NEUROSCIENCE TOOLS

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Introducing
Digital Clamp One™

Electrophysiology Clamping Amplifier

Introducing **Digital Clamp One™** from **NEUROSCIENCE TOOLS**

A NEW PLATFORM FOR CONDUCTING ION CHANNEL EXPERIMENTS

Digital Clamp One™ with Dual Headstages and Laptop. Available with 4 Headstages.

Developed with SBIR NS48682 from NINDS

Capabilities include changing clamping modes dynamically, without transients, implementing sophisticated and/or model-based control algorithms, and creating artificial connections between neurons. This instrument and its headstages can implement the following functions:

- Conductance Clamping (Dynamic Clamping) that can:
  - introduce an artificial conductance into a neuron and/or
  - artificially connect two neurons
- Voltage Clamping: Two Electrode, or Continuous or Intermittent Single Electrode
- Sophisticated Control Algorithms (such as detect then trigger intermittent voltage clamp)
- Current Clamping
- Whole Cell Preparations, or Single Channel Preparations
- Digital Filtering (built-in digital filter bank)
- Dynamic Mode Switching in Response to Real-Time Measurements
  - voltage, current, or conductance clamp
- Two or Four Headstage Models Available
- Ethernet Connection to the Computer at 100 MBPS
- Daisy chain to other **Digital Clamp One™**s Controlled from the Same Computer

Digital Clamp One™ will provide neuroscientists with a new kind of platform for conducting ion channel experiments.

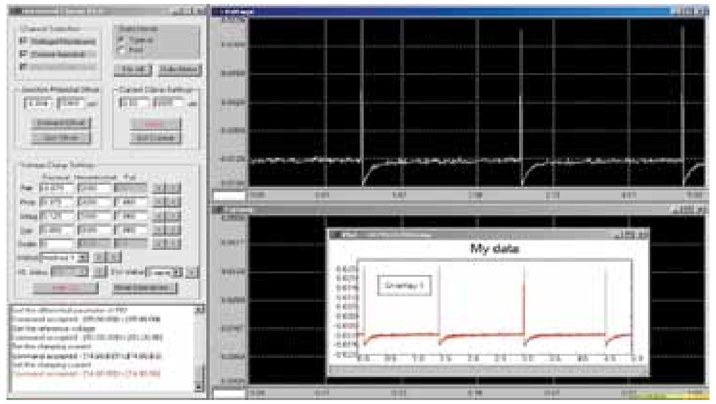

Fig. 1. Above: Software Screen. Below: Back of Digtial Clamp One

Digital Clamp One™ is the first clamping amplifier available with fast digital feedback implemented with a front-end digital signal processor without relying on the host PC. Digital signal processors have only recently become fast enough to fulfill this function in real time, and allow for digital processing of the fastest neuronal signals.

Since the **Digital Clamp One™** is an all-digital device, it has capabilities that are just not possible using standard analog feedback voltage clamps. These include Dynamic Clamping at a fast rate and Single Electrode Intermittent Clamping.

The **Digital Clamp One™** modules communicate through an Ethernet network. The number of headstages is scalable to satisfy the requirements for specific electrophysiological experiments. The Ethernet connector may be daisy chained to multiple **Digital Clamp One™** units controlled from one host computer.

DYNAMIC CLAMPING USING THE DIGITAL CLAMP ONE™

This instrument has been used, as one example of its novel capabilities, to force a second neuron to fire in synchrony with a recorded neuron (Figure 2).

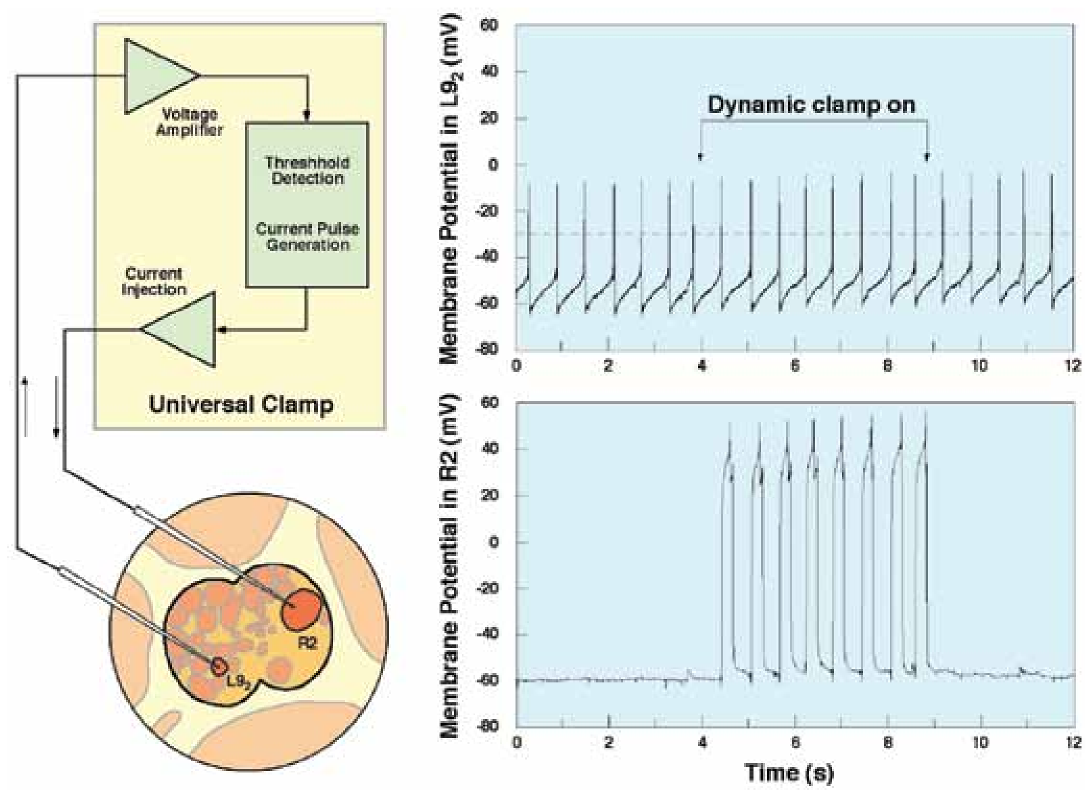

Fig. 2. A graphical representation of the visceral ganglion of the gastropod *A. californica* depicting two uncoupled neurons being connected by the Digital Clamp One. Right, the Digital Clamp successfully forces a silent neuron to beat in synchrony with the driving neuron.

Figure. 2 illustrates that **Digital Clamp One™** is capable of forcing a silent neuron to fire action potentials in synchronization with another beating neuron. The on-board DSP of the **Digital Clamp One™** makes it possible to respond to fast neuronal action potentials. The powerful DSP enables real-time algorithms capable of filtering noise or imposing sophisticated neuronal models.

SINGLE-ELECTRODE INTERMITTENT VOLTAGE CLAMPING WITH THE DIGITAL CLAMP ONE™

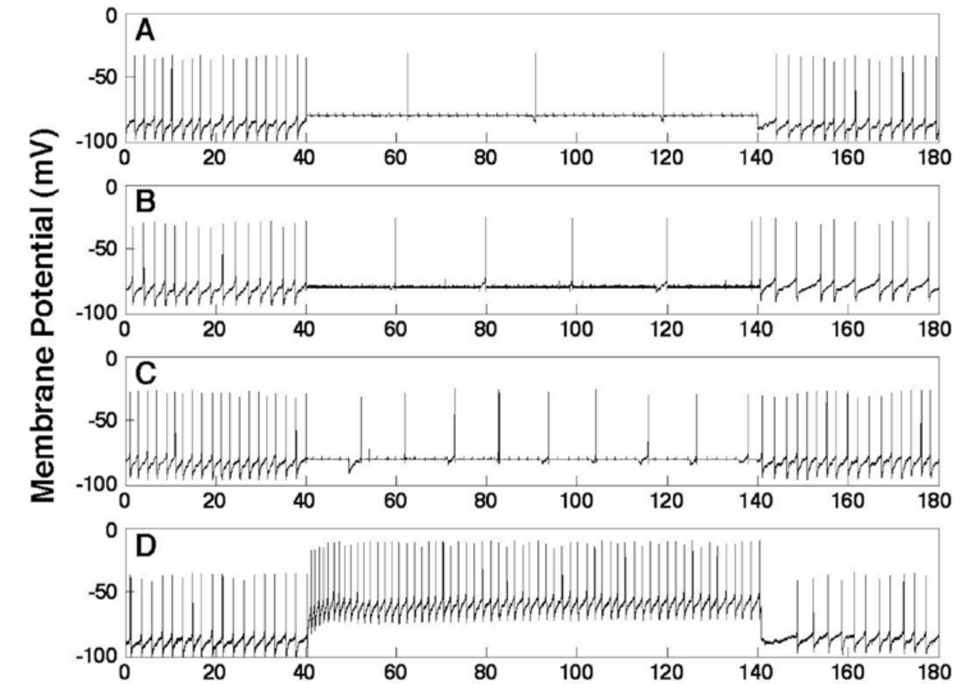

Fig. 3. Intermittent voltage clamp (IVC) on a beating neuron of *L.stagnalis*. The firing rate of action potentials was reduced with three different settings (A, B, and C). During IVC the voltage was clamped to the original membrane potential. For comparison, panel D shows a current clamp that the firing rate was changed in association with a change in the membrane potential.

Traditional voltage clamping requires two electrodes in the same cell, one to measure and one to respond to the measurement with current to maintain the desired voltage. However, it is not always possible to use two electrodes, for example in small cells, or cells below the surface in a living brain. Two methods to use a single electrode have been developed, but have significant drawbacks compared to the two electrode model. Continuous Single Electrode recording sets a voltage to clamp, and records how much current is needed.

The electrical properties of the electrode, both resistance and capacitance, become critical to the measurement and must be kept as low as possible, and not changed. Deep in brain, capacitance will be large and vary with depth. With discontinuous, or intermittent voltage clamping, the same electrode is used to alternately pass current, then, after resulting transients have settled, to record a reading. Duty cycle must be set on a switch, and may be too fast and cause oscillatory ringing, or slow and lose data.

DISCONTINUOUS VOLTAGE CLAMPING

The **Digital Clamp One™** can perform discontinuous voltage clamping with a single electrode without a fixed duty cycle switch. Being all digital enables a patented internal software switching method that collects the data when the transients have settled. The extremely fast sampling rate means as little time as possible passes between collections.

SUMMARY

The **Digital Clamp One™** One is capable of performing the following: 1) traditional voltage clamp and current clamp, 2) dynamic clamp that bridges two neurons, 3) single-electrode voltage clamp using a novel software-switched method, and 4) sophisticated control algorithms such as detect-then-trigger control and intermittent voltage clamp. All these capabilities in a single instrument opens up a world of new experiments possible in your lab.

Covered by U.S. Patents: Sun Y, Wu J, Collis L, Hill RB. Apparatus for neuromuscular measurement and control. US Patent No. 7,489,965 B2, February 10, 2009. Sun Y, Wu J, DiCecco J, Hill RB. Processor controlled voltage-current analysis of nerve and muscle tissues. US Patent No. US 8,000,783 B2, August 16, 2011.