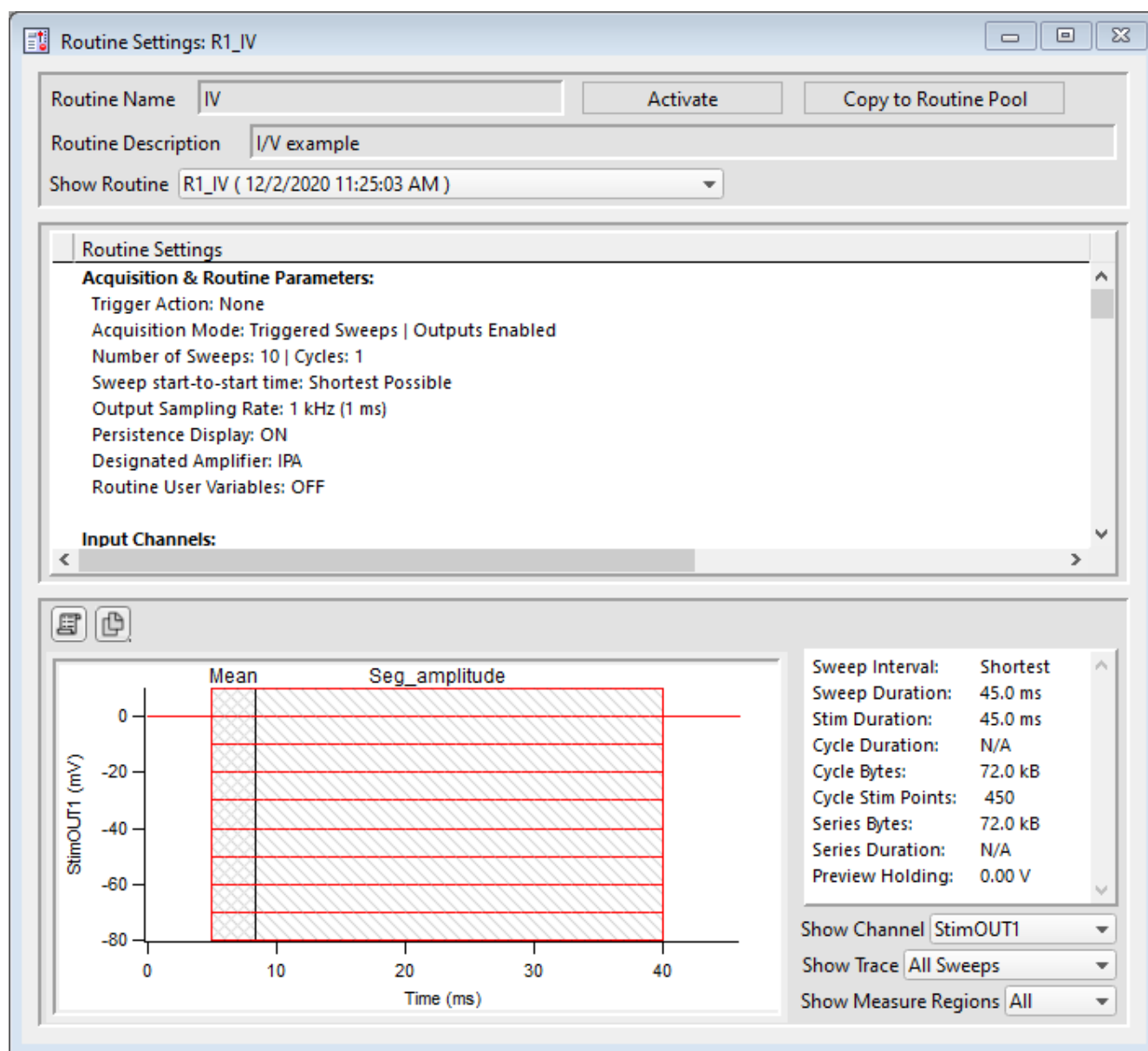
Figure 4-71. Routine Settings

Routine Name   Displays the Routine name.

Activate   Opens the 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 waveform.

  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 signal to display.

  Show Trace   Select the output trace to display

  Show Measure Regions   Select the measurement region to display.

4.2.16 Scope (Analysis)

This analysis version of the Scope window is used to display and reanalyze stored data.
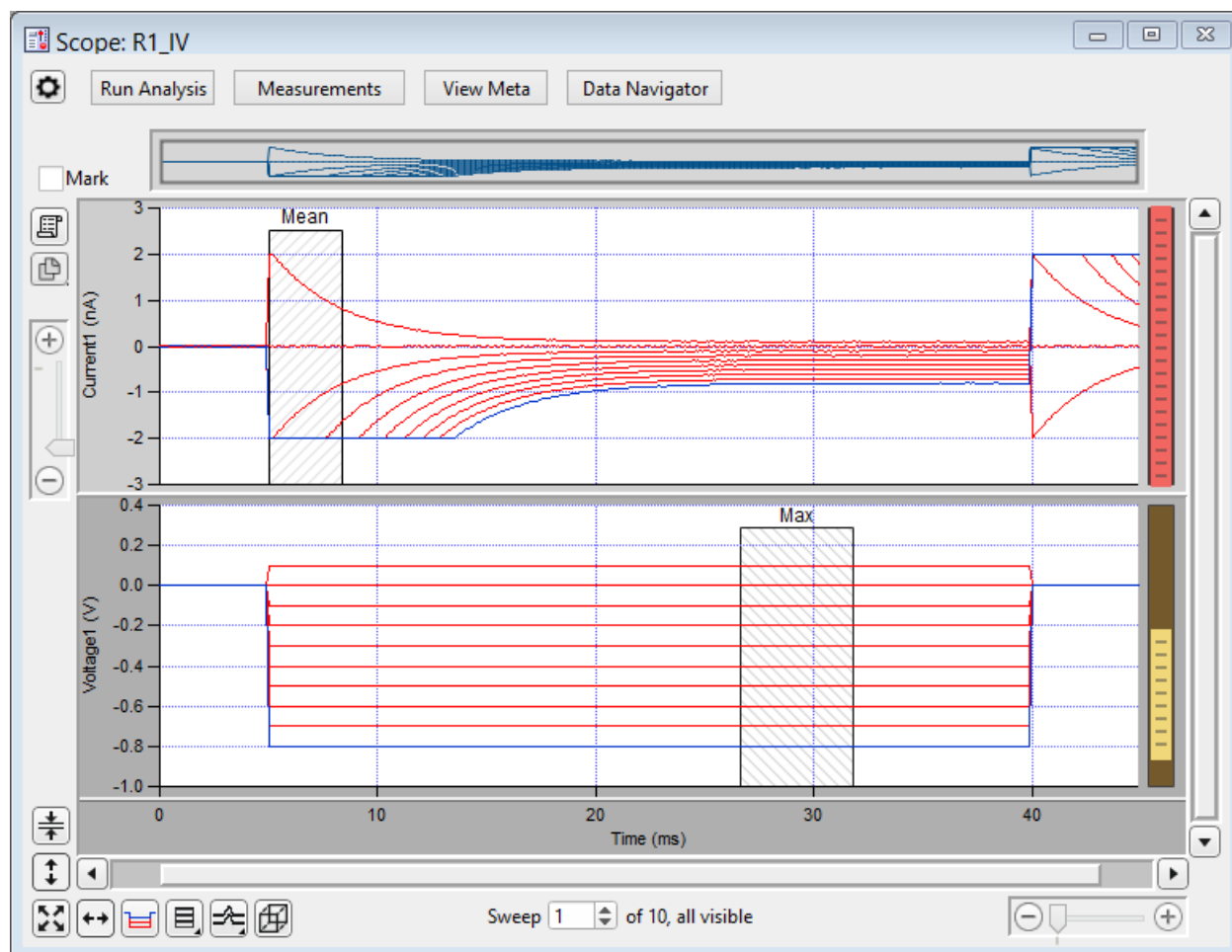
Figure 4-72. Scope (Analysis) Window

Both physical and virtual channels can be displayed here. Many of the controls are the same as in the Scope (acquisition) window, however additional window controls are also included.

Navigation pane
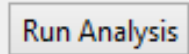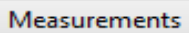
The Navigator pane appears at the top of the Scope window. It displays an overview of the active signal's full-scale data, with a gray box surrounding the magnification area.
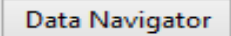
Figure 4-73. Navigator Pane

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:
	Set all marks in sweep of active series
	Clear all marks in sweep of active series

	Begin with all marks set (in sweeps of active series)
	Begin with all marks cleared (in sweeps of active series)
Run Analysis	Run the defined analysis for the 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 state displays as "Measurements(H)".
	Lock Cursors Prevent cursors from being moved or altered.
	Button state displays as "Measurements(L)".
	No Measurements or Graphs
	Analyze with Current Measurements
	Analyze with Original Routine Measurements
	Analyze with Routine Last Executed Measurements
	Load Default Measurements
	Save as Default Measurements
	These edits (temporarily) override the loaded routine for fast response.
	Edit Measurements:
	Open a special Reanalysis Measurements & Graphs dialog, where all edits apply instantly to the measurements and graphs, even during acquisition. These changes override the loaded routine for quick

	interactive control.
	Edit Virtual Signals Open the virtual input signals dialog 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.
View Meta	Display any extra information (metadata) associated with the displayed data Series, such as the operator, preparation details, solution information, etc.
Data Navigator	Open a Data Navigator window with all of your Experiment data and metadata available for analysis in a tree structure.
Mark	Enable to highlight the active sweep. The Data Navigator can process marked sweeps as a group.
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 graph to the system clipboard or, if the 'Shift' key is pressed, the complete Scope window.
Center	Center the mean of the data in the selected signal pane. The Y-axis offset is automatically adjusted, while the Y-axis scaling is unchanged.
Autoscale	Click to autoscale the Y-axes of all visible signals to their visible sweeps data limits, and to reset all X-axes to their full sweep duration. To include the zero amplitude in the Y-ranges, configure "Autoscale from zero" in the Set Preferences / Scope Window / Reanalysis / Y axis initial settings To autoscale the Y-axes of all (including hidden) signals, in Windows right-click / Shift-click / Ctrl-click the button, or in macOS, ctrl-click

	the button; also all X-axes are reset to their full sweep duration.
Y-Autoscale $\updownarrow$	Click to autoscale the Y-axis of the selected signal. To include the zero amplitude in the Y-range, configure "Autoscale from zero" in the Set Preferences / Scope Window / Reanalysis / Y axis initial settings To autoscale the Y-axes of all visible signals, in Windows right-click (or Shift-click or Ctrl-click) the button, or in macOS Control-click the button.. 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.
X-Scale $\leftrightarrow$	Full-scale all X-axes. All signals X-axes are reset to their full-scale setting
Persistence Display	Display all sweeps (per Preferences settings). Otherwise, when disabled, only one sweep is displayed at a time.
Signal Display	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 trace starts from time zero to the duration of the waveform.
	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: 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 similarly to the Time Course mode, but any blank portions are replaced by a vertical line.
		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.
Sweep #:	The 'Sweep #' display at the bottom of the Scope window indicates the 'active sweep' number, the total number of sweeps in the Series, and either "all" or the total number of visible sweeps (per Preferences).	

Table 4-6. Scope Window Buttons

<u>Right-click Menus</u>

Right-click on the indicated regions to display a context-sensitive menu.

X- and Y-Axes   Same as the acquisition Scope.

Main window area   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.

Same as the acquisition Scope, plus these additional items:

·   3D View

·   Zero Baselines

·   Show All Sweeps   (with triggered sweeps)

·   Select Sweeps   (with triggered sweeps)

Signal data   To display the full data modification menu, right-click on or near the data,

Same as the acquisition Scope, plus these additional items:

·   Hide Sweep_#   (with triggered sweeps)

·   Show Sweep_# Only   (with triggered sweeps)

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

- Toggle Cursor Info   Show/Hide the 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.

<u>Cursor A</u>

⊕   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.

<u>Cursor B</u>

⊠   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.

<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 fitting functions.

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

<u>Channel Timing Delays</u>

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.

4.2.17 3D View Window

The Scope (Analysis) 3D View window creates a 3D representation of your data, color-coded to show amplitude variations.

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.
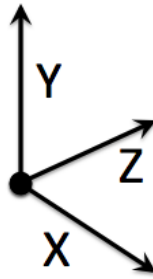
Figure 4-74. 3D Axes Definition
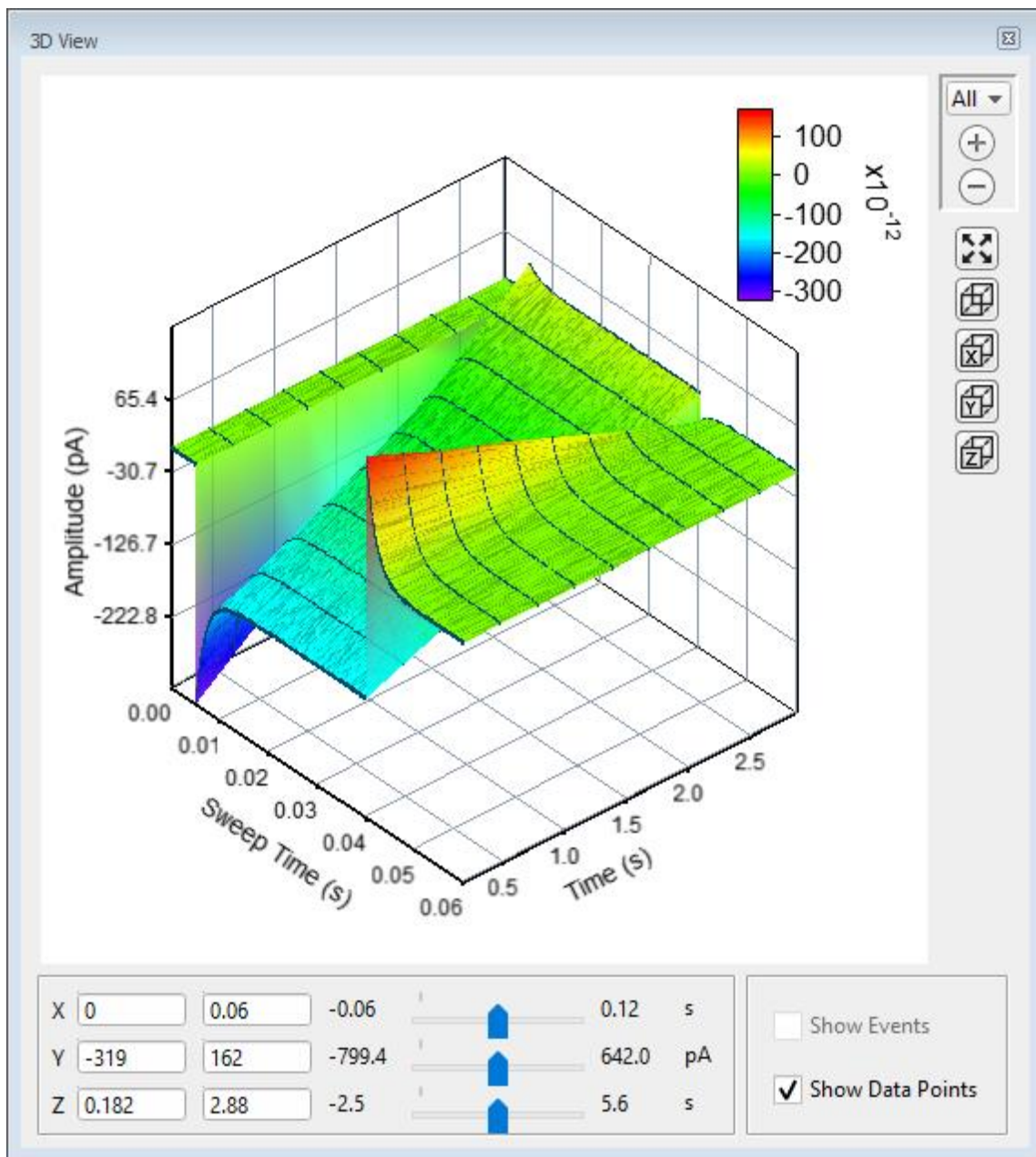
Figure 4-75. 3D View

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.

4.2.18 Set Metadata

A variety of optional experimental parameters (preparation, electrode, etc.) can be associated with an Experiment, Paradigm, or Routine as user-configurable "metadata".

Predefine the Metadata parameter values here.

Show Summary   An overview of the user-defined metadata parameters.

     <u>Metadata Summary dialog</u>

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   Listed per the SutterPatch > Set Preferences > 'Metadata detail level'.

Basic Level 1   (The default metadata groups.)

Preparation – Animal
Preparation – Tissue
Preparation – Cell
Experiment
Stimulus

Extended Level 2   (Includes two more metadata groups.)

Electrode
Recording Solution

Full Level 3   (Includes all 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

- 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.

<u>Confirm Metadata Settings for</u>   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 Units	Ex.: h, d, m
B	E	F	Animal Sex / Gender	Ex.: 1: F, 2: M, 3: Unde-termined
B	E	F	Animal Weight	
B	E	F	Animal Weight Units	
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 Units	
	E	F	Tissue Incubation Temperature	
	E	F	Tissue Incubation Temperature Units	
	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 Units	
B	E	F	Cell Preparation Incubation Duration	
B	E	F	Cell Prep. Incubation Duration Units	
B	E	F	Cell Preparation Incubation Temperature	
B	E	F	Cell Prep. Incubation Temperature Units	
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	
		F	Experiment Category Parameter 1 Name	
		F	Experiment Category Parameter 1	
		F	Experiment Category Parameter 2 Name	
		F	Experiment Category Parameter 2	
		F	Experiment Category Parameter 3 Name	
		F	Experiment Category Parameter 3	
		F	Experiment Category Parameter 4 Name	
		F	Experiment Category Parameter 4	
		F	Experiment Category Parameter 5 Name	
		F	Experiment Category 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 Heat-on Enabled	
		F	Puller Heat-on Time	
		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	
	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	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 Units	
		F	Ambient Temperature	
		F	Ambient Temperature Units	
		F	Atmospheric Composition	
		F	Atmospheric Pressure	
		F	Atmospheric Pressure Units	
		F	Atmospheric Humidity	
		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	
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 Units	
	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 Units	
	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 Units	
	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 Units	
	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 Units	
	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 Units	°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 Units	The intensity units 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	
		F	**SERIES (= ROUTINE DATA) /**	
		F	Routine User Comment	

Table 4-7. Metadata Parameters

4.2.19 Single Channel Analysis

Perform analysis of low-noise currents from single ion channels.   When single channel analysis is activated, a Single Channel Analysis control panel is opened, and the Scope window active signal is overlaid with the transition levels of a single-channel opening or closing event.
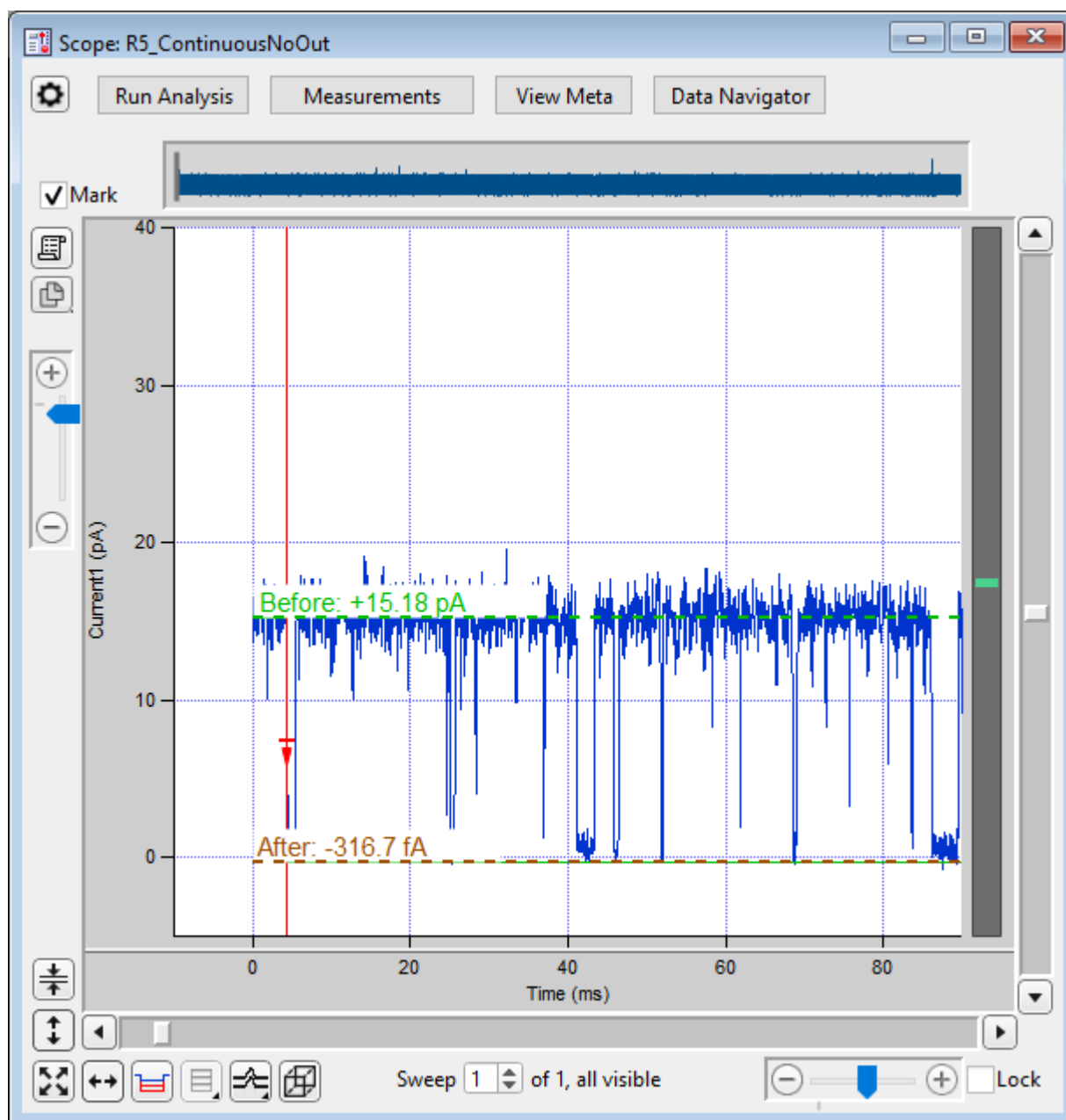
Figure 4-76. Single-Channel Scope

The Scope window active signal data is overlaid with single-channel event transition levels, and a Single Channel Analysis control panel is opened.

Zoom in on the data so that the single-channel activity can be well visualized. "Before" and "After" transition levels for open and closed channel events are displayed in the Scope window, overlaid on the raw data. However, the transition levels might not be appropriate until proper settings are entered in the Current Transition Controls section. Start with setting the estimated Amplitude and Start Level values. Then click the 'Clear All' button in the 'Find target transition' section.

Single-channel analysis is only available in the Sweeps display mode; Concatenated and Continuous display modes are not supported.
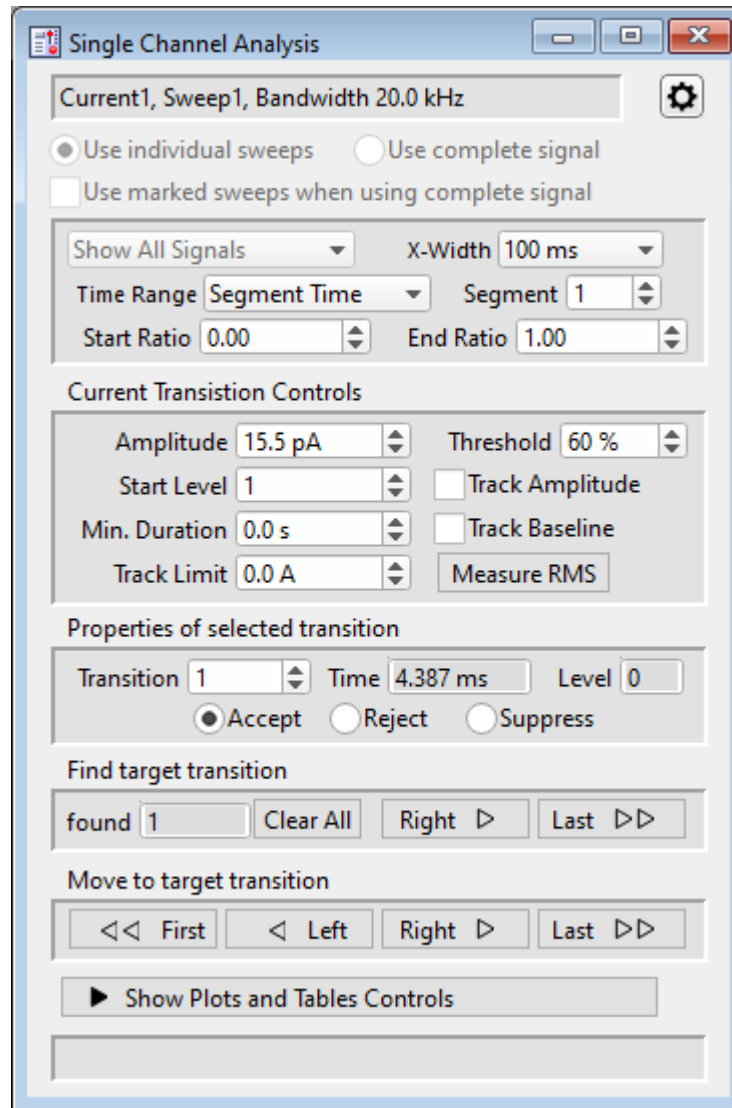
Figure 4-77. Single Channel Analysis

Access single-channel analysis via the Scope (analysis) window 'Measurements' button, or the Data Navigator (signal) 'Available actions' menu, or the main menu SutterPatch > Available Analysis Modules > Single Channel Analysis.

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 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 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 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.

When the analysis is first started, amplitude levels for the first found (open or closed) channel are displayed. Event levels are automatically overlaid onto the raw data in the Scope window, based upon the settings in the Single Channel Analysis control panel / Current Transition Controls section. If the initial levels are incorrect, a couple 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' value for the first Event transition in the data. (Use negative numbers for negative-going transitions.)

3. Set the Start Level number for the first transition (0 = baseline, 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.
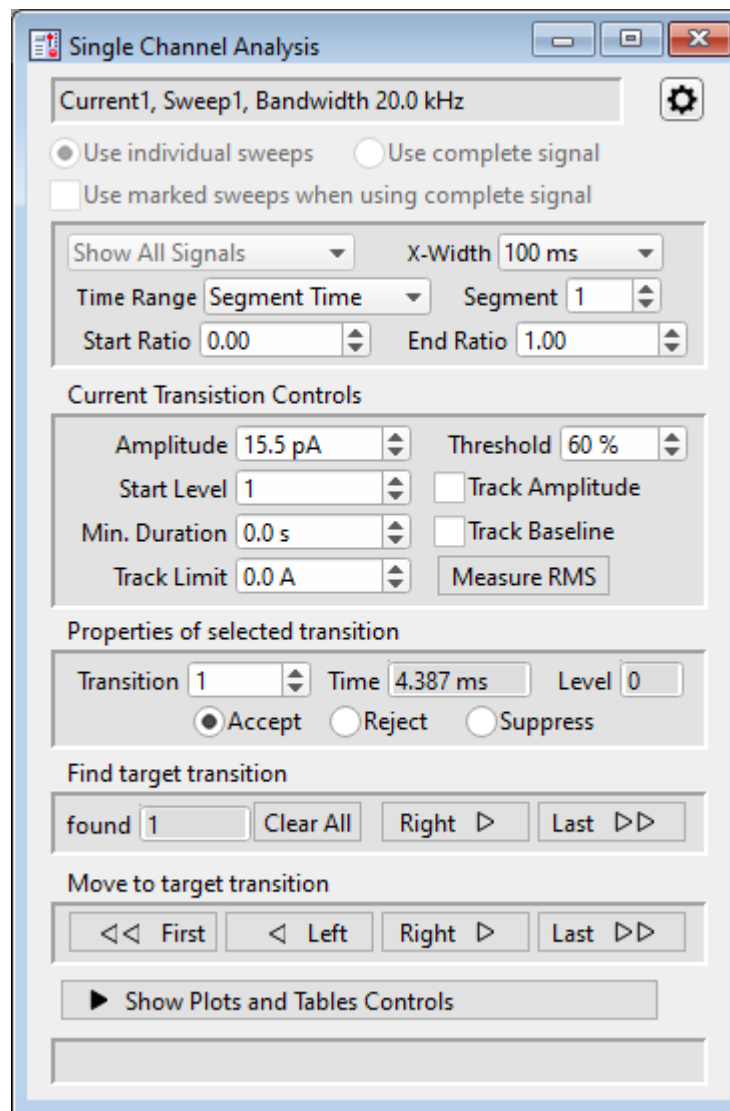
Figure 4-78. Single Channel Analysis

[Descriptive information]

- Use individual sweeps   Perform analysis on a single sweep at a time.

- Use complete signal   Perform analysis on all sweeps in the active signal.

[ ] Use marked sweeps when using complete signal

Perform analysis on a group of marked sweeps.

⚙ 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.

Cell Separator: Tab

Cell Separator: Comma

Invalid values: Use NaN

Invalid values: Use empty string

Digits in table entries:

Digits = 3, 4, 5, 7, 9, 11, 13, 15

Signal Controls
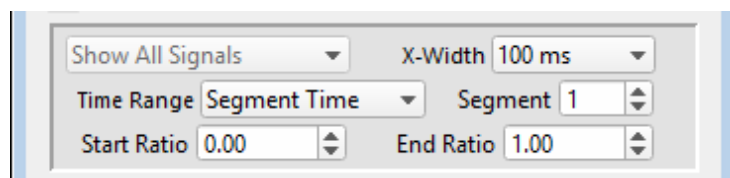
Figure 4-79. Signal Controls

Control the display of single channel data in the Scope window:

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

Setup the basic event level parameters.
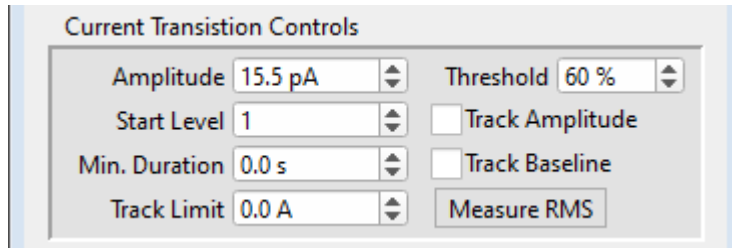
Figure 4-80. Current Transition Controls

Amplitude
Set to the expected transition size of the initial ion-channel level in the data.

For downwards-opening (negative) 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 Events are treated as a single Event of the highest level.

Min. Duration
The minimum duration for a "found" event.

Track Limit
The maximum amount that the Amplitude or Baseline measurements can change while being automatically tracked.

For baseline tracking, the absolute 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	Automatically adjust the predicted transition Amplitude of the next found transition, based on the prior data.
Track Baseline	Automatically adjust the baseline amplitude (Level 0) based on the prior data.
	To use, the 'Track Limit' absolute 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 event 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.

Properties of selected transition

View or alter how a transition is processed by the analysis.
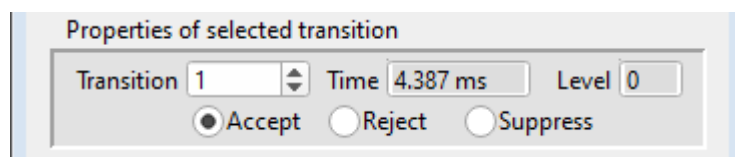
Figure 4-81. Properties of Selected Transition

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 a mischaracterized initial level that should be reset.
Status	The operational status of the selected transition.
• Accept	The selected transition is included in the idealized trace and all Plots. This is the default status.
• Reject	The selected transition is not included in Plots or the idealized trace.
• Suppress	The selected transition is not included in Plots or the idealized trace.

Any events contiguous to a suppressed transition will not be included in Plots.

Find target transition

Find an event transition based on the 'Current Transition Controls', and process the transition based on the 'Properties of selected transition'. An event is defined by a sharp transition at the start of the event, for the duration of the transition level.
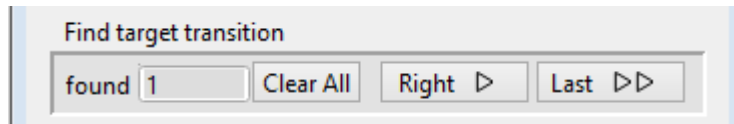
Figure 4-82. Find Target Transition

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 a "neighbor" transition, or jump to the beginning or ending transition.
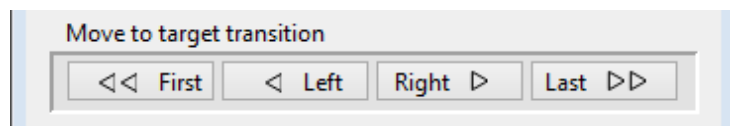
Figure 4-83. Move to Target Transition

<< 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.

[   ]   <u>Status bar for the total number of events in a particular Plot.</u>

<u>Single Channels: Plots and Tables</u>

Note: All plots and histograms support measuring X-Y data points or setting a fitting range via the 'Toggle Cursor Info' entry on their right-click menus. (See 'Right-Click Menus' for Scope windows.)
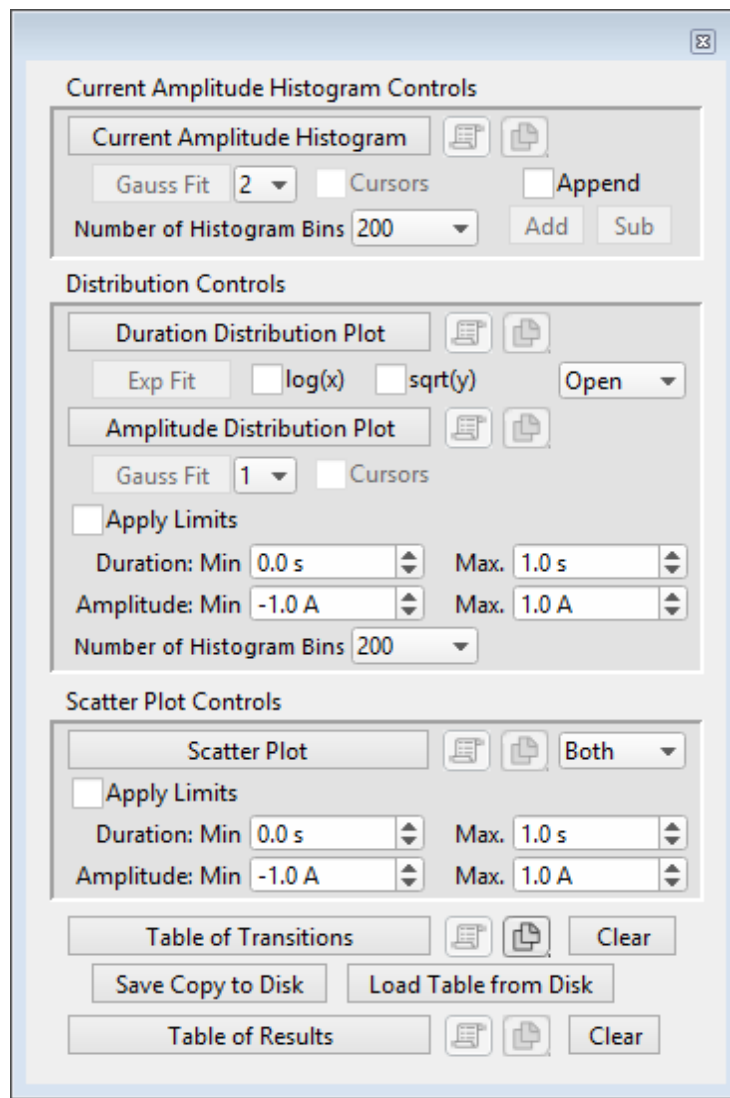
Figure 4-84. Plots and Tables Controls

Current Amplitude Histogram Controls
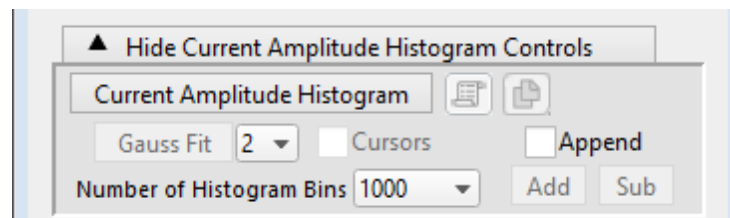
Figure 4-85. Current Amplitude Histogram Controls

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]

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Distribution Controls

Create histogram plots of the found Events.
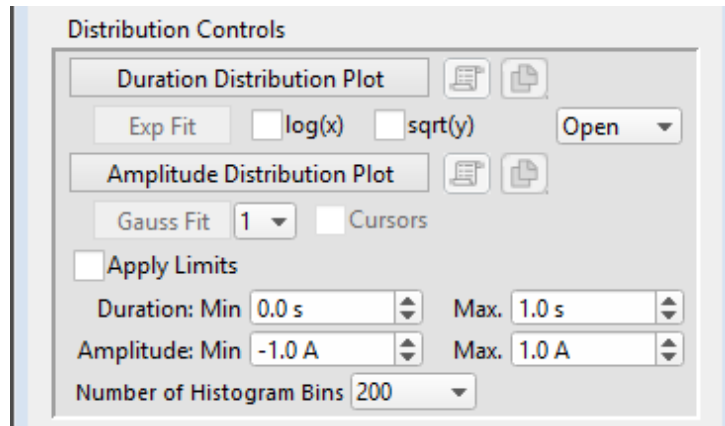
Figure 4-86. Distribution Controls

Duration Distribution Plot   Click to create a duration (dwell-time) histogram plot of
                                          the found Events.

 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 clip-
                                          board.

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 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

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📄 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

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]

Scatter Plot Controls
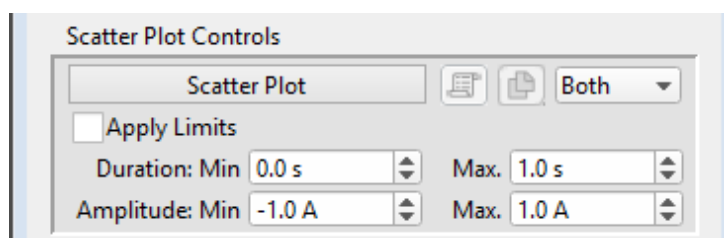
Figure 4-87. Scatter Plot Controls

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) = <mark>green</mark>

	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]
E Max.	[0.0 – 1.0 s]
Amplitude: Min	[-1.0 – 1.0 A]
Max.	[-1.0 – 1.0 A]

Table Controls
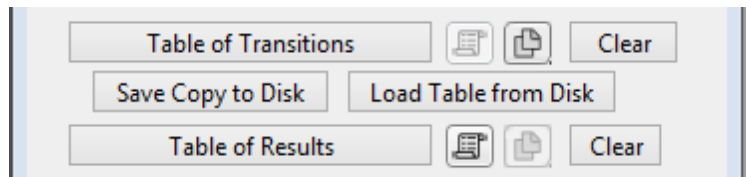
Figure 4-88. Table Controls

Table of Transitions   Click to view a listing of all Event transitions.

Header Row:	Column names.
Column Header row:	Event numbers.
Row 0: Status	The operational status of the selected transition.

1	=	Accepted	Include the selected transition in the idealized trace and all Plots. This is the default status
2	=	Rejected	Do not include the selected transition in the idealized trace or Plots.
3	=	Suppressed	Do not include the selected transitions in the idealized trace or Plots.

Any Events contiguous to a suppressed transition will not be included in Plots.

Row 1:	Time	Time of the start of the Event, 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 Event, i.e., the level before the transition point.
Row 4:	Amplitude_After	Amplitude of the Event, i.e., the level after the transition point.
Row 5:	Duration	Duration of the Event.
		The last column of data contains a zero duration
		The column after the last column of data contains the total duration for all transitions, i.e., the total analyzed time.
Row 6:	Amplitude	Amplitude of the Event.

Row 7:	Amplitude_Valid	0	=	Invalid	Not a transition Event
		1	=	Valid	A transition Event.

 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 wave (*.ibw) file.

Load Table from Disk — Load the 'Table of Transitions' from an Igor wave (*.ibw) file.

Table of Results

 Copy to Layout — Copy the 'Table of Results' into a new Layout window, or append to an existing Layout page.

[icon] 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.

<u>Table Column Labels</u>

    Gaussian Fit

<u>Header Row</u>	<u>Entry</u>
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	Entry
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	Entry
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	#

4.2.20 Synaptic Event Analysis

Post-synaptic potentials and currents from excitatory and inhibitory events (EPSPs, EPSCs, IP-SPs, IPSCs) are analyzed with this application module. Access via the Scope (analysis) 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).
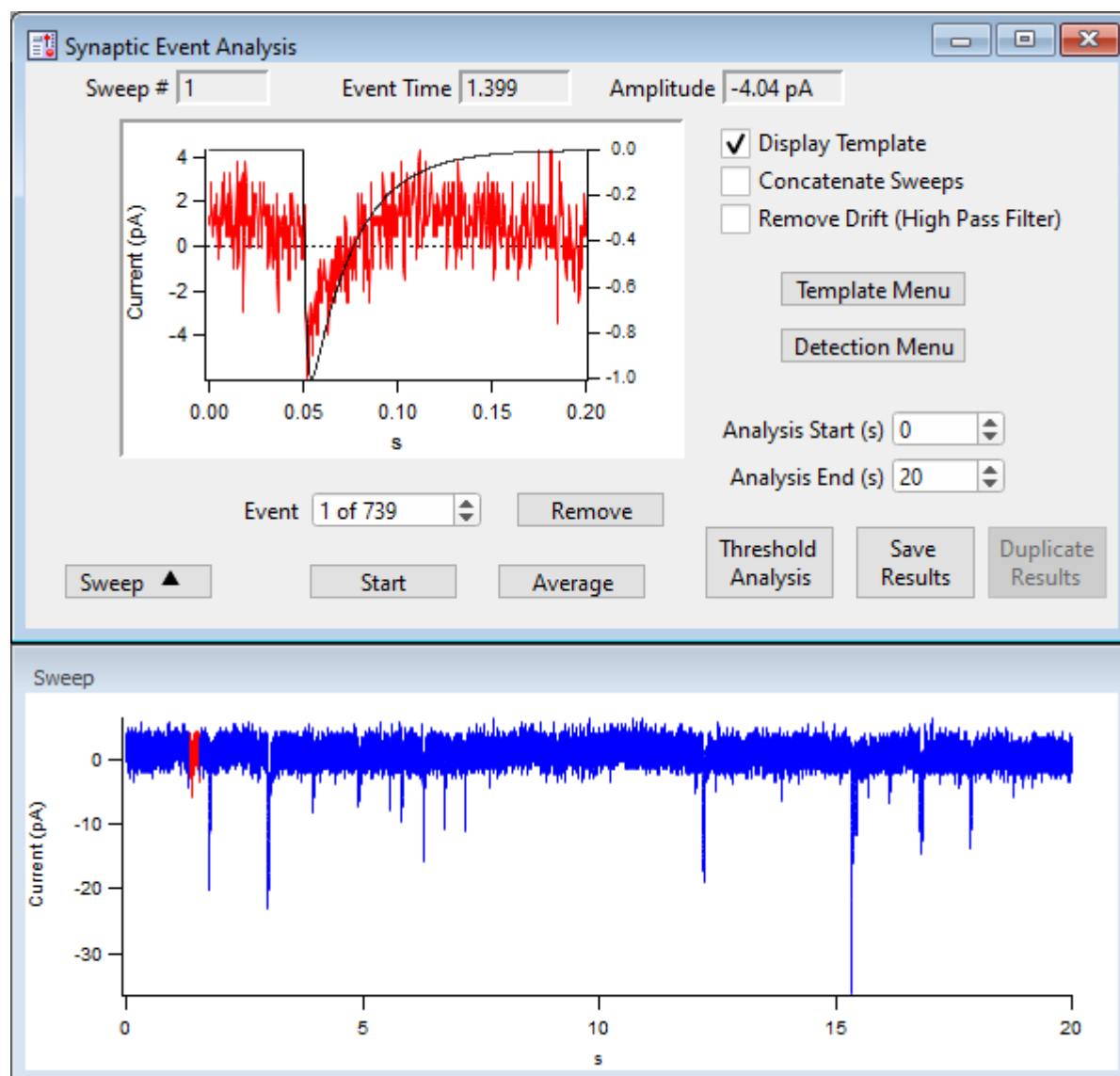
Figure 4-89. Synaptic Event Analysis

Sweep #   The sweep number of the displayed data.

                            Select arbitrary sweeps for processing by "marking" them in the Data Navigator tree (or during Scope acquisition/analysis.)

Event Time	The time (s) of the event's 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.

Concatenate Sweeps	Combine all sweeps into a single pseudo-sweep before processing. This can sometimes improve performance of the detection algorithm signal-to-noise ratio with shorter sweeps.

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 this button to create the template.	

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.

[Sweep pane]   The graph of a sweep (blue) containing a selected Event (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   Find and analyze synaptic events.

Average   The averaged event displays in the graph.

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   A Layout window report is created:

Synaptic Event Analysis Results

The results are copied into their own Layout window, accessible via Windows / Layout Macros.

Series Name: The path from the Igor 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

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)

(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

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.
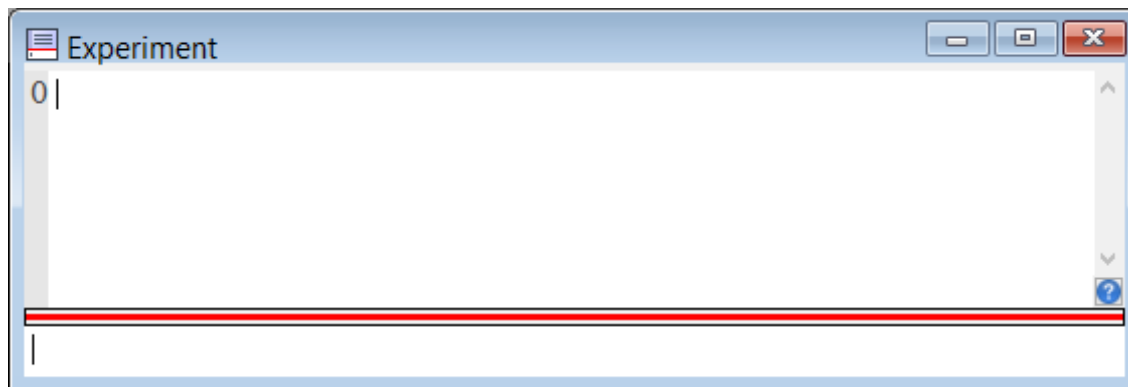
Figure 4-90. Command Window

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.

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 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

The Dashboard panel provides a convenient gateway to key areas of the SutterPatch program.

Figure 4-91. Dashboard

⚙ Preferences

Icon Size	Large Icon
	Small Icon
Icon Orientation	Vertical
	Horizontal

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.

Set Metadata — Configure metadata settings and values.

New Experiment — Start a new Experiment, and/or switch the amplifier model or emulation mode.

New HDF5 File — Start a new HDF5 file for the Experiment.
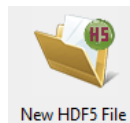
[Replaces the 'New Experiment' button when enabled in SutterPatch / Set Preferences / Files and Naming.]

Clicking the Acquire Data icon opens an adjoining secondary pane:

Figure 4-92. Dashboard - Acquire Data

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.

Note: While a Scope window is open, its icon remains depressed for Membrane Test / Free Run / Routine activation.

4.3.3 File Import/Export

Experiments & Data

There are two formats for saving an experiment. The packed format is recommended for most purposes.

- Packed experiment: (*.pxp file)

  A SutterPatch Experiment is saved by default as a "packed" (Igor Pro) experiment, which includes all data, analyses, graphs, routines, paradigms, etc., in one file.

  A Preferences option now allows data to be saved 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:

1. 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:

2. Much more disk space is used, especially for experiments that have a lot of small waves.

3. 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 into the current experiment via the Data Navigator 'Import' button.

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. Select the ABF or ATF file format in SutterPatch / Set Preferences / Data Export.

HDF5 Files

HDF5 is a modern efficient file format for managing and saving high volumes of data. Enable (*.h5) files for Experiments in SutterPatch / Set Preferences / Files and Naming.

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.

Igor 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 binary waves (*.ibw) can be loaded into the current Experiment via Data / Load Waves / Load Igor Binary. Find the files in Data / Data Browser.

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.

Graphs and Layouts

Import or export graphs for the current experiment via the Analysis Editor / Files options. Graph files are stored as Igor Binary Wave (*.ibw) files.

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.

Graphs can be exported to a Layout window via:

  Analysis Editor: [To Layout] button

  Scope window: "Export a layout" button

  Paradigms: Export step

Graphs exported to the Layout window use the SutterPatch / Set Preferences / Graphs and Layouts settings.

Individual graphs can be saved as Graph Macros - recall them via the Windows / Graph Macros menu.

Layout windows can be saved as Layout Macros - recall them via the Windows / Layout Macros menu.

4.3.4 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.

At start up, the Log window displays the SutterPatch Version and Build numbers.

The following unnamed columns are used by the Log window:

Date & Time   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.

4.3.5 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

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: Whenever a new Experiment is started, you will be asked to re-save the old Experiment, even if there were no changes to it; this is required by an internal Igor cleanup process.
Open Experiment	Open a previously saved SutterPatch Experiment (*.pxp, *.uxp) file. If a SutterPatch experiment is opened into an Igor-only session, SutterPatch is automatically loaded.

If the SutterPatch preference for HDF5 files is enabled, a SutterPatch Question will ask how to load the matching HDF5 file:

- Load and store changes in analysis files

  Open the HDF5 file in read-write mode, i.e. the original metadata and experiment structure, analysis results, images, etc. are overwritten when closing the present experiment. However, raw data are NEVER modified.

- Load in read-only mode, i.e. don't store any change back to the file

  Open the HDF5 file in read-only mode. Nothing is stored, and the data file remains unaffected. Anything done in this session is lost when closing the Experiment.

- Cancel loading HDF5 file

  Do not open the HDF5 data file. Nothing is stored, and anything done in this session is lost when closing the Experiment.

  A normal Igor session is launched, that includes a main menu SutterPatch menu 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. Revert Experiment   Undo any unsaved changes to the Experiment.

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.

New HDF5 File   [Only displays when the HDF5 file in SutterPatch / Set Preferences / Files and Naming is enabled.]

Stores all existing data into the present HDF5 file, cleans-up the Experiment, and creates a new HDF5 file, so that acquisition can continue as if you had started a "New Experiment", but without restarting SutterPatch.

Update HDF5 File   [Only displays when HDF5 file saving in SutterPatch / Set Preferences / Files and Naming is active.]

Update the HDF5 data file without resaving the entire Experiment.

Compact HDF5 File   [Only displays when HDF5 file saving in SutterPatch / Set Preferences / Files and Naming is active, and data has been discarded.]

Removes discarded data from an HDF5 data file without resaving the entire Experiment.

Data

Load Waves / Packages / Install HDF5 Package

Load Waves / New HDF5 Browser

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 fitting equations.

Windows

The Windows menu provides access to graphs, tables and layouts.

Control / Retrieve All Windows	Hidden unminimized windows can be brought into view with the menu command.
Command Window	Process SutterPatch and Igor commands.

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 the dialog to load, edit and run Paradigms.
Routine Editor	Open the dialog to load and edit Routines.
Template Editor	Open the dialog to manage templates.
Equation Editor	Open the dialog to load and edit Equations.
Solution Editor	Open the dialog to control solutions.
Camera Module	Open the window to capture images.

Data Navigator	Open the window to organize and display the experiment Paradigm, Routine and acquisition data in a tree structure.
Analysis Editor	Open the dialog to manage analysis graphs.
Layout Page	Show Layout
	Delete Layout

Set Metadata	Open the dialog to configure user-specified experimental information.
Set Preferences	Open the dialog to modify the default program settings.
Log Window	Open the window to display a history of program actions.

Shortcuts

Shortcut Editor	Open the Shortcut Editor dialog to manage keyboard shortcuts.

Action 1 [VHold+10mV:Right]	
Action 2 [VHold-10mV:Left]	
Action 3 [VHold+1mV:Right,shift]	
Action 4 [VHold-1mV: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 and SutterPatch Help Topics.

About SutterPatch   SutterPatch version and contact information.

<u>Scope Right-click Menus</u>

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
- Full Scale X Axis
- Axis Properties…

Scope Y-Axis   (right-click the Y-axis)

- Autoscale All Axes
- Continuous Autoscale Axis
- Autoscale Axis
- Full Scale Y Axis
- Axis Properties…
- Hide Signal '<signal name>'
- Show Signal '<signal name>' Only
- Stack All Signals

Scope (acquisition) 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

Scope (analysis) 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

- 3D View

- 3D View

- Zero Baselines   The average of the first four data points is subtracted from the sweeps display. Does not affect data values in measurements.

- Show All Sweeps

- Select 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_#

- Mode

- Line Style

- Line Size

- Markers

- Marker Size
- Color
- Bring to Front
- Send to Back
- Forward
- Backward
- Move to Opposite Axis
- Quick Fit
- Export Graphics
- Toggle Cursor Info
- Hide Signal '<signal name>'
- Show Signal '<signal name>' Only
- Stack All Signals

Scope marquee window   (click-and-drag in a signal)

- Expand
- Horiz Expand
- Vert Expand
- Shrink
- Horiz Shrink
- Vert Shrink

- Extract Template

4.3.6 Sample Files

Sample settings files (subject to change) are included in the ... / Documents / SutterPatch / Parameters folder:

<u>Dynamic Clamp Pool Sample Files</u>

SP_DynamicClampPool.spd Dynamic Clamp models for dPatch systems.

<u>Equation Pool Sample Files</u>

SP_EquationPool.txt Equations for all Sutter amplifier systems.

1. X3pi   3*pi
2. ElapsedTime   ParadigmTime - time
3. Temperature   aux[1]*1.23 − 273.15

Paradigm Pool Sample Files

LockIn / LockIn_dPatch.spp   Paradigms for dPatch lock-in tuning.

LockIn / LockIn_IPA.spp   Paradigms for D/IPA lock-in tuning.

SP_ParadigmPool_dPatch.spp   Paradigms for dPatch systems.

SP_ParadigmPool_IPA.spp   Paradigms for Dendrite and D/IPA systems.

1. Amplifier_Setup   Set initial amplifier settings.
2. Start_one_Series   Start acquisition of one routine.
3. Set_amplifier_and_start_IV   Set amplifier to a known state, then start a routine.
4. Start_two_Series   Start acquisition of two subsequent routines.
5. Start_ForEachSweep   Start acquisition of a routine, individually triggering each sweep.
6. Interactive_acquisition_1   Run an interactive acquisition stopping at a given analysis condition.
7. Interactive_acquisition_2   Run an interactive acquisition loop that selects between 2 routines, and manually stops via a Checkbox.
8. Toggle_Persistence   Use a Checkbox to toggle Scope trace persistence while acquiring a routine.
9. Switch_Headstages   Switch between multiple headstages.
10. Tuning_with_Keys   Use the keyboard to increment or decrement a Routine's stimulus output by 10 mV.
11. Tuning_with_Input   Use the paradigm "Input" control to increment or decrement a Routine's stimulus output.
12. CellHealth_From_CC   Monitor the cell's resistance and capacitance in current clamp mode.

Routine Pool Sample Files

LockIn / LockIn_DIPA.spr   Routines for Double IPA lock-in tuning.

LockIn / LockIn_dPatch.spr   Routines for dPatch lock-in tuning.

LockIn / LockIn_IPA.spr		Routines for IPA lock-in tuning.
SP_RoutinePool.spr		Routines for IPA sytems.
SP_RoutinePool_Dendrite.spr		Routines for Dendrite systems.
	1. Amplitude Equations	Equation 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		Routines for Double IPA systems.
SP_RoutinePool_dPatch.spr		Routines for two-headstage dPatch systems
SP_RoutinePool_dPatch_1HS.spr		Routines for one-headstage dPatch systems.

<u>ShortcutPool Sample Files</u>

SP_ShortcutPool.spo   Shortcuts for all Sutter amplifier systems.

    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 an analysis 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.

<u>Solution Pool Sample Files</u>

SP_SolutionPool.spo   Solutions for all Sutter amplifier systems.

    1. undefined   All solutions are blank.

<u>Template Pool Sample Files</u>

SP_TemplatePool.spt   Templates for all Sutter amplifier systems.

    1. RoutinePreview
    2. Single_actionPotential
    3. HodgkinHuxley
    4. Noise

<u>Experiment Sample Files</u>

Sample data (subject to change) are included in the ... / Documents / SutterPatch / Example folder:

    1. ActionPotentials.pxp   Action potential data.

2. LargeAPs.pxp   Large action potential data.

3. MiniExample.pxp   Spontaneous miniature synaptic potential data.

4.3.7 Set Preferences

Preferences settings customize the default settings for several areas of the SutterPatch program. To access, go to the SutterPatch / Set Preferences menu.
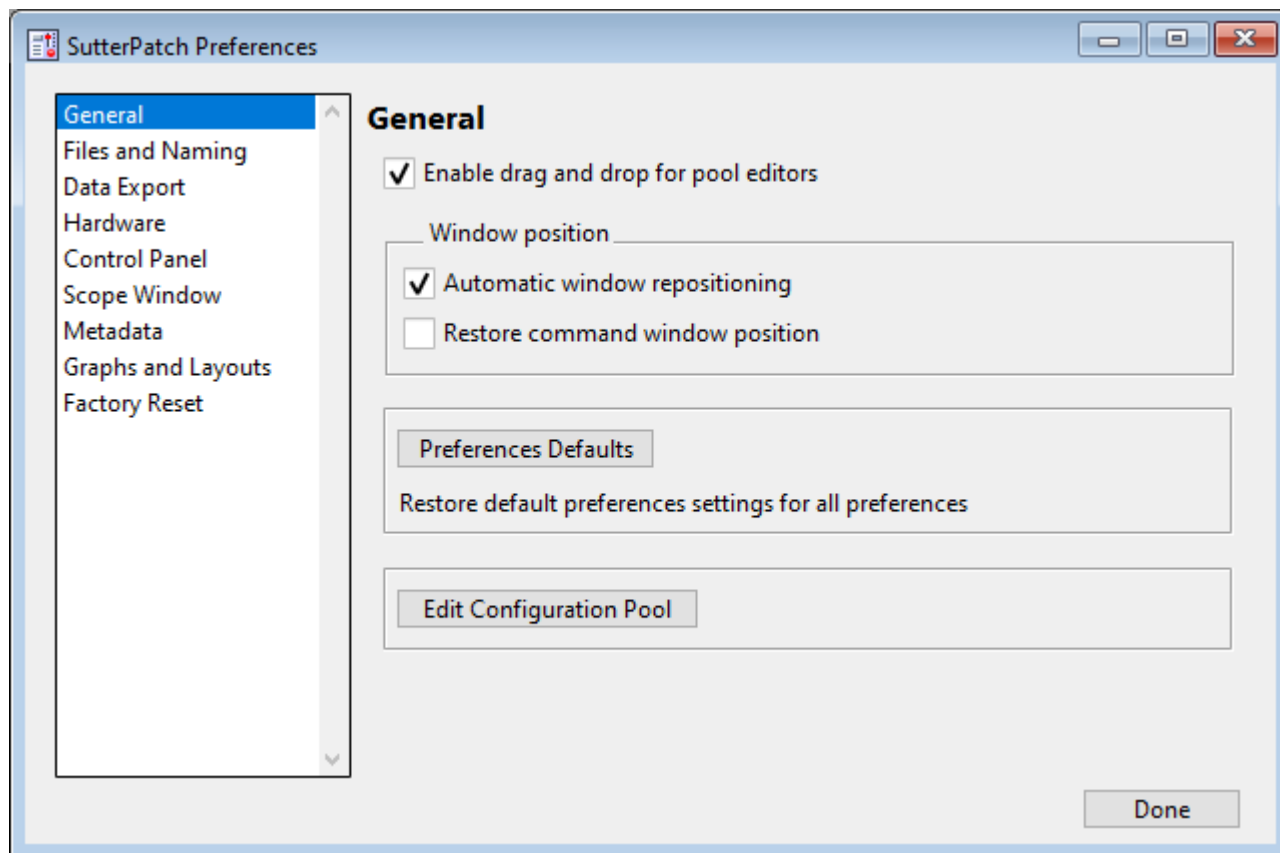
Figure 4-93. Preferences Settings

i.   General

Enable drag and drop for pool editors

The Routine Editor loads a "pool" of Routines from a Routine Pool file. These Routines can be re-arranged in the Routine Pool list by clicking and dragging with the mouse.

The Paradigm Editor operates in the same manner, and also displays a list of Paradigm Steps, which can also be re-arranged by dragging-and-dropping.

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.

Preferences Defaults   Restore default Preferences settings for all Preferences.

Edit Configuration Pool   Manage user Preferences configurations.

Delete Configuration   Remove the named Configuration from the list. The last remaining name is not deletable.

Add New Configuration   Create a new Configuration name for the current Preferences settings.

Configurations are selected for loading at the start of a new experiment.

Description   Enter the name for the Configuration (enclose in double quotes).

Update Active Configuration (#)

The "active" Configuration is updated with the current Preferences settings.

This dialog opens with the active Configuration

name listed. The number (#) indicates its
position in the Configuration list.

Note: SutterPatch Configuration files use the *.spc file extension. However,
this is reported by the OS as file type "PKCS #7 Certificates".

ii.   <u>Files and Naming</u>

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.

Enable automatic naming for experiment

Experiment file name example: (Maximum 34 characters)

[   ]

Note: At least one of the following file name components must be enabled.

Text: [   ]
Legal characters are A-Z, a-z, 0-9 and "_".

Include user text in the file name. At least one
character is required.

Date: YYMMDD   Include the date in the file name.

Time: hhmmss   Include the time in the file name.

Save to separate HDF5 file   Store the Experiment in data waves using the HDF5
format, a modern efficient file format for managing and
saving high volumes of data.

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. This
setting become active after starting a New Experiment
or starting 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, etc.) are stored to the HDF5 file. Anything outside of the Data folder (such as graphs and layouts) remains part of the ".pxp" Experiment file.

Note: It is strongly advised to enable the "automatic naming" option above, so that the '*.h5' file and its paired '*.pxp' Experiment file are kept "in sync".

Keep only one Sweep in Memory

[Only displays when 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 HDF5 is enabled.]

The raw signal data are written during acquisition, while the other SutterPatch Data folder information (metadata, Experiment structure, analysis results, Routines, Log, images, Dynamic Clamp conductances), are written to the HDF5 file at the end of the Routine.

Save Options   [Only displays when 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.

iii.   <u>Data Export</u>

- Igor Binary   Save the signal formatted as an "Igor Binary Wave" file (*.ibw).

- 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

  Note: If the new filename is the same as an existing filename in the target folder:
  -   Choose a different folder, or
  -   Delete the older file via the OS file browser.

- ATF Format   Save the signal formatted as an "Axon Text File" (*.atf).

iv. <u>Hardware</u>

- 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   Ultra-fast Digital Patch-clamp system

  - Dendrite   Low-noise 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.

v. <u>Scope</u>

Scope setting changes are only applied when a Scope window is opened.
    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.

    Acquisition

      Y axis initial settings   This setting is applied when a new acquisition Scope window is created. If autoscaling is selected, it is also applied to the Scope Y-axis and Y-axes autoscale buttons.

- Continuous autoscale
  The Y-axes limits are rescaled with each sweep so that all data are visible.

- Continuous autoscale from zero

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.

- Full scale   The full-scale range is used.

- Use last y-scale   The last setting of the Scope window Y-axis scaling is used.

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

Y axis initial settings   This setting is applied when a new analysis Scope window is created. If autoscaling is selected, it is also applied to the Scope Y-axis and Y-axes autoscale buttons.

- Autoscale   The Y-axis limits are rescaled with each sweep so that all data are visible.

- Autoscale from zero   The Y-axis 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, Full scale The full-scale range is used.

- Use last y-scale The last setting of the Scope window Y-axis scaling is used.

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 Scope (analysis) 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.

Show event tags Display tag lines in the Scope reanalysis window; also display tag text boxes in the Continuous and Concatenated display modes.

<u>Tag Position</u>

- Frozen
- Movable

<u>Tag types to show</u>

- User
- Input-triggered
- System

<u>Tag text box</u>

- Time

- Tag sample

- Description

<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   [blue]

    Inactive sweep color   [red]

    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.   <u>Metadata</u>

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.

1	Basic	Show only the most essential parameters.
2	Extended	Show additional detail.
3	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 may be 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   (typically the Y-axis)

Tick location:

- Outside
- Crossing
- Inside
- None

Labels:

- On
- Axis only
- Off

Grid:

- Off
- On
- Major only

bottom   (typically the X-axis)

Tick location:

- Outside
- Crossing
- Inside
- None

Labels:

- On
- Axis only
- Off

Grid:

- Off
- On
- Major only

viii.   <u>Factory Reset</u>

[Factory Reset]   Click this button to reset SutterPatch to it default settings. 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.)

4.3.8 Shortcut Editor

Keyboard control of SutterPatch is available by configuring keyboard shortcuts.
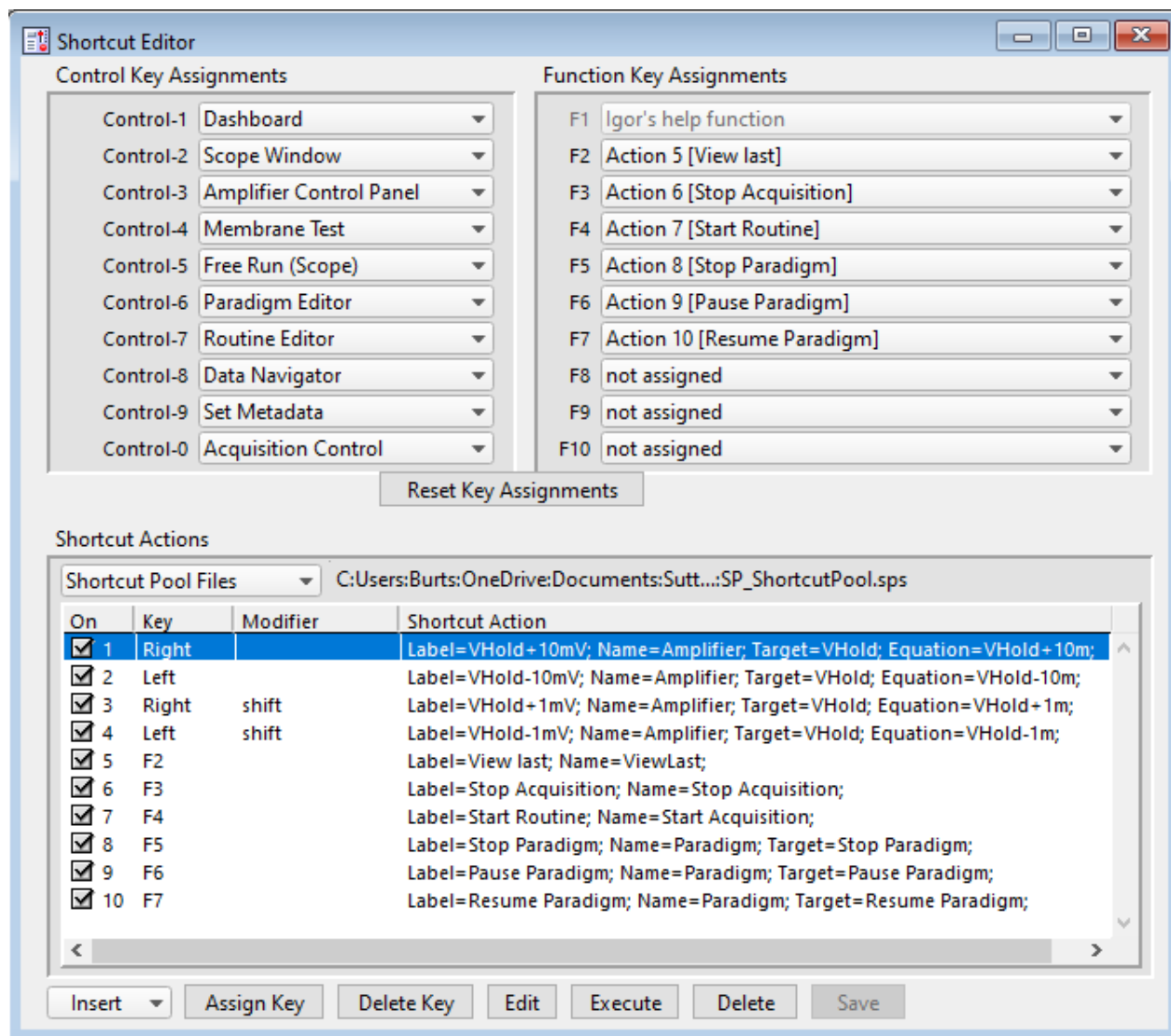
Figure 4-94. Shortcuts Editor

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.

Note: 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 Keys F1 is not available for assignment, as it is reserved for Igor's help function.

Default Functions

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]

Reset Key Assignments

Reset all Control and Function key "menu" assignments to their default settings. Shortcut Actions are not affected.

Shortcut Actions

Up to 10 additional custom keyboard Actions can be created, managed and stored in a file.

Shortcut Pool Files

New Shortcut Pool	Create a default Shortcut Pool.
Load Shortcut Pool	Load the Shortcuts of a previously saved Shortcut Pool file into the Shortcut Pool.
Revert to Last Saved	Undo any unsaved changes to the Shortcut Pool.

Save Shortcut Pool	Save the Shortcut Pool using its existing file name and path.
Save Shortcut Pool As…	Save the Shortcut Pool to a new file, and switch to the new file. The default file name is the same as the original file name.
Save Shortcut Pool Copy…	Save the Shortcut Pool to a new file, but do not switch to the new file. The default file name has 'Copy of' prepended to it.
Merge Shortcut Pools	Append the Shortcut Actions from a previously saved Shortcut Pool file into the loaded Shortcut Actions table.

[Shortcut Pool file path]

<u>Shortcut Actions Table</u>

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.

<u>Windows</u>

• Ctrl	Only for use with keys '0 – 9'.
• Alt	Keys '0 – 2' reserved by Igor for File / Recent Experiments.
• Shift	Shift key.
• Fn	Function key.
• Caps Lock	Ignored.

<u>macOS</u>

• Command	Only for use with keys '0 – 9'.
• Option	Option key.
• Shift	Shift key.
• ctrl	Keys '0 – 2' reserved by Igor for File / Recent Experiments.
• Caps Lock	Ignored.

Shortcut Action	An Action's instructions and settings.

Click a field in the pool to highlight an Action and make it the active entry. Click-and-drag a field to reposition an Action in the pool.

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.
Execute	Run an Igor 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.
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 (analysis) window is "marked" so that it is highlighted for group averaging or export in the Data Navigator.
Set Variable	Set Paradigm or Routine variables.
Set Tag	Write a comment tag to the Paradigm metadata.
Start Acquisition	In an open Scope (acquisition) window.
Stop Acquisition	In an open Scope (acquisition) window.
View Last	Display the last recording in a Scope (analysis) 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.)

Tips: If the CAPS LOCK button is on when assigning a key, the key is case insensitive.

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.

Delete Key	Remove the Key entry for the selected Action.
Edit	Open the Shortcut 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.

Predefined Actions

Action 1 [Hold+10mV | 10 pA:Right]

Action 2 [Hold-10mV | 10pA:Left]

Action 3 [Hold+1mV | 1pA:Right,shift]

Action 4 [Hold-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

Action 11 [Cursor Info]   F10

4.3.9 Startup

The SutterPatch application startup sequence:

1.   Click on the Igor Pro 8 icon to launch Igor Pro.

2.   The application opens an Igor 'Command' window along with a "splash" screen display-ing file opening information; both windows are then closed.

3.   Next a 'Welcome to SutterPatch' screen displays a few launch options:

- Igor Only   Run Igor Pro (without launching SutterPatch).
- Open   Launch SutterPatch from a saved Experiment.
- Start   Launch SutterPatch for a new Experiment.

4.   Click 'Start', an Igor 'Command' window opens, and the Welcome screen displays a pro-gress bar while compiling the SutterPatch code; the Welcome screen is then closed.

5.   A 'Save experiment as" dialog displays with standard file saving controls.

6.   Next, if no Sutter instrument is detected, the 'No USB Connection' pane allows you to try re-establishing the USB connections, or to select a hardware-emulation mode:

- IPA - Single Headstage
- DIPA – Double Headstage
- dPatch – Double Headstage
- Dendrite – Data Acquisition System

In demonstration mode, the Dendrite Control Panel and acquisition Scope window are labeled with "Demo", the input and output channels use simulated data, and most SutterPatch functions are available.

7.   The SutterPatch files are initialized, the Dashboard panel displays, and additional SutterPatch windows display if they were open in the prior experiment.

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 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 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 "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, 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'.

6.4.4   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   <u>USB Communication Fails</u>

Problem: When starting up SutterPatch in Windows, there is no USB communication
              with the computer.

Solution: Power off the Sutter instrument, then reseat the USB cable on both ends, and
              then power on the Suttter 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 Win-
                  dows 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 'dis-
                  abled', and click "OK".

              Or, a Windows 10 update can sometimes disable the computer's USB ports. Ei-
              ther 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.

6.4.2   <u>Sample Parameter Files Not Installed</u>

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.

6.5 Acquisition Issues

6.5.1 Acquisition In Progress

Problem: Unable to start an acquisition because the system thinks it is already running.

Solution: Use the menu command SutterPatch / Reset Acquisition to clear the acquisition status.

6.5.2 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.

6.5.3 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.

6.5.5 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 you are grounded and/or working in a Faraday cage.

6.5.6 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.

6.5.9   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.

6.5.10 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.

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.

6.5.11 Routine Loading Delays

Problem: Selecting a Routine in the Routine Editor temporarily hangs the SutterPatch program.

Solution: Hide the Routine Editor Preview pane.

If there is a very large number of sweeps to display, the Preview pane can take a long time to redraw, and the program becomes temporarily unresponsive.

6.5.11 <u>USB Errors</u>

Problem: A USB communications error occurs.

Solution: In the Control Panel, click the Reset USB button ![red 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.

6.5.12 <u>System Freezes</u>

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 ![red button] or the SutterPatch / Hardware Control menu.

6.6 Analysis Issues

6.6.1 <u>Analysis Not Deleted</u>

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 <u>Signal Axes Overlay</u>

Problem: The X-axes and units are overlaid in the Scope window.

Solution: There is not enough room for the X-axes 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 <u>Graphs & Layouts Not Visible</u>

Problem: Cannot see SutterPatch Experiment graphs or layouts on non-SutterPatch computers.

Solution: Use the Igor menu command Windows / Graph or Windows / Layout to see the object. Right-click it to modify with Igor 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.

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 issue.

Also, if the active window is maximized, creating a new window might automatically "maximize" the new window.

6.7.5 Slow Window Opening/Closing

Problem: Window opening and closing is slow on the macOS.

Solution: Close the SutterPatch Data Browser. This function consumes a lot of system resources.

6.7.4 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 issue.

6.7.6   File Operations Crash

Problem: In Windows 10, file opening or saving crashes SutterPatch.

Solution: Remove the Dell Backup and Recovery utility v1.8, or upgrade it to a newer version.

6.7.9   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.

6.7.10   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.

6.7.11   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 GP-17   Grounding point hardware
- Rack Pack   Rack mounting 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.
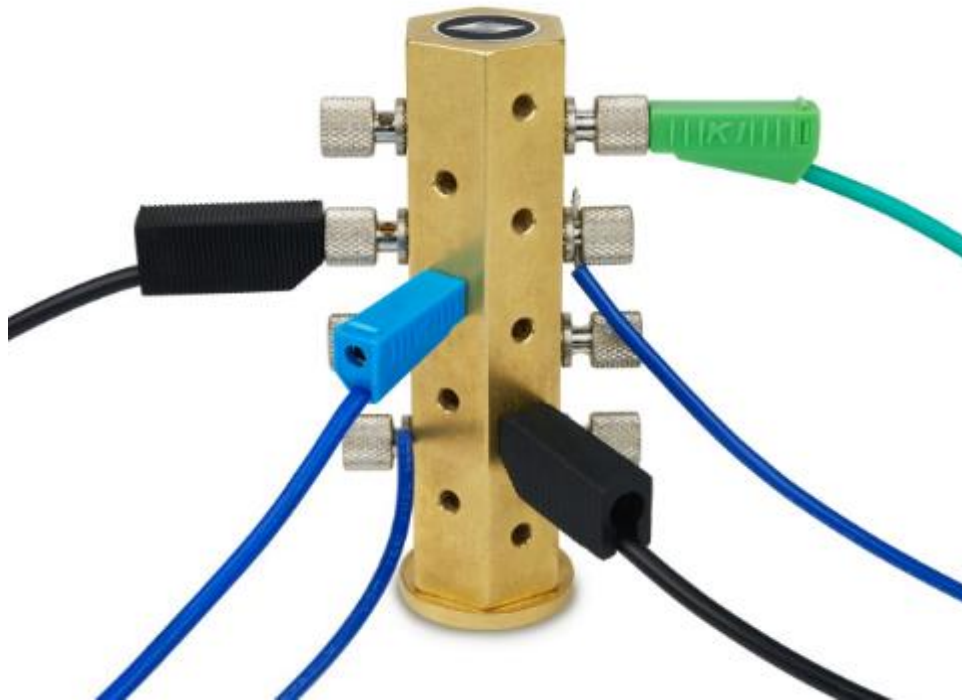
The Ground Point 10-item kit includes cables with banana plugs and alligator clips. For very complex rigs, two sets of cables might be needed.

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 (impedance: 16 Ω) 8 Auxiliary analog inputs (impedance: 10 kΩ) 8 Digital outputs (impedance: 10 kΩ) 1 Digital output trigger 1 Digital input trigger
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) Power Cord
- (1) USB 2 Cable
- (1) Rack Mount Kit   RACK-PK
- (1) Quick Start Guide   (with Igor Pro 8 Serial #)
- (1) USB Flash Drive   (with SutterPatch and Igor Pro 8 software)

APPENDIX F. SUTTERPATCH ALGORITHMS

Action Potential Threshold Algorithm

[for Action Potential Analysis]

Math used in the 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.

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]

Math used in the 'Standard Error of the Mean' computation:

$$SEM = \sqrt{} \; (\; SumSq - Mean^2 * N \;) \; / \; (N\text{-}1)$$

SumSq = sum of all squared samples

Mean = sum of all samples / N

Note: The SEM algorithm is similar to the Standard Deviation "$\sqrt{}$ (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.