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AMPLIFIER SYSTEMS

Sutter Instrument is proud to announce one of the most significant additions to our product lineup in years: a full suite of electrophysiology recording hardware and software.

The dPatch® Digital Patch Amplifier System combines an unmatched sampling rate of up to 5 MHz, with noise performance that supports the quietest single-channel recordings, and digital architecture for the highest signal fidelity and ultra-stable compensation circuitry. The dPatch system is the most advanced amplifier for electrophysiology on the market today.

The IPA® family of Integrated Patch Amplifier Systems enables efficient, low-noise whole-cell recordings. The IPA system, available with one (IPA) or two headstages (Double IPA), combines state-of-the-art amplifier technology with fully integrated D/A and A/D conversion and a high-speed USB interface. Acquisition, data management, and streamlined analysis are performed using the bundled SutterPatch® Data Acquisition and

Analysis Software, built on the foundation of Igor Pro (WaveMetrics, Inc.).

All Sutter Amplifier Systems were designed with the attention to detail our customers expect and appreciate. The faceplates are sculpted and feature recessed connectors. The pipette holder connects to machined aluminum threads designed for the utmost in mechanical stability and improved shielding. Available accessories include expansion panels, which present amplifier back panel connections at the front of a 19" rack, a machined brass ground point, and pipette holders in polycarbonate or quartz, which minimizes thermal expansion (now standard on dPatch Systems).

dPatch®

LOW-NOISE ULTRA-FAST DIGITAL PATCH CLAMP AMPLIFIER SYSTEM

New Feature

(Shown: DPATCH-2)

FEATURES dPatch®

- **New:** Fully-integrated dynamic clamp interface with update rates up to 500 kHz

- Fully integrated single- or dual-headstage patch clamp amplifier and data acquisition system ensures quick and easy setup

- Ultra-high bandwidth enables characterization of the fastest signals

- Optimized for low-noise single-channel as well as whole-cell patch clamp recordings in nanopores, tissue slices, adherent or dissociated cells

- Full computer control provides automated compensation of electrode and whole-cell capacitance

- Lock-in amplifier technology for high-resolution capacitance measurements

- Extensive digital compensation circuitry provides the utmost precision and signal fidelity

- Voltage and FastFollower™ Current Clamp capability for accurate characterization of cells' electrical activity

- Online adaptive AC line frequency reduction in SutterPatch® ßsoftware

- Three headstage feedback ranges for single-channel and whole-cell patch clamp recordings

- Bundled SutterPatch® software provides a contemporary user interface, versatile data management, intuitive navigation and streamlined data analysis

COMMON APPLICATIONS dPatch®

- Single-channel recordings

- Auditory research and other rapidly changing signals

- Nanopore studies

- Tissue slice recordings

- Exo- and endocytosis measurements

- Cultured cell experiments

- Cell line studies from adherent or dispersed cells

- Optogenetics

The dPatch® amplifier system was built around a simple idea: What if we built a clean-sheet design that used the latest technology to make the next generation of patch clamp amplifiers? We hired the best hardware and software designers available in the industry, the same engineers who created the leading amplifiers already in the market. We asked them to design the best amplifier system possible, using the very latest in digital architecture, and pair it with a contemporary, easy-to-use, yet powerful software platform.

The resulting design represents a complete rethinking of how to best reduce noise and preserve signal to get the cleanest recordings possible, at a bandwidth that far exceeds anything else on the market. The dPatch amplifier system's digital architecture uses state-of-the-art methods in signal processing, such as field-programmable gate arrays (FPGAs) and Arm Core processors – technologies unavailable when the leading amplifiers in the market were designed well over 20 years ago. The processing power of this design FINALLY enables fully integrated dynamic clamp, as well as digital capacitance and resistance compensation. The included SutterPatch® software facilitates data acquisition, mangement and analysis with an intuitive and easy to learn interface.

Available in either a single- or dual-headstage configuration, the dPatch amplifier system's architecture makes swapping headstages, or adding a second one to a single-headstage unit, a plug-and-play operation. The two headstages are independently configurable for either voltage clamp or FastFollower™ current clamp.

5 MHz SAMPLING RATE, UP TO 22-BIT RESOLUTION
One unique feature with dPatch is the headstage data sampling system. Each headstage is continually sampled at 5 MHz. Output filtering has thirteen settings between 100 Hz and 1 MHz. A resolution of 18 bits is achieved at 1 MHz. For lower filter settings, automatic downsampling increases resolution while optimizing data rates. At a bandwidth setting of 1 kHz, the dPatch system provides a signal resolution of better than 22 bits.

NO ACTIVE COOLING REQUIRED
Active cooling causes numerous problems that actually create more "noise" in the long run. Active cooling in amplifier headstages use Peltier cells, which cool the electronics for slightly better performance, but generate considerable heat on the opposite side of the cell. The heat generated causes thermal drift which makes it almost impossible to stay patched while doing single-channel work. This is THE MOST COMMON source of what users perceive as "manipulator drift". As a company that makes micromanipulators, we are highly sensitive to the performance of the system within a complete electrophysiology rig.

Active cooling can help get a slightly better noise specification on paper, but in the real world the disadvantages far outweigh the slight gain in specsmanship. One of the development goals of the dPatch headstage was achieving a comparable noise performance at room temperature, without the need for a cooled headstage. In the two resistive feedback modes, the dPatch amplifier is even quieter than any of the competitor systems. In addition, the limited life expectancy of Peltier elements causes reliability concerns that we found unacceptable.

Patent No. 10,393,727

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BUILT-IN DATA ACQUISITION SYSTEM MEANS NO THIRD-PARTY COMPUTER INTERFACE
Using a multiplexer-free design, the dPatch provides 8 fully differential analog input channels, 4 analog output channels, and 16 digital outputs (TTL). All I/O channels are sampled continuously (200 kHz for analog inputs, 250 kHz for analog and digital outputs) and available through the user interface.

SUTTERPATCH® SOFTWARE
The dPatch amplifier system, in combination with SutterPatch software, has been engineered to automatically capture and store all amplifier settings, stimulus information and external experiment parameters, and associate them in time with the raw data traces. This includes all amplifier and acquisition settings, as well as timing and progress of the experiment. Fully integrated computer control of the amplifier stages means that the acquisition software is aware of the internal state of the amplifier and digitizer at all times, and can track any changes that may occur. This is independent of whether a change is triggered automatically or initiated by the user.

• NEW FEATURE • DYNAMIC CLAMP
The patented digital architecture of the dPatch amplifier system provides an ideal platform for dynamic clamp. The dPatch is powered by a system-on-chip which provides parallel processing across a Field Programmable Gate Array (FPGA) and two high-speed ARM core processors. Several sophisticated dynamic clamp models are implemented within this architecture. In each model, the update of the applied current values occurs without communication between the dPatch and a computer. Depending upon the complexity of the model, update rates of up to 500 kHz can be achieved. (read more on the SutterPatch Software page)

TRACKING OF OTHER EXTERNAL DATA
In addition to status changes in connected hardware that are automatically tracked, the researcher can manually trigger tags to document events like stimulus application using instruments not connected to the amplifier. Information about environmental parameters and a more detailed specification of sample properties can be recorded and stored with the raw data. A total of over 650 metadata attributes are supported. Examples include: animal species, genotype, date/time when a cell sample was prepared, recording solutions, pipette resistance, hardware properties, and detailed information about stimuli applied.

DATA VISUALIZATION AND ANALYSIS
SutterPatch software has been designed to simplify the navigation and analysis of complex datasets. The scope window supports multiple view modes in both two-dimensional and an innovative three-dimensional display. The 3D view is particularly useful during assay development. Built on top of the latest version of the proven Igor Pro platform, SutterPatch combines native Igor Pro functionality with a wealth of features that are tailored to electrophysiology applications. Both the newcomer and the experienced user of patch clamp programs will feel comfortable using SutterPatch software.

Application modules provide focused functionality for particular applications.

Currently Available
- Event Detection Module: A deconvolution algorithm that excels at detecting miniature synaptic events, even on a noisy background
- Action Potential Analysis Module: Phase plane plot, timing and waveform statistics
- Single-Channel Analysis Module: All-points histogram, idealized trace, dwell time, open and closed probability and more
- Camera Module: An easy way to document the identity and condition of the recorded cell

A LABORATORY WORKHORSE

While the dPatch® System is ready for cutting-edge research, its feature set also makes it immediately valuable in any electrophysiological lab setting.

- Three headstage feedback ranges for optimal whole-cell and single-channel recording
- Automated or manual compensation of electrode and whole-cell capacitance
- Series resistance compensation
- Simple cabling, quick and easy set-up
- High dynamic range of digitizer means no need for additional variable gain stages
- Ultra high speed of digitizer means no concerns about inadequate sample rate

The dPatch® Integrated Digital Patch Clamp Amplifier is a computer-controlled single- or dual-headstage system optimized for both single-channel and whole-cell recording applications.

Amplifier
- Hardware architecture enables all data conversion to be performed near the preparation, well away from known noise sources, such as power supplies and high-speed digital circuitry
- Voltage clamp and FastFollower™ True Current Clamp modes with smart switching between modes to avoid current artifacts
- Three choices of headstage feedback elements to optimize both single-channel and whole-cell recording

Feedback Element	Range	Analog Bandwidth	Noise 10 kHz BW	Pipette Capacitance Compensation Range	Series Resistance Range	Cell Capacitance Range
Capacitive	±20 nA	1 MHz	<0.22 pA$_{RMS}$	20 pF	N/A *	N/A *
500 MΩ	±20 nA	>250 kHz	<0.75 pA$_{RMS}$	20 pF	100 MΩ	100 pF
50 MΩ	±200 nA	>250 kHz	<2.4 pA$_{RMS}$	20 pF	10 MΩ	1000 pF

* Capacitive feedback range is optimized for single-channel voltage clamp recordings. Whole-cell compensation and current clamp mode are disabled with this range.

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Back panel of dPatch

- Automatic compensation routines for pipette compensation, whole-cell compensation, and series resistance compensation
- Novel 2D matrix and triple-slider controls for manual compensation adjustment
- Series resistance prediction and correction independently programmable
- 8-pole Bessel filter: 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100, 250, 500, 1000 kHz
- Signal processing of filter output to increase resolution and reduce data file size
- Resolution over 22 bits at 1 kHz filter setting
- High dynamic range of analog-to-digital converters eliminates need for variable output gain stages
- Holding potential ±750 mV
- Current clamp bridge compensation and pipette capacitance compensation
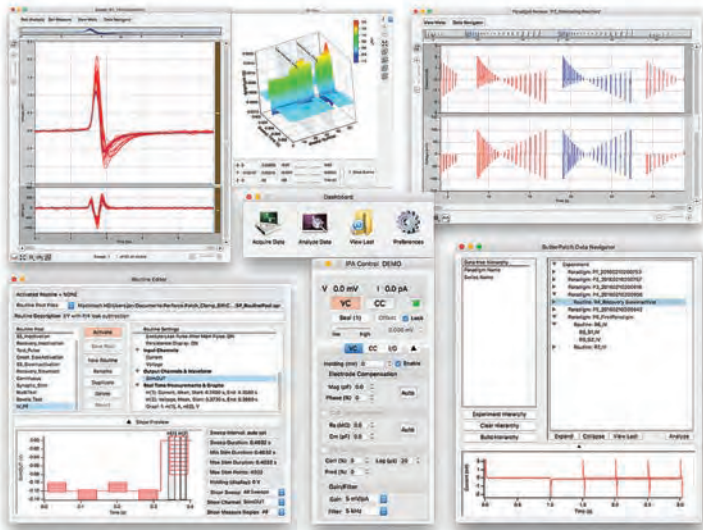- Software lock-in amplifier with up to 20 kHz base frequency for high-resolution capacitance measurements

Data Acquisition
- Embedded data acquisition system eliminates the need for an external data acquisition board
  - 5 MHz sampling rate per headstage, up to 22-bit resolution
  - 8 Auxiliary analog inputs, 16-bit fully differential, ±10 V input, each continuously sampled at 200 kHz
  - 4 Analog outputs, 16-bits, ±10 V output each continuously updated at 250 kHz
  - 16 Digital outputs (TTL) each running at 250 kHz
  - Independent Trigger IN / Trigger OUT for synchronization of external instrumentation
- Single SuperSpeed 3.0 USB connection controls both data acquisition and amplifier settings
- Complex command waveforms
- Data acquisition can be initiated by an onboard microsecond clock or external (TTL) trigger

SutterPatch® Software

- Built on the foundation of Igor Pro (WaveMetrics, Inc.)
- Paradigms and Routines provide complete experimental control of program execution
- Waveform Editor for easy execution of even the most complex stimulus patterns or user-defined templates
- Associated metadata stores all relevant information regarding your experiment
- Specialized data analysis modules and publication quality graphics
- Rapid-response online adaptive AC line-frequency reduction
- Runs on Windows or Mac OS X

Screen shot of SutterPatch software

Shown: DPATCH-PCH expansion panel

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SPECIFICATIONS   dPatch®

■ **Dimensions**

dPatch®: 19 in x 11 in x 3.5 in / 48.2 cm x 28 cm x 9 cm
dPatch® Preamplifier: 7.6 in x 3.5 in x 1.2 in / 19.5 cm x 9 cm x 3 cm
dPatch® Headstage: 3.7 in x 1.1 in x 0.66 in / 9.5 cm x 2.9 cm x 1.7 cm

■ **Weight**

dPatch®: 15 lbs / 6.8 kg
dPatch® Preamplifier: 15 lbs / 6.8 kg
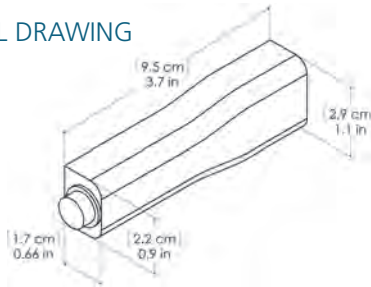*dPatch® Headstage:* 15 lbs / 6.8 kg

■ **Electrical**

110/240 Volts
50/60 Hertz power line

CE

dPATCH HEADSTAGE DIMENSIONAL DRAWING

SYSTEM REQUIREMENTS

■ **Computer Hardware**

Minimum Configuration

Windows 10 or later: 64-bit versions, or
Mac OS X 10.11 (El Capitan) or later
Processor: Dual-core i5
Memory: 8 GB
Solid-state Drive (SSD), 500 GB or greater
Display Resolution: 1024 x 768 (XGA)
1 available USB 3.0 SuperSpeed port
(on the main board, not a PCIx card or similar)

Recommended Configuration for Bandwidths of >50 kHz

Windows 10 or later: 64-bit versions, or
Mac OS X 10.11 (El Capitan) or later
Processor: Dual-core i5
Memory: 16 GB
Solid-state Drive (SSD), 500 GB or greater
Display Resolution: 1920 x 1080 (Full HD)
1 available USB 3.0 SuperSpeed port
(on the main board, not a PCIx card or similar)

SUTTERPATCH® Data Acquisition Management System and Analysis Software: Included with all
Sutter Instrument Amplifier Systems

dPatch®

■ **DPATCH**   Includes: dPatch® System with headstage and preamplifier, EH-Q170 pipette holder, model cell; SutterPatch® software suite with Igor Pro 8 license, rack mounting hardware.

■ **DPATCH-2**   Includes: dPatch System with two headstages and preamplifiers, two EH-Q170 pipette holders, two model cells; SutterPatch software suite with Igor Pro 8 license, rack mounting hardware.

ACCESSORIES dPatch®

■ **DPATCH-HS**   Headstage & preamplifier for dPatch Amplifier System
■ **DPATCH-PCH**   dPatch expansion panel

PIPETTE HOLDERS

NEW: All dPatch systems now come standard with quartz pipette holders!
While polycarbonate is a proven material for patch pipette holders, it undergoes significant thermal expansion. Uneven warming may lead to motion of the pipette tip and is often incorrectly perceived as drift in the micromanipulator. Quartz has a significantly lower thermal expansion coefficient and virtually eliminates thermal drift. Note: Quartz is fragile and may crack or shatter on impact. Treat your quartz electrode holder with the same care you would with any optical component.

■ **EH-P170**   Polycarbonate holder 1.0 mm to 1.7 mm O.D.
■ **EH-P170-S**   Polycarbonate holder (short shaft) 1.0 mm to 1.7 mm O.D.
■ **EH-Q170**   Quartz holder 1.0 mm to 1.7 mm O.D.

ACCESSORIES

■ **RACK-PK**   Rack mounting hardware
■ **GP-17**   Ground point
■ **GP-W10**   Ground wiring kit (10 assorted cables, 5 alligator clips)

The Ground Point GP-17 provides reliable, low resistance connections for a star ground configuration, the proven method to avoid ground loops in any electrophysiology setup. Accepts 9 banana plugs + 8 bare wires up to 10 gauge or banana plugs. The GP-17 mounts directly on imperial or metric air table tops with the included ¼-20 and M6 screws. Made of solid, machined brass with plated banana/clamp connectors.

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dPatch® FAQ

Q: How does dPatch compare to other amplifiers on the market?
A: The dPatch uses current state-of-the-art digital architecture. By converting the signal from analog to digital out near the headstage, we preserve the signal integrity as much as is possible. Almost every noise specification of the dPatch exceeds those of all other amplifiers on the market. In addition, the dPatch constitutes a complete patch clamp system, all data acquisition hard-and software are included, and no external hardware is required for dynamic clamp. *(See our Comparison Sheet)*

Q: Why doesn't the dPatch have active cooling?
A: Active cooling causes numerous problems that actually create more "noise" in the long run. The heat generated by Peltier cells cause thermal drift in manipulators, making it almost impossible to stay patched while doing single-channel work. As a company that makes micromanipulators, we are highly sensitive to the performance of the system within a complete electrophysiology rig. Active cooling can help get a slightly better noise specification on paper, but in the real world the disadvantages far outweigh the slight gain in specsmanship *(See the Comparison Sheet)*. In addition, the limited life expectancy of Peltier elements causes reliability concerns that we found unacceptable.

Q: Why is the dPatch pipette holder made from quartz?
A: It was a huge challenge to make a pipette holder from pure quartz. While these are expensive to manufacture, and somewhat fragile, they remove the second most common source of thermal drift: the acrylic pipette holder. Only a few degrees temperature difference from side to side can cause acrylic to expand or contract. This is easily visible under magnification, and a constant source of irritation for users. *(See our Video Demonstration)*

Q: Is the quartz pipette holder available separately?
A: Yes, both the quartz and acrylic pipette holders are available separately *(See PRICES page to see the accessories)*. The pipette holders are compatible with the HL-U standard established by Axon Instruments and used by several other manufacturers. We do not recommend mixing parts, however.

Q: Do I need to buy a digitizer or software with the dPatch?
A: No, because the dPatch is inherently a digital design, no additional digitizer is necessary. SutterPatch® software and a license for Igor Pro are included with every dPatch system. The dPatch includes everything you need to start running experiments.

Q: Can I retrofit a second headstage to my single-headstage dPatch system later?
A: Yes, dPatch headstage/preamplifier units are interchangeable and self-contained. All calibration and tuning information is stored directly in the headstage/preamplifier unit and read during startup. That makes adding a second headstage easy.

Q: Do the headstages fit on my existing micromanipulator?
A: All Sutter Instrument headstages come with a standard dovetail fitting. This fitting was jointly introduced by Sutter Instrument and Axon Instruments almost 30 years ago and has since been adopted by most manufacturers of patch clamp amplifiers and micromanipulators. That makes Sutter headstages a drop-in replacement on an existing rig, in most cases without even requiring any adjustment.

dPatch® Ultra-fast Low-noise Digital Patch Clamp Amplifier System vs. Brand aX Low-noise Amplifier

Major Features

Specification	dPatch	Brand aX	Sutter Advantage
Computer Control	YES, fully digital design, controlled by SutterPatch® software	NO, analog knobs and buttons	State-of-the-art design
Data Acquisition	YES, high-speed computer interface integration, SutterPatch software included	NO, requires separate interface and software	12 analog I/O, 16 digital outs
Field Upgradable Software And Firmware	YES	NO	Easy upgrades to keep performance optimized
Built-in Software Lock-in Amplifier	YES	NO	High-resolution membrane capacitance measurements
Integrated Dynamic Clamp Capability	YES	NO	The fastest dynamic clamp for ion channel research
Support For Two Headstages	YES	NO	Headstages with full Plug-and-Play capability
Installation	Simple	Complicated	System is ready to run "out of the box" with a USB 3 computer connection. Grounding problems are minimized.

Whole Cell Voltage Clamp

Specification	dPatch	Brand aX	Sutter Advantage
Feedback Elements	500 MΩ, 50 MΩ	Same	
Noise, 500 MΩ Range (10 kHz)	0.7 pA$_{RMS}$	1.1 pA$_{RMS}$	36% lower noise
Noise, 50 MΩ Range (10 kHz)	2.3 pA$_{RMS}$	3.0 pA$_{RMS}$	23% lower noise
Bandwidth, Both FB Ranges	250 kHz	50 kHz	5X higher bandwidth
Output Filter Ranges	13 settings from 100 Hz to 1 MHz	5 settings from 1 kHz to 100 kHz	More settings, 10X higher bandwidth
Output Filter Type	8-pole Bessel	4-pole Bessel	8-Pole provides a lower-noise signal
Pipette Cap Compensation Range	20 pF	10 pF	2X compensation range

Single Channel Voltage Clamp

Specification	dPatch	Brand aX	Sutter Advantage
Feedback Element	1 pF / integrator	Same	
Bandwidth	1 MHz	100 kHz	10X higher bandwidth
Noise, 10 kHz	0.22 pA$_{RMS}$	0.13 pA$_{RMS}$	No active cooling*
Pipette Cap Compensation Range	20 pF	10 pF	2X compensation range

Current Clamp

Specification	dPatch	Brand aX	Sutter Advantage
Circuit Architecture	FastFollower™ true current clamp	Modified voltage clamp	Produces very accurate membrane voltage waveforms
10 to 90% Rise Time			
Rp = 1 MΩ	2 µs	15 µs	7.5X faster rise time
Rp = 10 MΩ	3 µs	20 µs	6.7X faster rise time
Mode Switching Voltage Clamp to Current Clamp	Special circuitry minimizes glitches	No glitch compensation	Near-zero glitch

* Active cooling causes numerous problems that actually create more "noise" in the long run. The heat generated by Peltier cells cause thermal drift in manipulators, making it almost impossible to stay patched while doing single-channel work. As a company that makes micromanipulators, we are highly sensitive to the performance of the system within a complete electrophysiology rig. Active cooling can help get a slightly better noise specification on paper, but in the real world the disadvantages far outweigh the slight gain in specsmanship. In addition, the limited life expectancy of Peltier elements causes reliability concerns that we found unacceptable.

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IPA® and DOUBLE IPA®
INTEGRATED PATCH AMPLIFIERS
WITH DATA ACQUISITION SYSTEM

FEATURES   IPA® / DOUBLE IPA®

- Combination of any two IPA or Double IPA devices enables up to four headstage channels for as many as 16 signals

- Fully integrated patch clamp amplifier and data acquisition system ensures quick and easy setup

- Optimized for whole-cell patch clamp recordings in tissue slices, and adherent or dissociated cells

- Full computer control provides automated compensation of electrode and whole-cell capacitance

- Voltage and current clamp capability for complete characterization of cells' electrical activity

- Bundled SutterPatch® software excels in complete data management, intuitive navigation and streamlined data analysis

- Online adaptive AC line frequency reduction in SutterPatch software

COMMON APPLICATIONS   IPA® / DOUBLE IPA®

- Tissue slice recordings

- Cultured-cell experiments

- Cell line studies from adherent or dispersed cells

- *In vivo* patch clamp

- Network studies

- Optogenetics

The IPA® family of Integrated Patch Amplifier Systems enables efficient, low-noise whole-cell recordings. The IPA systems, available in either a single headstage (IPA) or dual headstage (DOUBLE IPA), combine state-of-the-art amplifier technology with fully integrated D/A and A/D conversion and a high-speed USB interface. Acquisition, data management, and streamlined analysis are performed using the bundled SutterPatch® Data Acquisition and Analysis Software, built on the foundation of Igor Pro (WaveMetrics, Inc.).

EXTERNAL INPUTS & OUTPUTS
External signals, such as environmental parameters or stimulus information, can be recorded using 4 auxiliary analog input channels. The IPA systems also support the control of peripheral hardware, such as wavelength or solution switchers, with 2 analog and 8 digital (TTL) output channels. Alternatively to the standard breakout cable, the available Patch Panel provides a tidy way of connecting auxiliary signals on the front of your rack.

SUTTERPATCH® SOFTWARE
The IPA system, in combination with SutterPatch software, has been engineered to automatically capture and store all amplifier settings, stimulus information and external experiment parameters and associate them in time with the raw data traces. This includes all amplifier and acquisition settings, as well as timing and progress of the experiment. Fully integrated computer control of the amplifier stages means that the acquisition software is aware of the internal state of the amplifier and digitizer at all times, and can track any changes that may occur. This is independent of whether a change is triggered automatically or initiated by the user.

TRACKING OF OTHER EXTERNAL DATA
In addition to status changes in connected hardware that are automatically tracked, the experimenter can manually trigger tags to document events like stimulus application in external instruments not connected to the IPA system.

Information about environmental parameters and a more detailed specification of sample properties can be recorded and stored with the raw data. A total of over 600 metadata attributes are supported. Examples include: animal species, strain, genotype, date/time when a cell sample was prepared, recording solutions, pipette resistance, hardware properties, and detailed information about stimuli applied.

DATA VISUALIZATION AND ANALYSIS
SutterPatch software has been designed to simplify the navigation and analysis of complex datasets. The scope window supports multiple view modes in both two-dimensional and an innovative three-dimensional display. The 3D view is particularly useful during assay development. Built on top of the latest version of the proven Igor Pro platform, the SutterPatch program combines native Igor Pro functionality with a wealth of features that are tailored to electrophysiology applications. Both the newcomer and the experienced user of patch clamp programs will feel comfortable using SutterPatch software.

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Application modules provide focused functionality for particular applications.

- Action Potential Analysis Module: Phase plane plot, timing and waveform statistics
- Event Detection Module: A deconvolution algorithm that excels at detecting miniature synaptic events, even on a noisy background
- Single-channel Analysis Module: All-points histogram, idealized trace, duration and amplitude distribution and scatter plot.
- Camera Module: An easy way to document the identity and condition of the recorded cell

The IPA® and Double IPA® Integrated Patch Clamp Amplifiers are computer-controlled single- or dual-headstage amplifiers optimized for whole-cell recording applications.

Amplifier
- Voltage clamp and FastFollower™ True Current Clamp modes with smart switching between modes to avoid current artifacts
- Open-Circuit (RMS) noise of 1.4 pA in a 0.1–10 kHz bandwidth
- 500 MΩ headstage feedback resistor provides a maximal range of ±20 nA
- Fast pipette capacitance compensation and whole-cell compensation
  - Pipette capacitance compensation up to 25 pF
  - Whole-cell compensation: Cm from 1–100 pF; Rs from 1–100 MΩ
- Onboard automatic compensation routines
- Series resistance prediction and correction (0–100 MΩ)
- Four-pole Bessel low-pass filter (cutoff = 0.5–20 kHz)
- Output gain: 0.5–25 mV/pA (voltage clamp); 10–500 mV/mV (current clamp)
- Holding potential ±1000 mV
- Current clamp bridge compensation and capacitance neutralization
- Slow holding potential tracking can compensate for drift during current clamp recordings

Data Acquisition
- Embedded data acquisition system eliminates the need for an external data acquisition board and facilitates setup
- Single high-speed USB connection controls both data acquisition and amplifier settings
- Up to 6 or 8 input channels (0.1–50 kHz sampling rate per channel)
- Up to 400 kHz aggregate sampling rate
- Multi-amplifier mode: A combination of any two IPA or Double IPA Amplifiers can be connected, providing up to 16 input channels
- Complex command waveforms
- Auxiliary input / output for control of other instrumentation
  - 4 analog input channels (±10 V)
  - 2 analog output channels (±10 V)
  - 8 digital output channels (TTL)
- Data acquisition can be initiated by an onboard microsecond clock or external (TTL) trigger

SutterPatch® Software

- Built on the foundation of Igor Pro (WaveMetrics, Inc.)
- Paradigms and Routines provide complete experimental control of program execution
- Waveform Editor for easy creation of even the most complex stimulus patterns or user-defined templates
- Associated metadata stores all relevant information regarding your experiment
- Specialized data analysis modules and publication quality graphics
- Rapid-response online AC line-frequency reduction
- Runs on Windows or Mac OS
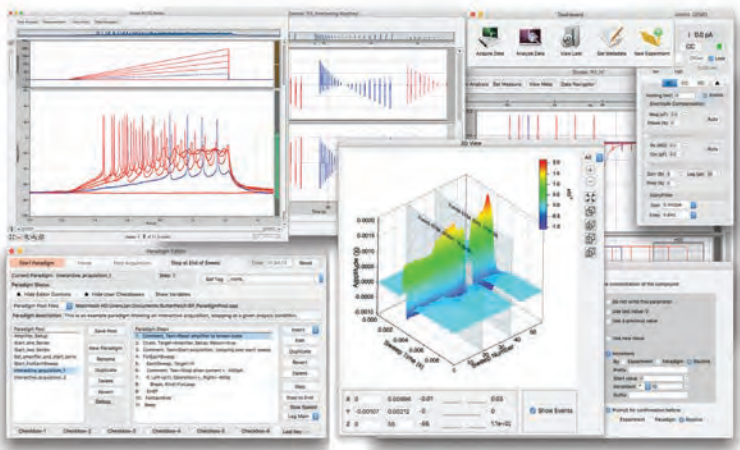
Screen shot of SutterPatch software

Optional IPA Patch Panel

The IPA and Double IPA Amplifiers come standard with an "octopus" breakout cable for auxiliary inputs and outputs, and digital outputs. The optional IPA Patch Panel, machined from ½ inch thick billet aluminum stock like the IPA faceplate, brings the auxiliary I/O connections to the front of the rack in a tidy 2U rack mount panel with BNC connectors.

The IPA Patch Panel includes a 2.5 ft (76 cm) connector cable and replaces the standard cable that ships with the IPA system.

IPA-PCH Patch Panel for tidy, convenient connection of peripherals at the front of the rack

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■ **Dimensions**
IPA®: 18.8 in x 11.8 in x 1.8 in / 48 cm x 30 cm x 4.5 cm
DOUBLE IPA®: 18.8 in x 11.8 in x 3.5 in / 48 cm x 30 cm x 9 cm
IPA® Headstage: 3.9 in x 1.4 in x 0.75 in / 10 cm x 3.5 cm x 1.9 cm
PATCH PANEL: 18.8 in x 2 in x 3.5 in / 48 cm x 5 cm x 9 cm

■ **Weight**
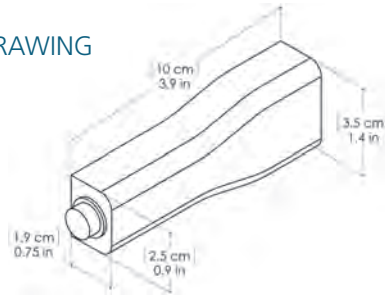*IPA®:* 9 lbs / 4 kg
DOUBLE IPA®: 8.1 lbs / 3.7 kg
PATCH PANEL: 3.5 lbs / 1.6 kg

■ **Electrical**
110/240 Volts / 50/60 Hertz power line

IPA HEADSTAGE DIMENSIONAL DRAWING

SYSTEM REQUIREMENTS

■ **Computer Hardware**
Minimum Configuration
Windows 10 (64-bit) or later, or
Mac OS X 10.11 (El Capitan)
Processor: Dual-core i5
Memory: 3 GB
Hard Disk: 500 GB or greater
Display Resolution: 1024 x 768 (XGA)
1 available USB 2.0 High-speed port

Recommended Configuration
Windows 10 (64-bit) or later, or
Mac OS X 10.11 (El Capitan) or later
Processor: Dual-core i5
Memory: 8 GB
Solid-state drive (SSD), 500 GB or greater
Display Resolution: 1920 x 1080 (FULL HD)
1 available USB 2.0 High-speed port

Notes:
USB 3.0 ports are compatible with USB 2.0 High-speed specifications.
Slower USB 2.0 'full-speed' ports, which are sometimes found on older Windows PCs
or USB add-in cards, are not supported.

IPA® / DOUBLE IPA®

*U.S. prices available at **www.sutter.com**. International prices vary by country. Contact a distributor or Sutter Instrument for a quotation. Prices subject to change without notice.*

■ **IPA**　　Includes: IPA® system with headstage, EH-P170 pipette holder, model cell, "octopus" break-out cable, rack mounting hardware, and SutterPatch® software suite with Igor Pro license.

■ **IPA-2**　　Includes: DOUBLE IPA® system with two headstages, two EH-P170 pipette holders, model cell, "octopus" break-out cable, rack mounting hardware, and SutterPatch software suite with Igor Pro license.

ACCESSORIES   IPA® / DOUBLE IPA®

PATCH PANEL

■ **IPA-PCH**　　Patch panel with 8 digital out / 4 aux. in / 2 aux. out BNC connectors, 19" x 2U rack format, D-Sub connecting cable, rack mounting hardware

PIPETTE HOLDERS

While polycarbonate is a proven material for patch pipette holders, it undergoes significant thermal expansion. Uneven warming may lead to motion of the pipette tip and is often incorrectly perceived as drift in the micromanipulator. Quartz has a significantly lower thermal expansion coefficient and virtually eliminates thermal drift. Note: Quartz is fragile and may crack or shatter on impact. Treat your quartz electrode holder with the same care you would with any optical component.

■ **EH-P170**　　Polycarbonate holder 1.0 mm to 1.7 mm O.D.

■ **EH-P170-S**　　Polycarbonate holder (short shaft) 1.0 mm to 1.7 mm O.D.

■ **EH-Q170**　　Quartz holder 1.0 mm to 1.7 mm O.D.

ACCESSORIES

■ **RACK-PK**　　Rack mounting hardware

■ **GP-17**　　Ground point

■ **GP-W10**　　Ground wiring kit (10 assorted cables, 5 alligator clips)

The Ground Point GP-17 provides reliable, low resistance connections for a star ground configuration, the proven method to avoid ground loops in any electrophysiology setup. Accepts 9 banana plugs + 8 bare wires up to 10 gauge or banana plugs. The GP-17 mounts directly on imperial or metric air table tops with the included ¼-20 and M6 screws. Made of solid, machined brass with plated banana/clamp connectors.

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DENDRITE™
DATA ACQUISITION, MANAGEMENT AND ANALYSIS SYSTEM

New

FEATURES DENDRITE™

- Data acuquisition with included SutterPatch® software ensures quickl and easy setup

- Eight analog inputs

- Four analog outputs

- Eight digital ouputs

- Trigger input and output

- Bundled SutterPatch® software excels in complete data management, intuitive navigation and streamlined data analysis

- Online adaptive AC line frequency reduction in SutterPatch® software

The conventional architecture of an electrophysiology system follows a three-tier structure consisting of an amplifier, a computer interface, and data acquisition software. Sutter Instrument's patch clamp amplifier systems, the IPA® Family and the dPatch® Amplifier systems combine these three tiers into convenient, fully integrated packages that include the increasingly popular SutterPatch® Data Acquisition, Management and Analysis Software. The Dendrite™ system meets the needs of customers who want to combine an existing amplifier with the functionality of SutterPatch software.

Featuring eight analog input signals, four analog output lines and eight digital outputs, at a sampling rate of up to 50 kHz, the Dendrite system covers the majority of electrophysiology applications. Independent 16-bit A-D and D-A converters constitute state-of-the-art technology that avoids crosstalk and provides adequate resolution for virtually all use case scenarios. Trigger input and output lines enable coordination with other equipment.

Connection to the computer is conveniently established through a High-speed USB 2.0 connection, and the installation of drivers and SutterPatch software is typically completed within minutes. The Dendrite system accepts input from the majority of patch clamp and other electrophysiology amplifiers that comply with the common standard of +/-10 V signal range. It also controls amplifiers and peripherals that accept analog or digital input according to common standards.

SUTTERPATCH SOFTWARE
The Dendrite and SutterPatch software systems have been engineered to let the user add information about instrument settings, stimulus application and external experiment parameters, and associate them in time with the raw data traces. This includes all acquisition settings, as well as timing and progress of the experiment. In addition, the experimenter can manually trigger tags to document events like stimulus application in instruments not connected to the Dendrite system.

Information about environmental parameters and a more detailed specification of sample properties can be recorded and stored with the raw data. A total of over 600 metadata attributes are supported. Examples include: animal species, genotype, date/time when a cell sample was prepared, recording solutions, pipette resistance, hardware properties, and detailed information about stimuli applied.

DATA VISUALIZATION AND ANALYSIS
SutterPatch software has been designed to simplify the navigation and analysis of complex datasets. The scope window supports multiple view modes in both two-dimensional and an innovative three-dimensional display. The 3D view is particularly useful during assay development. Built on top of the latest version of the proven Igor Pro platform, SutterPatch combines native Igor Pro functionality with a wealth of features that are tailored to electrophysiology applications. Both the newcomer and the experienced user of patch clamp programs will feel comfortable using SutterPatch software.

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Data Acquisition

- High-speed USB 2.0 connection controls data acquisition
- Up to 8 analog input channels (±10 V; 0.1–50 kHz sampling rate per channel)
- 4 analog output channels (±10 V)
- 8 digital output channels (TTL)
- Up to 400 kHz aggregate sampling rate
- Complex command waveforms
- Data acquisition can be initiated by an onboard microsecond clock or external (TTL) trigger

SutterPatch® Software

- Built on the foundation of Igor Pro (WaveMetrics, Inc.)
- Paradigms and Routines provide complete experimental control of program execution
- Waveform Editor for easy creation of even the most complex stimulus patterns or user-defined templates
- Associated metadata stores all relevant information regarding your experiment
- Specialized data analysis modules and publication-quality graphics
- Rapid-response online adaptive AC line-frequency reduction
- Runs on Windows 10 or later (64-bit), or Macintosh OS X 10.11 (El Capitan)

Application modules provide focused functionality for particular applications.

- Action Potential Analysis Module: Phase plane plot, timing and waveform statistics
- Event Detection Module: A deconvolution algorithm that excels at detecting miniature synaptic events, even on a noisy background
- Single-channel Analysis Module: All-points histogram, idealized trace, duration and amplitude distribution and scatter plot
- Camera Module: An easy way to document the identity and condition of the recorded cell
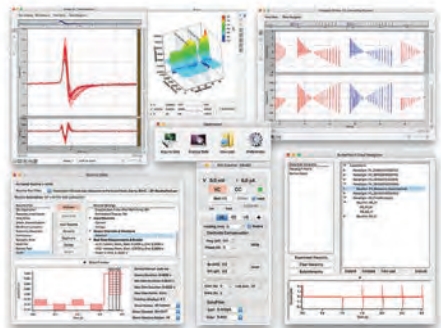
Screenshot of SutterPatch Software

SPECIFICATIONS DENDRITE™

■ **Dimensions**   18.8 in x 11.8 in x 1.8 in
48 cm x 30 cm x 4.5 cm

■ **Weight**   5 lbs
2.3 kg

■ **Electrical**   110/240 Volts
50/60 Hertz power line

$C\epsilon$

SYSTEM REQUIREMENTS

■ **Computer Hardware**

Minimum Configuration

Windows 10 or later: 64-bit versions, or Mac OS X 10.11 (El Capitan) or later
Processor: Dual-core i5
Memory: 3 GB
Hard Disk: 500 GB or greater
Display Resolution: 1024 x 768 (XGA)
1 available USB 2.0 High-speed port

Recommended Configuration

Windows 10 or later: 64-bit versions, or Mac OS X 10.11 (El Capitan) or later
Processor: Dual-core i5
Memory: 8 GB
Hard Disk: 500 GB or greater
Display Resolution: 1920 x 1080 (Full HD)
1 available USB 2.0 High-speed port

SUTTERPATCH® Data Acquisition Management System and Analysis Software: Included with all Sutter Instrument Amplifier Systems

Notes:

USB 3.0 ports are compatible with USB 2.0 High-speed specifications.
Slower USB 2.0 'full-speed' ports, which are sometimes found on older Windows PCs or USB add-in cards, are not supported.

To check for High-speed USB 2.0 or USB 3.0 on a PC computer running Windows, look in the Control Panel > Device Manager > Universal Serial Bus controllers section for "Enhanced" host controllers. As this does not provide any mapping information to the computer's physical ports, and there can be a mix of USB port versions, you should check individual USB ports for USB 2.0/3.0 High-speed operational performance. As a visual indicator, USB 3.0 ports are often color coded blue.

USB hubs are not supported. USB add-in cards, even if they formally meet High-speed or SuperSpeed specifications, are not recommended. They are often architecturally configured as USB hubs and may lead to intermittent transfer errors that are hard to troubleshoot.

Operating systems installed within virtualization software platforms such as VMware and Parallels are not supported.

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DENDRITE™

■ **DENDRITE**   Dendrite Data Acquisition, Management and Analysis System w/ SutterPatch Software and Igor Pro license

ACCESSORIES DENDRITE™

PATCH PANEL

■ **IPA-PCH**   Patch panel with 8 digital out / 4 aux. in / 2 aux. out BNC connectors, 19" x 2U rack format, D-Sub connecting cable, rack mounting hardware

PIPETTE HOLDERS

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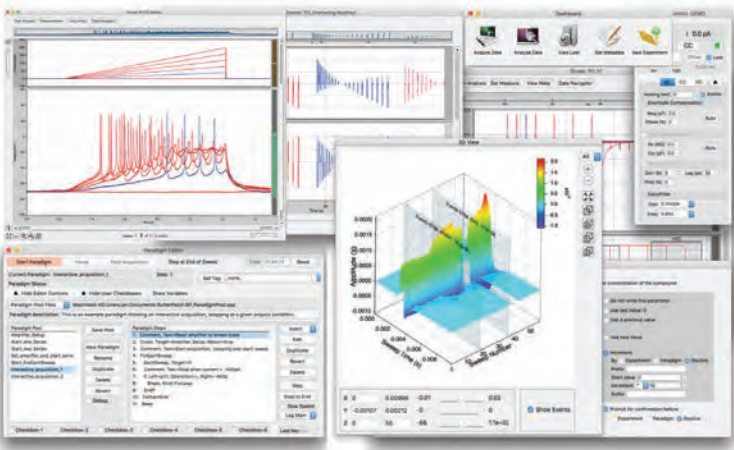
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SUTTERPATCH®
DATA ACQUISITION, MANAGEMENT AND ANALYSIS SOFTWARE

New Feature

Screen shot of SutterPatch software

FEATURES   SUTTERPATCH®

- Support for all Sutter Instrument amplifier systems, including the dPatch® Digital Patch Clamp Recording System

- *New:* Fully-integrated dynamic clamp interface with update rates up to 500 kHz

- Scope Window provides intuitive, efficient navigation through your data

- Routines control data acquisition with or without application of command waveforms

- Line frequency reduction

- Paradigms enable process automation and eliminate operator bias

- The Data Navigator displays the entire experiment in a tree structure

- Real-time and off-line analysis, including mini / synaptic event detection and action potential characterization

SutterPatch® software is a full-featured electrophysiology data acquisition, management and analysis application for Windows or Mac OS computers. SutterPatch comes bundled with all Sutter Instrument Patch Clamp Amplifier Systems. The software controls data acquisition, provides real-time measurements to aid decision making during the experiment, keeps track of all amplifier parameters, records the experimental progress and stores a set of up to 600 metadata parameters. Built within the latest version of Igor Pro by WaveMetrics, Inc., SutterPatch provides immediate access to Igor's powerful scientific and engineering analysis tools.

Version 2 of SutterPatch software adds support for the new dPatch® Digital Patch Amplifier System as well as a multitude of new features and user interface improvements that also apply to the IPA Family of Amplifier Systems. The Membrane Test and Free Run have been upgraded. New triple slider and 2D-matrix controls facilitate compensation adjustments in the Amplifier Control Panel.

Particular emphasis was put into intuitive navigation through large data sets. Controls that are familiar from electrophysiology software or applications in other fields, as well as entirely new approaches make finding a particular section of an experiment very easy.

The structured architecture of the data files was designed to retain the context of every sample within an experiment. With little effort at the beginning of an experiment, a plethora of metadata parameters are recorded – automatically where possible, configured by the user where desired. Each parameter can be reviewed before a Paradigm or Routine is executed.

SutterPatch software comes with a collection of sample Paradigms and Routines that facilitate the configuring of commonly executed experimental scenarios.

SutterPatch provides real-time analysis capability that creates graphs like I-V curves or a time course plot while the experiment is in progress. Up to 8 analysis graphs can be shown, each derived from 16 possible measurements from the input signals. Analyses include mean, slope, rise time, frequency of threshold crossing, etc. This facilitates making decisions about the further course of an experiment.

In addition to real-time analysis, SutterPatch supports further processing after the experiment for the most sophisticated analysis procedures and adds application-specific capabilities on top of the expansive analysis feature set that is native to Igor Pro. Equations and Variables facilitate the use of more complex algorithms in both Routines and Paradigms.
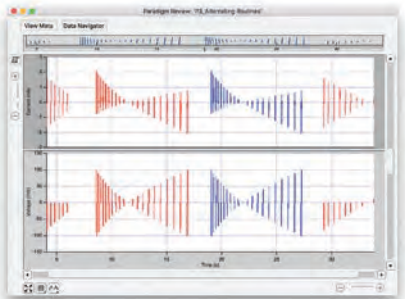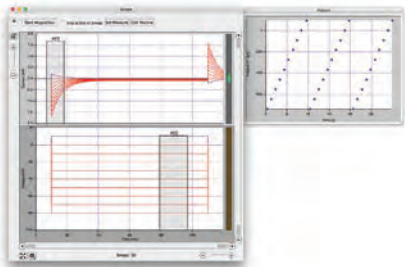
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FEATURE HIGHLIGHTS

- ◼ Scope Window provides intuitive, efficient navigation through your data
  - • Zoom control buttons and sliders
  - • Drag along axis to zoom in
  - • Mouse wheel zoom
  - • Marquee zoom
  - • Scroll bars
  - • Continuous and snapshot autoscale
  - • Sweep, time course and concatenated display
  - • Novel 3D display
  - • Unique Overview Navigator for panoramic examination of and convenient movement within a data section
  - • Paradigm Review window gives quick access to individual Routine Data

- ◼ Membrane Test keeps track of cell health and other quality control parameters
  - • Waveform types include double pulses, sine and triangle trains and instantaneous RMS noise measurement.
  - • Simultaneous display of up to two amplifier or auxiliary input signals and a command waveform.
  - • Test pulse parameters fully configurable
  - • Pulse averaging
  - • Audio monitor

- ◼ Routines control data acquisition with or without application of command waveforms
  - • Sample Routine Pool with pre-configured Paradigms for many common applications
  - • Hard-wired signals from Sutter Instrument hardware and auxiliary input signals are recorded
  - • The command signal as applied to the cell is monitored and recorded
  - • Analog and digital output signals control peripherals and third-party information
  - • Up to 50 Segments per Sweep for utmost flexibility in shaping the most complex command waveforms
  - • Preconfigured Segment shapes, such as Sine, Square and Chirp, for easy waveform design
  - • Waveform Template enables "playback" of a recorded signal to a cell or applying a mathmatical expression as a waveform
  - • Measurements provide the basis for real-time analysis and enable decision making in the course of the experiment

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- Paradigms enable process automation and eliminate operator bias
  - Sample Paradigm Pool with pre-configured Paradigms for many common applications
  - Configure the amplifier to reproducible standard settings
  - Acquisition of Routine sequences enables pre-planned experimentation and minimizes operator bias
  - Flow control for interactive or automated decision-making during the experiment
 - Chaining Paradigms provides added flexibility
  - Automatic creation of Layouts for standardized documentation
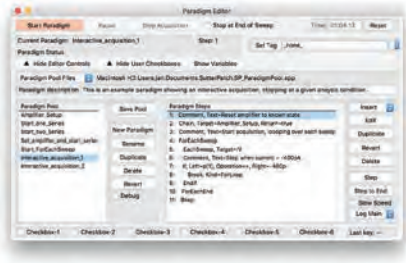
- The Solution Editor lets you keep track of solutions and compounds, and supports direct control of a solution switcher
  - Initial conditions and all solution changes are automatically written to the MetaData
  - Analog or digital outputs control all common solution switchers

- The Data Navigator displays the entire experiment in a tree structure
  - Preview of the first acquired signal
  - Quick access to Paradigm Review, Reanalysis Scope, Metadata and Routine information
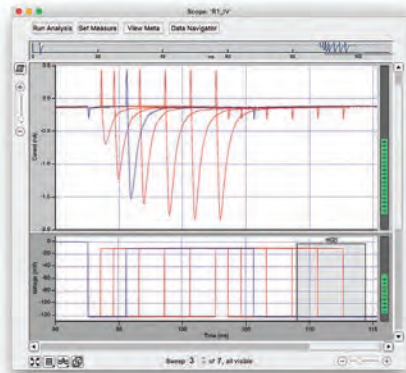
- Real-time and off-line analysis
  - Measurements configured as part of Routines create real-time graphs
  - Virtual signals provide the user with information derived from physical input signals, mathematical equations, signal modification, or any combination thereof. High- and low-pass filters, lock-in amplifier capability and subtraction of a reference sweep are new in version 2.
  - Paradigms can access measurements for further real-time analysis
  - Equations and variables provide utmost flexibility
  - Event detection using a high-performance, deconvolution-based algorithm
  - Easily exports data to Microsoft Excel and other spreadsheet programs for compatibility with existing analysis procedures
  - A wealth of native Igor Pro analysis features

- Support for IPA multi-amplifier mode
  - A combination of any two IPA® or Double IPA® Amplifiers can be connected
  - Up to 16 input channels are supported

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SUTTERPATCH®

■ **SUTTERPATCH**   Data Acquisition Management
System and Analysis Software

**Included with
all Sutter Amplifier
Systems**

Notes:

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