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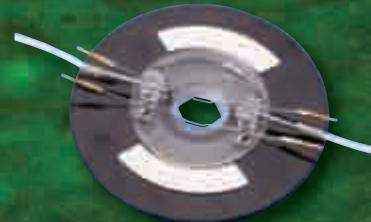




# Cell Biology Research Catalog



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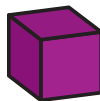
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# electrophysiology

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# PC-505B

## Patch Clamp

# patch clamp

*The lowest noise, switchable, resistive-feedback patch clamp amplifier currently available*



- Lowest noise — approaching theoretical limit
- Calibrated Cap Comp and Series R circuitry
- % Compensation circuitry
- Independent V hold and I hold controls
- Zap safety switch
- LED meter
- 3 year warranty

The PC-505B is the lowest noise, switchable, resistive-feedback patch clamp amplifier available. This model also has features of particular interest to those doing whole cell studies. The slow capacitance compensation circuitry has been combined into a single control and allows direct measurement of membrane capacitance. The companion Series R control displays the access resistance and the new % correction circuit compensates up to 90% of the access resistance. These and other features make the PC-505B an extremely capable amplifier.

### Switching Headstages

Two selectable feedback resistors in the headstages permit single channel and whole cell recording on the same cell. A 50 G $\Omega$  resistor is used in both switching models for low noise single channel recording with currents to 200 pA.

#### LC-201B Headstage (50 G $\Omega$ /500 M $\Omega$ )

This headstage with 500 M $\Omega$  feedback resistor will handle whole cell currents up to 20 nA.

#### HC-202B Headstage (50 G $\Omega$ /50 M $\Omega$ )

For larger whole cell currents, the 50 M $\Omega$  resistor in this headstage permits currents up to 200 nA.

### Bilayer Headstage

#### W4-205B Bilayer Headstage (50 G $\Omega$ /500 M $\Omega$ modified)

The 50 G $\Omega$  resistor headstage is modified for artificial bilayer capacitances up to 250 pF.

### Headstage Resistor Selection

Headstage feedback resistance is dynamically switched at the amplifier front panel. LED's indicate resistor selection and the corresponding multiplying factor applied to the current gain [Im] switch setting.

### Operating Modes

The PC-505B has three modes of operation: voltage clamp, zero current clamp, and current clamp.

#### V Clamp

In voltage clamp mode, the input range is  $\pm 1$  V. Active commands (V hold, junction and auto zero, test pulse, zap) and external inputs are scaled and summed at the headstage input. Capacity compensation and speed test are also active.

#### I<sub>o</sub>

Zero current is essentially a standby mode used to preset voltage hold or current hold levels before switching to voltage or current clamp. All commands are inactive with the exception of junction zero which, in this case, functions as an offset control for the electrode and tip potentials associated with the pipette.

#### I Clamp

Current clamp mode clamps the cell to a current level determined by the current hold setting and any external commands. Capacitance compensation is inactive in this mode.

### Commands

Voltage and current commands applied to the cell include: voltage and current hold, junction and auto zero, test pulse, speed test, and zap.

#### V & I Hold

Holding potentials and currents are set with separate controls eliminating the need to reset levels when switching between voltage and current clamp modes.

#### Junction & Auto Zero

Adjusting for offset potentials is performed with either the manual junction zero control or with auto zero. The offset potential is read on the meter or at the V<sub>c</sub> x10 output.

#### Test Pulse & Speed Test

Test Pulse and Speed Test are internally generated 50/60 Hz signals. Test pulse is attenuated by the command sensitivity and is useful for monitoring the formation of a gigaseal. The speed test signal is applied to the headstage input to allow for tuning the headstage response. A rear panel speed test switch allows for an external signal to be used.



## PC-505B

### Patch Clamp (continued)

#### Zap

Variable duration pulse used to rupture the cell membrane for whole cell recording.

Signals applied to the command input are attenuated at one of three levels with the command sensitivity selector.

#### Capacitance & Resistance Compensation: Fast Compensation

Stray capacitance between the input and electrode resistance is compensated with two pair of controls, C-Fast 1 and C-Fast 2. Amplitude and time constant of each pair is independently adjustable. Whole cell capacitance compensation is adjusted with the single control, C-Slow. Membrane capacitance is read from the C-Slow calibrated dial. The companion Series R control is used in conjunction with the C-Slow and its calibrated dial provides a reading of the access resistance. C-Slow may be disabled to view the uncompensated signal. The % Correction control is used to increase the command signal to compensate for the voltage drop across the access (Series R) resistance. Correction is adjustable up to 90%.

#### Outputs

Signals at the Im output are filtered at the selected cutoff frequency set with the 4-pole Bessel filter. Selecting Bypass presents the full bandwidth signal to the Im output. Filtered and unfiltered Im output is also available at the instrument rear panel. Additional outputs are the membrane voltage Vm x10 and the sum of the voltage commands Vc x10, both at x10 gain.

#### Voltammetry with PC-505B

PC-505B functions as an excellent low-noise potentiostat for voltammetric and other electrochemical measurements. In this mode, the V hold (electrode potential) is increased to a maximum of  $\pm 1$  volt and the maximum external command signal to  $\pm 2$  volts at electrode or sensor.

#### Specifications

##### Headstages:

###### LC-201B Headstage (50 G $\Omega$ /500 M $\Omega$ )

Single channel currents to 200 pA, whole cell currents to 20 nA.

###### HC-202B Headstage (50 G $\Omega$ /50 M $\Omega$ )

Single channel currents to 200 pA, whole cell currents to 200 nA.

###### W6-205B Bilayer Headstage (50 G $\Omega$ /500 M $\Omega$ modified)

For artificial bilayer capacitances up to 250 pF, currents to 20 nA.

##### Noise (referred to input)

Measured with an 8-pole Bessel filter, input open, 50 G $\Omega$  resistor:

DC to 1 kHz	0.035 pA RMS
DC to 5 kHz	0.150 pA RMS

Bandwidth	25 kHz
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##### Voltage Clamp Commands:

Command In BNC	$\pm 10$ V Max, AC or DC, applied to input
Voltage Hold	$\pm 200$ mV Max with 10-turn control
Junction Zero	$\pm 100$ mV Max with 10-turn control
Internal Test Pulse	1 V 50/60 Hz (line freq.) square wave attenuated by Command Sensitivity
Command Sensitivity	x0.1, x0.01, and x0.001
Zap	1.0 V Pulse, adjustable duration from 0.1 to 10 msec

##### Current Clamp Commands:

Command In	$\pm 1000$ pA max with Command Sensitivity @ x0.1 $\pm 100$ pA max with Command Sensitivity @ x0.01 $\pm 10$ pA max with Command Sensitivity @ x0.001
Current Hold	$\pm 1$ nA with 10-turn control
Internal Test Pulse	1 nA 100 Hz square wave through Command Sensitivity
Command Sensitivity	x 0.1, x 0.01, and x 0.001

#### Specifications (continued)

Fast Capacitance Compensation (Voltage Mode):	
C Fast 1	0.1 to 1.75 $\mu$ sec, 0 to 5 pF
C Fast 2	0.33 to 8.5 $\mu$ sec, 0 to 15 pF
Whole Cell Compensation:	
C Slow	0-100 pF with 10 turn control
Series R	0-10 M $\Omega$ with 10 turn control
% Correction	0-90% of Series R
Leak Subtraction	50 G $\Omega$ Headstage Resistor $\infty$ to 50 G $\Omega$ 500 M $\Omega$ Headstage Resistor $\infty$ to 500 M $\Omega$ 50 M $\Omega$ Headstage Resistor $\infty$ to 50 M $\Omega$
Front Panel Outputs: Im (membrane current), selected in the range of: Gains of 0.05 to 10 mV/pA with 50 M $\Omega$ headstage resistor Gains of 0.5 to 100 mV/pA with 500 M $\Omega$ headstage resistor Gains of 5 to 1000 mV/pA with 50 G $\Omega$ headstage resistor	
Vc x10	Summation of all commands amplified by 10
Vm x10	Membrane voltage amplified by 10
Im Low-Pass Filter	0.05, 0.1, 0.2, 0.5, 1, 2, 5, 10, 20 kHz and Bypass (4-Pole Bessel)
Panel Meter: 3 $\frac{1}{2}$ Digit LED reads (full scale):	
Junction Zero	$\pm 199.9$ mV
Vc + h In	Sum of all commands and V Hold, $\pm 199.9$ mV
Vc	Sum of all commands, $\pm 199.9$ mV
Vm	Membrane voltage (current clamp mode) $\pm 199.9$ mV
Im	Membrane current, $\pm 1999$ pA
RMS Noise	1.999 pA
Rear Panel Outputs:	
Gain Telegraph	From 0.5 to 7.0 V in 0.5 V steps.*
Filter Telegraphs	From 0.2 to 2.0 V in 0.2 V steps.*
Im/Vm Telegraph	Logic levels, V-Clamp=1, I-Clamp=0
Sync Out	Signal for synchronizing an oscilloscope to internal test
Power Requirements	110 to 130 or 220 to 250 VAC, 50/60 Hz, 15 VA
Physical Dimensions:	
Main Unit	8.9 x 43.2 x 30.5 cm, H x W x D
Headstage	1.9 x 3.5 x 5.7 cm, H x W x L, with 1.8 m cable
Mounting Rod	6.3 mm D x 6.3 cm cm L
Shipping Weight	11.4 kg
Warranty	Three years, parts and labor

\* Compatible with Axon pClamp and Heka PatchMaster.

#### Order # Model Product

##### Line operating voltage if other than 100-130 VAC.

W4 64-0000	PC-505BLC	Patch Clamp PC-505B with LC-201B Headstage*
W4 64-0001	PC-505BHC	Patch Clamp PC-505B with HC-202B Headstage*
W4 64-0002	PC-505BHB	Patch Clamp PC-505B with HB-205B Bilayer Headstage*

\* Supplied with model cell and rack mount hardware.

#### Additional/Replacement Headstages

W4 64-0004	LC-201B	50 G $\Omega$ /500 M $\Omega$ Headstage
W4 64-0005	HC-202B	50 G $\Omega$ /50 M $\Omega$ Headstage
W4 64-0006	HB-205B	50 G $\Omega$ Headstage for Bilayer

#### Electrode Holders for PC-501A and PC-505B

W4 64-0821	QSW-A10P	Straight Holder 1.0 mm glass OD
W4 64-0822	QSW-A12P	Straight Holder 1.2 mm glass OD
W4 64-0823	QSW-A15P	Straight Holder 1.5 mm glass OD
W4 64-0978	QSW-A17P	Straight Holder 1.7 mm glass OD
W4 64-0824	QSW-A20P	Straight Holder 2.0 mm glass OD

# PC-501A

## Patch Clamp

# patch clamp

*A workhorse patch clamp amplifier equally at home in research and teaching labs*



- Independent V Hold and I Hold
- Stability in Current Clamp with selection of three I Clamp response speeds
- 4-Pole low-pass Bessel filter
- Internally generated test signals
- Zap circuit with variable duration

The PC-501A Patch Clamp is a “workhorse” equally at home in research and teaching labs. Most single channel and whole cell studies are easily handled with this modestly priced instrument.

With a choice of four headstages, a wide range of patch, whole cell and bilayer applications are covered.

### Headstage Choices

Four resistive-feedback headstages are available for the PC-501A:

- 5101-10G (10 G $\Omega$ ) headstage for recording single channel currents up to  $\pm 1$  nA. Noise level measured at 1 kHz is 60 fA.
- 5101-01G (1 G $\Omega$ ) headstage for whole cell studies with currents to  $\pm 10$  nA.
- 5101-100M (100 M $\Omega$ ) headstage for whole cell studies with currents to  $\pm 100$  nA.
- 5101-10GB (10 G $\Omega$ ) headstage modified for bilayer capacitances up to 250 pF. Maximum current is  $\pm 1$  nA.

### Operating Modes

- V Clamp Mode: Input is clamped to a maximum of  $\pm 1$  V. Commands are the sum of the holding voltage and any external input signals.
- Zero Current Mode: Bridges the voltage and current clamp modes. All commands are inactive except the junction zero, which functions in this case as an offset control for the electrode and tip potentials associated with the pipette.

- I Clamp Mode: In current clamp mode, active commands are the current hold and any external command input signals, summed. Clamp stability is enhanced with the selection of three clamp speeds.

### Compensation Controls

- Voltage Offsets (including junction potentials): are automatically compensated with the auto zero or manually with the junction zero.
- Capacity Compensation: Paired controls; fast (0-5  $\mu$ sec), medium (0-2 msec) and slow (0-20 msec) compensate the current transient caused by a step command signal. Each pair has a separate control for amplitude and time constant.
- Series Resistance: Signal errors contributed by the electrode (access) resistance in whole cell recording are subtracted from the output with the series R comp control. The compensated resistance (0-100 M $\Omega$ ) is read from a 10-turn dial.
- Leak Subtraction: Used to compensate leakage current due to the voltage drop across the seal (shunt) resistance.

### Outputs/Signal Conditioning

The I<sub>m</sub> signal is bandwidth limited by a 4-pole Bessel filter with six frequency cut-offs and can be bypassed to obtain the full 10 kHz bandwidth. Gain is selected with a 7 position switch and scaled to the headstage resistor.

Additional outputs are  $V_m \times 10$  (membrane voltage at x10 gain) active in current clamp mode and  $\sum V_c \times 10$  (the sum of all commands at x10 gain). Rear panel outputs include; gain telegraph and sync output.

### Voltammetry with PC-501A/V

A simple modification to the PC-501A makes it suitable for voltammetric measurements. This includes increasing the holding voltage potential to  $\pm 1$  V and the external voltage signal level to  $\pm 2$  V maximum. Internal switches can be installed to allow switching between normal [patch] and voltammetry operation. Contact our technical support department for details.



# PC-501A

## Patch Clamp (continued)

### Specifications

Headstages:	
5101-10G Headstage	With 10 GΩ resistor for single channel recording, maximum current ±0.8 nA*
5101-01G Headstage	With 1 GΩ resistor for whole cell currents to ±8 nA*
5101-100M Headstage	With 100 MΩ resistor for whole cell currents to ±80 nA*
5101-10GB Headstage	With 10 GΩ modified for bilayer capacitances up to 250 pF Maximum current is ±1 nA
Noise:	
Measured with an 8-pole Bessel filter and 10 GΩ headstage, input open.	
DC to 1 kHz	0.06 pA RMS
DC to 5 kHz	0.20 pA RMS
DC to 10 kHz	0.40 pA RMS
High Frequency Boost	Increases bandwidth to 10 kHz. Front panel adjustable with Speed Test for 1 GΩ and 10 GΩ headstages
Voltage Clamp Commands:	
Command Input	Applied voltage attenuated by Command Sensitivity, Max input ±10 V
Command Sensitivity	Attenuates CMD IN by x0.1, x0.01 or x0.001.
V Hold	Adjustable from zero to ±200 mV with 10 turn control.
Junction Zero	Adjustable between ±100 mV with 10 turn control.
Test Pulse	100 Hz square wave, amplitude at the electrode dependent on Command Sensitivity;
	100 mV @ x0.1
	10 mV @ x0.01
	1.0 mV @ x0.001
Zap	1.5 V pulse with duration adjustable from 0.1 to 10 msec
Current Clamp Commands:	
Command Input	±1.0 nA max. with Command Sensitivity @ x0.1 ±100 pA max. with Command Sensitivity @ x0.01 ±10 pA max. with Command Sensitivity @ x0.001
Series Resistance	Zero to 100 MΩ, read from 10 turn digital dial
Compensation Capacity	Three ranges with amplitude and time constant
Compensation	Fast (0-5 μsec), Medium (0-2 msec), Slow (0-20 msec)
Leak Subtract	Adjustable from ∞ to 10 GΩ for 10 GΩ headstage, ∞ to 1 GΩ for 1 GΩ headstage, ∞ to 100 MΩ for 100 MΩ headstage
Im Output Low Pass Filter	4 pole Bessel with -3 dB frequencies at 0.1, 0.2, 0.5, 1, 2, and 5kHz. Bypass allows full 10 kHz bandwidth
Outputs:	
Im (membrane current)	Gain is adjustable, in the range of: 10 to 1000 mV/pA with 10 GΩ headstage 1 to 100 mV/pA with 1 GΩ headstage 0.1 to 10 mV/pA with 100 MΩ headstage
Vc x10	Sum of all commands (Vc +h, Junction Zero, Auto Zero and Series R) x 10
Vm x10	Membrane Voltage x 10
Gain Telegraph	DC voltage scaled to Im:
Output (rear panel)	From 3.0 to 4.2 Volts for 10 GΩ headstage, 0.2 V steps From 1.6 to 2.8 Volts for 1 GΩ headstage, 0.2 V steps From 0.2 to 1.4 Volts for 100 MΩ headstage, 0.2 V steps Compatible with acquisition software.*
Panel Meter	3½ digit LCD provides DC or average readout of:
Vc + h In	Sum of all commands and V Hold, ±199.9 mV
∑ Vc	Sum of all Commands, ±199.9 mV
Vm	Membrane voltage (current clamp mode) ±199.9 mV
Im	Membrane Current, ±1999 pA
Power Requirements	100 -130 VAC or 220-240 VAC, 50/60 Hz, 10 VA

# patch clamp

### Specifications (continued)

Physical Dimensions:	
Control Unit	13.3 x 43.2 x 25.4 cm, H x W x D
Headstage	5.7 x 2.9 x 2.5 cm, H x W x L, with 1.8 m long cable
Detachable Mounting Rod	6.2 mm dia x 6.3 cm L
Shipping Weight	11.4 kg (25.1 lbs)
Warranty	Three years, parts & labor

\* Output volt maximum 8V/Rf

\*\* Molecular Devices pClamp and Heka PatchMaster.

Order #	Model	Product
W4 64-0007	PC-501A/10	Patch Clamp PC-501A with 5101-10G Headstage (10 GΩ)
W4 64-0008	PC-501A/9	Patch Clamp PC-501A with 5101-01G Headstage (1 GΩ)
W4 64-0009	PC-501A/8	Patch Clamp PC-501A with 5101-100M Headstage (100 MΩ)
W4 64-0010	PC-501A/10B	Patch Clamp PC-501A with 5101-10GB Bilayer Headstage
W4 64-0012	PC-501AV/9	Patch Clamp PC-501A for Voltammetry with 5101-01G Headstage (1 GΩ)
W4 64-0013	PC-501AV/8	Patch Clamp PC-501A for Voltammetry with 5101-100M Headstage (100 MΩ)

Supplied with rack mount hardware. Electrode Holder must be purchased separately based on your glass outer diameter.

Also, specify line operating voltage if other than 100-130 VAC.

### Electrode Holders for PC-501A and PC-505B

W4 64-0821	QSW-A10P	Straight Holder 1.0 mm glass OD
W4 64-0822	QSW-A12P	Straight Holder 1.2 mm glass OD
W4 64-0823	QSW-A15P	Straight Holder 1.5 mm glass OD
W4 64-0978	QSW-A17P	Straight Holder 1.7 mm glass OD
W4 64-0824	QSW-A20P	Straight Holder 2.0 mm glass OD

### Additional/Replacement Headstages

W4 64-0014	5101-10G	Headstage with 10 GΩ Resistor
W4 64-0015	5101-01G	Headstage with 1 GΩ Resistor
W4 64-0016	5101-100M	Headstage with 100 MΩ Resistor
W4 64-0017	5101-10GB	Headstage with 10 GΩ Resistor for Bilayer

### Optional Accessories

W4 64-0018	MC-10G	Model Cell for 5101-10G (10 GΩ) Headstage
W4 64-0019	MC-01G	Model Cell for 5101-01G (1 GΩ) Headstage
W4 64-0020	MC-100M	Model Cell for 5101-100M (100 MΩ) Headstage
W4 64-0021	MC-10GB	Model Cell for 5101-10GB (10 GΩ) Bilayer Headstage

# bilayer workstation

## Bilayer Workstation

### The Planar Lipid Bilayer Workstation

*The tool for measuring pico- to nano-scale charge currents across a lipid membrane*

The **Planar Lipid Bilayer (BLM) Workstation** from Warner Instruments integrates every significant component required for the use of a working BLM rig. This unique device allows the user to quickly get up to speed in performing research using this powerful technology.



- Integrated instrumentation for Planar Lipid Bilayer recording
- Simple and integrated design
- Complete System
- Optional power line conditioning
- Popular data acquisition packages
- Available on-site setup and training

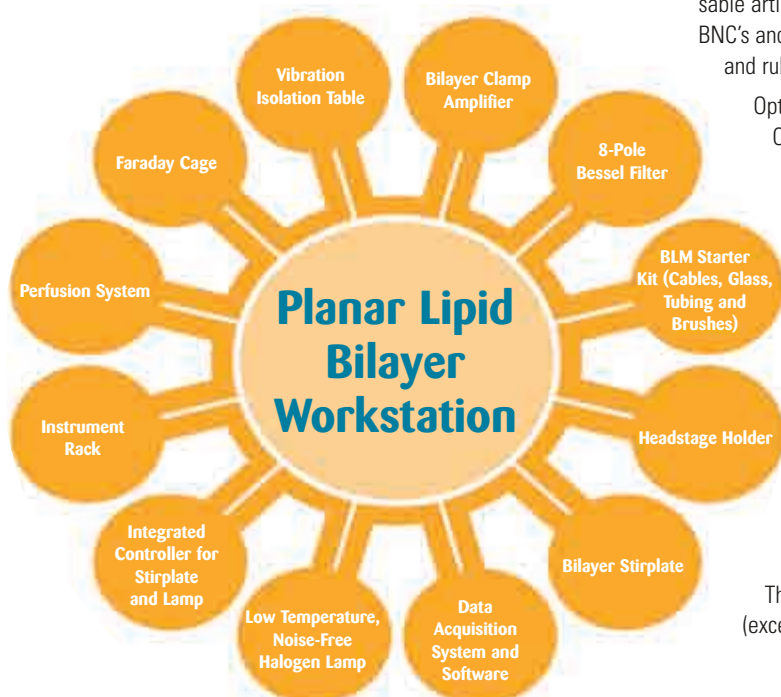
The BLM Workstation is comprised of an FC Series Faraday cage, a BenchMate vibration isolation table from Kinetic Systems, our BC-535 bilayer clamp amplifier and LPF-8 8-pole Bessel filter, a SUN-1 halogen lamp, a SPIN-2 bilayer stirplate, the SUNStir integrated controller (for the stirrer and lamp), and the BPS-2 perfusion system. The HST-1 headstage holder with magnetic base rounds out the package. Also included is a RAC-14 table top rack and the BLM-ST starter kit which includes a red sable artist dotting brush, glass capillary tubing for lipid application, BNC's and grounding cables, spare stirbars for bilayer cups and chambers, and rubber matting for traction control of the bilayer chamber.

Optional components include the BLM-TC Bilayer Thermocycler, the ON-750 power line conditioner and a stereo zoom microscope for viewing the membrane. We also supply accessories useful for bilayer work. These include the CM-3 (variable) and CM-1 (fixed value) single channel simulators.

**Additional items required for a complete Workstation include our popular BCH-13A or BCH-22A bilayer cups and chambers, acquisition hardware/software and a computer.**

The BLM workstation supports the use of either pClamp (Molecular Devices, Union City, CA) or PatchMaster (HEKA Instruments, Bellmore NY) for data acquisition. You may purchase your acquisition system directly from the vendor or from us at no additional charge (Technical support and warranty are through the manufacturer).

The complete system from Warner includes everything you need (except the computer) to begin collecting data.





# Bilayer Workstation

# bilayer workstation

## The Planar Lipid Bilayer Workstation (continued)

### Ordering Information

Order #	Model	Product
W4 64-0452P	BLM-WS-P	Bilayer Workstation Passive Table
W4 64-0452A	BLM-WS-A	Bilayer Workstation Active Table

### System Includes

<b>FC-Series Cage</b>	Faraday Cage with Vibration Isolation Table
<b>BC-535</b>	Bilayer Clamp Amplifier
<b>LPF-8</b>	Bessel Filter, 8 Pole, Low Pass
<b>SUNStir-3</b>	Dual Function Rack Mountable Controller with SUN-1 Lamp and SPIN-2 Stirrer
<b>BPS-2</b>	Bilayer Perfusion System
<b>RAC-14</b>	Instrument Rack
<b>HST-1</b>	Headstage Holder with Magnetic Base
<b>BLM-ST</b>	Bilayer Starter Kit

Purchase of a bilayer cup and chamber, and a data acquisition system are needed to complete the Workstation

All components available separately. Please contact our Sales Department.

### Add on Acquisition System (to complete the system)

Order #	Model	Product
W4 64-0436	DIGI	Molecular Devices – Digidata 1440 + pClamp 10

### Accessories

Order #	Model	Product
W4 64-0083	OST-1*	On-site Setup and Training 2 Day Minimum. Price Per Day*
W4 64-0450	BLM-TC	Bilayer Thermocycler
W4 64-0026	CM-3	Single Channel Simulator, Adjustable Characteristics
W4 64-0024	CM-1	Single Channel Simulator, Fixed Characteristics
W4 64-0069	ON-750A	6.5 A Power line conditioner
W4 64-1803	Z850	Stereo Zoom Horizontally Mounted Microscope with Boom Stand
W4 64-0420	MAG-13	2 x 5 mm Stirbars for 13 mm Chambers and Cuvettes (pkg. of 5)
W4 64-0421	MAG-22	2 x 7 mm Stirbars for 22 mm Chambers and Cuvettes (pkg. of 5)

Note: Price is per day with a 2 day minimum. Travel expenses are additional.

### Cup Chamber Set A

Order #	Model	Product
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#### Classic 13 mm Chamber (1 ml volume)

W4 64-0451	BCH-M13	Bilayer Chamber (Includes Two 2 x 5 mm Stirbar Magnets)
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#### Classic 13 mm Cuvettes

W4 64-0404	CP13A-150	Polystyrene with 150 µm Aperture
W4 64-0403	CP13A-200	Polystyrene with 200 µm Aperture
W4 64-0402	CP13A-250	Polystyrene with 250 µm Aperture
W4 64-0410	CD13A-150	Delrin with 150 µm Aperture
W4 64-0409	CD13A-200	Delrin with 200 µm Aperture
W4 64-0408	CD13A-250	Delrin with 250 µm Aperture
W4 64-0416	CF13A-150	Polysulfone with 150 µm Aperture
W4 64-0415	CF13A-200	Polysulfone with 200 µm Aperture
W4 64-0414	CF13A-250	Polysulfone with 250 µm Aperture

### Cup Chamber Set B

Order #	Model	Product
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#### Classic 22 mm Chamber (3 ml volume)

W4 64-0453	BCH-M22	Bilayer Chamber (Includes Two 2 x 7 mm Stirbar Magnets)
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#### Classic 22 mm Cuvettes

W4 64-0407	CP22A-150	Polystyrene with 150 µm Aperture
W4 64-0406	CP22A-200	Polystyrene with 200 µm Aperture
W4 64-0405	CP22A-250	Polystyrene with 250 µm Aperture
W4 64-0413	CD22A-150	Delrin with 150 µm Aperture
W4 64-0412	CD22A-200	Delrin with 200 µm Aperture
W4 64-0411	CD22A-250	Delrin with 250 µm Aperture
W4 64-0419	CF22A-150	Polysulfone with 150 µm Aperture
W4 64-0418	CF22A-200	Polysulfone with 200 µm Aperture
W4 64-0417	CF22A-250	Polysulfone with 250 µm Aperture

### Cup Chamber Set C

Order #	Model	Product
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#### Perfusion Bilayer Chamber (1 ml volume)

W4 64-0423	BCH-P	Perfusion Bilayer Chamber (Includes Two 2 x 5 mm Stirbar Magnets)
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#### Perfusion Bilayer Cups

W4 64-0424	CP-P-150	Polystyrene Perfusion Cup with 150 µm Aperture
W4 64-0425	CP-P-200	Polystyrene Perfusion Cup with 200 µm Aperture
W4 64-0426	CP-P-250	Polystyrene Perfusion Cup with 250 µm Aperture
W4 64-0427	CD-P-150	Delrin Perfusion Cup with 150 µm Aperture
W4 64-0428	CD-P-200	Delrin Perfusion Cup with 200 µm Aperture
W4 64-0429	CD-P-250	Delrin Perfusion Cup with 250 µm Aperture

**BC-535****Bilayer Clamp Amplifier**

# bilayer workstation

*The only amplifier specifically dedicated to research using the planar lipid bilayer*

The **BC-535** is the newest version of our popular bilayer clamp amplifier. Warner Instruments is the only company to supply an instrument specifically designed for research using planar lipid bilayer technology and this device forms an integral component of the BLM Workstation.



### Major improvements in this model include:

- Reduced noise and wider bandwidth
- Improved stability with gains to 1000 mV/pA
- Digital hold potential
- AutoZero function
- Digital readout of membrane capacitance
- Multi-step 4-pole Bessel filter
- Hold potentials to 1400 mV; currents to 20 nA

### Resistive Feedback Headstage

The BC-535 sports an advanced, resistive feedback headstage which provides high bandwidth and low noise recording. The switchable headstage resistance is automatically selected based on the gain selection. The low current mode provides up to 100 pA of current carrying capability, while the high current mode provides up to 20 nA of current capacity!

### Hold Control

The hold control for the BC-535 has been redesigned to function entirely within the digital domain. This unique approach allows the user to make holding potential adjustments in highly reproducible and discrete steps of 1, 10, and 100 mV, up to  $\pm 400$  mV. Hold potentials up to  $\pm 1000$  mV or step sizes greater than 100 mV can be applied at the Command Input BNC's located on the front and rear panels of the instrument. Internal and external hold potentials sum for a possible total of 1400 mV.

### AutoZero

The large currents flowing through the low resistance aperture prior to bilayer formation saturates the amplifier input. Under these conditions, junction potential offsets can be easily nullified by using the AutoZero function. Once armed, the AutoZero measures and compensates for any offset potentials within the conducting pathway. Traditional manual controls remain for making small corrections or for resetting the offset potential without re-activating the AutoZero cycle.

### Audio Output

The BC-535 sports a VCO circuit providing auditory feedback during membrane formation. This feature is selectable from the front panel and an internal speaker is included. An external speaker output is provided on the instrument rear panel.

### Capacitance Test

This test circuit has been completely redesigned and is used to monitor the formation of the bilayer membrane. A calibrated triangular waveform is applied to the command input and the amplitude of the resulting square wave is proportional to the membrane capacitance. When selected, the membrane capacitance is read directly from the meter.

### 4-Pole Bessel Filter

The filtering capacity if the instrument has been expanded to include a low pass, 4-pole Bessel filter ranging from 0.05 to 20 kHz in 1-2-5 steps. The internal filter can be bypassed allowing realization of the instrument's full 75 kHz bandwidth.

### Capacitance Compensation

Large capacitance transients are cancelled using both fast (0-10  $\mu$ s) and slow (0-2 ms) controls. Each control provides separate adjustment of both amplitude and time constant. Maximum capacitance compensation is 500 pF.

### I/O

Input and output BNC's have been duplicated or moved to the instrument rear panel except for those requiring user interaction. Front panel BNC's include Command Input,  $V_c \times 10$  and  $I_m$  Output. Rear panel BNC's include the headstage connector,  $I_m$  Output, Cap Sync, Command In, and Gain and Filter telegraphs. A speaker output is also available on the rear panel.



**BC-535**

# bilayer workstation

## Bilayer Clamp Amplifier (continued)

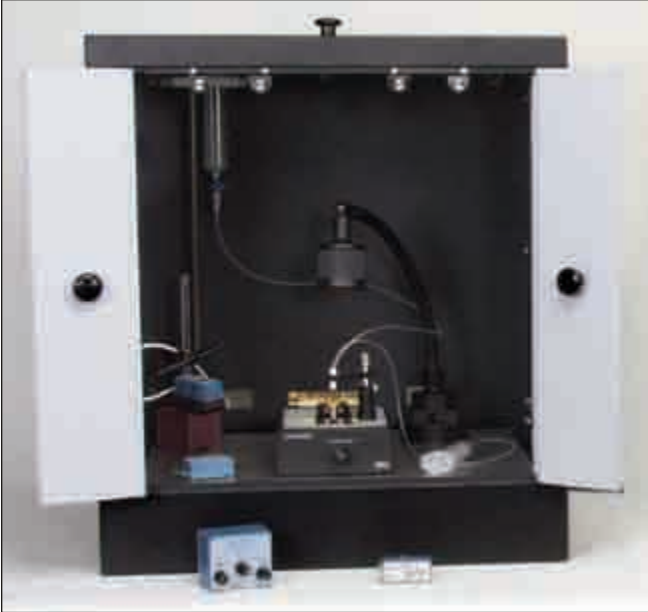
### Specifications

Noise frequency	Measured with 8-pole Bessel filter at specified cutoff		
	<b>Frequency Range</b>	<b>Open Input</b>	<b>100 pF at Input</b>
	DC to 1 kHz	0.060 pA RMS	0.82 pA RMS
	DC to 100 Hz	0.009 pA RMS	0.28 pA RMS
Bandwidth	75 kHz		
Input Commands:			
Internal Hold	Digital; 1, 10 or 100 mV steps to $\pm 400$ mV maximum		
Command In	Front and rear external input, 10 V/V (applied voltage is attenuated by 10/100/1000 at the command electrode)		
Junction zero	AutoZero or manual adjust. AutoZero lockout feature. Cycle time 1.5 s. Correction to $\pm 120$ mV		
Audio	VCO with off switch and volume control. Internal speaker and external speaker output		
Capacitance Test	Triangle wave applied to command electrode. Derived membrane capacitance read from meter up to 1000 pF. Calibrated (1 mV/pF) square wave available at Im output. Cap Sync (rear panel) synchronized with input triangle wave		
Gain	Membrane current gain selectable from 0.5 to 1000 mV/pA in 1-2-5 steps		
Filter	4-pole Bessel selectable from 0.05 to 20 kHz in 1-2-5 steps, or bypassed for full amplifier bandwidth		
Capacity Compensation	Fast (0-10 $\mu$ s) and slow (0-2 ms) with adjustment of amplitude and time constant for each range. Maximum compensation 500 pF		
Headstage:			
<i>Switching:</i>			
Low Current Mode	50 gigohm feedback, 100 pA maximum current		
High Current Mode	500 megohm feedback, 20 nA maximum current		
I/O:			
<i>Front Panel:</i>			
Command Input	BNC input up to $\pm 10$ V. Attenuated by 10, 100 or 1000		
Im Output	Membrane current scaled by amplifier gain setting		
Vc x 10 Output	Applied command voltage x 10		
<i>Rear Panel:</i>			
Im Output	Membrane current scaled by amplifier gain setting		
Cap Sync	TTL compatible		
Cap Out	Reports calculated membrane capacitance scaled to 1 mV/pF		
Command Input	BNC input up to $\pm 10$ V. Attenuated by 10, 100 or 1000		
Gain Telegraph	Stepped DC voltage 0.5 to 5.5 V in 0.5 V steps for gain settings of 0.5 to 1000 mV/pA. Telegraphed value of 0.0 V for bypass		
Filter Telegraph	Stepped DC voltage 0.5 to 4.5 V in 0.5 V steps for filter settings of 0.05 to 20 kHz. Telegraph value of 5.0 V for full bypass		
External Speaker	Standard RCA jack		
Digital Meter:			
3.5 digit LED	$\pm 1999$ mV full scale		
Junction offset	$\pm 120$ mV full scale		
Cap Test	0 to 1999 pF		
Vc	$\pm 1999$ mV full scale		
Im	$\pm 1999$ pA full scale		
Power	100-125 or 220-240 VAC, 50/60 Hz		
Dimensions (H x W x D):			
Case	9 x 42 x 25 cm (3.5 x 16.5 x 10 in.)		
Headstage	2.3 x 2.8 x 5.8 cm (0.9 x 1.1 x 2.25 in.) 1.8 m connecting cable		

Order #	Model	Product
W4 64-0432	BC-535	Bilayer Clamp Amplifier

*A self-contained, tabletop Faraday cage with vibration isolation*

The **Faraday cage** provides critical shielding of electromagnetic interference from outside sources and is an integral component of the Bilayer Workstation. FC Series Faraday cages from Warner include the vibration isolation table and are designed to optimize the user's experience.



- Convenient benchtop design
- Enclosed vibration isolation table
- Passive or active support mechanisms
- Large access doors
- Magnetic closures
- Solid brass grounding block
- Durable powder coat finish

### The Cage

The Faraday cage is a critical component in the Bilayer Workstation since it functions to shield the sensitive electronics contained therein from externally generated electrical interference. Without such, the ability to make single channel measurements would be mitigated.

FC Series cages from Warner are designed to be conveniently placed on a sturdy workbench and are supplied with a choice of automatic or manual vibration isolation table. A version of the cage without a table is also available.

Large access doors allow entry into the cage from all sides and the fan-fold front doors are designed to be placed out of the way when open. Doors along the base of each side allow access to table controls. There are also ports on the rear panel for entry of electronic cabling into the cage enclosure.

### The Table

The cage is shipped with a custom 16" x 19" table manufactured for Warner Instruments by Kinetic Systems, Inc. When installed, the table is entirely contained within the cage enclosure and this design successfully isolates the tabletop from external acoustic and mechanical noise sources. The table has a steel top allowing the attachment of magnetically coupled devices to its surface.

### Specifications

Dimensions (H x W x D)	25 x 22 x 18 in.
Materials	Aluminum with durable powder coat finish. Solid brass grounding block
Design	Electrically continuous cage with solid wall construction. Cage base accommodates 16" x 19" vibration isolation table (either automatic or manual support) manufactured by Kinetic Systems, Inc. Table top forms cage floor. Large panel doors with magnetic closures. Dual fan-fold front doors. Large panel doors on top and sides. Cage base has wing doors for access to vibration isolation table controls. Access ports on back panel for electrical connection to cage contents
Table	Specifications are supplied by Kinetic Systems, Inc. Contact our offices or Kinetic Systems for a copy of the table specifications
Model:	
FC-2	Faraday cage with automatic pneumatic vibration isolation table
FC-1	Faraday cage with manual pneumatic vibration isolation table, includes hand pump
FC-0	Faraday cage without vibration isolation table. This model has a shallow (1.5"), weighted base for improved access and stability in the absence of the enclosed table

Order #	Model	Product
<b>W4 64-0062</b>	FC-0	Faraday Cage without Vibration Isolation Table
<b>W4 64-0063</b>	FC-1	Faraday Cage with Manual Vibration Isolation Table (Includes Hand Pump)
<b>W4 64-0064</b>	FC-2	Faraday Cage with Automatic Vibration Isolation Table (Requires Pressurized Air)
<b>W4 64-0081</b>	KS-1	Vibration-Free Platform, 16 x 19 in, Manual Air, (Includes Hand Pump)
<b>W4 64-0082</b>	KS-2	Vibration-Free Platform, 16 x 19 in, Automatic Air



# BCH-M13 and BCH-M22

## Classic Bilayer Chambers and Cuvettes

# bilayer workstation

### The standard membrane support system

Since the pioneering work on black lipid membranes by Paul Mueller and co-workers in the early '60s, several generations of membrane biologists have exploited this model membrane for biophysical and reconstitution studies. The planar bilayer formed by painting lipids across a small aperture in a partition is one of the simplest techniques available to the novice and expert alike, and the cup/chamber system has been used to reconstitute and record the single-channel behavior of a wide variety of ion channel proteins from diverse tissues.



- Polystyrene, polysulfone or Delrin cuvettes
- Precision machined apertures of 150, 200 or 250  $\mu\text{m}$
- *cis* and *trans* stirbar wells
- Stirbar included with each cup and chamber
- Viewing window
- Shipments from stock

### The Basics

Classic design cups and chambers from Warner Instruments are designed such that addition of equal volumes to the *cis* and *trans* sides results in a balanced solution height, thus minimizing mechanical gradients across the bilayer membrane.

All cuvettes have a 0.5 mm well milled into their base to confine the motion of stirbars and to reduce mechanical noise artifacts. A 2 x 5 mm or 2 x 7 mm Teflon-coated stirbar is supplied with each cuvette. Standard available aperture diameters are 150, 200 or 250  $\mu\text{m}$ . **Contact our offices for custom aperture sizes.** The wall thickness at the aperture is 250  $\mu\text{m}$ .

### Bilayer Chambers

Chambers are made from black Delrin and have a 0.5 mm recessed well milled into the floor of the non-cup side to confine the motion of stirbars and to reduce mechanical noise artifacts. A 2 x 5 mm or 2 x 7 mm Teflon-coated stirbar is supplied with each chamber.

Polyethylene centrifuge tubes (supplied) serve as intermediate wells for electrical connections between the headstage electrodes and the cup or chamber. Chambers include a nylon screw and rubber plug to secure the cups during use. The classic model has a window for viewing the aperture during membrane formation.

### Classic Models BCH-M13 and BCH-M22

Two classic models are offered: The BCH-M13 is a small volume chamber (1.0 ml) with a 13 mm ( $\frac{1}{2}$ " diameter) cuvette. The BCH-M22 is a larger volume chamber with (3.0 ml) chamber with a 22 mm ( $\frac{7}{8}$ " diameter) cuvette.

### Bilayer Cuvettes

Polystyrene has been a favored material for cuvettes for several years. The physical properties of this material make for a high quality membrane support. However, its poor resistance to organic solvents can lead to degradation of the aperture.

Cuvettes have also been made from Delrin (acetyl resin) and many users report good membrane formation as well as easier maintenance. It should be noted, however, that Delrin cuvettes do not work equally well in all applications and with all users.

Warner Instruments now offers bilayer cups made from polysulfone. This material has many of the mechanical properties of polystyrene coupled with enhanced solvent resistance. The choice of material will depend on your application.

Order #	Model	Product
<b>Classic 13 mm Chamber (1 ml volume)</b>		
W4 64-0451	BCH-M13	Bilayer Chamber (Includes Two 2 x 5 mm Stirbar Magnets)
<b>Classic 13 mm Cuvettes</b>		
W4 64-0404	CP13A-150	Polystyrene with 150 $\mu\text{m}$ Aperture
W4 64-0403	CP13A-200	Polystyrene with 200 $\mu\text{m}$ Aperture
W4 64-0402	CP13A-250	Polystyrene with 250 $\mu\text{m}$ Aperture
W4 64-0410	CD13A-150	Delrin with 150 $\mu\text{m}$ Aperture
W4 64-0409	CD13A-200	Delrin with 200 $\mu\text{m}$ Aperture
W4 64-0408	CD13A-250	Delrin with 250 $\mu\text{m}$ Aperture
W4 64-0416	CF13A-150	Polysulfone with 150 $\mu\text{m}$ Aperture
W4 64-0415	CF13A-200	Polysulfone with 200 $\mu\text{m}$ Aperture
W4 64-0414	CF13A-250	Polysulfone with 250 $\mu\text{m}$ Aperture
<b>Classic 22 mm Chamber (3 ml volume)</b>		
W4 64-0453	BCH-M22	Bilayer Chamber (Includes Two 2 x 7 mm Stirbar Magnets)
<b>Classic 22 mm Cuvettes</b>		
W4 64-0407	CP22A-150	Polystyrene with 150 $\mu\text{m}$ Aperture
W4 64-0406	CP22A-200	Polystyrene with 200 $\mu\text{m}$ Aperture
W4 64-0405	CP22A-250	Polystyrene with 250 $\mu\text{m}$ Aperture
W4 64-0413	CD22A-150	Delrin with 150 $\mu\text{m}$ Aperture
W4 64-0412	CD22A-200	Delrin with 200 $\mu\text{m}$ Aperture
W4 64-0411	CD22A-250	Delrin with 250 $\mu\text{m}$ Aperture
W4 64-0419	CF22A-150	Polysulfone with 150 $\mu\text{m}$ Aperture
W4 64-0418	CF22A-200	Polysulfone with 200 $\mu\text{m}$ Aperture
W4 64-0417	CF22A-250	Polysulfone with 250 $\mu\text{m}$ Aperture

*Helps minimize membrane breakage and maintains solution volume*



Order #	Model	Product
W4 64-0423	BCH-P	Perfusion Bilayer Chamber
<b>Perfusion Bilayer Cups</b>		
W4 64-0424	CP-P150	1 ml Polystyrene Perfusion Cup, 150 $\mu$ m Aperture
W4 64-0425	CP-P200	1 ml Polystyrene Perfusion Cup, 200 $\mu$ m Aperture
W4 64-0426	CP-P250	1 ml Polystyrene Perfusion Cup, 250 $\mu$ m Aperture
W4 64-0427	CD-P150	1 ml Delrin Perfusion Cup, 150 $\mu$ m Aperture
W4 64-0428	CD-P200	1 ml Delrin Perfusion Cup, 200 $\mu$ m Aperture
W4 64-0429	CD-P250	1 ml Delrin Perfusion Cup, 250 $\mu$ m Aperture

### Perfusion Design

- Polystyrene or Delrin cuvettes
- Precision machined apertures of 150, 200 or 250  $\mu$ m
- *cis* and *trans* stirbar wells
- Stirbar included with each cup and chamber
- Maintains fixed volume
- Dedicated perfusion line ports
- Unique aspiration shelf

The Perfusion Bilayer Chamber is designed to simplify the exchange of solutions in both the cup and chamber. The BCH-P incorporates unique features which can improve your perfusion success rate.

The design of the BCH-P has two features not found in our classic cup and chamber. First, ports have been permanently milled into both the chamber and cup body for attachment of perfusion lines. The input port is routed to the bottom of the cup (or chamber) while the output port collects solution from the top of the cup (or chamber).

A second improvement is the incorporation of an aspiration shelf in both the cup and chamber. This shelf provides two advantages. First, the aspiration line can remain attached to the chamber without introducing noise artifacts into the bath. Second, the fixed height of the shelf, coupled with rapid aspiration of overflow solutions, helps maintain the working volume.

Connection between your PE perfusion lines and the perfusion ports is conveniently made via standard 200  $\mu$ l pipette tips. Alternatively, PE-90 tubing can be attached directly to the cup (or chamber) to minimize dead volume.

The BCH-P chamber is machined from black Delrin and has a working volume of 1 ml. Cups are available in either white Delrin or polystyrene and have a working volume of 1 ml.

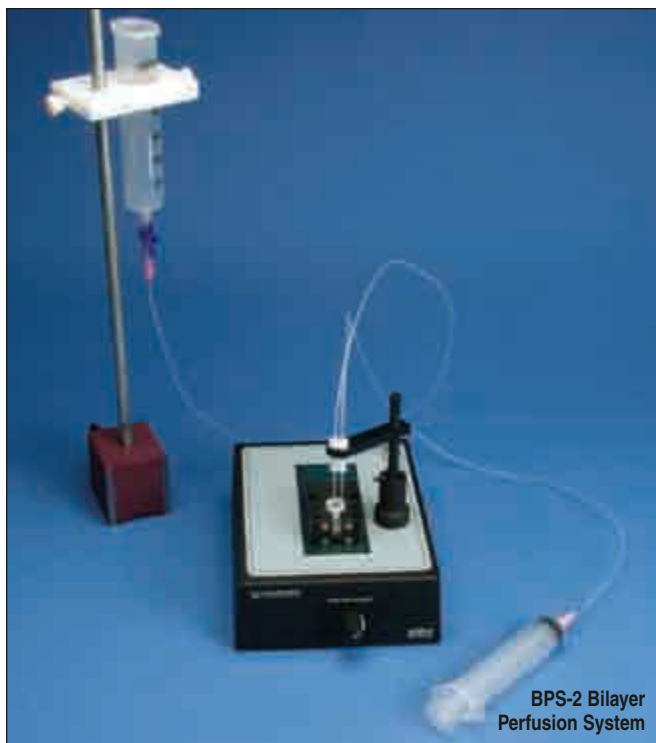
Not compatible with BLM-TC Thermocycler.

# bilayer workstation

## BPS-2 and LPF-8

### Bilayer Perfusion System and 8-Pole Bessel Filter

*An easy to use perfusion system that helps reduce membrane breakage*



BPS-2 Bilayer Perfusion System

### Bilayer Perfusion System

- Complete gravity-feed system
- Quiet operation
- High volume flow rates possible
- Includes everything shown (except for the cup, chamber, and stirplate)

The BPS-2 Bilayer Perfusion System from Warner Instruments provides a simple and straightforward way to exchange solutions in either the bilayer cup or the chamber. The magnetic base holds the perfusion head ready for quick insertion into your solution when expedited solution exchange is necessary.

The gravity-feed mechanism allows the device to support flow rates of up to 10 ml/min without breaking the bilayer membrane. The commonly available syringe reservoirs are easily replaced to reduce cross-contamination between different reservoir solutions.

A perfusion system is a critical component of a Bilayer Workstation. The ability to exchange solutions on both sides of the bilayer membrane is important if complicated experimental protocols are to be performed. Warner Instruments recommends the use of a gravity-driven system as this is the best way to remove biological and chemical materials with a minimum of noise.

Order #	Model	Product
W4 64-0431	BPS-2	Basic Bilayer Perfusion System
W4 64-0774	G200-3	Capillary glass, 2 mm OD

*One of the best*



### 8-Pole Bessel Filter

- 8-Pole low-pass Bessel filter with cutoff frequencies from 0.1 Hz to 20 kHz.
- Differential amplifier gains to x200
- Frequency selection with single control
- Input offset adjustment
- Digital frequency readout
- Rack mountable

The LPF-8 is the premier low-pass Bessel filter from Warner Instruments and provides superior control of analog signal filtering. This instrument incorporates both low-pass signal filtering and output gains from 1 to 200. Selectable dual signal inputs allow the instrument to be configured to operate in normal, inverted or differential modes.

This instrument features optically encoded circuitry which permits frequency selection with a single control. Since the set frequency control is not a physical part of the filtering circuit, adjustments to the instrument do not introduce noise artifacts into the output signal. This unique design uses no mechanical switching and ensures long term instrument reliability.

The LPF-8 is a signal conditioner combining an 8-pole low-pass Bessel filter and DC amplifier. Special features include digital frequency readout, visual input offset indicator, clipping indicator, and gain telegraph outputs.

### Specifications

Input	DC differential
Input impedance	1 M $\Omega$ each channel
Input range	$\pm 10$ V
Input offset control	2 Ranges, $\pm 100$ mV and $\pm 1$ V, variable from 0 with 10-turn control
Offset indicator	20 LED display
Low frequency range	0.1 to 199.9 Hz
Low range resolution	0.1 Hz
High frequency range	10 to 19.99 kHz
High range resolution	10 Hz
Gains	x1, x2, x5, x10, x20, x50, x100 and x200
Output impedance	50 $\Omega$
Power requirements	100-130 VAC or 200-250 VAC, 50/60 Hz

Order #	Model	Product
W4 64-0050	LPF-8	LPF-8 Bessel Filter, Low Pass Filter/DC Amplifier. Specify Line Operating Voltage if Other Than 100-130 VAC



# SUNStir-3 System

## Lamp, Stirplate and Dual Function Controller

# bilayer workstation

*An integrated system for stirring and illumination*

The **SUNStir-3 System** is comprised of the **SUNStir controller**, a **SUN-1 lamp** and a **SPIN-2 stirplate**. This convenient, rack-mountable system is designed to provide simultaneous control for both the SUN-1 lamp and the SPIN-2 stirplate.



### Lamp

- Dichroic reflector
- Noise-free electronics
- Halogen bulb
- Adjustable spotlight intensity with external control device
- Magnetic base with gooseneck and swivel-head lamp

### SPIN-2 Stirrer

- Very low noise!
- Stir while recording
- Independent cis/trans dipoles
- Minimized magnetic flux through bilayer membrane
- Magnetic steel side panels

### Controller

The SUNStir controller is a rack-mountable instrument designed to provide quiet and efficient control of the SUN-1 Lamp and SPIN-2 Stirrer.

### Lamp

The SUN-1 is an externally controlled, noise-free halogen light source suitable for inclusion in a shielded enclosure. The magnetic base attaches securely to any steel tabletop and the lamp swivel-head allows projection of the beam in virtually any direction. Modifications to the design of the reflector result in significant improvements in the lamp's performance.

The lamp is comprised of a magnetic base with 12" gooseneck for accurate positioning of the illumination spot. A jointed swivel-head at the end of the gooseneck allows the beam to easily subtend a solid angle of  $2\pi$  steradians (half of a sphere).

Beam intensity is adjustable to one of eight levels via the rack-mount controller. The lamp electronics are well isolated to prevent the introduction of external EMF into the Faraday cage enclosure and allows recording of data even while the lamp is on.

A dichroic reflector reduces much of the projected heat from the lamp and allows longer illumination times without significantly warming the object under study.

# SUNStir-3 System

## Lamp, Stirplate and Dual Function Controller (continued)

### Stirrer

Bilayer work often requires stirring of contents on both sides of a bilayer membrane. The SPIN-2 Bilayer Stirplate achieves this task by providing two spinning dipoles in a mechanically quiet apparatus.

Stirring of solutions in a bilayer cup and chamber has traditionally been achieved using a commercial stirplate. Unfortunately, these devices are not designed for use in a bilayer rig and present a single rotating magnetic dipole to the bilayer chamber.

A result of these characteristics is that it is impossible to simultaneously stir both wells since the stirbars will be drawn to a common rotational axis defined by the stirplate magnet. The resulting collisions between the stirbars and the bilayer cup introduces a noise artifact into the acquired data. Many researchers avoid this problem by not stirring while recording, which is an undesirable state of affairs.

The SPIN-2 stirplate from Warner Instruments is designed to specifically address these problems experienced by researchers in the field.

First, it has two separate spinning dipoles, one each for the cis and trans wells. This design allows the stirbars within each well to be independently controlled which virtually abolishes cup/stirbar collisions. The relative separation between the two dipoles is adjustable allowing the apparatus to be used with bilayer cups and chambers of different sizes.

Second, the rotation characteristics (speed and phase) of the two spinning dipoles is digitally controlled. This allows the device to present the minimum magnetic flux to the bilayer membrane. A liquid crystal display allows the researcher to view the rotating dipoles in real-time.

Third, the apparatus is both electrically isolated and mechanically quiet. In addition, steel strips are provided on each side of the liquid crystal window for attachment of magnetic holders and the like. This provides a convenient method of positioning a perfusion head.

Taken together, these features allow the SPIN-2 to be used while acquiring data.

### SUNStir Controller Specifications

SUNStir	Master power switch, Power on LED
Lamp control Power on LED	Eight position intensity selection with on/off switch, Power on LED
Stirrer control switch, Power on LED	Continuously variable speed control with on/off
Power requirements	20 W-12 V internal, 100-125 VAC, 60 Hz external
Dimensions	1.75 x 16.5 x 8 in (H x W x D)

### SUN-1 Lamp Specifications

Lamp	High impact polyamide housing; swivel head; spot reflector; clear lens Halogen bulb, dichroic reflector; 20 W-12 V
Gooseneck	1.4 cm diameter x 30.5 cm length; with PVC sleeve

### Spin-2 Stirplate Specifications

Controls:	
Controller	Power on/off switch, Speed rotary control
Stirplate	Position adjust (rotary)
Display:	
Controller	LED; flashes once per complete rotation
Stirplate	Magnetic field display; passive LCD
Speed Range	300 to 600 RPM
Rotor:	
Synchronization	Counter-rotating with magnets repelling
Position Adjustment Range (center-to-center)	0.4 to 2.5 inches
Dimensions (W x D x H)	
Stirplate	5.5 x 8.0 x 2.3 in
Weight	
Stirplate	3.0 lb

Order #	Model	Product
W4 64-0076	SUNSTIR-3	Complete SunStir-3 System, Includes Sun-1 Lamp, Spin-2 Stirrer and SunStir Controller

### System Components

W4 64-0061	SUN-1	Halogen Lamp with Tabletop Controller
W4 64-0074	SPIN-2	Dual Channel Spin Plate with Tabletop Controller
W4 64-0075	SUNSTIR	Dual Function Controller (Lamp plus Stirplate)
W4 64-0065	SUN-DCH	Replacement 12W-12V Dichroic Bulb for Sun-1 Lamp

# bilayer workstation

## Additional Components

RAC-14



### RAC-14 Instrument Rack

An instrument rack provides an organizing influence on the electronics and facilitates the tabletop design of the Workstation.

The RAC-14 is a 14" tabletop rack and comes with all the hardware needed to mount your amplifier, filter, stirring-illumination controller and A/D board into one integrated unit. A ground point is provided for attachment to a Power Line Conditioner. Powder black finish.

Order #	Model	Product
W4 64-0070	RAC-14	Instrument Rack

### BLM Starter Kit

Warner Instruments has put together a Starter Kit to aid you in completing your Bilayer Workstation. The kit includes 3 BNC cables, grounding cables, a Red Sable artist's dotting brush, glass capillary tubing, PE tubing (for your perfusion system), and one replacement pack of stirbars (2 x 5 mm).

Order #	Model	Product
W4 64-0067	BLM-ST	Bilayer Starter Kit

HST-1 Headstage Holder Kit



### HST-1 Headstage Holder Kit

- Shock mounting for headstage
- Non-conducting surface
- Flexible headstage attachment
- Magnetic base with on/off switch

The HST-1 is designed as a shock mount positioning device for the bilayer headstage. The non-conducting neoprene pad, mounted onto a polycarbonate base, serves as a stable platform for the headstage. Two medium elasticity rubber bands are used to fix the headstage to the pad and provides a secure but flexible attachment.

Convenient positioning of the HST-1 Headstage Holder is provided by an MB/B magnetic base. The base contains a magnet with on/off switch for easy re-positioning of the assembly within your application.

### Specifications

Platform, H x W x D	5.7 x 4.4 x 1.3 cm (2.24 x 11.2 x 0.5 in)
Material	Polycarbonate base; non-conducting neoprene pad
Shaft, Dia x L	0.6 x 6.4 cm; anodized aluminum

Order #	Model	Product
W4 64-0435	HST-1	Headstage Holder System

### Replacement parts

W4 64-0422	HH-1	Headstage Holder
W4 64-0060	MB/B	Magnetic Base



## BLM-TC

### Planar Lipid Bilayer Thermocycler

# bilayer workstation



- Peltier driven
- Cools to 5°C
- Heats to 50°C
- Heats and cools at 3°C/minute
- Stable to 0.2°C

The new BLM-TC from Warner uses Peltier technology to cool, heat, or thermocycle a planar lipid bilayer membrane.

The tight and reproducible temperature control provided by this unique device can facilitate the measurement of single channel events at physiologic temperatures, or at any temperature between 5 °C and 50 °C.

The device heats and cools at an average rate of 3 °C/min when transitioning between 40 °C to 10 °C. More importantly, the BLM-TC can maintain a temperature to within 0.2 °C of the set temperature.

The BLM-TC system is comprised of a Peltier-driven bilayer platform (compatible with Warner's SPIN 2 bilayer stirplate), a CL-100 bipolar temperature controller, and an LCS-1 (for the water jacket, see page 142).

The purchase of a standard bilayer cup and chamber completes the package.

*Note: If you will be primarily working at temperatures above ambient, then we recommend using the larger BCH-M22 chamber to reduce the impact of evaporative losses in the system during use.*

Order #	Model	Product
W4 64-0450	BLM-TC	Planar Lipid Bilayer Thermocycler System
W4 64-0400	BCH-M13	1 ml Bilayer Chamber (Cup Purchased Separately)
W4 64-0401	BCH-M22	3 ml Bilayer Chamber (Cup Purchased Separately)
W4 64-1922	LCS-1	Liquid Cooling System
W4 64-0352	CL-100	Bipolar Temperature Controller

## On-Site Setup and Training

Investigators first entering the arena of research using the planar lipid bilayer can be overwhelmed by the wealth of design and application issues surrounding the proper assembly and use of a Bilayer Workstation. While tractable, this state of affairs can result in an investigator choosing a less effective means to achieve his or her research goals.

Warner Instruments recognizes the need to make this technology more accessible and is the only company to establish on-site assembly and training in the proper care and use of the Bilayer Workstation. Our senior scientist, Dr. Edmond Buck, has over 18 years experience using this powerful technology and is committed to providing extensive support for this important technique.

Dr. Buck will visit your site, assemble the Workstation and instruct you in how to use and maintain the equipment. If desired, he will also provide guidance and insight in the best way to use your acquisition and analysis software.\*

It is our committed goal to quickly and efficiently optimize your equipment and skill set allowing you to focus your efforts on data acquisition.

*\*Support and warranty rights are retained by the manufacturer of the acquisition software package.*

**We invite you to contact Dr. Buck to discuss your needs and application.**

References available.

## CM-3 and CM-1 Channel Model Simulator

*Ideal for testing and training*

CM-3 Variable Single-Channel Model



CE



CE

### CM-3 Variable Channel Model

- Independent selection of open and close time constants via calibrated rotary dial
- Selection of unitary channel conductance via calibrated rotary dial
- Available in 10 and 100 pF membranes
- Small dimensions allow easy attachment to the amplifier headstage within the Faraday cage enclosure
- Battery operated

The CM-3 is a continuously variable single channel simulator which models an actively gating ion channel. Gating transitions from the closed to the open, or from the open to the closed state are randomly induced within the constraints imposed by the mean open and mean close time settings. This unique device provides the researcher with a means to generate well-defined ion channel gating kinetics allowing critical analysis of data acquisition hardware and software and data analysis software. The instrument is also an ideal teaching aid.

#### Specifications

Mean time constants	Individually adjustable from 1-200 ms
Conductance	Continuously variable from 0-750 pS
Battery	9 V, 3 years of continuous operation
Dimensions (H x W x D)	6.6 x 7.6 x 4.2 cm

Order #	Model	Product
W4 64-0026	CM-3/10	Variable Simulator with 10 pF Membrane
W4 64-0027	CM-3/100	Variable Simulator with 100 pF Membrane
W4 64-1618	–	CM Cable for Non-Warner Amps

### CM-1 Fixed Channel Model

The CM-1 is a fixed variable single channel model which simulates an actively gating ion channel. Gating transitions from the closed to the open, and from the open to the closed state, are randomly induced within the constraints imposed by the mean open and mean close time settings. Attaches directly to the headstage.

#### Specifications

Mean time constants	Open and closed factory set to 10 ms
Conductance	20 and 200 pS for patch and bilayer models, respectively
Battery	3 V lithium, 3 years of continuous operation
Dimensions (H x W x D)	2.8 x 5.7 x 2.2 cm

Order #	Model	Product
W4 64-0024	CM-1/10	Simulator with 10 pF Membrane
W4 64-0025	CM-1/100	Simulator with 100 pF Membrane
W4 64-1618	–	CM Cable for Non-Warner Amps



### Stereo Zoom Microscope

The Z850 Stereo Zoom Microscope, when used in conjunction with the Planar Lipid Bilayer Workstation, is an ideal instrument for viewing the formation of bilayer membranes. The included boom stand permits the device to be positioned within the cage during use and then swung out of the way after the membrane has stabilized. The microscope can be mounted both vertically or horizontally for diverse applications. A binocular version lacking the camera c-mount is also available.

The rugged boom stand features a 14.3" chrome steel vertical post and a 20.4" horizontal bar. The 42 lb, 10" x 10" rectangle metal base assures positive stability. The locking collars prevent accidental slippage on the horizontal and vertical poles.

The Z850 has a drift free focusing range of 11.5 cm. See pages 338-341 for more details.

### Stirbars

Replacement **stirbars** (magnetic fleas) are available for the BCH Series bilayer chambers. Stirbars are Teflon coated and are available in two sizes. Stirbars are sold in packages of 5 each and come in 2 x 7 mm and the more difficult to find 2 x 5 mm sizes.

### Glass Capillary Tubing

Glass capillary tubing has gained favor among bilayerologists as the preferred tool for applying lipids to the aperture in the bilayer cup. The advantages of this approach (as compared to Sable hair brushes) are durability and the ability to sterilize the applicator between uses. Glass tubing from Warner Instruments has been chosen with dimensions that facilitate this use. The 1.5 mm OD and 15 cm length of this thick-walled tubing make for good quality glass applicators.



### Power Line Conditioning

An often overlooked source of noise in electrophysiological recording is that introduced by fluctuations in the power circuit supplying the apparatus. Many labs are placed on upper floors in large research facilities where the power circuit is shared by many other labs. While most instrumentation used in BLM work are designed to compensate for variances in the power circuit, these effects cannot be completely abolished in a distributed network of components.

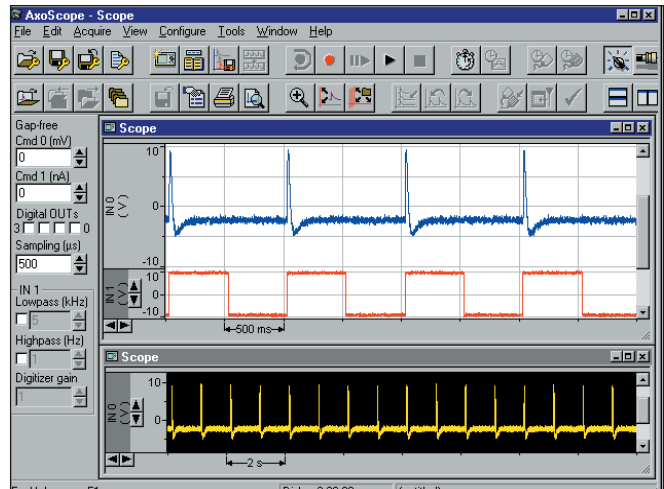
An elegant solution to this problem is provided by the use of an isolation transformer to supply power to the entire Workstation. The ON-750 Power Line Conditioner is a two-sided device wherein one side connects to the institutionally supplied power and the other, isolated, side connects to the BLM Workstation. This configuration results in the presentation of a stable power source to the Workstation which abolishes noise artifacts introduced from varying loads on the "house circuit".

Order #	Model	Product
W4 64-0067	BLM-ST	Bilayer Starter Kit
W3 64-1803	Z850	Stereo Zoom Microscope with Boom Stand without Camera C-Mount
W4 64-1805	Z850	Stereo Zoom Microscope with Boom Stand and Camera C-Mount
W4 64-0069	ON-750A-US	Power Line Conditioner for 120 VAC/60 Hz
W4 64-0073	ON-750A-EU	Power Line Conditioner for 220 VAC/60 Hz
W4 64-0772	G150-4	Capillary glass 1.5 mm OD
W4 64-1327	WA10-5	Silver wire, 10 cm long, 0.25 mm dia, with 1 mm pin, 2 pack
W4 64-0420	MAG-13	2 x 5 mm Stirbars for 13 mm Chambers and Cuvettes (pkg. of 5)
W4 64-0421	MAG-22	2 x 7 mm Stirbars for 22 mm Chambers and Cuvettes (pkg. of 5)



## Acquisition Hardware and Software

### PClump Package from Molecular Devices



### Digidata 1440A Low-noise Data Acquisition System with pClamp Software

Molecular Devices presents the latest Digidata 1440A digitizer for low-noise experiments. This high-resolution 16-bit data acquisition system is self-contained and communicates with the host computer via a USB 2.0 interface, which means extremely easy installation and setup. Designed for ease-of-use and fast results, the Digidata 1440A comes with versatile AxoScope for Windows software and is ready to take data immediately after installation. Absolutely no programming is necessary.

The Digidata 1440A has a maximum sampling rate of 250 kHz per channel, with an outstanding total data throughput rate of 4 megasamples per second. Both the inherent digitizer noise and channel crosstalk noise are rated at less than  $\pm 1$  mV average p-p at 10 kHz, within a  $\pm 10$  V input range. The front panel is well laid out with sixteen analog input channels and four analog output channels, eight general digital outputs, one dedicated digital output to trigger devices such as oscilloscopes, trigger inputs to start acquisition and to tag data. The back panel has four additional analog instrument telegraph inputs, as well as a DB-25 connector for the digital outputs.

Designed to support continuous data acquisition within a multitasking operating system, the Digidata 1440A digitizer is fully supported by our AxoScope 10 for Windows and pCLAMP 10 for Windows electrophysiology software.

With its USB 2.0 interface, you can easily connect the Digidata 1440A to a laptop computer without the need for a peripheral PC card.

*A data acquisition system is an integral component of the Planar Lipid Bilayer Workstation. To facilitate a convenient purchasing experience for our customers, Warner Instruments can include these products as part of a Workstation purchase.\* We can also install and configure the acquisition system if you desire. Contact our Sales Department for details. (\*Axon system not available in Japan.)*

The pCLAMP 10 software suite fulfills many different experimental needs, such as synchronized stimulation, event detection, and online analysis. It is the most widely-used data acquisition and analysis program for the control and recording of voltage-clamp, current-clamp, and patch-clamp experiments. Three separate programs are included: Clampex 10, AxoScope 10, Clampfit 10.

Clampex 10 expands the range and quality of your data acquisition experiments. These improvements should prove useful for a wide variety of applications, allowing more flexibility in your experimental protocols.

AxoScope 10 provides a convenient way to produce background recordings with the included MiniDigi 2-channel digitizer. You can monitor cells during intra-sweep periods, or create an overview of the entire day's activities including voice tags.

Clampfit 10 is a powerful solution for analyzing, graphing and layout of all of your Clampex and AxoScope data. Clampfit includes an extensive array of filtering and fitting routines. Functionality includes I-V graphs, power spectrums, and special "linked data views" for threshold (AP), template (minis) and single-channel modes of event detection and analysis.

*The pClamp package (comprised of Molecular Devices' Digidata 1440 computer interface and pClamp 10 software) represents a state-of-the-art acquisition system from Molecular Devices Corporation.*

Warner Instruments is pleased to include the following information detailing a compatible acquisition systems from Axon Instruments. We provide this information and product as a service to our customers and make it available as an optional component of the Warner Instruments Planar Lipid Bilayer Workstation. All product warranty and support rights for this acquisition package are retained by Axon Instruments.

*Please contact the vendor directly if you require additional information.*

#### Order # Product

W4 64-0436 Molecular Devices - Digidata 1440 + pClamp 10

# voltage clamps

## TEV700

### Oocyte Two-Electrode Voltage Clamp Workstation

*The most common components in a single package*

W4 64-0034 TEV700 Oocyte Two-Electrode Voltage Clamp Work Station



- **NEW** Automated Two-Electrode Voltage Clamp System, see page 200
- Oocyte Clamp OC-725C, see pages 201-202
- RC-3Z Oocyte Chamber, see page 13
- MM-33L Manipulator, see page 295
- MM-33R Manipulator, see page 295
- MB/B Magnetic Base, see page 304

## BPM-1

### Steel Base Plate

This solid steel plate provides a stable platform for mounting micromanipulators mounted on magnetic bases. A highly durable powder coating applied to the surface makes it impervious to most common spills in the lab.

#### Specifications

Dimensions	30.5 x 61.0 x 0.95 cm (12 x 24 x 3/8 in)
Weight	14.06 kg (31 lb)

BPM-1 shown with components of our TEV-700 Oocyte voltage clamp workstation



The **TEV700 Workstation** provides many of the necessary components typically used with the OC-725C voltage clamp. When these components are purchased with the OC-725 Oocyte Clamp, the complete package is discounted as shown. The individual components of the system are listed below.

Order #	Model	Product
W4 64-0034	TEV700	Complete Oocyte Two-Electrode Voltage Clamp Work Station

#### System Components (included in TEV700)

W4 64-0028	OC-725C	Oocyte Clamp
W4 64-0319	RC-3Z	Oocyte Chamber
W4 64-0055	MM-33L	Left Manipulator
W4 64-0056	MM-33R	Right Manipulator
W4 64-0060	MB/B	Magnetic Base, must purchase 2 for complete system

#### Accessories

W4 64-1586	BPM-1	Base Plate Magnetic Steel
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## NEW Automated Two-Electrode Voltage Clamp Systems



- Single and dual channel systems available
- Eliminates microscope
- Manipulators may be used for both patch and oocyte voltage clamp experiments
- High efficiency design

Warner Instruments in collaboration with NeoBiosystems, Inc., is pleased to introduce an automated workstation for oocyte two-electrode voltage clamp experiments.

This complete workstation is built on a strong foundation of the NeoBiosystems ChannelMAX 100A Mini computer controlled manipulators, the Warner Instruments OC-725C oocyte voltage clamp, a VC-8P eight channel valve control system, and a custom perfusion chamber.

Save time, money, and increase throughput using a system featuring the world's most widely used two electrode whole-cell voltage clamp for *Xenopus* oocytes. The unique design of the OC-725C bath clamp eliminates the need for series resistance compensation. It also provides an accurate measurement of bath current by creating a virtual bath ground while simultaneously clamping the bath potential at zero.

The high compliance of  $\pm 180$  volts, and the AC clamp gain of  $2 \times 10^3$  in addition to the DC gain of  $1 \times 10^6$ , ensures accurate clamp voltage is maintained even when working with high conductance (leaky) oocytes.

Order #	Model	Product
W4 64-1740	TEV-S12	Automated two-electrode voltage clamp - single channel for 1.2 mm electrodes: Includes one OC-725C, one ChannelMAX 100A Mini, one VC-8P pinch valve controller, one perfusion chamber, and two electrodes holders for 1.2 mm O.D. glass
W4 64-1741	TEV-S15	Automated two-electrode voltage clamp - single channel for 1.5 mm electrodes: Includes one OC-725C, one ChannelMAX 100A Mini, one VC-8P pinch valve controller, one perfusion chamber, and two electrodes holders for 1.5 mm O.D. glass
W4 64-1742	TEV-D12	Automated two-electrode voltage clamp - dual channel for 1.2 mm electrodes: Includes two OC-725C, one ChannelMAX 100A Twin, one VC-8P pinch valve controller, two perfusion chambers, and four electrodes holders for 1.2 mm O.D. glass
W4 64-1743	TEV-D15	Automated two-electrode voltage clamp - dual channel for 1.5 mm electrodes: Includes two OC-725C, one ChannelMAX 100A Twin, one VC-8P pinch valve controller, two perfusion chambers, and four electrodes holders for 1.5 mm O.D. glass



## OC-725C Oocyte Clamp

# voltage clamps

Designed for two-electrode whole-cell voltage clamping of *Xenopus* oocytes



The **OC-725C** Oocyte Clamp is designed for two-electrode, whole-cell voltage clamping of *Xenopus* oocytes. The dedicated design of the OC-725C includes such features as high compliance voltage ( $\pm 180$  V) and unique bath clamp circuitry. These same features also make the OC-725C ideal for clamping other large cells and cell structures such as squid axons. Improvements to this version include an extended current measuring range, decreased noise level and a 4-pole Bessel filter.

### Fast Stable Voltage Clamping

The OC-725C combines high AC and DC gains and a voltage compliance of  $\pm 180$  volts to insure fast, nonsaturating clamp performance under nearly any condition. The AC clamp gain is variable up to 2000. An additional DC gain of  $1 \times 10^6$  may be employed for high conductance cells (leaky oocytes).

Two clamp speeds are available: The Slow mode is used for screening oocytes or for applications not requiring fast response times. The Fast mode is used for accurate voltage clamp of fast whole cell currents. Clamp response time in the Fast mode is 350  $\mu$ sec (10-90% rise time) when applying a 100 mV step to a model cell.

### Improved Bath Clamp Headstage

The current measuring range of the OC-725C bath clamp headstage has been extended at both ends by the addition of a 3 position range multiplier. Smaller currents are amplified to usable levels and larger currents up to 1 mA can be recorded without output saturation. The unique design of the bath clamp eliminates the need for series resistance compensation. It provides an accurate measurement of bath current by creating a virtual ground in the bath while simultaneously clamping the bath potential at zero.

### Voltage Headstage Probe

The voltage measuring headstage is a single-ended, high-impedance probe. Its small size, convenient mounting rod and 2 meter cable make for easy attachment to a micropositioner. The headstage input is a 2 mm diameter pin. An electrode holder with a 2 mm jack (supplied) mounts directly on the headstage.

### Voltage & Current Meters

Independent meters provide simultaneous displays of membrane voltage  $V_m$  and membrane current  $I_m$ . To assure proper impalement of the current electrode, the current meter displays membrane potential  $V_e$  from the current electrode before the clamp circuit is turned on.

### Clamp Commands

The internal Hold control is a digital push button control with two ranges;  $\pm 1$  to 99 mV (x1) and  $\pm 2$  to 198 mV (x2). Hold can be incremented in steps of 1, 2, 10 and 20 mV for I-V studies. External command signals applied to Command IN  $\pm 10$  are attenuated to reduce noise from the command source. Hold and external commands are summed.

### Additional Features

- Buzz controls (1 kHz square wave) for each electrode aid in penetration of cell membranes with a minimum of leakage.
- Overload alarm (audible and visual) indicate when the compliance voltage is exceeded safeguarding the oocyte and indicating that current records are subject to saturation.
- DC Offsets for both voltage and current electrodes.
- Electrode Test for both electrodes.
- Capacity Compensation for the  $V_m$  voltage input.

### Electrode Holders

Two vented electrode holders with silver wires are typically required with the clamp; a straight type for use with the voltage headstage and a 45° type with mounting handle for use with current electrodes. Vents have been added to the electrodes to prevent pressure build-up inside the electrode which can damage oocytes. A two meter length cable assembly is provided to connect the current electrode holder to the clamp.

# voltage clamps

## OC-725C

### Oocyte Clamp (continued)



RC-3Z chamber shown with the Warner OC-725 bath clamp headstage.

### Dual Oocyte Studies

Some studies, such as voltage control across gap junctions, require the clamping of two oocytes in a common bath using two voltage clamps. The combined currents from the two oocytes cause problems since the bath clamp headstage cannot separate the individual currents and therefore cannot provide effective clamping.

OC-725C has two features to address these problems:

- An internal switch permits measurements of the current in series with the current electrode instead of in the bath.
- Optional differential voltage headstages (7255 DI): The differential measurement subtracts the voltage drop across the series resistance in the bath, which is normally eliminated by the bath clamp.

### Specifications

Test Conditions	
1. Model cell used to obtain specifications: model membrane, 1 MΩ in parallel with 220 nF, 1 MΩ current and voltage electrodes.	
2. Noise measurements made with an 8-pole Bessel filter.	
Voltage Recording Channel (Vm):	
V Probe Input Impedance	0.5 x 10 <sup>12</sup> Ω, 1 pF
Output Resistance	100 Ω
DC Offset	±200 mV at input, var. from zero with 10 turn control, (20 mV/turn)
Noise (0-10 kHz)	3 μV RMS with input grounded 20 μV RMS with model cell
Electrode Test	10 mV/MΩ read on meter 100 mV/MΩ at Vm x10 output
Meter Range	±199.9 mV full scale
Capacity Compensation	0 - 90 pF
Current Sensing (Bath Clamp) Channel (Im):	
Noise (0-1 kHz)	4.5 nA RMS with bath clamp 10 nA RMS in output leg
I Monitor Output	1 nA/mV to 1 mA/10V in 7 steps and 3 ranges, x0.1, x1, and x10
Gain Telegraph Output	0.2 to 2.6 V in 7 steps (200 mV/step) and 3 ranges, x0.1, x1, and x10. Compatible with data acquisition software*
Meter Range, Full Scale	Clamp Current: ±199.9 μA

### Specifications (continued)

Electrode Voltage Ve	±199.9 mV (Current meter reads Ve when clamp mode switch is off)
Current Electrode Channel:	
Compliance Voltage	±180 V
Clamp Speed	350 μsec. (10-90%) with 100 mV square wave command applied to model cell
Gain	Variable AC/DC: 0 to 2000
Fixed DC Gain	Switch selected: 1 x 10 <sup>6</sup>
Ve DC Offset	±200 mV at input (20 mV/turn)
Electrode Test	10 mV/MΩ read on current meter 100 mV/MΩ at Ve x10 output, rear panel
Commands:	
Hold	Manually set with digital potentiometer, 2 digit resolution and 2 ranges: x1 range: ±1 to 99 mV in 1 mV steps x2 range: ±2 to 198 mV in 2 mV steps
External	Signals applied to COMMAND IN=10 are attenuated by a factor of 10, 1 V applied = 100 mV command
Power Requirements	100-130 V or 220-240 VAC, 50/60 Hz, 20 VA
Physical Dimensions:	
Case	8.9 cm H x 43.2 cm W x 30.5 cm D
Voltage Headstage	12.5 mm D x 5 cm L with 1.8 m cable
Mounting Handle	4.8 mm D x 6.3 cm L
Bath Headstage	2.3 cm H x 3.5 cm W x 4.2 cm L with 1.8 m cable
Shipping Weight	6.8 kg
Warranty	Three years, parts & labor

\*Molecular Devices pClamp and Heka PatchMaster

Order #	Model	Product
<b>W4 64-0028</b>	OC-725C	Oocyte Clamp supplied with 7250V Voltage Headstage, 7251I Bath Clamp Headstage, 7259C Current Cable, Model Membrane and Rack Mount Hardware. Specify line operating voltage if other than 100-130 VAC. <i>One straight holder and one 45° holder purchased separately.</i>

### Optional/Replacement Headstages

<b>W4 64-0030</b>	7255DI	Optional Differential Headstage
<b>W4 64-0031</b>	7250V	Replacement Voltage Headstage
<b>W4 64-0032</b>	7251I	Replacement Bath Clamp Headstage
<b>W4 64-0033</b>	7259C	Replacement Current Electrode Cable
<b>W4 64-0029</b>	725MC	Model Cell

### For Use with OC-725C Voltage Probe

<b>W4 64-1008</b>	ESW-F12V	Straight Holder 1.2 mm glass OD
<b>W4 64-1009</b>	ESW-F15V	Straight Holder 1.5 mm glass OD
<b>W4 64-1010</b>	ESW-F20V	Straight Holder 2.0 mm glass OD
<b>W4 64-1007</b>	ESW-F10V	Straight Holder 1.0 mm glass OD

### For Use with OC-725C Current Electrode

<b>W4 64-1051</b>	E45W-F10VH	45° Style Holder 1.0 mm glass OD
<b>W4 64-1052</b>	E45W-F12VH	45° Style Holder 1.2 mm glass OD
<b>W4 64-1053</b>	E45W-F15VH	45° Style Holder 1.5 mm glass OD
<b>W4 64-1054</b>	E45W-F20VH	45° Style Holder 2.0 mm glass OD

## HAI 118

### Data Acquisition System

*A fast, high-resolution data acquisition system suitable for most physiological recording studies*



- 100kHz 16 bit A/D converter
- Easy to install USB connection
- Built-in stimulator and digital outputs
- Low noise
- Full gain telegraph support for Warner Instruments clamp amplifiers

The **HAI 118** is a fast high-resolution data acquisition system suitable for most data recording studies in the research laboratory. It offers 8 analog input channels, 8 digital outputs, 4 digital inputs and 2 DACs. The Hardware connects to PC compatible computers via the popular USB interface, so setup is plug-and-play easy.

#### Hardware Features

##### DAC

The HAI 118 offers two  $\pm 10V$  DACs. Each DAC is independently programmable and can be synchronized with one another. Basic stimulus parameters for each DAC, such as pulse width, frequency and amplitude can be changed on the fly using handy controls located in the LabScribe® software tool bar. Standard protocols include pulse, train, and step waveform. Each standard protocol allows the quiescent state to be a holding voltage thereby making it ideal for voltage clamping applications.

##### Resolution and Noise

The HAI 118 employs a 16 bit A/D converter to sample data over its  $\pm 10 V$  input range. Typical noise on any input is less than 1 V. This allows the recording of signals from 10 mV to 10V without the need for additional external gain.

##### Digital Input/Output

8 digital output lines are available. The digital output connectors are industry standard BNC, eliminating the need for custom cables. Programming the output lines is point-and-click easy as well - no complicated scripting language is required. Four digital input lines are also provided, with one configured as an external trigger.

#### Speed

The HAI 118 is a fast recorder. At top speed it can collect 100,000, 16 bit samples per second on a single channel. With 8 channels enabled it can collect data at 10,000 samples per second on each of the open channels.

#### USB Connection

Connection to the computer is accomplished over the popular USB port. This eliminates the need to install special interface cards and makes the HAI 118 compatible with notebook computers. The HAI 118 has a small footprint and in combination with a notebook requires very little bench space.

#### Software Included

Powerful LabScribe® software is included with each HAI 118. LabScribe is provided with a site license at no additional charge and upgrades are free forever. The program will actually upgrade itself on any Internet connected machine.

#### LabScribe Software Features:

##### Real Units

LabScribe software allows you to calibrate the displayed data in any units that you choose. Reading your data in mm Hg, g, or mA is a snap.

##### Display Controls

LabScribe uses an AutoScale feature that automatically ensures the optimal scaling of displayed data. A simple click centers and expands the data in the display window to fill the available space. Time base or y axis scaling can be zoomed in or out with a single click.

##### Realtime Notations

Keyboard input from the user may be time locked to the data to indicate drug delivery or stimulus points. Annotations can be positioned in the data much as you would write on chart paper.

##### Thirteen Realtime Functions

LabScribe currently supports 13 functions that are calculated and displayed in realtime, each called from a single click in the main window. These include Rate, Frequency, Period, Max, Min, Mean, Integral,  $dV/dt$  and Filter. Functions can be applied to raw data in real time or they can be called after the data has been recorded. No matter how data may be permuted, raw data is always preserved.

##### Twenty-Six Off Line Calculations

Twenty-six off line calculations are also supported. These operate on a selection of data and return a value. The list includes Area Under the Curve, Max-Min, Slope at a Point, Slope of the Line of Best Fit, and the mean.

##### Data Exported to .txt or .png Files

Any view of the data can be exported to the disk as a text file or a graphic. This is ideal for post calculation in programs like Excel or MACLAB. Picture formats make reports or poster presentations easy. Of course you can always print data from any window in the program.



# voltage clamps

## HAI 118

### Data Acquisition System (continued)

#### Software Features (continued):

##### Gain Telegraph

LabScribe will automatically calibrate and display the output of Warner Voltage/Patch clamp amplifiers. This feature takes into account the changes in gain that may be applied from the voltage clamp.

##### Fast Scrolling

LabScribe display can smoothly scroll data at any speed. This is particularly useful when high resolution data is compressed on the time axis to create a data overview.

##### Settings

Settings or templates for various experiments are stored in the programs settings menu. This makes changing program settings to accommodate different experiments point-and-click easy.

#### Applications Supported:

##### Oocyte clamp

LabScribe's gain telegraph feature automatically calibrates the software to any Warner Oocyte Clamp so that the main display reads in current and voltage. The on-board stimulator includes a flexible voltage clamp protocol so an external stimulator is not required. Finally, the digital output capability of the HAI 118 also adds the ability to automate your oocyte rig.

##### Epithelial Clamp

Output from Warner Instruments or other epithelial voltage clamps can be fed directly into the HAI 118. The voltage clamp protocol in the LabScribe program's stimulator section makes recordings of four to six channels of epithelial data possible.

##### Blood Flow and Blood pressure

Blood flow data from doppler devices and blood pressure signals from available transducer amplifiers can be fed directly into the HAI 118. Analytical features in the LabScribe software can give beat-to-beat rate, systolic, diastolic, and mean pressures, as well as dP/dt.

##### Hemodynamic Studies

Blood pressure signals from available transducer amplifiers can be fed directly into the HAI 118. Analytical features in the LabScribe software can display beat-to-beat rate, systolic, diastolic, and mean pressures as well as dP/dt. Up to 8 channels of pressure data can be recorded and the high speed nature of the hardware makes it ideal for use with rapid heart rate animals such as mice.

##### Electrophysiology.

The high speed nature of the HAI 118 make it perfect for studies involving blood pressure and sympathetic nerve activity as well as all types of cardiac electrophysiology, even in rapid heart rate animals such as mice where extra speed is required.

#### Specifications

##### Input:

Number of Inputs	8 single ended BNC
Input Impedance	1 M $\Omega$
Input Range	$\pm 10$ V
Noise	1 mV typical
Gain Telegraph	Software or hardware 8 bit

##### Output:

Number of DACs	2
DAC Resolution	12 bit
DAC Speed	100 kHz independent of sample speed
DAC Output Range	$\pm 10$ V
Digital Output Lines	8 TTL
Digital Output Connector	BNC

##### A/D Converter:

Sample Speed	1 Hz - 100 kHz
Resolution	16 bit
Interface	USB
Trigger/Digital Input Lines	4, TTL

Enclosure	Aluminum
Power	120/220 VAC, 60/50 Hz, CE compliant
Trigger Modes	External trigger, Threshold trigger from data, User trigger
Display	Real time, User definable screen time independent of sample rate. User definable units, AutoScale, Full Scale or User defined scale

DAC Modes	Pulse, Train, Step, DC, Custom
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##### DAC Performance:

Pulse Width	0.01 msec to 6500 msec (Pulse mode)
Frequency	0.2 Hz to 50 kHz (Pulse Mode)

#### Order # Product

<b>W4 69-3130</b>	HAI 118 Data Acquisition System
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## IE-210

### Intracellular Electrometer

*A high impedance electrometer designed specifically for intracellular studies*



- High impedance microelectrode amplifier for intracellular studies
- Simultaneous stimulation and recording

The **IE-210** is an intracellular microelectrode amplifier with low noise, low drift, and fast response time for recording from high impedance fluid-filled glass electrodes. Current injection (bridge) circuitry permits simultaneous stimulation and recording through a single electrode. These features, in combination with a small lightweight headstage, a 4-pole Bessel low pass filter, and optional probe breakaway make it an ideal instrument for easy, accurate and reliable intracellular recording and current injection.

#### The Headstage

Fluid-filled microelectrodes can have resistances of over 100 m $\Omega$ . To faithfully record potentials with such high resistances, the amplifier input resistance must be at least 100 times greater. The input resistance of the IE-210 is 5000 times greater ( $5 \times 10^{11} \Omega$ ) to assure accurate measurements with high resistance electrodes.

To maximize the bandwidth of voltage recording with high resistance electrodes, care must be taken to limit the input capacitance of the amplifier and minimize stray capacitance associated with the electrode and the cable which connects it to the amplifier. The IE-210 headstage is designed to minimize both. The headstage utilizes bootstrap circuitry and a driven shield to limit input capacitance to 0.5 pF. Stray input capacitance is reduced with two design features of the headstage: 1) the pencil-sized headstage mounts directly on the micromanipulator, therefore the electrode holder can connect directly to the headstage input and requires no connecting cable; 2) the headstage driven shield is available at the probe input to permit attachment of additional shielding. This allows the driven shield to be extended to surround the electrode holder and further reduce the stray input capacitance. This method of capacitance neutralization is preferable to the common method of capacitance neutralization since capacitance compensation circuitry can increase noise levels.

#### Electrometer Features

The probe/electrometer output is available at a gain of one. Amplifier gain is increased to x10 at the current injection Bridge Output. Input junction potentials can be compensated with the Input Offset control. If desired,

remaining stray input capacitance, up to 50 pF, can be neutralized with Cap Comp (capacity compensation). Convenient electrode resistance measurement is available using Electrode Test which produces a voltage proportional to the electrode resistance. Cell impalement is facilitated with a Buzz voltage (variable in both frequency and amplitude) applied to the electrode. An overload condition at the input (blocked electrode or oscillations caused by excessive capacity compensation) is indicated by the Input Overload light.

#### Current Injection

Simultaneous stimulation and recording with a single electrode is made possible with an active bridge circuit. Stimulus currents are generated either internally with the DC Current source or by a voltage applied to the external Stimulus Input. The internal source supplies currents up to  $\pm 100$  nA in the Low range and up to  $\pm 1000$  nA in the High range. The current injection feature is often used for iontophoretic injection of dyes or drugs. External signals can be of any waveform or DC level. Internal and external stimulus currents are summed when applied simultaneously.

Voltage drops across the electrode are subtracted from the Bridge Output using the DC Balance and AC Balance controls. The remaining output represents the cell's response to the applied current. Electrode resistance can be read directly from the DC Balance dial. Gain of the Bridge Output signal is x10 at the front panel and can be switch-selected to x20 or x50 at the rear panel. The output signal is available at either the full amplifier bandwidth (30 kHz) or filtered with the internal 4-pole Bessel low pass filter.

#### Additional Features

- Meter: The  $3\frac{1}{2}$  digit LED meter provides readouts of the x1 Amplifier Output voltage and the stimulus DC Current, and is easily viewed in a darkened room.
- Probe Test: Checks of amplifier operation are quick and convenient with the front panel Probe Test facility, a real time-saver when troubleshooting set-up problems.
- Differential Amplifier: Signals from another amplifier can be applied to the Differential Input and are then summed with the IE-210 x1 output.
- Filter Telegraph: The filter frequency is encoded by a stepped DC voltage for input to a data acquisition system.

## IE-210

### Intracellular Electrometer (continued)

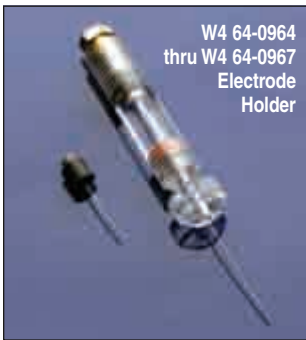
#### Electrode Holder

An electrode holder is not included with the IE-210. Please purchase the holder separately based on your glass outer diameter. Electrical coupling between the electrode and headstage can be either a Ag wire or Ag-AgCl pellet and is easily replaceable. The holder is supplied with the silver wire installed and a pellet is included for conversion to a pellet type holder.

#### Optional Accessories

The Remote Buzz (RB-1) control provides convenient remote operation of the Buzz voltage. It is supplied with a 3 m length cable.

The Breakaway Box (BB-15) permits the application of large voltages to the electrode for iontophoretic injection of dyes or drugs. Voltages up to  $\pm 200$  V may be applied to the Breakaway input without damage to the probe input. Breakaway Current = applied voltage  $\div$  (electrode resistance + 2 M $\Omega$ ).



#### Specifications

##### Electrometer Section:

Input Impedance	5 x 10 <sup>11</sup> $\Omega$ shunted By 0.5 pF
Output Resistance	100 $\Omega$
Gain	x1 $\pm 0.1\%$
Probe Input Range	$\pm 10$ V
Risetime (10-90%)	25 $\mu$ sec, measured through 20 M $\Omega$
Noise Level	25 $\mu$ V p-p input shorted
(0.1 Hz – 10 kHz)*	250 $\mu$ V p-p, 20 M $\Omega$ at input
Capacitance Compensation	0 to 50 pF
Leakage Current	1 pA typical, adjustable to zero

#### Specifications (continued)

Input Offset	$\pm 200$ mV, referred to input
Electrode Resist. Test	1 mV/M $\Omega$ (Low Range) 10 mV/M $\Omega$ (High Range)
Buzz	Amplitude variable 0 to 6 V, frequency variable 100 Hz to 10 kHz
Current Injection Bridge:	Bridge operates in Low and High current ranges. Specifications shown for each range where applicable.
Bridge Resist.	0 to 100 M $\Omega$ and 0 to 1000 M $\Omega$ (Low Range)
Ranges	0 to 10 M $\Omega$ and 0 to 100 M $\Omega$ (High Range)
Internal DC	0 to $\pm 100$ nA (Low Range)
Current Source	0 to $\pm 1000$ nA (High Range)
External Stimulus	Current is limited by electrode resistance up to maximums shown: $\pm 10$ V $\div$ electrode R or 0.5 $\mu$ A (Low Range) $\pm 10$ V $\div$ electrode R or 5 $\mu$ A (High Range)
Max. Stimulus Input	$\pm 15$ V
Stimulus Input Resist.	10 K $\Omega$
I Monitor Output	100 mV/nA (Low Range), 10 mV/nA (High Range)
Bridge Output Gain	x10 at front panel, x20 or x50 at rear panel
Bridge Output Filter	4-pole low pass Bessel with cut-offs at 0.05, 0.1, 0.2, 0.5, 1, 2, 5, 10 and 20 kHz
Bridge Output Resist.	100 $\Omega$
Meter	3 $\frac{1}{2}$ digit LED, Full Scale Ranges: Amplifier Output: 200 mV, 2 V and 20 V Current: 200 nA and 2 $\mu$ A
Power Requirements	100 to 130 or 220 to 240 VAC, 50/60 Hz, 10 VA
Physical Dimensions:	
Probe	12.5 mm D x 6.2 cm L with 1.8 m L cable
Case	8.9 x 43.2 x 30.5 cm (H x W x D)
Shipping Weight	5.5 kg
Warranty	Three years, parts and labor

\* At x1 output

#### Order # Model Product

W4 64-0039	IE-210	Intracellular Electrometer; Supplied with Probe and Rack Mount Hardware. Specify Line Operating Voltage if Other Than 100 to 130 VAC.
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W4 64-0042	2100	Replacement Headstage
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#### Optional Accessories

W4 64-0040	BB-15	Breakaway Box
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W4 64-0041	RB-1	Remote Buzz Control
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W4 64-0964	ESP/W-F10N	Electrode Holder, Straight 1.0mm for IE-210/251A
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W4 64-0965	ESP/W-F12N	Electrode Holder, Straight 1.2mm for IE-210/251A
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W4 64-0966	ESP/W-F15N	Electrode Holder, Straight 1.5mm for IE-210/251A
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W4 64-0967	ESP/W-F20N	Electrode Holder, Straight 2.0mm for IE-210/251A
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## IE-251A

### Intracellular Electrometer

*A moderately priced intracellular electrometer complete with current passing capability*



The **IE-251A** is a moderately priced intracellular electrometer, complete with current passing capability, incorporating the same basic design as the more costly IE-210. The important features required for low noise, drift free recording from glass microelectrodes have been retained in this lower cost model. The IE-251A is easy to use and an excellent choice for the budget-conscious researcher or student teaching lab.

The IE-251A features a very small active headstage, essentially the same as used with the more costly IE-210. Epoxy-sealed construction affords maximum resistance to saline corrosion. Its small size and low mass permit easy mounting in a micro-positioner. The electrode holder supplied connects directly to the probe input.

The amplifier features include:

- Fixed gains are at x1 and x10.
- Capacity Compensation neutralizes input capacitance up to 50 pF.
- Junction potentials up to  $\pm 200$  millivolts are nulled with the DC Position control.
- Electrode Test provides convenient electrode resistance check.
- Push button operated Buzz produces oscillations at pipette tip to facilitate cell impalement.
- Convenient Probe Test port permits fast check of amplifier performance.

#### Current Injection

The injection circuitry of the IE-251A allows simultaneous stimulation and recording through microelectrode resistances up to 1 G $\Omega$  in two ranges. Voltages at the Stimulus Input are converted to constant currents applied to the electrode. The steady state and transient components of the current injection artifact are nulled with the DC and transient balance controls. The corrected signal is viewed at the single-ended bridge output. Electrode resistance is read from the DC balance ten-turn dial.

#### Overdrive Indicators

Two visual indicators call attention to overload conditions:

- Input Overdrive is illuminated whenever the probe input voltage exceeds  $\pm 1$  V, caused by either excessive current through the microelectrode or an open circuit (open or blocked electrode).
- Current Overdrive warns of excessive voltage ( $>50$  V) applied to the Stimulus Input.

This Intracellular Electrometer is supplied with a probe. An Electrode Holder must be purchased separately based on your glass outer diameter. Also, specify line operating voltage if other than 100-130 VAC.

#### Specifications

##### Amplifier:

Input Impedance	$>10^{10}\Omega$ shunted by 0.5 pF
Noise Level	(0.1 Hz to 10 kHz)* 25 $\mu$ V p-p input shorted 250 $\mu$ V p-p, 20 M $\Omega$ at input
Output Resistance	100 $\Omega$
Gains	x1 and x10
Rise Time (10 to 90%)	10 $\mu$ sec measured with 20 M $\Omega$ resistor
Capacity Compensation	0 to 50 pF
Probe Input Voltage Range	$\pm 1$ V
DC Positioning Range	$\pm 200$ mV referred to input
Leakage Current	Adjustable to zero
Electrode Test	1 mV/M $\Omega$

##### Buzz:

Amplitude variable	0 to 15 V
Frequency variable	100 Hz to 10 kHz

##### Current Injection:

Balance Ranges	0 to 100 M $\Omega$ and 0 to 1000 M $\Omega$
Current Injection Limit	$\pm 1$ V divided by electrode R or 0.5 $\mu$ A, whichever occurs first
Stimulus Input Resistance	3.3 k $\Omega$
Maximum Stimulus Input	$\pm 50$ V
Bridge Bal. Output Resist.	100 $\Omega$
I Monitor Output Resist.	1 k $\Omega$
I Monitor Output Scale Factor	1V = 50 nA

Power Requirements	100 to 130 or 220 to 240 V, 50/60 Hz, 10 VA
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##### Physical Dimensions:

Case Size	12.5 x 20.3 x 25.4 cm (H x W x D)
Probe	9.5 mm x 6.5 cm (D x L) with 1.8 m L cable
Probe Handle	6.5 mm x 6.5 cm (D x L)

Shipping Weight	4.5 kg
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Warranty	Two years, parts & labor
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\* At x1 output.

Order #	Model	Product
<b>W4 64-0090</b>	IE-251A	Intracellular Electrometer Electrode Holders for IE-210/251A, 110 VAC
<b>W4 64-1514</b>	IE-251A	Intracellular Electrometer Electrode Holders for IE-210/251A, 200/240 VAC
<b>W4 64-0964</b>	ESP/W-F10N	Electrode Holder, Straight 1.0mm glass OD for IE-210/251A
<b>W4 64-0965</b>	ESP/W-F12N	Electrode Holder, Straight 1.2mm glass OD for IE-210/251A
<b>W4 64-0966</b>	ESP/W-F15N	Electrode Holder, Straight 1.5mm glass OD for IE-210/251A
<b>W4 64-0967</b>	ESP/W-F20N	Electrode Holder, Straight 2.0mm glass OD for IE-210/251A

#### Optional Accessories

<b>W4 64-0043</b>	2510	Replacement Headstage
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## DP-301 & DP-304

### Differential Amplifier: Single Channel and 4-Channel

*Single and four channel AC/DC differential pre-amplifiers suited for EEG, EKG and extracellular recording*



The DP-300 Series are AC/DC differential amplifiers highly suited for EEG, EKG and extracellular recording. Features include high input impedance, high common mode rejection [100 dB @ 60 Hz], low noise, high gain, high tolerance to DC, and bandwidth filtering.

#### High Input Z, High CMR

High common mode rejection (CMR) is very important in minimizing electrical interference. The high input resistance of the DP-300 Series ( $10^{12} \Omega$  typical) ensures that the instrument's high CMR will not be degraded by differences in source impedance at the input. This is important in extracellular recording, where the difference in resistance of the recording and indifferent electrode is often large.

#### High DC Tolerance

Extracellular action potentials are typically measured in microvolts but are usually accompanied by much larger DC electrode voltages. DP-300 Series are designed to amplify these microvolt level events with as much as  $\pm 3$  V DC at the input.

#### High Gain, Low Noise & Bandwidth Limiting

With gain selections at x100, x1000 and x10,000, even microvolt signals are sufficiently amplified for computer and recorder inputs. Noise is very low, typically  $10 \mu\text{V}$  p-p at 1 Hz to 10 kHz bandwidth. Reducing the bandwidth with the low pass and high pass filters further lowers noise.

#### Calibration Signal

The internal Cal signal provides a convenient check of amplifier gain and operation.

#### Battery Powered/Portable DP-301

The single channel DP-301 is powered with 4 standard 9 V transistor batteries yielding approximately 500 hours of normal operation.

The small size of the DP-301 makes it possible to be placed at the measurement site or inside a Faraday cage. End of battery life is indicated by the Low Bat light.

#### Rack Mounted DP-304

The DP-304 is housed in a rack mounting cabinet and is line powered.

#### Input Cables

The standard IC-2S input cables (2/channel) are BNC and unterminated at the outboard end. Optionally available are BNC cables with 2 mm pin and alligator clip, (p/n IC-4M). There is no additional cost if specified at time of order.

#### Specifications

Voltage Gain, AC & DC	x100, x1,000 & x10,000
Input Resistance	$10^{12} \Omega$ typical
Leakage Current	50 pA typical at the input has 100 m
Common Mode Rejection	100 dB min (100,000:1) at 60 Hz
Noise, Input Shorted	$10 \mu\text{V}$ p-p, 1 Hz to 10 kHz, $\approx 14 \text{ nV}/\sqrt{\text{Hz}}$ @ 10 KHz Maximum
Low Frequency (high pass) Filter Settings	0.1, 1.0, 10 & 300 Hz
High Frequency (low pass) Filter Settings	0.1, 1.0, 3.0 & 10 kHz
Calibration Signal	1 mV p-p at 10 Hz
Max. Common Mode Signal	$\pm 3$ V
Output Voltage Swing	$\pm 10$ V
Output Resistance	220
Input & Output Connectors	BNC
Power Requirements:	
DP-301	4 x 9 V alkaline batteries
DP-304	110 to 130 or 220 to 240 VAC, 50/60 Hz, 10 VA
Physical Size, H x W x D:	
DP-301	8.8 x 20 x 17.5 cm
DP-304	17.8 x 43.2 x 25 cm
Shipping Weight	DP-301: 2.3 kg; DP-304: 6.8 kg
Warranty:	
DP-301	Two years, parts and labor (excluding batteries)
DP-304	Three years, parts and labor

Order #	Model	Product
W4 64-0044	DP-301	Differential Amplifier, Single Channel Bench Top
W4 64-0045	DP-304	Differential Amplifier, 4-Channel Rack Mount Case. Each Channel Supplied with IC-2S Input Cables, qty. of 2
W4 64-0046	IC-2S	Replacement Input Cable Set, qty. of 2
W4 64-0047	IC-4M	Replacement Input Cable Set, qty. of 2

## DP-311

### Differential Amplifier with Active Headstage

*The DP-311 AC/DC differential pre-amplifier is highly suited for EEG, EKG and extracellular recording*



- Excellent common mode rejection: 120 dB at 60 Hz
- Small active headstage which can be mounted in micromanipulators
- Suitable for use with high impedance glass or metal microelectrodes

The **DP-311 AC/DC Differential Amplifier** is highly suited for EEG, EKG and extracellular recording using glass or metal microelectrodes. Features include high input impedance, high common mode rejection [120 dB at 60 Hz], low noise, high gain, high DC tolerance, bandwidth filtering and an active headstage.

#### High Input Z, High CMR

High common mode rejection is very important in minimizing electrical interference. The high input resistance of the DP-311 Series ( $10^{12} \Omega$  typical) ensures that the instrument's high CMR will not be degraded by differences in source impedance at the input. This is important in extracellular recording, where the difference in resistance of the recording and indifferent electrode is often large.

#### High DC Tolerance

Extracellular action potentials are typically measured in microvolts but are usually accompanied by much larger DC electrode voltages. The DP-311 is designed to amplify these microvolt level events with as much as  $\pm 2$  Volts DC at the input.

#### High Gain, Low Noise & Bandwidth Limiting

With gain selections at x10, x100, x1000 and x10,000, even microvolt signals are sufficiently amplified for computer and recorder inputs. Noise is very low, typically 8  $\mu\text{V}$  p-p at 1 Hz to 10 kHz bandwidth. Reducing the bandwidth with the low pass and high pass filters further lowers noise.

#### Calibration Signal

An internal Cal signal provides a convenient check of amplifier gain and operation.

#### Specifications

Voltage Gain, AC & DC	x10, x100, x1,000 & x10,000
Input Resistance	$10^{12} \Omega$ typical
Leakage Current	1.0 pA typical
Common Mode Rejection	120 dB min (1,000,000 :1) at 60 Hz
Noise, Input Shorted	8 $\mu\text{V}$ p-p, 1 Hz to 10 kHz typical, $\approx 14 \text{ nV}/\sqrt{\text{Hz}}$ @ 10 KHz Maximum
Low Frequency (high pass) Filter Settings	DC, 0.1, 1.0, 10 & 300 Hz
High Frequency (low pass) Filter Settings	0.1, 0.3, 1.0, 3.0 & 10, 50 kHz
Offset Control Range	$\pm 600$ mV min at output, any gain set
Calibration Signal	1 mV p-p at 100 Hz
Max. Common Mode Signal	$\pm 2$ V
Output Voltage Swing	$\pm 10$ V ( $\pm 5$ V in gain of 10)
Output Resistance	50 $\Omega$
Input Connectors	2 mm male pins, 0.5" in (12.7 mm) spacing
Output Connector	BNC
Power Requirements	90 to 270 VAC, 50/60 Hz, 10 VA
Physical Size, H x W x D	5.1 x 21.25 x 18 cm
Shipping Weight	2.3 kg
Warranty	Two years, parts and labor

Order #	Model	Product
<b>W4 64-1422</b>	DP-311	Differential Amplifier
<b>W4 64-1423</b>	3110	Replacement Headstage
<b>W4 64-1323</b>	PJ2-5	2 mm Jack uninsulated, pkg. of 5

## Model HiZ-223

### Dual Channel Differential Electrometer

*The HiZ-223 is a very high input impedance, dual channel electrometer designed for measurements with high resistance ion-selective microelectrodes*



- $10^{15}\Omega$  Input Resistance
- Designed for measurements with ion-selective microelectrodes
- Probe Test Port
- Standby mode protects input amplifiers
- Driven Guard Shield reduces stray capacity and noise

The HiZ-223 is a very high input impedance, dual channel electrometer designed for measurements with high resistance ion-selective microelectrodes. The amplifier features two small active headstages, allowing the first stage of amplification to take place at the electrode site. Shunt capacity is reduced and electrical interference, such as electrostatic noise and motion artifact, common with this type of recording, are greatly minimized.

To further reduce the noise and stray capacity, the probe housing includes a signal driven guard. A portion of this inner driven shell is exposed at the probe tip allowing a spring shield to be extended over the electrode holder and microelectrode.

The amplifier features a probe test port that permits testing of the electrode test feature and setting of the probe leakage current, (IG).

A standby mode is included and should be used when attaching glass microelectrode or electrode holders to the probe input. While in the standby mode the voltage at the probe input is clamped near zero volts thus protecting the input.

#### Specifications

Input Resistance	$10^{15}\Omega$
Input Capacitance	1.0 pF nominal
Input Leakage Current	75 fA max
Voltage Gain	$1.000 \pm 0.1\%$
Output Resistance	50 $\Omega$
Input Voltage Swing	$\pm 10$ V
Risetime	5 $\mu$ s (10 -90%, small signal)
Output Noise (input shorted)	100 $\mu$ V peak-to-peak
Baseline Stability	$\pm 0.1$ mV/day
Position Control Range	$\pm 600$ mV
Power Requirements	90 to 265 VAC, 50/60 Hz, 10 VA
Physical Dimensions:	
Case Size	8.8 x 21 x 17.5 cm (H x W x D)
Probe	12.7 mm x 6.5 cm (D x W) with 1.8 m cable length
Shipping Weight	2.5 kg
Warranty	Two years, parts & labor

#### Order # Model Product

**W4 64-1650** HiZ-223 Dual Differential Electrometer

#### Accessories/Replacement Parts

**W4 64-1651** HiZP Replacement Probe

**W4 64-1658** DG-1 Driven Guard Shield Pkg. 2

**W4 64-0980** ESP-F10N E Series Holder for 1.0 mm glass OD

**W4 64-0981** ESP-F12N E Series Holder for 1.2 mm glass OD

**W4 64-0982** ESP-F15N E Series Holder for 1.5 mm glass OD

**W4 64-0983** ESP-F20N E Series Holder for 2.0 mm glass OD

# low pass filters

## LPF-8

### 8-Pole Bessel Filter with DC Differential Amplifier—Single Channel

*A signal conditioner combining an 8-pole Bessel filter with a DC amplifier*



- Provides greater frequency control for Bilayer, Patch, and Oocyte Clamps
- High quality 8-pole Bessel filter
- 8-Pole low pass Bessel filter with cutoff frequencies from 0.1 Hz to 20 kHz.
- Differential amplifier gains to x200
- Frequency selection with single control
- Input offset adjustment
- Digital frequency readout
- Rack mountable

#### Specifications

Input	DC Differential
Input Impedance	1 M $\Omega$ each channel
Input Range	$\pm 10$ V
Input Offset	2 Ranges, $\pm 100$ mV and $\pm 1.0$ V variable from zero with 10-turn control; Max offset compensation
Offset Indicator	20 LED Display
Frequency Ranges:	
Low	0.1 to 199.9 Hz
High	10 Hz to 19.99 kHz
Low Range Resolution	0.1 Hz
High Range Resolution	10 Hz
Gains	x1, x2, x5, x10, x20, x50, x100 and x200
Gain Telegraph Output	2.5 V to 6.0 V in 0.5 V steps, x1 Gain = 2.5 V
Output Impedance	50 $\Omega$
Power Requirements	100-130 VAC or 200-250 VAC 50/60 Hz, 15 VA
Enclosure	Rack Mount Cabinet, H x W x D, 4.4 x 43.2 x 20 cm rack hardware included
Shipping Weight	4.6 kg
Warranty	2 years

The **LPF-8** is a signal conditioner combining an 8-pole low pass Bessel filter and DC amplifier. Special features include a digital frequency readout, visual input offset indicator, clipping indicator, and gain telegraph outputs.

The LPF-8 is the premier low-pass Bessel filter from Warner Instruments and provides superior control of analog signal filtering from 0.1 Hz to 20 kHz. The instrument incorporates low-pass signal filtering and output gains from 1 to 200. Dual selectable signal inputs allow the instrument to be configured to operate in normal, inverted or differential modes.

This instrument features an optically encoded circuit which permits frequency selection in two ranges with a single control. Since the set frequency control is not a physical part of the filtering circuit, adjustments to the instrument do not introduce noise artifacts into the output signal.

The unique circuit design uses no mechanical switching which insures long-term instrument reliability.

#### User Conveniences

- Frequency is dialed up with a single rotary control in 2 ranges. Resolution is 0.1 Hz or 10 Hz, depending on range selected.
- BYPASS switch selects full amplifier bandwidth for comparison of filtered and unfiltered signal.
- The DC OFFSET/CLIPPING indicator is a zero center display serving two functions; it is used as a null meter with the offset control and it indicates overload (clipping) conditions.
- Gain telegraph signals are provided for data acquisition systems.

Order #	Model	Product
W4 64-0050	LPF-8	Low Pass Filter/DC Amplifier, Single Channel Rack Mount 100-130 VAC
W4 64-1524	LPF-8	Low Pass Filter/DC Amplifier, 200-240 VAC 50/60 HZ



# low pass filters

## LPF-100B and LPF-202A

### Low Pass Filters, Single and Dual Channel

*These DC amplifier and signal conditioners are used to filter noise and boost signals to levels compatible with computers, chart recorders, and DAT recorders*



LPF-100B (inset) and LPF-202A

- Useful with Epithelial and Oocyte Clamps

#### 4-Pole low pass Bessel filters with DC Amplifier Gains from 1 to 100

LPF DC Amplifier/Filter signal conditioners are used to filter noise and boost signals to levels compatible with computers, chart recorders and tape recorders. Built with analog circuitry, these instruments exhibit very low noise and excellent stability.

The 4-pole low pass Bessel filter frequencies are selected in six steps, from 100 Hz to 5 kHz and gains are selectable from 1 to 100 in seven steps, both in 1, 2, 5 sequence. The full 10 kHz bandwidth is also available. DC signals at the input can be nulled with the Input Offset control. If the gain is set too high for the signal being processed, the Overload indicator will light.

#### Single & Dual Channel Models

The LPF-100B is a single channel bench top instrument. The LPF-202A is a dual-channel model packaged in a low profile rack mounting cabinet (hardware supplied). Both models have input shorting switches that are handy for quickly establishing a zero level at the input. The LPF-202A also has a digital meter for reading DC or average voltage levels. Both models are line powered and covered by a 2-year warranty.

#### Specifications

Input Impedance	1 M $\Omega$
Input Offset	$\pm 200$ mV @ input
Gains	x1, x2, x5, x10, x20, x50, & x100
Input Range	$\pm 10$ V
Noise (referred to input)	12 $\mu$ V RMS DC-5 kHz, 20 $\mu$ V RMS wideband
Max. Output	$\pm 10$ V
Bandwidth	10 kHz @ x100 gain
Filter	4-Pole Bessel low pass
-3 dB Frequencies	0.1, 0.2, 0.5, 1, 2 & 5 kHz
Digital Meter (LPF-202A):	
Low Range	$\pm 1.999$ V
High Range	$\pm 19.999$ V
Overload Indicator:	Lights when output exceeds $\pm 10$ V
Power Requirements	100-130 VAC or 220-240 VAC, 50/60 Hz, 3 VA
Physical Size, H x W x D:	
LPF-100B	6.3 x 14 x 23 cm, shipping weight 2.3 kg
LPF-202A	4.4 x 43.2 x 20 cm, shipping weight 4.6 kg
Warranty	Two years, parts and labor

Order #	Model	Product
W4 64-0048	LPF-100B	Low Pass Filter/DC Amplifier, Single Channel
W4 64-0049	LPF-202A	Low Pass Filter/DC Amplifier, Dual Channel Rack Mount
W4 64-1510	LPF-100B	Low Pass Filter/DC Amplifier, Single Channel, for 200 to 240 VAC
W4 64-1511	LPF-202A	Low Pass Filter/DC Amplifier, Dual Channel Rack Mount, for 200 to 240 VAC

*Rack mount hardware supplied with LPF-202A.*

# Introduction to Ussing Chamber Systems

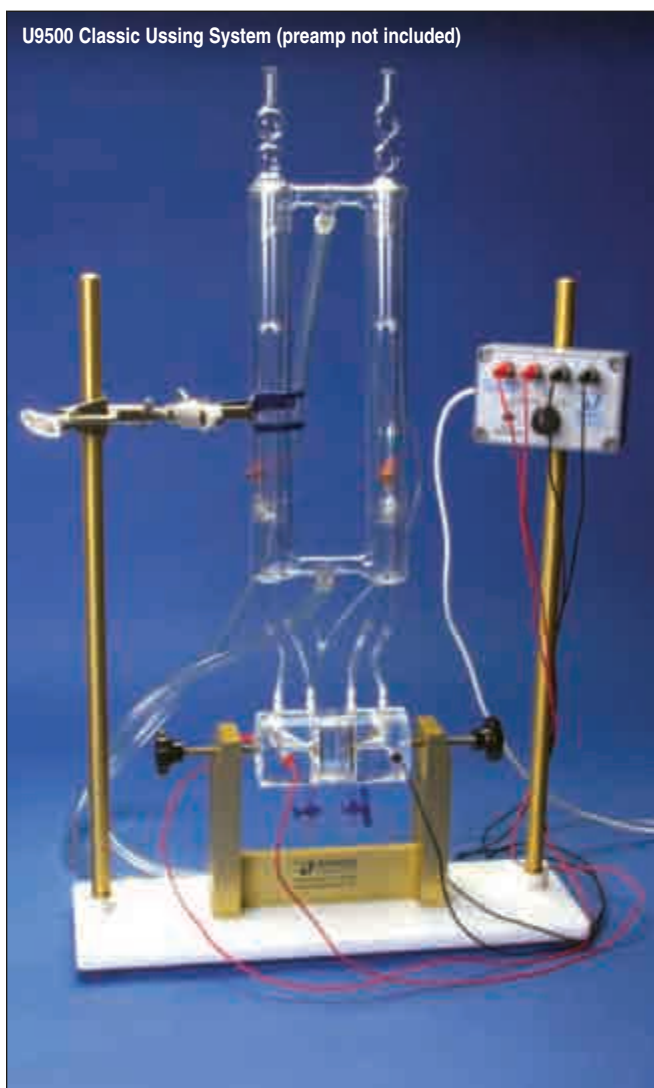
# Ussing/diffusion

**For the investigation of ionic transport across epithelial cells, whether by diffusion or active transport**

An Ussing System, used to measure transport across epithelial membranes, is generally comprised of a chamber and perfusion system, and, if needed, an amplifier and data acquisition system. The heart of the system lies in the chamber with the other components performing supporting roles. The 'Classic' chamber design, first introduced by the Danish physiologist Hans Ussing in the early 1950's, is still in wide use today. However, several newer designs are now available that optimize for convenience and for diffusion- or electrophysiology-based measurements. Epithelia are polar structures possessing an apical (or mucosal) and basolateral (or serosal) side. It is the movement of electrolytes, non-electrolytes, and H<sub>2</sub>O

across this membrane that is of interest to the researcher. Ussing systems have been used to make measurements from native tissue including stomach, large and small intestine, gall and urinary bladder, skin, and trachea, as well as from tissue derived cell monolayers from various sources including renal tubes, pancreas, and salivary and sweat glands.

A well designed Ussing chamber supports an epithelia membrane or cell monolayer in such a way that each side of the membrane is isolated and faces a separate chamber-half. This configuration allows the researcher to make unique chemical and electrical adjustments to either side of the membrane with complete control.



U9500 Classic Ussing System (preamp not included)

## Study Types

Ussing systems can be used for either electrophysiology- or diffusion-based studies, or for a combination of both. They can also be used for radiotracer studies wherein the ionic species under transport is radiolabeled. For convenience, we will consider radiotracer studies to operate within the context of a diffusion- or electrophysiology-based system.

While each approach described above makes use of a chamber and fluid handling system, an electrophysiology-based setup has the added dimension of a current and/or voltage clamp amplifier and data acquisition system. Relevant components include:

### Diffusion-based system

- A chamber with perfusion system and tissue holding apparatus
- Temperature and gas control, if needed
- The ability to acquire data

### Electrophysiology-based system

- A chamber with perfusion system and tissue holding apparatus
- Temperature and gas control, if needed
- Amplifier
- Data acquisition system and software

## A Systems Approach

Warner instruments offers many Ussing system components embodying several different design philosophies. Fortunately, the various components are generally interchangeable with each other (i.e., all the amps are compatible with all the chambers). While this presents the potential for a great degree of flexibility and customization, it can also increase the complexity of selecting the optimum combination of Ussing system components for your needs.

The goal of this article is to outline the advantages and disadvantages associated with each Ussing chamber design with an eye towards guiding you in selecting the best components for your application.

## Introduction to Ussing Chamber Systems (continued)

### Ussing Measurements

A basic understanding of different Ussing measurements commonly made can guide you in determining which components best fit your needs when building a system. As stated earlier, Ussing systems can be defined as being either diffusion- or electrophysiology-based.

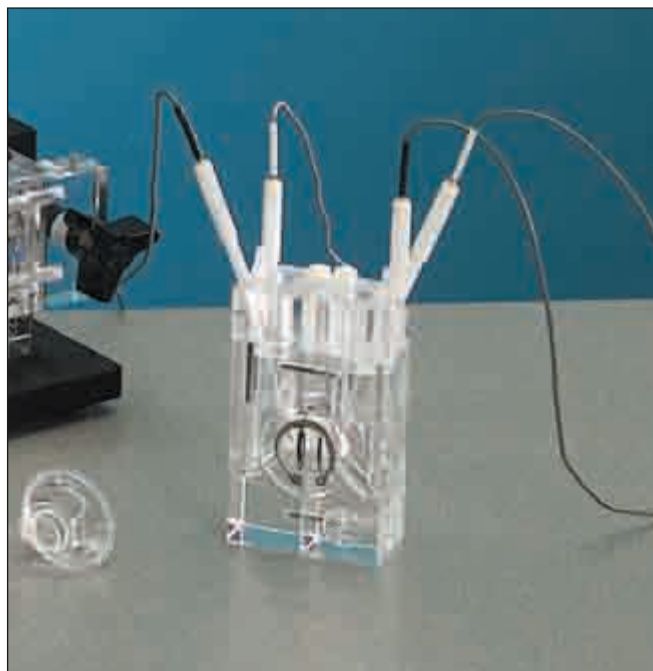
A diffusion-based system is generally focused on measuring transepithelial fluid transport and is used to follow net movement of  $H_2O$  or solute across the membrane. By itself, diffusion-based systems do not provide specific information regarding the underlying transport mechanism and are best suited towards measurements of leaky epithelia characterized by electroneutral transport.

While fluid transport can result in a volume change in the recording chamber, it is usually quantitated by measuring a corresponding change in a volume marker. Volume markers include changes in salt or dye concentration, or changes in physical characteristics such as fluid capacitance or resistance. Advantages of fluid transport measurements using a volume marker include good temporal resolution and sensitivity to small fluxes (volume changes as low as  $\pm 1$  nl/min have been reported). A disadvantage is the requirement for small volume chambers.

An electrophysiology-based system focuses on measuring transepithelial electrical responses to experimental perturbations. These systems are used to quantitate the operation of electrogenic pathways in the membrane (e.g., ion pumps, channels, etc). As such, an electrophysiology-based system carries the additional hardware requirement of a voltage and/or current clamp amplifier, a data acquisition system, and collection/analysis software.

Basic measurement parameters in electrophysiology-based Ussing systems include transmembrane voltage ( $V_t$ ), epithelial membrane resistance ( $R_t$ ), and short circuit current (ISC; the current required to bring  $V_t$  to 0 mV). A limitation with these systems is that non-electrogenic ion transport mechanisms such as fluid transport and electroneutral ion transport cannot be directly monitored. This limitation, however, can be addressed by employing indirect or secondary measurements such as ion replacement, transport inhibition, and the use of hormones and second messengers.

The use of radioisotope tracers is one measurement technique deserving special mention. This technique can be applied equally well to both diffusion- and electrophysiology-based measurements and is usually employed to provide information regarding ion-specific transport mechanisms. For example, a diffusion-based model cannot identify the fluid being transported or if the measured volume change is the result of a hydrostatic or osmotic process. Finally, if an osmotic-driven volume change is mediated by an ionic mechanism, then the responsible ion is not identified. By comparison, a limitation with the electrophysiology-based model is that while ionic transport can be measured, the specific ion crossing the membrane is not specifically determined. This is especially true for multi-ionic salt conditions. For both cases, the use of a radiolabeled ionic species allows for directly monitoring ion-specific translocation for the two measurement systems described above.



### The Components

An Ussing system is comprised of a chamber and perfusion system, and if needed, an amplifier and data acquisition package. If working at defined temperatures, then a circulating water bath is also needed for the heat jackets.

### The Chamber System

While decisions need to be made for each step in assembling a complete Ussing system, the greatest complexity is associated with choosing the chamber and its associated tissue support. Once these elements have been addressed, then the task of selecting the other components (amplification, data acquisition, etc) is more or less direct.

All Ussing chamber systems have the following features in common: a means to hold the membrane while minimizing tissue damage, a means for holding and exchanging solutions, a means to facilitate precise electrode placement, and a means to control solution temperature and gas load.

Ussing chamber systems from Warner include the Classic, introduced by Ussing in the 50's, Self-Contained, incorporating the full classic setup within a small housing, and Multi-Channel systems, allowing simultaneous measurement from many epithelia in parallel. Most chamber systems, except the Classic and NaviCyte Vertical make use of inserts allowing them to accommodate various tissues as well as cultured cells on permeable supports (e.g., Snapwell, Millicell, Falcon, and Transwell) without having to purchase a separate chamber for each support.

## Introduction to Ussing Chamber Systems (continued)

**The Classic** is the fundamental chamber system as designed by Ussing. It is comprised of a cylindrical tissue holder to which the electrodes and plumbing attach. Tissues are mounted directly onto and are compressed between the two chamber-halves. A variety of tissue chambers are available with both round and slotted openings. The enclosed baths (apical, basolateral) are perfused via a glass circulation reservoir that mounts above the chamber. The reservoir uses a 'gas-lift' mechanism to drive circulation and to provide gas tension. Reservoirs are available in 4, 10, and 20 ml volumes.

**The Classic with Insert** chamber system is the same as the Classic system except that the tissues are supported via inserts. This system also supports cultured cells on Snapwell, Millicell, Falcon, or Transwell culture cups.

**The Self-contained** chamber systems provide all of the features of the Classic system but houses the full apparatus (chamber, electrodes, and perfusion system) within a single Lucite block. Tissues or cultured cells mount into a two piece assembly (an insert) that is easily placed into the chamber from the top. Temperature control is provided via an external circulating water bath. Self-contained chambers are available in both single and dual channel models.

**The Multi-channel** chamber systems include the Navicyte and EasyMount designs. Both designs make use of a support assembly to hold anywhere from 2 to 24 independent chambers (depending on design) and to couple the perfusion and electronic components to the chambers. Navicyte chambers are available in both horizontal and vertical configurations and the EasyMount chambers are only available in the vertical configuration.

- The **Navicyte Horizontal** configuration accommodates from 1 to 6 chambers and is ideal for studying mucosal layers at an air/liquid interface. Navicyte Horizontal chambers make use of a mounting ring or Snapwell insert to support the tissue of interest.
- The **Navicyte Vertical** configuration is well designed for diffusion-based studies and accommodates from 1 to 24 chambers. Tissues are supported directly in the chamber block and no insert is required. However, a chamber block supporting a Snapwell insert is also available.
- The **EasyMount** configuration accommodates from 2 to 8 chambers and are well designed for electrophysiology-based measurements. EasyMount chambers are visually similar to the Navicyte Vertical chambers but differ in that they require the use of an insert to secure and place the tissue into the chamber.

### The Amplifier

An amplifier is required if making electrophysiology-based measurement. Warner offers a large selection of amplifiers, all compatible with the chamber systems described above. Available options include the EC-800 and VCC-600 single channel amplifiers, the EC-825A and VCC-MC2 dual channel amplifiers, and finally, the VCC-MC6 and VCC-MC8 six and eight channel amplifiers, respectively.

### Data Acquisition Packages

Data acquisition is necessary for collecting data from the Ussing system (usually from the amplifier when making electrophysiological recordings) and processing it into a digital form for later analysis on a computer. The basic system offered for this purpose by Warner is the Acquire and Analyze acquisition system.

A second acquisition system offered is the HAI-118. Output from Warner's EC-800 and EC-825A, as well the VCC Series epithelial voltage clamps, can be fed directly into the HAI-118. The voltage clamp protocol in the LabScribe program's stimulator section makes recording of data of four to six epithelial channels possible.

There is another option, however, that bears special mention. This is the Computer Controlled Multi-clamp with Software. This is a unique package that houses several amplifiers (2, 4, or 6), a computer, and the software all in a single box. As such, a separate amplifier and data acquisition system are not needed when using the Multi-clamp with Software.



## U9500 & U2520 Classic Ussing Systems

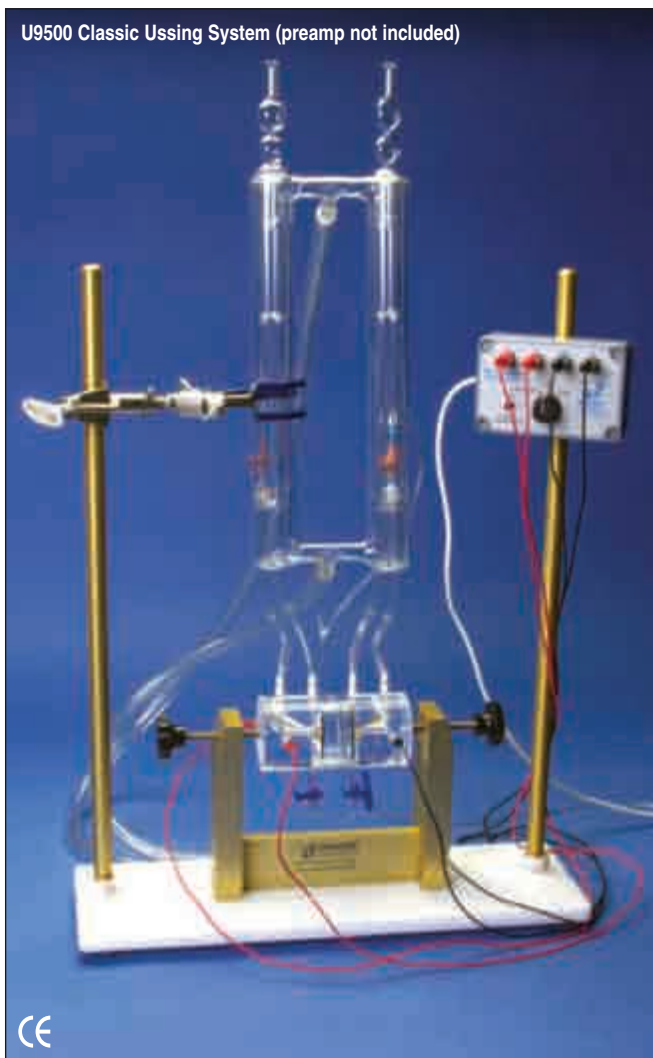
# Ussing/diffusion

### *The Classic system as designed by H.H. Ussing*

*The investigation of ionic transport across epithelial cells was greatly facilitated by the development of a chamber system designed by Dr. H. H. Ussing more than 40 years ago. Today this equipment bears his name. The U9500 'Classic' design presented here varies little from Dr. Ussing's original equipment which remains in wide use for the study of electrophysiological properties of epithelial tissues.*

*A newer design, the U9520 'Classic with Inserts' allows for insertion of cell culture or tissue supports and greatly increases the functionality of the classic Ussing chamber. The low initial cost of the Classic design, coupled with the modest cost of add-on components, makes this system an ideal option for classroom instruction and in-the-field research.*

U9500 Classic Ussing System (preamp not included)



### **The Classic Ussing Chamber Systems**

The U9500 and U9520 are complete chamber systems consisting of an Ussing chamber, chamber support stand, circulation reservoir, 3-prong clamp, air/gas fitting kit, and electrode set. Both systems are virtually identical with the difference embodied in the actual chamber.

### **U9500 'Classic' Ussing Chambers**

The U9500 'Classic' chambers are machined from solid acrylic into two halves and have vertical and horizontal ports in each half for connection to the circulation system and for making electrical connections.

The face of one chamber-half is imbedded with sharp stainless-steel pins which mate with corresponding holes in the other chamber-half face. These pins allow for puncturing and positioning of an epithelium membrane within the chamber. Chambers are available in a variety of sizes and pin configurations. In the 'Classic' design, a separate chamber must be purchased for each different desired pin configuration. This is a good choice if you intend to study a single tissue type as the assembly is direct and simple.

### **U9520 'Classic with Inserts' Ussing Chambers**

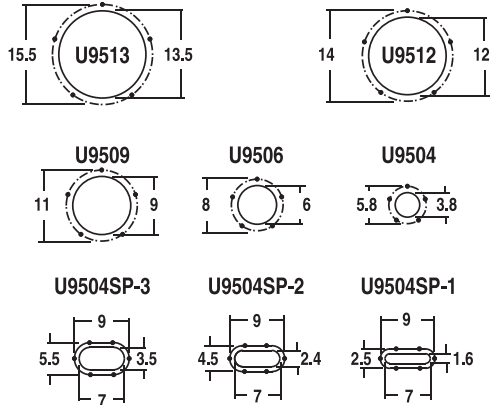
The U9520 'Classic with Inserts' chamber is functionally similar to the U9500 except that it makes use of low-cost adapters (inserts) to position and support tissues or cultured cells within the chamber body. Inserts are interchangeable and permit the researcher to investigate a variety of tissues without having to purchase a separate chamber for each different tissue. The U9520 'Classic with Inserts' chamber is mounted in the standard support stand and procedures for experimentation are the same as with the 'Classic' system.

# U9500 & U2520

## Classic Ussing Systems (continued)

# Ussing/diffusion

Tissue Insert Sizes, Openings and Pin Layouts



\*All dimensions in millimeters



### Chamber configurations

U9500 chambers are available with pinned openings in diameters from 3.8 to 13.5 mm and in slot widths from 1.6 to 3.5 mm to accommodate a variety of tissue dimensions. The choice of pin configuration depends on the epithelia under study. The specified diameter designates the main opening to which the buffer makes contact with the membrane.

U9520 chamber inserts are available with openings in diameters from 3.8 to 13.5 mm. Inserts are also available for culture cups from Falcon, Millicell, Snapwell, and Transwell.

Both U9500 and U9520 chambers are available with and without drains.

### Circulation Reservoirs, 3 Volumes

Available in 4, 10, and 20 ml capacities (per side), circulation reservoirs are two sided, hand-blown apparatus made from borosilicate glass. Each side has two outlets at the base for connection to the perfusion fittings on the associated Ussing chamber-half. Each side also has a separate air/gas inlet to drive the circulation system. Gas, commonly a 95% O<sub>2</sub>/5% CO<sub>2</sub> mixture, is forced under low pressure into these inlets and allowed to come into contact with the buffer solution. The rising bubbles drive circulation and oxygenate the buffer. This method is commonly referred to as a 'gas-lift' perfusion system.

Each horizontal reservoir arm has either an inlet or outlet port for access to the water jacket. Water at the desired temperature is pumped through the jacket and allowing thermoregulation of the perfusion solutions. Glass condensers are provided to minimize evaporative solution losses from the top. Reservoirs are.

### Electrode Sets and Agar Bridge Fittings

Each chamber is supplied with a U9975A Electrode Set comprised of 4 electrodes, 2 Ag-AgCl pellet electrodes (for voltage) and 2 Ag wire electrodes (for current). Electrodes include 1 meter (3 feet) of wire and a connector to plug into the amplifier headstage.

Also supplied are Luer taper fittings that screw onto the electrodes to provide an agar salt bridge connection into the chamber. Fittings can be filled with agar either before or after assembly onto the electrodes.

# U9500 & U2520

# ussing/diffusion

## Classic Ussing Systems (continued)

### How To Order:

- **Select Base Assembly with desired reservoir size.** Systems include support stand with rods, circulation reservoir, 3-prong clamp, U9303 Air/Gas Fitting Kit, U9975A Electrode Set, and U9965EP Electrode Bridge Fitting Kit.
- **Select chamber.** Choices are 'Classic' or 'Classic with Insert'. Both available with or without drains.
- Finally, if using 'Classic with Insert', **select desired insert.**

Order #	Model	Product
<b>Base Assembly</b>		
W4 64-0500R4	U95004R	Classic Ussing Base Assembly with 4 ml circulation reservoir
W4 64-0500R10	U950010R	Classic Ussing Base Assembly with 10 ml circulation reservoir
W4 64-0500R20	U950020R	Classic Ussing Base Assembly with 20 ml circulation reservoir

### 'Classic' Chambers

Without Drains	With Drains			w/o	with
W4 64-0504	W4 64-0512	U9504	'Classic' Chamber with 3.8 mm D round opening		
W4 64-0505	W4 64-0513	U9506	'Classic' Chamber with 6.0 mm D round opening		
W4 64-0506	W4 64-0514	U9509	'Classic' Chamber with 9.0 mm D round opening		
W4 64-0507	W4 64-0515	U9512	'Classic' Chamber with 12.0 mm D round opening		
W4 64-0508	W4 64-0516	U9513	'Classic' Chamber with 13.5 mm D round opening		
W4 64-0509	W4 64-0517	U9504SP-1	'Classic' Chamber with 1.5 x 7.0 mm slotted opening		
W4 64-0510	W4 64-0518	U9504SP-2	'Classic' Chamber with 2.5 x 7.0 mm slotted opening		
W4 64-0511	W4 64-0519	U9504SP-3	'Classic' Chamber with 3.5 x 7.0 mm slotted opening		

### 'Classic with Insert' Chamber

Without Drains	With Drains		
W4 64-0532	W4-64-0533	U9521	'Classic with Insert' Chamber, no insert

Order #	Model	Product
<b>Chamber Inserts</b>		
<b>Inserts with pins</b>		
W4 64-0539	U9524B-04	3.8 mm Round Insert with 5 Pins
W4 64-0540	U9524B-06	6.0 mm Round Insert with 5 Pins
W4 64-0541	U9524B-09	9.0 mm Round Insert with 5 Pins
W4 64-0542	U9524B-12	12.0 mm Round Insert with 5 Pins
W4 64-0543	U9524B-13	13.5 mm Round Insert with 5 Pins
<b>Inserts with o-rings</b>		
W4 64-0534	U9524A-04	3.8 mm Round Insert with O-Ring
W4 64-0535	U9524A-06	6.0 mm Round Insert with O-Ring
W4 64-0536	U9524A-09	9.0 mm Round Insert with O-Ring
W4 64-0537	U9524A-12	12.0 mm Round Insert with O-Ring
W4 64-0538	U9524A-12	13.5 mm Round Insert with O-Ring
<b>Inserts for culture cups</b>		
W4 64-0549	U9524S	Snapwell™ Adapter
W4 64-0544	U9524F-09	Falcon® Adapter, 9 mm
W4 64-0545	U9524F-12	Falcon® Adapter, 12 mm
W4 64-0546	U9524F-25	Falcon® Adapter, 25 mm
W4 64-0547	U9524M-12	Millicell® Adapter, 12 mm
W4 64-0548	U9524M-30	Millicell® Adapter, 30 mm
W4 64-0550	U9524T-06	Transwell® Adapter, 6.5 mm
W4 64-0551	U9524T-12	Transwell® Adapter, 12 mm
W4 64-0552	U9524T-24	Transwell® Adapter 24 mm

Order #	Model	Product
<b>Accessories and replacement parts</b>		
W4 64-0553	U9565EP	Electrode Bridge Fittings, pkg. of 12, and Adapters, pkg. of 6
W4 64-0554	U9975A	Electrode Set, 2 Ag/AgCl Pellet, 2 Ag Wire
W4 64-0555	U9985	Bridge Fitting Adapters, pkg. of 6
W3 64-0556	U9304	Circulation reservoir, 4 ml total volume
W3 64-0557	U9310	Circulation reservoir, 10 ml total volume
W3 64-0558	U9320	Circulation reservoir, 20 ml total volume
W4 64-0560-4ml	U9302-4	Condenser Set for 4 ml Circulation Reservoir, Set of 2
W4 64-0560-10ml	U9302-10	Condenser Set for 10 ml Circulation Reservoir, Set of 2
W4 64-0560-20ml	U9302-20	Condenser Set for 20 ml Circulation Reservoir, Set of 2
W4 64-0561	U9303	Air/Gas Connection Kit
W4 64-0562	U9403	Support Stand with One Ring Stand Rod
W4 64-0563	U9403R	Ring Stand Rod
W4 64-0564	U9404	3-Prong Clamp
W4 64-0567	SL-6U	Stopcocks with Luer Connectors for U9926 and U2500
W4 64-0165	SL-6	Stopcocks, pkg. of 6

Electro-physiology

ussing/diffusion

# U9926 & U2500

## Self-Contained Ussing Chambers

# Ussing/diffusion

*The Classic system in a small package. Inserts available for excised tissue and cultured cells*

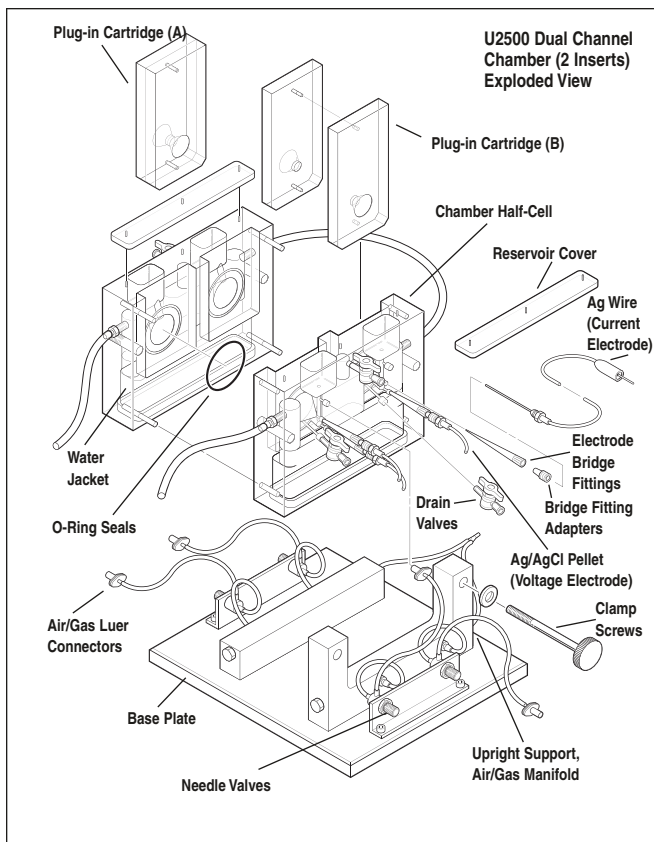
*The U9926 and U2500 Self-Contained Ussing chambers improve on the Classic design by bringing the solution reservoir into the chamber housing. This dramatically reduces the size of the apparatus and increases the ease-of-use of the system.*



U9926 Single Channel Chamber



U2500 Dual Channel Chamber (2 Inserts)



U2500 Dual Channel Chamber (2 Inserts) Exploded View

## The Self-Contained Ussing Chamber Systems

The Self-Contained Ussing Chambers systems come in single- and dual-channel models and offer many advantages over the Classic design. The single-channel **U9926** and dual-channel **U2500** are shown above. Both systems make use of inserts to secure and position the tissue or culture cup within the chamber body.

Chamber bodies (single- and dual-chamber models) consist of chamber-halves which clamp around the insert(s). Each chamber-half has four ports that enter into its respective bath compartment: a voltage electrode port, a current electrode port, an air/gas port, and a solution drain port. Solution warming is provided by pumping heated water through each chamber-half and there are no delicate glass heat exchangers to be broken. The dual-chamber U2500 has the additional feature of including four needle valves for adjusting the air/gas mixture into each individual chamber-half.

Inserts can be easily exchanged between experiments. Solutions are removed from the chambers through the drain valves and the halves unclamped from each other. The insert is then simply replaced. Inserts are available to support a variety of tissue sizes and culture cups.

### Standard Accessories Supplied with U9926 and U2500

The U9926 (single-channel chamber) is supplied with 1 electrode set (consisting of 2 voltage and 2 current electrodes), 12 bridge fittings with adapters; and a tubing/ fitting kit. The U2500 (dual channel) chamber is supplied with two each of the above described accessories. Chamber inserts are ordered separately.



# U9926 & U2500

# ussing/diffusion

## Self-Contained Ussing Chambers (continued)

### How to Order:

- **Select Base Assembly.** Each system includes one or two U9975A Electrode Set(s) and U9965EP Electrode Bridge Fitting Kit(s)
- **Select Insert.** Order 1 if using the U9926 and order 2 if using the U2500

Order #	Model	Product
<b>Base Assembly</b>		
W4 64-0568S	U9926	Single-channel Ussing Chamber Base Assembly, does not include insert
W4 64-0575S	U2500	Dual-channel Ussing Chamber Base Assembly, does not include inserts
<b>Inserts for U9926 and U2500 Base Assembly</b>		
<b>Inserts for tissue, with o-ring</b>		
W4 64-0582	U9924A-04	Round Insert, 3.8 mm, with O-Ring
W4 64-0583	U9924A-06	Round Insert, 6.0 mm, with O-Ring
W4 64-0584	U9924A-09	Round Insert, 9.0 mm, with O-Ring
W4 64-0585	U9924A-12	Round Insert, 12.0 mm, with O-Ring
W4 64-0586	U9924A-13	Round Insert, 13.5 mm, with O-Ring
<b>Inserts for tissue, with pins</b>		
W4 64-0587	U9924B-04	Round Insert, 3.8 mm, with 5 Pins
W4 64-0588	U9924B-06	Round Insert, 6.0 mm, with 5 Pins
W4 64-0589	U9924B-09	Round Insert, 9.0 mm, with 5 Pins
W4 64-0590	U9924B-12	Round Insert, 12.0 mm, with 5 Pins
W4 64-0591	U9924B-13	Round Insert, 13.5 mm, with 5 Pins
W4 64-0592	U9924C-03	Slotted Insert, 1.6 x 7.0 mm, with 6 Pins
W4 64-0593	U9924C-04	Slotted Insert, 2.4 x 7.0 mm, with 6 Pins
W4 64-0594	U9924C-05	Slotted Insert, 3.5 x 7.0 mm, with 6 Pins

Order #	Model	Product
<b>Inserts for Culture Cup</b>		
W4 64-0595	U9924F-09	Falcon® Adapter, 9 mm
W4 64-0596	U9924F-12	Falcon® Adapter, 12 mm
W4 64-0597	U9924F-25	Falcon® Adapter, 25 mm
W4 64-0598	1U9924M-12	Millicell® Adapter, 12 mm
W4 64-0599	U9924M-30	Millicell® Adapter, 30 mm
W4 64-0600	U9924S	Snapwell™ Adapter, 12mm
W4 64-0601	U9924T-06	Transwell® Adapter, 6.5 mm
W4 64-0602	U9924T-12	Transwell® Adapter, 12 mm
W4 64-0603	U9924T-24	Transwell® Adapter, 24 mm
<b>Replacement Parts</b>		
W4 64-0565	U9406	Tubing/Fitting Kit; Includes 3/16 in x 10 ft (ID x L) Tygon Tubing, 1/16 in x 10 ft (ID x L) Tygon Tubing, Eighteen 1/16 in Fittings (six each of straight, Y and Luer Fittings)
W4 64-0553	U9565EP	Electrode Bridge Fitting Kit; Includes twelve Bridge Fittings, six Bridge Fitting Adapters
W4 64-0554	U9975A	Electrode Set; Includes two Ag-AgCl Pellet Voltage Electrode, two Ag Wire Current Electrode
W4 64-0555	U9985	Bridge Fitting Adapters, pkg. of 6

## Multichannel Ussing Chamber Systems NaviCyte and EasyMount Systems

Designed for parallel studies on epithelial membranes

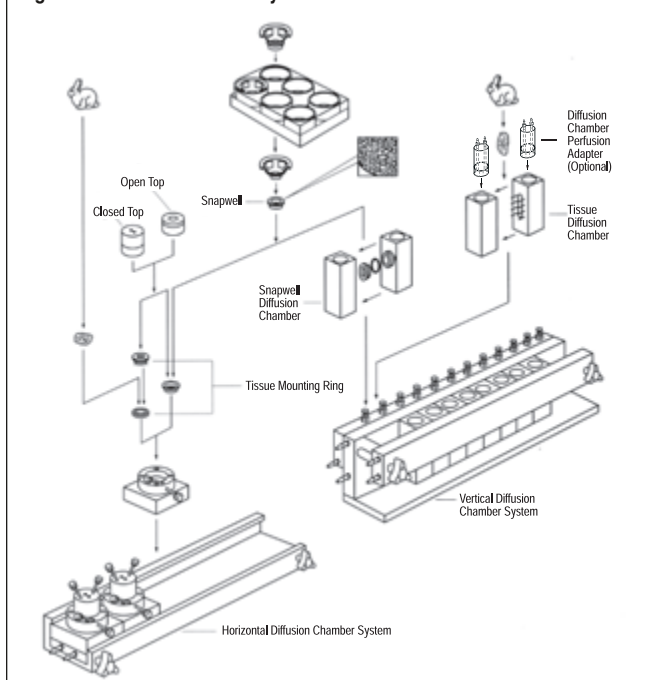


NAVICYTE™

EasyMount

Warner Instruments offers three multichannel Ussing chamber systems capable of supporting up to 24 independent chambers, all operating in parallel. Two systems position the membrane vertically and the one positions the membrane horizontally. All three multichannel chamber systems embody the self-contained design and are fully capable of supporting either membranes or cell culture cups. Differences between these systems exist, however, and are explained below.

Figure 1: Diffusion Chamber Systems



The **NaviCyte Horizontal** chamber system is designed for transport and toxicology studies using cells or tissue exposed to an air interface such as occurs in the in vivo environment (e.g., nasal, pulmonary, corneal, or dermal cells). The chambers create an environment wherein the apical surface can be exposed to liquids, semi-solid compounds, or to gases while the basolateral surface remains perfused with medium. NaviCyte Horizontal chambers accept either tissue mounting rings or Snapwell™ cell culture cups and can be used in either open or closed configurations. In the closed configuration, electrodes can be brought to bear to make electrophysiological membrane resistance measurements. Accepts from 1 to 6 chambers.

Similar to the NaviCyte Horizontal, the **NaviCyte Vertical** chamber system is designed for transport studies on filter grown cell monolayers or excised tissue sections. This system differs, however, in that membranes are mounted vertically and the chamber blocks do not use inserts to secure tissues. Instead, tissue is affixed between the opposing faces of the chamber-halves using a series of pins surrounding the opening. Chambers are available with both circular and oblong openings, depending on the tissue type under study, and can also accommodate Snapwell™ culture cups. Several low volume chambers that reduce the amount of compound required to conduct permeability studies are also available. Accepts from 1 to 24 chambers.

### NaviCyte Electrodes

The NaviCyte electrodes can be used with either the NaviCyte horizontal or vertical chamber systems and provide the ability to make electrophysiological recordings. Electrodes are terminated with a 2 mm pin connector and are compatible with the NaviCyte electric manifolds (used to connect chambers to our current/voltage clamps). The Ag/AgCl reference electrode is contained in a glass barrel that terminates in a micro-porous ceramic tip. The barrel is filled with a suitable electrolyte solution, usually the buffer used for the external media or 3M KCl, and is refillable.

### EasyMount Vertical Chamber Systems

The **EasyMount Vertical** chamber systems are ideal for studies requiring electrophysiological measurement of transmembrane resistance. While visually similar to the NaviCyte Vertical chambers, EasyMount chambers are different in that they use inserts to position and secure tissues or culture cups within the chamber body. Inserts can be easily exchanged without removing the chamber from its support assembly or disturbing the electrodes. Chambers come in standard and low volume designs with a variety of inserts available for each. All chambers, however, mount into the same support assembly. Accepts from 2 to 8 chambers.

The EasyMount chamber systems consist of 2 to 8 vertical Ussing chambers, a heater block/support stand, needle valves for adjustment of gas flow (for oxygenation and gas lift stirring), and Ag/AgCl voltage/current electrodes for measuring transepithelial voltage and for passing current. Tissue specific inserts are ordered separately.

### NaviCyte Horizontal and Vertical Chamber Systems

The Harvard/NaviCyte patented line of horizontal and vertical diffusion chambers is designed for the study of transport across cultured cell monolayers or excised tissue under dynamic conditions. The basic system architecture shown here demonstrates the fundamental design of both the horizontal and vertical diffusion chamber systems.

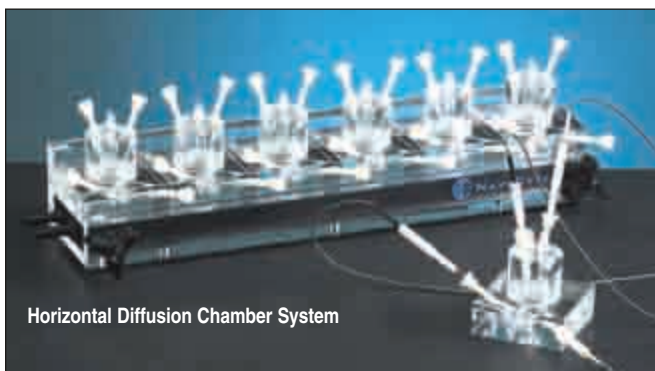
These systems are extremely well suited for non-electrical applications, however, the introduction of electrodes can provide the ability to make electrophysiological measurements. For larger applications, electrical manifolds can be employed to organize and simplify the connections to our various voltage/current clamps.

NaviCyte chamber systems are manufactured from acrylic and can be temperature controlled.

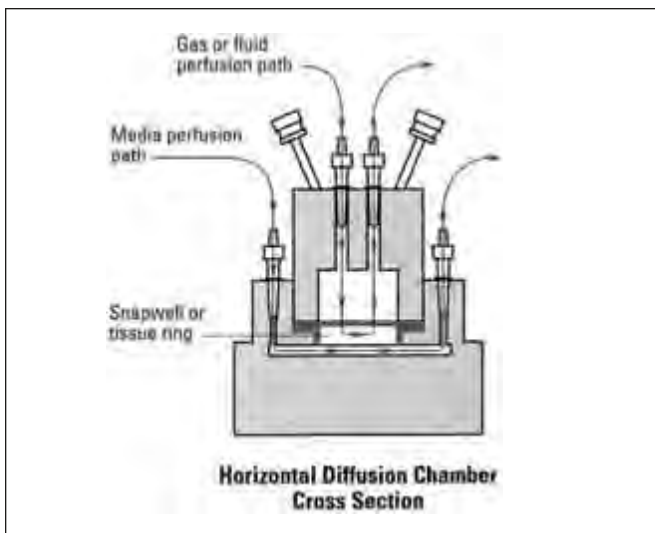
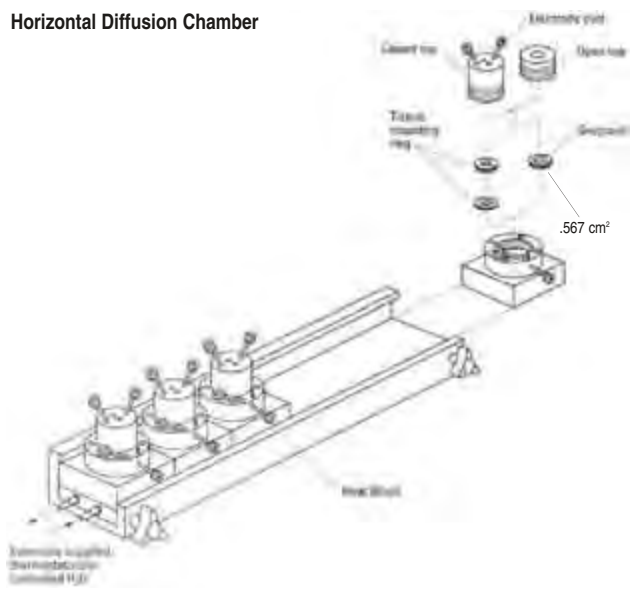
## NaviCyte Horizontal Multichannel Ussing Chamber Systems

*Optimized for diffusion studies on membranes at an air interface*

The NaviCyte Horizontal system features the ability to run up to six chambers simultaneously and is optimized for transport studies on cells and tissues exposed to an air interface. The included heater block permits temperature control, with the use of a circulating water bath, for these chambers in both open and closed configurations. While optimized for diffusion-based studies, the use of optional electrodes permits electrophysiological membrane resistance measurements.



Horizontal Diffusion Chamber



The **NaviCyte Horizontal** chamber system consists of a heater/support block and up to six horizontal chambers. Chambers require the use of a supplied open or closed chamber cap into which either a Snapwell™ culture cup or a tissue mounting ring may be fitted. Culture cups or tissues are mounted on a horizontal plane. Chambers have basolateral and apical inputs for attachment to perfusion lines, and in the closed configuration chambers can accept electrodes.

### Single or multichannel setups

Chambers can be used singly as a stand-alone entity, or can be mounted into the heater/support block in sets of up to six chambers per block. The heater/support block provides chamber heating and is recommended even if using a single chamber. Inserts are easily exchanged in mounted chambers. The compact footprint (38.1 x 8.9 x 10.2 cm) of the heater/support block conserves lab bench space.

### Open and Closed Configurations

Open and closed chamber configurations are defined by the use of an open or closed chamber cap. Either cap completes the chamber and holds the culture cup or tissue ring into place. Both an open and closed cap is supplied with each chamber.

In the open configuration, the upper surface (usually the apical side) of the membrane is directly accessible, making the system suitable for drug transport studies or cytotoxicity testing of liquids or semi-solid materials. In the closed configuration, the membrane can be exposed to solutions, exposed to gases, perfused with gas, or perfused with liquid.

### NaviCyte Electrodes and Electrical Manifolds

While optimized for diffusion-based assays, NaviCyte electrodes are available for making electrophysiology-based measurements from NaviCyte chambers. Electrodes can only be used with the NaviCyte Horizontal chamber in its closed configuration.

Electrical manifolds are available to organize the multiple connections between the amplifiers and the electrodes when making electrophysiology-based measurements using multiple chambers. Two manifolds are available, one compatible with the VCC amplifiers and the other compatible with the 'Computer Controlled Multi-Clamp with Software' package. See the associated amplifiers for these components.

## NaviCyte Horizontal Multichannel Ussing Chamber Systems (continued)

### How to order:

- **Select Base Assembly.** This is the heater block and is needed only if using more than one chamber or if heating.
- **Select Chambers.** Order from 1 to 6 per heater block. Each chamber includes both open and closed caps, and electrode port screws (for perfusion-only applications).
- **Order a tissue mounting ring** if not using Snapwell. Order one per chamber.
- **Order electrodes, glass barrels, and open screws** if making electrophysiological recordings.

Order #	Product
<b>Base Assembly</b>	
W4 66-0017	Heater Block for Horizontal Chambers
<b>NaviCyte Horizontal Chambers</b>	
W4 66-0016	Single NaviCyte Horizontal Diffusion Chamber
W4 66-0022	Tissue mounting ring, 9 mm Round Aperture
<b>Electrode Components</b>	
W4 66-0023	Ag/AgCl electrodes with KCl, pkg. of 4
W4 66-0024	Glass barrel for Electrode, with Ceramic Tip, pkg. of 8
W4 66-0058	Open screw (straight hole) and O-rings, Serves as an Electrode Holder, pkg. of 24
<b>Replacement Parts</b>	
W4 66-0054	Closed Caps for Horizontal Chambers
W4 66-0055	Open Caps for Horizontal Chambers
W4 66-0053	Closed Screws, Used when perfusion is not needed, pkg. of 24
W4 66-0056	Male Luer Fitting - 3/32 Bar, pkg. of 24
W4 66-0057	Small O-rings for Electrodes, pkg. of 24
<b>The Package System</b>	
W4 66-0005	NaviCyte Horizontal Chamber System – Includes Base Assembly and Six Horizontal Chambers only



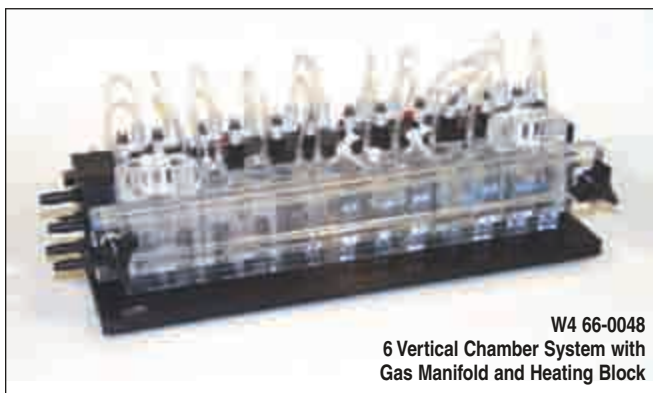
# NaviCyte Vertical Multichannel Ussing Chamber Systems

# Ussing/diffusion

*Optimized for simultaneous diffusion studies on up to 24 membranes*

*This system features the capacity of running up to 24 chambers simultaneously and is optimized for transport studies on both filter grown cell monolayers and surgically excised tissue sections. 14 different chamber types are currently available. The standard support assembly holds 6 chambers and the included 12 channel gas manifold provides*

*air regulation to both sides of each chamber. An included heater block allows for temperature control with the use of a circulating water bath. While optimized for diffusion-based studies, the use of optional electrodes allows for electrophysiological membrane resistance measurements.*

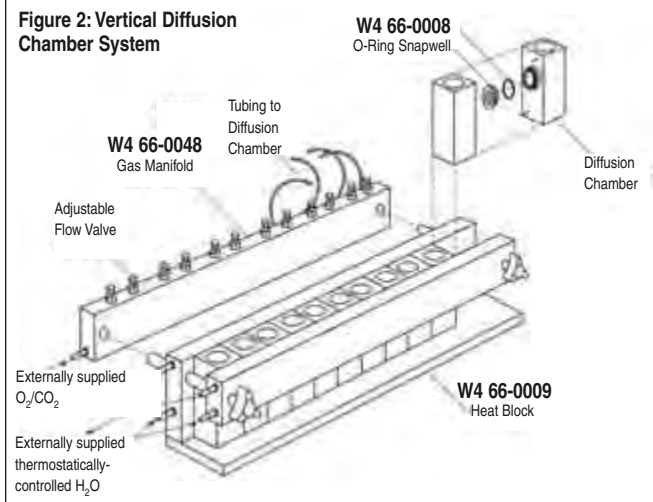


W4 66-0048  
6 Vertical Chamber System with  
Gas Manifold and Heating Block



W4 66-0021  
24 Chamber Heating Block  
for Vertical System

Figure 2: Vertical Diffusion Chamber System



## Heater Blocks

The standard heater block of the NaviCyte Vertical chamber system provides efficient and precise temperature control of chambers. Temperature is regulated by use of an external, user supplied circulating water bath. An optional 24 channel heat block (shown above) allows a greater number of simultaneous measurements to be made.

## Gas Manifold

The 6-chamber (12-channel) gas manifold distributes gas to the chambers where media circulation is generated by the previously described gas-lift process. Gas manifolds can be ganged to accommodate the 24 chamber heater block.

## NaviCyte Vertical Chambers

NaviCyte Vertical chambers are primarily designed for work with excised tissue segments. Chambers are two piece assemblies held together by a high spring-tension retaining ring to insure leak free operation. Tissue is affixed between the opposing faces of two half-chambers using a series of pins that surround the opening. Chambers are available with both circular and oblong openings of various sizes.

The optimal choice of opening will depend on the size and type of tissue under study. For example, an oblong opening can increase the effective sample surface area for an intestinal tissue.

## Low Volume Chambers

Several low volume tissue chambers are offered and are designed to reduce the amount of compound required for permeability studies.

## Snapwell™ Chamber

The Snapwell™ chamber is specifically designed for use with Snapwell™ culture inserts from Corning Costar. This chamber accepts the lower section of the insert, which contains the cultured cell monolayer.

The **NaviCyte Vertical** chamber system consists of up to six vertical chambers, a gas manifold, and a heater block. The system can be extended to 24 channels by the use of an available 24 channel heater block. NaviCyte Vertical chambers do not use inserts, except for the Snapwell chamber, and 14 different chambers are currently available. Chambers are described in detail below.

## Single or Multichannel Setups

Chambers can be used singly as a stand-alone entity, or can be mounted in quantity into the heater/support blocks. The heater/support blocks provide chamber heating. The standard heater block and associated gas manifold allows up to six experiments to be run in parallel. The compact design (38.1 x 10.2 x 12.7 cm) of this setup conserves valuable bench space.

# NaviCyte Vertical

# Ussing/diffusion

## Multichannel Ussing Chamber Systems (continued)

### Perfusion Caps

Perfusion caps provide perfusion capability to the standard volume Snapwell™, 8 x 24 mm oblong, and 9 mm round chambers. They are not needed for, and cannot be used with, the other standard volume or any of the low volume chambers. The use of a perfusion cap places a chamber into its 'closed' configuration.

### Electrode Caps

Electrode caps provide electrode placement, if making electrophysiological measurements, within the standard volume Snapwell™, 8 x 24 mm oblong, and 9 mm round chambers. They are not needed for, and cannot be used with, the other standard volume or any of the low volume chambers. The use of an electrode cap places a chamber into its 'closed' configuration. You do not need to use a perfusion cap if using an electrode cap.

### NaviCyte Electrodes and Manifold

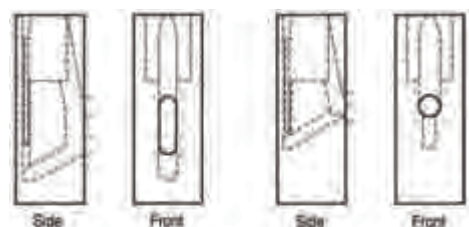
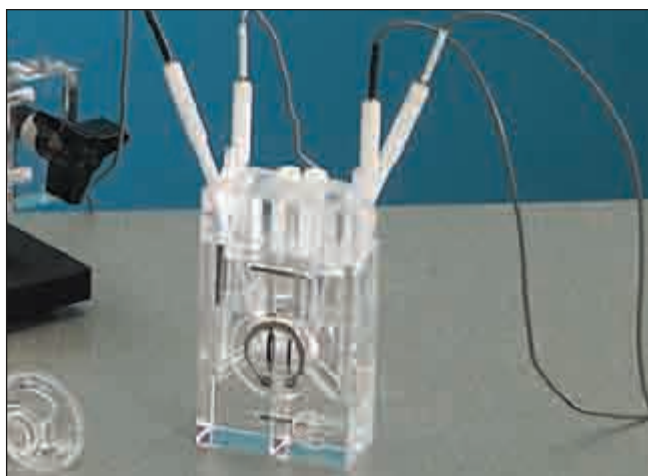
While optimized for diffusion-based assays, NaviCyte electrodes are available for making electrophysiology-based measurements with NaviCyte chambers. Electrodes can be used with NaviCyte Horizontal chambers in both their open and closed configurations. Snapwell™, 8 x 24 mm oblong, and 9 mm round chambers (standard volume) require the use of electrode caps for proper electrode placement.

Electrical manifolds are available to organize the multiple connections between the amplifiers and the electrodes when making electrophysiology-based measurements using multiple chambers. Two manifolds are available, one compatible with the VCC amplifiers and the other compatible with the 'Computer Controlled Multi-Clamp with Software' package. See the associated amplifiers for these components.

### References

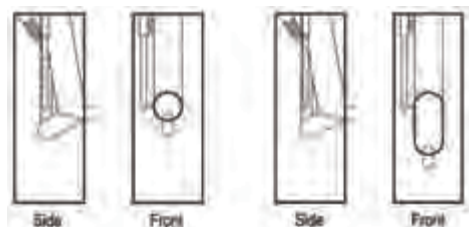
- 1) Grass, G.M. and Sweetana, S.A., "In vitro measurement of gastrointestinal tissue permeability using a new diffusion cell", *Pharm. Res.* 5:372-76 (1988)
- 2) Hidalgo, I.J., Hilgren, K.M., Grass, G.M., and Borchardt, R.T., "Characterization of the unstirred water layer in Caco-2 cell monolayers using a novel diffusion apparatus", *Pharm. Res.* 8:222-227 (1991)

For additional references, please visit our website.



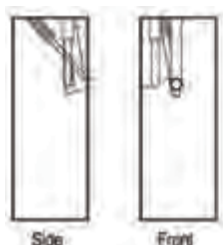
Standard Diffusion Chamber  
W4 66-0013,0032,0038,0046

Standard Diffusion Chamber  
W4 66-0014, 0036

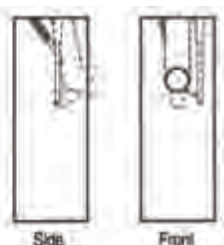


Low Volume Diffusion Chamber  
W4 66-0027

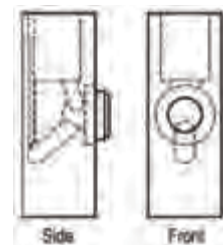
Low Volume Diffusion Chamber  
W4 66-0034, 0042



Low Volume Diffusion Chamber  
W4 66-0026, 0040



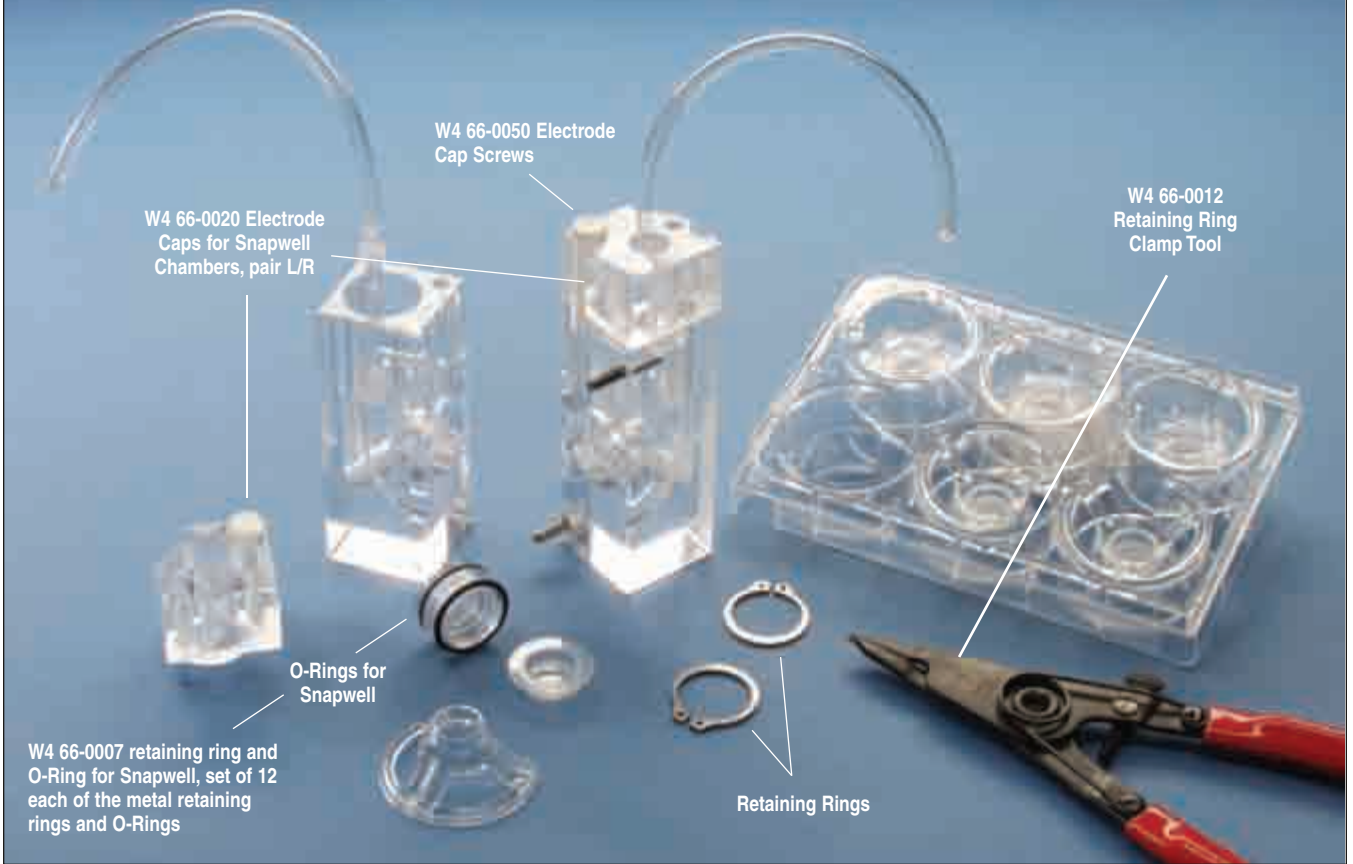
Low Volume Diffusion Chamber  
W4 66-0015



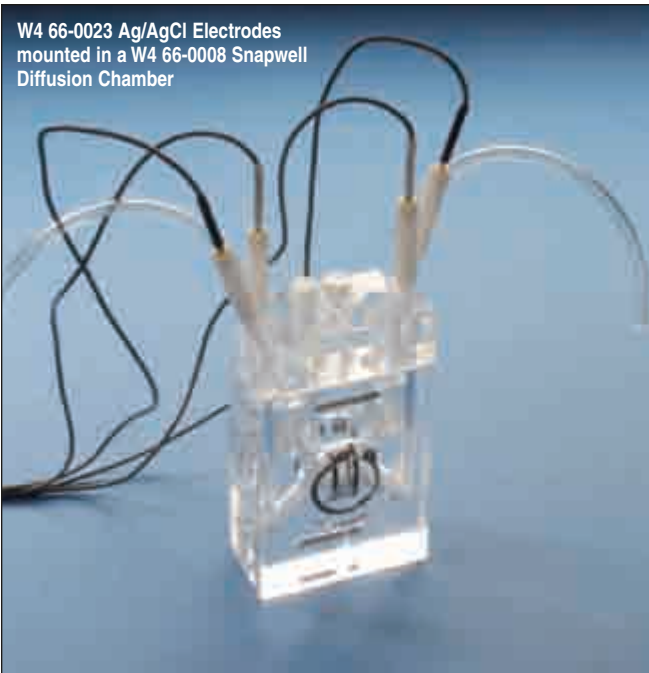
Snapwell™ Diffusion Chamber  
W4 66-0008

# NaviCyte Vertical **ussing/diffusion** Multichannel Ussing Chamber Systems (continued)

W4 66-0008 Snapwell Diffusion Chamber with Electrode Caps



W4 66-0023 Ag/AgCl Electrodes mounted in a W4 66-0008 Snapwell Diffusion Chamber



W4 66-0019 Perfusion Caps mounted in a Snapwell Diffusion Chamber





# NaviCyte Vertical

## Multichannel Ussing Chamber Systems (continued)

# Ussing/diffusion

### How to order:

- **Select Base Assembly.** Only needed if using more than one chamber or if heating.
- **Select Chambers.** Order from 1 to 6.
- **Order Perfusion Caps.** Only needed if perfusing in the standard volume Snapwell, 8 x 24 mm oblong, and 9 mm round chambers. Not needed if using electrode cap. One set per chamber.
- **Order electrodes and glass barrels** if making electrophysiological recordings. One set per chamber.
- **Order electrode caps and electrode cap screws** if making electrophysiological recordings in the standard volume Snapwell, 8 x 24 mm oblong, and 9 mm round chambers. One set per chamber.

### Order # Product

#### Base Assembly

**W4 66-0075** 6-Chamber Heater Block Assembly – System includes 6-Chamber Heating Block, 6-Chamber Air/Gas Manifold, Clear Front Panel, and Retaining Ring Clamp Tool

#### NaviCyte Vertical Chambers

Order #	Chamber Type	Exposed Tissue Area	Working Reservoir Volume
<b>Standard Volume (working volume 5-7 ml per chamber half)</b>			
<b>W4 66-0014*</b>	9 mm Round	0.64 cm <sup>2</sup>	5 to 7 ml
<b>W4 66-0036</b>	4 mm Round	0.12 cm <sup>2</sup>	5 to 7 ml
<b>W4 66-0013*</b>	8 x 24 mm Oblong	1.78 cm <sup>2</sup>	5 to 7 ml
<b>W4 66-0032</b>	4 x 8 mm Oblong	0.29 cm <sup>2</sup>	5 to 7 ml
<b>W4 66-0038</b>	6 x 9 mm Oblong	0.46 cm <sup>2</sup>	5 to 7 ml
<b>W4 66-0046</b>	5 x 24 mm Oblong	1.15 cm <sup>2</sup>	5 to 7 ml
<b>Low Volume (working volume 1-4 ml per chamber half)</b>			
<b>W4 66-0026</b>	5 mm Round	0.20 cm <sup>2</sup>	0.2 to 0.4 ml
<b>W4 66-0015</b>	9 mm Round	0.64 cm <sup>2</sup>	1 to 2 ml
<b>W4 66-0027</b>	12 mm Round	1.13 cm <sup>2</sup>	2 to 4 ml
<b>W4 66-0040</b>	3 mm Round	0.07 cm <sup>2</sup>	1 to 2 ml
<b>W4 66-0034</b>	2 x 10 mm Oblong	0.10 cm <sup>2</sup>	2 to 4 ml
<b>W4 66-0042</b>	4 x 8 mm Oblong	0.28 cm <sup>2</sup>	2 to 4 ml
<b>Specialty</b>			
<b>W4 66-0008*</b>	Snapwell™	1.13 cm <sup>2</sup>	4 to 6 ml

\*May require perfusion or electrode caps, available separatel.

### Order # Product

#### Accessories

**W4 66-0019** Tissue Chamber Perfusion Cap, pkg. of 2

**W4 66-0021** 24-Chamber Heating Block

#### Electrodes

**W4 66-0018** Electrode Cap for Chambers, pair L/R

**W4 66-0020** Electrode Cap for Snapwell Chambers, pair L/R

**W4 66-0050** Electrode Cap Screws, pkg. of 12

**W4 66-0023** Ag/AgCl Electrodes with KCl, pkg. of 4, with O-rings

**W4 66-0024** Glass Barrel for Electrode with Ceramic Tip, pkg. of 8

### Order # Product

**W4 66-0049** Open Screws (with step) and O-rings, pkg. of 12. Serves as Electrode Holders for Low Volume Chambers

**W4 66-0057** Small O-rings for Electrodes, pkg. of 24

#### Replacement parts

**W4 66-0009** 6-Chamber Heating Block

**W4 66-0048** 12 Channel (6 chamber) Air Manifold

**W4 66-0010** Clear Front Panel

**W4 66-0007** Retaining Ring and O-Ring, pkg. of 12

**W4 66-0012** Retaining Ring Clamp Tool

**W4 66-0006** Replacement Air Line for Air\Gas Manifold, 6 inch long, pkg. of 12

#### The Package Systems

##### Standard Volume Systems (does not include electrodes)

**W4 66-0003** NaviCyte Vertical Chamber System – Includes base assembly and six **9 mm round** (W4 66-0014) chambers (does not include perfusion or electrode caps)

**W4 66-0037** NaviCyte Vertical Chamber System – Includes base assembly and six **4 mm round** (W4 66-0036) chambers

**W4 66-0002** NaviCyte Vertical Chamber System – Includes Base Assembly and six **8 x 24 mm oblong** (W4 66-0013) Chambers (does not include perfusion or electrode caps)

**W4 66-0033** NaviCyte Vertical Chamber System – Includes base assembly and six **4 x 8 mm oblong** (W4 66-0032) chambers

**W4 66-0039** NaviCyte Vertical Chamber System – Includes base assembly and six **6 x 9 mm oblong** (W4 66-0038) chambers

**W4 66-0047** NaviCyte Vertical Chamber System – Includes base assembly and six **5 x 24 mm oblong** (W4 66-0046) chambers

##### Low Volume Systems (does not include electrodes)

**W4 66-0028** Low Volume NaviCyte Vertical Chamber System – Includes base assembly and six **5 mm round** (W4 66-0026) chambers

**W4 66-0004** Low Volume NaviCyte Vertical Chamber System – Includes base assembly and six **9 mm round** (W4 66-0015) chambers

**W4 66-0029** Low Volume NaviCyte Vertical Chamber System – Includes base assembly and six **12 mm round** (W4 66-0027) chambers

**W4 66-0041** Low Volume NaviCyte Vertical Chamber System – Includes base assembly and six **3 mm round** (W4 66-0040) chambers

**W4 66-0035** Low Volume NaviCyte Vertical Chamber System – Includes base assembly and six **2 x 10 mm oblong** (W4 66-0034) chambers

**W4 66-0043** Low Volume NaviCyte Vertical Chamber System – Includes base assembly and six **4 x 8 mm oblong** (W4 66-0042) chambers

##### Specialty Systems

**W4 66-0009** NaviCyte Vertical Chamber System – Includes base assembly and six **Snapwell** (W4 66-0008) chambers (does not include perfusion or electrode caps)



## EasyMount Multichannel Ussing Chamber Systems

**Optimized for simultaneous electrophysiological studies on up to 8 membrane**

The EasyMount chamber systems are ideal for studies requiring electrophysiological measurement of transmembrane resistance. While visually similar to the NaviCyte Vertical chambers, EasyMount chambers are different in that they use inserts to position and secure tissues or culture cups within the chamber body.



The EasyMount chamber systems consist of 2 to 8 vertical Ussing chambers, a heater block/support stand, needle valves for adjustment of gas flow (for oxygenation and gas lift stirring), and Ag/AgCl voltage/current electrodes for measuring transepithelial voltage and for passing current. Tissue specific inserts are ordered separately.

### Multichannel setups

All EasyMount chambers (P2300 and P2400,) use the same stands and electrodes. Stands are available to support 2, 4, 6, or 8 chambers and can be readily ganged to allow for higher count applications. Stands have an incorporated heater block that warms all chambers to the same temperature. A needle valve assembly (one set per chamber) is mounted on the rear of the heater block for regulation of the gas flow.

### EasyMount Chambers

EasyMount chambers are a two piece assembly using an insert to secure and position tissues or culture cups. Tissues are placed in the chamber by loosening a thumbscrew, sliding the tissue holding insert into the space between the chamber halves, and retightening the thumbscrew. Chambers do not need to be removed from the heater block, nor are the electrodes disturbed, when placing an insert. This easy and rapid replacement process makes the EasyMount system an excellent choice for high-throughput applications.

Chambers are available in two styles; the P2300 is the standard chamber and accommodates a large variety of inserts and the P2400 is designed for low-volume applications. The P2300 has chamber caps available for sealing the chamber when radioligands or toxic chemicals are used.

### EasyMount Inserts

EasyMount inserts are available to mount a variety of tissues and can also accommodate cell culture cups. Each chamber type has its own supporting family of inserts.

The P2300 Series inserts are available to accommodate Snapwell, Millicell, Nunc, and Transwell culture cups. Inserts are also available with pins or o-rings in both oblong and round formats.

P2400 Series inserts do not support culture cups but are available with pins or o-rings in both oblong and round formats.

### Electrodes and Accessories

Electrodes are available in sets comprised of two sintered Ag/AgCl pellet electrodes for voltage sensing (black), two Ag wire electrodes for current passing (white), and eight electrode tips. The number of sets provided is dependent on the system purchased, however, one electrode set is required for each chamber.

Replacement current and voltage electrodes are available, as are electrode tips. Additional accessories include electrode lead sets and chamber filling needles.

### How to order:

- **Select Chamber Assembly.** Each assembly includes heater block/stand, chambers, needle valves, and electrodes.
- **Select Chamber Inserts.** Select from P2300 or P2400 Series depending on the volume of the system assembly chosen. Order at least 1 insert per chamber.
- **Select FN15 filling needles** and extra electrode tips.
- **Select P2300 Chamber Caps** if using radioligands or toxic chemicals with P2300 chambers.

Order #	Model	Product
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#### EasyMount Chamber Assembly

##### P2300 Chamber Systems (Standard Volume)

<b>W4 69-1070</b>	CSYS-2-HA	P2300 EasyMount Assembly, 2 Chambers, No Inserts
<b>W4 69-1071</b>	CSYS-4-HA	P2300 EasyMount Assembly, 4 Chambers, No inserts
<b>W4 69-1072</b>	CSYS-6-HA	P2300 EasyMount Assembly, 6 Chambers, No Inserts
<b>W4 69-1073</b>	CSYS-8-HA	P2300 EasyMount Assembly, 8 Chambers, No Inserts

##### P2400 Chamber Systems (Low Volume)

<b>W4 69-1074</b>	LVSYS-2-HA	P2400 EasyMount Assembly, 2 Chambers, No Inserts
<b>W4 69-1075</b>	LVSYS-4-HA	P2400 EasyMount Assembly, 4 Chambers, No Inserts
<b>W4 69-1076</b>	LVSYS-6-HA	P2400 EasyMount Assembly, 6 Chambers, No Inserts
<b>W4 69-1077</b>	LVSYS-8-HA	P2400 EasyMount Assembly, 8 Chambers, No Inserts

Order #	Model	Aperture	Working Area	Description
<b>Chamber Inserts (Fits P2300 Chamber Systems)</b>				
W4 69-0956	P2302	12 mm Round	1.12 cm <sup>2</sup>	For Snapwell cell culture cups
W4 69-1081	P2302M	8.75 mm Round	0.60 cm <sup>2</sup>	For Millicell cell culture cups
W4 69-1082	P2302N	8.0 mm Round	0.50 cm <sup>2</sup>	For Nunc/Anopore cell culture cups
W4 69-1083	P2302T	6.5 mm Round	0.33 cm <sup>2</sup>	For Costar Transwell cell culture cups
W4 69-1084	P2303	2.8 x 4.5 mm	0.10 cm <sup>2</sup>	For juvenile mouse intestine
W4 69-1085	P2303A	2.8 x 4.5 mm	0.10 cm <sup>2</sup>	For juvenile mouse intestine or bladder, with pins
W4 69-0957	P2304	2.8 x 11.0 mm	0.30 cm <sup>2</sup>	For mouse intestine, with pins
W4 69-0958	P2305	4.5 x 11.2 mm	0.50 cm <sup>2</sup>	For rat and larger animal intestine, with pins
W4 69-0959	P2306	2.8 x 1.5 mm	0.036 cm <sup>2</sup>	For mouse trachea and similar tissue
W4 69-0960	P2307	2.0 mm Round	0.031 cm <sup>2</sup>	For small tissues (e.g., biopsies)
W4 69-1086	P2308	1.0 mm Round	0.008 cm <sup>2</sup>	For very small, thin tissues (e.g., lower mouse trachea)
W4 69-0961	P2310	5.0 mm Round	0.20 cm <sup>2</sup>	With pins
W4 69-0962	P2311	6.2 mm Round	0.30 cm <sup>2</sup>	With pins
W4 69-1087	P2311A	5.7 mm Round	0.26 cm <sup>2</sup>	With pins
W4 69-0963	P2312	8.0 mm Round	0.50 cm <sup>2</sup>	With pins
W4 69-0964	P2313	9.5 mm Round	0.71 cm <sup>2</sup>	With pins
W4 69-0965	P2314	11.3 mm Round	1.00 cm <sup>2</sup>	With pins
W4 69-0966	P2315	12.7 mm Round	1.26 cm <sup>2</sup>	With pins
W4 69-1088	P2316	5.0 mm Round	0.20 cm <sup>2</sup>	for Skin, with o-ring
W4 69-1089	P2317	10.8 mm Round	0.93 cm <sup>2</sup>	For synthetic membranes, with o-ring
W4 69-1090	P2318	11.3 mm Round	1.00 cm <sup>2</sup>	For Frog Skin, with o-ring
W4 69-1091	P2319	12.7 mm Round	1.26 cm <sup>2</sup>	For studying mucus layer, with spacer ring
<b>Chamber Inserts Fits (P2400 Chamber Systems)</b>				
W4 69-1092	P2403	2.8 x 4.5 mm	0.10 cm <sup>2</sup>	For small Tissue Specimens
W4 69-0969	P2404	2.8 x 9.2 mm	0.25 cm <sup>2</sup>	For mouse intestine
W4 69-0970	P2405	4.5 x 9.2 mm	0.40 cm <sup>2</sup>	For rat and larger animal intestine
W4 69-0971	P2406	2.8 x 1.5 mm	0.04 cm <sup>2</sup>	For mouse trachea
W4 69-0972	P2407	2.0 mm round	0.031 cm <sup>2</sup>	For biopsies
W4 69-1093	P2408	0.8 mm round	0.005 cm <sup>2</sup>	For biopsies
W4 69-1094	P2408A	0.5 mm round	0.002 cm <sup>2</sup>	For biopsies
W4 69-1095	P2408B	1.0 mm round	0.008 cm <sup>2</sup>	For biopsies
W4 69-0973	P2410	5.0 mm round	0.20 cm <sup>2</sup>	With pins
W4 69-0975	P2412	8.0 mm round	0.50 cm <sup>2</sup>	With pins
W4 69-0976	P2413	9.5 mm round	0.71 cm <sup>2</sup>	With pins
Order #	Model	Product		
<b>Accessories</b>				
W4 69-1096	P2300-CAP	Chamber Caps for P2300 Chamber – set of 2		
W4 69-1097	FNS15-2	Two Syringes with Filling Needles		
W4 69-1098	FN15	Replacement Filling Needle		
W4 69-0990	P2023-20	Electrode Tips – 20 Pack		
W4 69-0991	P2023-50	Electrode Tips – 50 Pack		
W4 69-0992	P2023-100	Electrode Tips – 100 Pack		
<b>Replacement Parts</b>				
W4 69-0993	P2300	EasyMount Chamber – Standard Volume (Chamber Only)		
W4 69-0995	P2400	EasyMount Chamber – Low Volume (Chamber Only)		
W4 69-0987	P2020-S	Electrode Set (2 current, 2 voltage, 8 tips)		
W4 69-0988	P2020-IS	Electrode Set (4 current, 8 tips)		
W4 69-0989	P2020-VS	Electrode Set (4 voltage, 8 tips)		
W4 69-3147	P2024-36	Electrode Lead Set (36 in, 4 pk)		
W4 69-1099	P2060	Air Control Valve Assembly, Mounts on Stand, Fits One Chamber		

## EC-800 and EC-825A

### Single and Dual Channel Epithelial Voltage Clamps

*Our single and dual channel epithelial voltage clamps*

EC-825A



CE

- For studies of epithelial transport and the electrical properties of tissue
- High common mode rejection
- Clamp Speed Selection
- Membrane Resistance Measurement Circuit
- Watertight Headstage with Model Membrane

#### Single Channel EC-800 and Dual Channel EC-825A

Epithelial voltage clamps from Warner provide accurate measurements of transepithelial voltage, short circuit current, and membrane resistance. Important features include fluid resistance compensation, membrane resistance readout, choice of voltage compliance, and small water-tight preamp headstages. Operating modes include voltage clamp, current clamp, voltmeter, and resistance. The dual channel model includes an internal timer.

The **EC-800** and **EC-825A** are state-of-the-art instruments with several unique and important design features offering more reliable recording and operator convenience.

#### High CMR

Differential voltage recordings are made with very high common mode rejection providing accurate measurements free from the effects of common mode potential changes of a noisy environment.

#### Membrane Resistance Measurement

Accurate resistance measurements are made with the membrane mounted in the chamber. This measurement is made using a low frequency 2 Hz bipolar signal to avoid polarization of the membrane (ideal for monolayers). Resistances up to 200 k $\Omega$  are displayed on the meter with push-button convenience.

#### Clamp Speed Selection

Three clamp speeds provide optimum recording conditions for a variety of applications. In Fast mode, preparations with low access resistance (small tissues or monolayers) can be clamped with speeds as fast as 10 $\mu$ sec. Typical Ussing chambers with larger tissues will use Medium or Slow modes for stable, oscillation free clamping.

#### Commands

Internal DC Command (Hold) control for both Voltage clamp and Current clamp modes.

#### Watertight Headstage with Model Membrane

The small compact headstage can be located close to the measurement site to keep input leads short for reduced noise pick-up. The model membrane circuit simulates a preparation to provide convenient operational checks of the clamp. Internal circuits are protected against the invasion of corrosive saline solutions by a watertight seal.

#### Choice of Voltage Compliance

The EC-800 has a voltage compliance of  $\pm 120$  V and the EC-825A has a voltage compliance of  $\pm 50$  V.

The high voltage compliance of these instruments are important for studies of low resistance (leaky) epithelial cells and in applications in which long agar leads in the current passing circuit produce large voltage drops (which must be compensated). Additionally, the high compliance helps in charging large membrane capacitances typical of epithelial tissues, resulting in faster settling times and improved overall clamp performance.

## EC-800 and EC-825A

### Single Channel and Dual Channel Epithelial Voltage Clamps (continued)



#### External Control

The clamp can be operated by an external programmer, lab timer or computer. Logic control of clamp mode and clamp command levels is possible as well as simultaneous mixing of external linear commands.

#### Onboard Timer Controller

The dual channel EC-825A includes event timers (2) to provide cycle times and clamp durations up to 2000 seconds. Times are set with 2 digit thumbwheel switches and 4 position range switches. Once set, the timer will free run, eliminating the need for a computer or other external device to control the experiment.

#### Model EC-800LV $\pm 15$ Volt Compliance

Studies with small tissue samples or monolayers in set-ups with low access resistance may not require high compliance. For these applications, models EC-800LV offers both a lower cost and a safer environment for the membrane.

#### Specifications

##### EC-800, EC-800LV, EC-825A

##### Headstage:

Input Impedance	$1 \times 10^{10} \Omega$ shunted by 6 pF
Input Voltage	$\pm 1.5$ V maximum
Common Mode Voltage	$\pm 13$ V maximum
Common Mode Rejection	100 dB at 60 Hz
Leakage Current	20 pA maximum
Offset Voltage Range	$\pm 120$ mV

##### Voltage Clamp Ranges:

Int. Clamp Potentiometer	$\pm 100$ mV with 10-turn control
Ext. Command	$\pm 1$ V
Ext. Command Factor	1 mV/10 mV applied

##### Current Clamp Ranges:

Clamp Potentiometer	$\pm 1$ mA
External Command	$\pm 10$ mA
Command Factor	1 $\mu$ A/10 mV applied
Speed	10 $\mu$ sec measured with model membrane

##### Resistance:

Fluid Resistance	0-100 $\Omega$ standard
Compensation Range	0-1 k $\Omega$ optional
Membrane Resistance Measurement	(made with 2 Hz bipolar constant current square wave)
Ranges	0-2 k $\Omega$ , injected current = 10 nA 0-200 k $\Omega$ , injected current = 1 nA

#### Specifications (continued)

Membrane Resistance	0-2 k $\Omega$ , 1mV/ $\Omega$
Output (EC-825A)	0-200 k $\Omega$ , 10mV/ $\Omega$
Panel Meter EC-800	3-1/2 digit LCD; Voltage Range: 200 mV max; Current Range: 2000 $\mu$ A max
Panel Meter EC-825A	3-1/2 digit LED; Voltage Range: 200 mV max; Current Range: 2000 $\mu$ A max

##### Outputs:

Voltage Monitor	x10
Current Monitor	10 mV/ $\mu$ A

##### Compliance:

EC-800	$\pm 120$ V
EC-800LV	$\pm 15$ V
EC-825A	$\pm 50$ V

##### Timers (A & B) EC-825A:

Range	10 ms to 1000 secs, set with 2 digit resolution and 4 ranges (each channel)
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##### Power Requirements

Power Requirements	100-130 VAC or 220-240 VAC, 50/60 Hz, 15 VA
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##### Physical Dimensions, H x W x D:

EC-800, EC-800LV & EC-825A	8.9 x 43.2 x 30.5 cm
Headstage	7.7 x 7.7 x 5 cm

##### Shipping Weight:

EC-800 & EC-800LV	6.4 kg
EC-825A	9.1 kg

##### Warranty

Warranty	Two years, parts & labor
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#### Order # Model Product

<b>W4 64-0035</b>	EC-800	Single Channel Voltage Clamp with $\pm 120$ V Compliance* for Leaky Tissue
<b>W4 64-1508</b>	EC-800	Single Channel Voltage Clamp with $\pm 120$ V Compliance* for Leaky Tissue, 200 - 240 VAC
<b>W4 64-0036</b>	EC-800LV	Single Channel Voltage Clamp with $\pm 15$ V Compliance* for Tight Tissue and Culture Type Monolayers
<b>W4 64-1509</b>	EC-800LV	Single Channel Voltage Clamp with $\pm 15$ V Compliance* for Tight Tissue and Culture Type Monolayers, 200 - 240 VAC
<b>W4 64-1605</b>	EC-825A	Dual Channel Voltage Clamp with $\pm 50$ V Compliance*

\*Supplied with rack mount hardware.



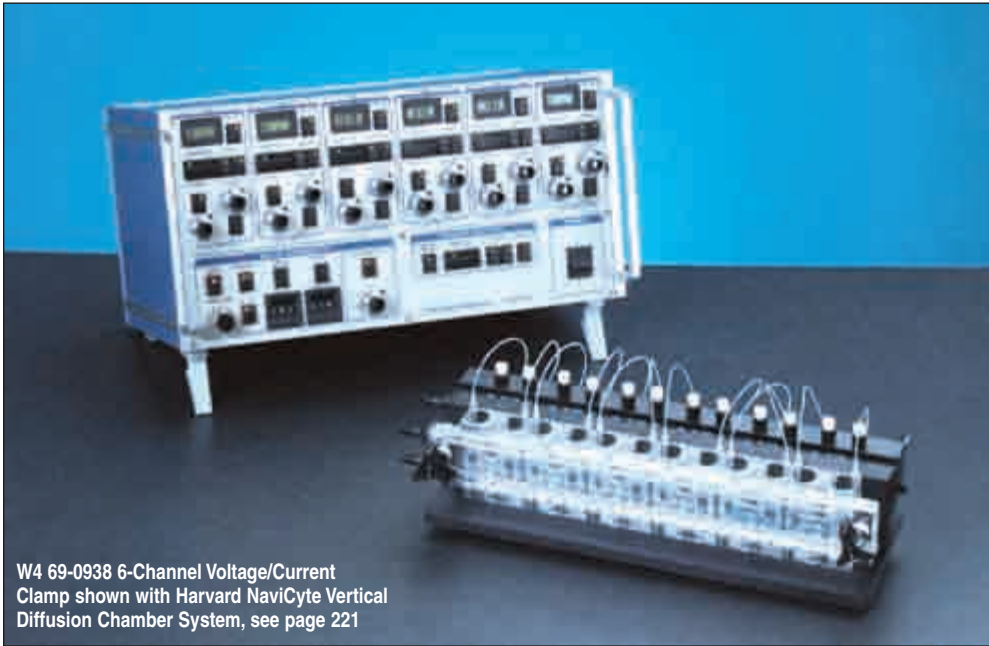
## VCC-MC

### Multichannel Epithelial Voltage Clamps

# ussing/diffusion

*Supports from 2 to 8 amplifiers in a single package*

*The VCC-MC family of epithelial voltage/current clamps are ideal instruments for use with the multichannel chamber systems described earlier. Configurations range from 2 to 8 amplifiers and these systems integrate fully with the Acquire and Analyze software package.*



W4 69-0938 6-Channel Voltage/Current Clamp shown with Harvard NaviCyte Vertical Diffusion Chamber System, see page 221

The **VCC-MC** family of voltage/current clamps and accessories have been designed to be flexible tools for studying ion transport across epithelial tissue.

The VCC-MC family is of particular benefit in high throughput, multi-channel applications and where laboratory bench space is limited. All models in this family provide similar capabilities and specifications as the VCC-600 single channel clamp to control the voltage or the current across the epithelium. However, unlike the VCC-600, these clamps are modular in design.

The **VCC-MC2** contains two voltage/current clamp modules, a pulse generator, and a computer interface in a compact 9.5 inch chassis.

The VCC-MC2 is best suited for small scale applications and for student laboratories. The VCC-MC2 is compatible with all chamber systems offered by Warner. Each VCC-MC2 comes complete with two single channel input modules (DM MC6) for connection to electrodes.

The **VCC-MC6** and **VCC-MC8** are multichannel chassis that can be configured with 2 to 8 voltage/current clamp channels, depending on model. These instruments are ideally suited for experiments where multiple specimens are sampled in parallel. They offer the distinct advantage of expandability within the same instrument chassis.

A useful feature built into the VCC-MC6 and VCC-MC8 instruments is a master control section. This section enables the investigator to quickly change the function, mode, and meter settings on each clamp module from a single switch bank. This markedly simplifies the use of the instrument and removes some of the tedium associated with continually having to change multiple, identically placed switches (e.g., changing the meter switch to display current instead of voltage on eight channels).

The VCC-MC Multichannel clamps are well suited for the NaviCyte and EasyMount systems. For use with the NaviCyte systems, a special 24-lead input module (EP-MC6) replaces the individual DM-MC6 input modules for making electrode connections. The EP-MC6 mounts between the heat block and air manifold on the NaviCyte system and must be ordered separately.

# VCC-MC

## Multichannel Epithelial Voltage Clamps (continued)

# ussing/diffusion

### Specifications

Input Resistance	≥ 10 <sup>9</sup> Ω, differential
Common Mode Rejection	≥ 100 dB
Frequency Response	4-stage adjustment via internal switch
Display:	3.5 digit, 3/8 in LCD with green backlight for each channel
Transepithelial Voltage	±199.9 mV
Transepithelial Current	±19.90, ±199.9, ±1999 μA, jumper selectable
Switches	Push button, digital switching with LED indicators
Power	100/125 VAC, 60 Hz or 200/250 VAC, 50 Hz, user selectable
Meter	Selects current or voltage to be displayed on panel meter
Function:	Three position switch with LED indicator of state
Zero	Standby mode, voltage inputs are internally grounded
Open	Open circuit, voltage inputs are connected to sensing electrodes
Clamp	Feedback loop is closed to control either current or voltage
Mode:	Two switches select operating modes
Voltage/Current (I/V)	Selects transepithelial voltage or current to be controlled when Function is on Clamp
Remote (REM)	Selects control to be from front panel switches or from remote interface
Offset Potential	±10 or ±100 mV, set via precision 10-turn dial, jumper selectable ranges and lighted polarity switch
Fluid Resistance	Push-button current injection, compensation set by precision 10-turn dial, jumper selectable ranges
On/Off	'On' sends pulse output to clamp, red indicator light
Polarity	Selects +, - or bipolar pulses to be generated
Single Pulse	Injects single pulse during interval between pulses
Reset	Initializes interval timer and injects pulse
Amplitude	0 to 10 mV in 1 mV steps at X1 gain; 0 to 100 mV in 10 mV steps at X10 gain
Period	0.1 to 99.9 sec time period between pulses; set by 3-decade thumbwheel switch
Duration	0.01 to 9.99 sec duration of each pulse; set by 3-decade thumbwheel switch
DC Clamp Level:	Sets DC holding voltage or current
Voltage Clamp	±100 mV via 10-turn dial, lighted polarity switch
Current Clamp	Current gain dependent, 50% of max. displayed current
Master Override	Permits control of function, mode, and meter features on all installed clamp channels

### I/O Connection Specifications

Electrode Inputs	2 mm pin tip via DM-MC6 single channel input module, 1 per channel (VCC-MC6 and VCC-MC8) 2 mm pin tip via electrode panel (EP-MC6) for Harvard/Navicyte chamber system (VCC-MC6)
Recorder Output Voltage	10 mV/mV, x10 transepithelial voltage
Recorder Output Current	Jumper selectable, 1, 10 or 100 mV/μA
Pulse Generator	0 to ±100 mV and 0 to ±1 V
External Input	Allows arbitrary analog input signal to be clamped
Remote Interface	9-pin DB connector, 1 per channel (VCC-MC2) 25-pin DB connector (all others)

### VCC Amplifiers

VCC Series Amplifier	w/DM-MC6 Input Module (for EasyMount)	w/EP-MC6 Input Module (for NaviCyte)	w/DM-MC6-HV Input Module (High Voltage) (for EasyMount)	w/EP-MC6-HV Input Module (High Voltage) (for NaviCyte)
VCC-MC2	<b>W4 69-0933</b>	---	<b>W4 69-0934</b>	---
VCC-MC6				
2-Channel	<b>W4 69-0946</b>	<b>W4 69-0944</b>	<b>W4 69-0947</b>	<b>W4 69-0945</b>
4-Channel	<b>W4 69-0942</b>	<b>W4 69-0940</b>	<b>W4 69-0943</b>	<b>W4 69-0941</b>
6-Channel	<b>W4 69-0938</b>	<b>W4 69-0936</b>	<b>W4 69-0939</b>	<b>W4 69-0937</b>
VCC-MC8				
8-Channel	<b>W4 69-1003</b>	---	<b>W4 69-1001</b>	---

### VCC Amplifiers (CE Version)

VCC Series Amplifier	w/DM-MC6 Input Module (for EasyMount)	w/EP-MC6 Input Module (for NaviCyte) (for EasyMount)	w/DM-MC6-HV Input Module (High Voltage) (for NaviCyte)	w/EP-MC6-HV Input Module (High Voltage)
VCC-MC2	<b>W4 69-0933CE</b>	---	<b>W4 69-0934CE</b>	---
VCC-MC6				
2-Channel	<b>W4 69-0946CE</b>	<b>W4 69-0944CE</b>	<b>W4 69-0947CE</b>	<b>W4 69-0945CE</b>
4-Channel	<b>W4 69-0942CE</b>	<b>W4 69-0940CE</b>	<b>W4 69-0943CE</b>	<b>W4 69-0941CE</b>
6-Channel	<b>W4 69-0938CE</b>	<b>W4 69-0936CE</b>	<b>W4 69-0939CE</b>	<b>W4 69-0937CE</b>
VCC-MC8				
8-Channel	<b>W4 69-1003CE</b>	---	<b>W4 69-1001CE</b>	---

### Order # Model Product

#### Accessories and replacement parts

<b>W4 66-0025</b>		6-Channel Electrical Manifold for NaviCyte Chamber Systems
<b>W4 69-1004</b>	MC601	Add-on/replacement amplifiers for VCC amplifier case for NaviCyte Chamber Systems

# VCC-600

## Single Channel Epithelial Voltage Clamp

# ussing/diffusion

**A single channel epithelial voltage clamp**

The VCC-600 is a single channel voltage/current clamp for epithelial tissue. It is the most versatile instrument in the VCC series. Basic features include 10-turn dials for electrode offset and fluid (series) resistance compensation, user selectable current gain and response frequency.

W4 69-0930 Single Channel Voltage/Current Clamp



The VCC-600 epithelial clamp amplifier is a versatile single channel instrument. In addition to its basic features, a clamp level control allows the holding voltage or current to be set while a built-in pulse generator provides unipolar or bipolar step changes from the holding level for tissue conductance/resistance measurements.

Voltages and currents can be monitored via recorder outputs on the front panel and by a bright 3.5 digit LED digital panel meter. An interface connector, for remote instrument control and data acquisition, is provided on the rear panel. A high voltage option is also available to increase the output compliance voltage to  $\pm 35$  V DC for certain types of experiments.

The VCC-600 also has special features making it a popular instrument for electrophysiological studies of epithelia. These features include an active headstage that incorporates a virtual grounding amplifier for current measurement and an extra level of current gain to measure currents in the nA range. This allows the instrument to be used for studies on very small tissues such as isolated renal tubules and single isolated colonic crypts. A switch and buffer amplifier in the headstage allows selection and continuous measurement of the potential on either side of the epithelium. The output on the rear of the instrument can be used as a reference for microelectrode experiments so that the intracellular voltage can be directly measured across either apical or basolateral membranes regardless of side of impalement. Similarly, it can be used as the reference voltage in pH stat experiments, thereby eliminating a problem with some combination electrodes and pH meters in which a fraction of the transepithelial current may be shunted to ground.

### Specifications

Input Resistance	$10^9$ W, differential, $\geq 10^{12}$ W available as option
Common Mode Rejection	$\geq 100$ dB
Frequency Response	4-stage adjustment via internal switch
Clamp Output	$\pm 13$ V standard, $\pm 35$ V optional high voltage
Display:	3.5 digit, 1/2 in red LED
Transepithelial Voltage	$\pm 199.9$ mV
Transepithelial Current	$\pm 1.990, \pm 19.90, \pm 199.9, \pm 1999$ $\mu$ A, jumper-selectable
Switches	Subminiature toggle
Grounding	Signal (circuit) ground is isolated from chassis and power grounds; binding posts on rear panel allow connection of circuit to chassis ground

### Specifications (cont'd)

Power	100/125 VAC, 60 Hz or 200/250 VAC, 50 Hz, user selectable
Meter	Selects current or voltage to be displayed on panel meter
Function:	Three position rotary switch
Zero	Standby mode, voltage inputs are internally grounded
Open	Open circuit, voltage inputs are connected to sensing electrodes
Clamp	Feedback loop is closed to control either current or voltage
Mode:	Two switches select operating modes
Voltage/Current (I/V)	Selects transepithelial voltage or current to be controlled when Function is on Clamp
Local/Remote	Selects control to be from front panel switches or from remote interface
Offset Potential	$\pm 10$ mV, set via precision 10-turn dial
Fluid Resistance	Push-button current injection, compensation set by precision 10-turn dial, jumper selectable ranges
On/Off	'On' sends pulse output to clamp, red indicator light
Polarity	Selects +, - or bipolar pulses to be generated
Single Pulse	Injects single pulse during interval between pulses
Reset	Initializes interval timer and injects pulse
Amplitude	0 to 10 mV in 1 mV steps at X1 gain; 0 to 100 mV in 10 mV steps at X10 gain
Period	0.1 to 99.9 sec time period between pulses; set by 3-decade thumbwheel switch
Duration	0.01 to 9.99 sec duration of each pulse; set by 3-decade thumbwheel switch
DC Clamp Level:	Sets DC holding voltage or current
Voltage Clamp	$\pm 100$ mV and $\pm 300$ mV via 10-turn dial
Current Clamp	Current gain dependent, 50% and 150% of max. displayed current
Headstage	Active input stage for sensing voltage and current near preparation, cable length 6 ft
Reference Buffer	Switch selectable to send V1 or V2 inputs to buffer amplifier in headstage; allows monitoring of bath potential on either side of epithelium; output via rear panel permits micro-electrode impalements or pH electrodes to be referenced to either V1 or V2

### I/O Connection Specifications

Electrode Inputs	Banana jacks on headstage
Recorder Output Voltage	10 mV/mV, x10 transepithelial voltage
Recorder Output Current	Jumper selectable, 1, 10, 100 or 1000 mV/ $\mu$ A
Pulse Generator	0 to $\pm 100$ mV and 0 to $\pm 1$ V
External Input	Allows arbitrary analog input signal to be clamped
Remote Interface	9 pin DB connector

Order #	Model	Product
W4 69-0930	VCC600	Single Channel Voltage/Current Clamp
W4 69-0931	VCC600HV	Single Channel Voltage/Current Clamp with High Voltage Option

## DM MC6, EP MC6, DM660 and DM6 Input Manifolds and Dummy Membranes

W4 69-0950 DM MC6 Single Chamber  
Input Module and Dummy Membrane



The VCC MC family of instruments utilizes standard 2 mm pintip jacks for connection to the electrode leads. The **DM MC6** is a single channel input module that can be mounted close to individual Ussing chambers and is compatible with all of the VCC MC series of voltage/current clamps. It connects to modular plugs on the rear of the VCC MC instruments via shielded cable. The DM MC6 contains an integral dummy membrane, see below, that is activated by a slide switch on the module. One DM MC6 is required for each clamp channel/Ussing chamber and is compatible with both EasyMount and Harvard/Navicyte chamber systems.

The **EP MC6** is 6-channel (24 pintip jacks) electrode input manifold is designed specifically for use with the Harvard/Navicyte vertical diffusion chamber system. The EP MC6 mounts directly behind the heat block and in the front of the air valve manifold to provide clean, organized connection to the electrode leads (W4 69-0998 not included). Connection between the EP MC6 and VCC MC6 is by means of a flat cable assembly (included).

Dummy membranes are useful both for quickly verifying the operating status of the instrument during an experiment and as a learning aid for students.

The **DM660** is a single channel dummy membrane for use with the VCC600. A similar dummy membrane is built into the DM MC6 input module for the multi-channel clamps.

Finally, the **DM6** is a 6-channel dummy membrane for VCC MC6 in which each dummy membrane may be individually manipulated. The DM6 connects to the VCC MC6 by way of the EP MC6 flat cable assembly.

W4 69-0932 DM660  
Single Channel Dummy



W4 69-0952  
DM6 Six Channel Dummy

Order #	Model	Product
W4 69-0950	DM MC6	Single Channel Electrode Input Module and Dummy Membrane
W4 69-0951	EP MC6	Electrode Input Panel for VCC MC6 Vertical Diffusion
W4 69-0932	DM660	Single Channel Dummy Membrane
W4 69-0952	DM6	6-Channel Dummy Membrane for VCC MC6



## Computer Controlled Multi-Clamp with Software Data Acquisition and Analysis System with integrated amplifiers

**Acquire data, analyze data, and control up to 8 amplifiers from a single integrated software/hardware package!**

*The system provides individual data acquisition and control for 2, 4 or 6 chambers and is fully compatible with the NaviCyte horizontal/vertical Ussing chamber systems. Windows 95/98/2000/XP compatible.*



Figure 1

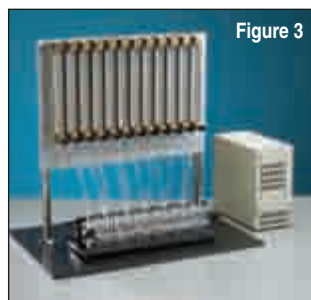


Figure 3

**W4 69-0300, W4 69-0301 or  
W4 69-0302 2-, 4- or 6- Channel  
Microcomputer Current/Voltage  
Clamp System**

- Individual voltage clamp, current clamp or open circuit control for each chamber
- Overlay of uni/bipolar current pulses with variable parameters for dynamic definition of Gt/Rt
- I/V and V/I curves with freely adjustable parameters
- Minimum pulse duration 200 ms, max. amplitude  $\pm 250 \mu\text{A}$  for dynamic definition of Gt/Rt
- Alphanumeric display of measured parameters
- Ability to input marker and comments and save with data file
- Printout of parameters in variable timetable
- Data format compatible to Excel
- Continuous graphics display
- Experimental time up to 8 hours

The Computer Controlled Multi-Clamp with Software is a combined voltage/current clamp and data acquisition system in one compact microcomputer controlled unit. The amplifiers are entirely controlled by the associated acquisition and analysis software running on a Windows PC computer. This makes for a clean, elegant, and simple to operate system. In its full configuration the multi-clamp can be used to control and collect electrophysiological data from up to six NaviCyte horizontal or vertical diffusion chambers.

The system provides independent chamber control in three different modes: voltage clamp, current clamp, and open circuit. A change between these modes is possible during the experiment at each time point.

The Multi-Clamp is available in 2-, 4- or 6-channel configurations and is fully compatible with both NaviCyte Ussing chamber systems. The clamp provides a separate A/D converter and isolated current source for each chamber, and current and voltage electrodes from each half-cell are connected to the Multi-Clamp via an electrode manifold. Data exchange between the PC and the Multi-Clamp is via standard COM ports, and depending on the number of ports available, a single PC can handle several clamps.

An interesting option consists of the incorporation of a gas delivery system into a NaviCyte/Multi-Clamp system. This gas delivery system consists of 12 precision gas flow meters mounted to a stabilizing base and connect to a 6-channel NaviCyte vertical or horizontal chamber systems. The 600 x 400 mm stabilizing base also houses an electrode manifold for connecting each Ag/AgCl electrodes to their respective half-cells.

### Software

The Multi-Clamp system comes complete with an easy to use Windows 95/98/2000/XP based control and data acquisition software package that allows for the individual control and monitoring of each chamber.

Some features of the software include:

- Automatic compensation of fluid resistance and electrode potential during the experiment

### Specifications

Channels	2, 4 or 6
A/D Subsystem for Analog Data Acquisition	13 Bit
Current Source by D/A	12 Bit, isolated
Serial Connection to PC	COM1 / COM2 for bi-directional data transfer
Case Dimensions	24.5 x 11.4 x 19.7 cm (9.6 x 4.5 x 7.8 in)
Power	100/230 VAC, 50/60 Hz
<b>System Parameters</b>	
Input Resistance	$> 10^9 \Omega$ differential
Input Current	$< 100 \mu\text{A}$
Input Voltage	$\pm 400 \text{ mV}$ , 0.1 mV step
Current Output	$\pm 2000 \mu\text{A}$ , 1 $\mu\text{A}$ step
Product of Current and External Resistance Max	13 V

### Order # Product

<b>W4 69-0300</b>	2-Channel Voltage/Current Clamp System with Software
<b>W4 69-0301</b>	4-Channel Voltage/Current Clamp System with Software
<b>W4 69-0302</b>	6-Channel Voltage/Current Clamp System with Software

### Perfusion and Electrical Accessories

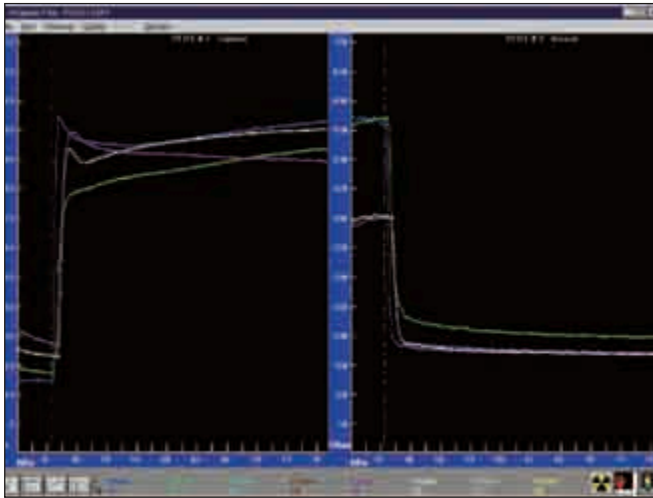
<b>W4 69-0303</b>	12-Channel Precision Flowmeter and Electrode Manifold
<b>W4 66-0025</b>	6-Channel Electrical Manifold for NaviCyte Chamber Systems

## Data Acquisition & Analysis System

### Acquire & Analyze

*Acquisition and analysis system to accompany our epithelial voltage clamps*

*Acquire & Analyze is a comprehensive data acquisition and analysis package designed specifically for recording transepithelial electrophysiological data from epithelia mounted in Ussing chambers. The system consists of a data acquisition hardware and software to record current, voltage and conductance/resistance from up to 8 tissues as well as analysis software that enables one to quickly extract selected data and output it to summary spreadsheets.*



Unlike general-purpose data acquisition packages, Acquire & Analyze is written specifically for the study of epithelial tissues.

For example, say you want to measure the dose/response curve of an agent on the  $I_{sc}$  and  $G_t$  by progressive additions in eight tissue samples. To do this you monitor the  $I_{sc}$  and  $G_t$  on the computer until stable basal readings are attained. You then place an event mark in the file and make the first addition to all 8 tissues. When the current reaches a new stable level (or a specified time has passed) you place another event mark and make the second addition. This process is repeated until all additions have been made.

To summarize the effect of the additions, use Analyze to graph the data for all 8 tissues. Begin by displaying the movable data bar and positioning it over the basal currents just to the left of the first event mark. Right-click the mouse to save the mean values of current, conductance and voltage to a spreadsheet. Simply repeat the mouse movements and clicks to obtain the data for each subsequent addition. The spreadsheet thus created can be saved and imported directly into Excel for further analysis.

### Data Acquisition and Analysis Capabilities

Acquire & Analyze runs under Windows and includes a data acquisition card, input/output cables, and software. The system can measure currents and voltages from up to 8 voltage-current clamp channels.

- Activate/deactivate acquisition on individual clamp units
- Setup and toggle between fast and slow acquisition speeds to capture transient events; speeds can be set by user and can be changed at any time during experiment
- Place time marks into file to indicate when experimental manipulations (e.g., drug additions) have been made; marks can be predefined and selected from menu or be entered from keyboard
- Graphically display current, voltage, conductance, resistance, calculated open circuit voltage and calculated  $I_{sc}$  during data acquisition in multiple formats
- Graphical/digital readout of current, voltage or conductance vs. time
- Plot raw or area corrected data
- User definable x, y scaling; zoom all, in, out, or previous; pan left, right, up or down
- Extract data under movable, adjustable width time bar in file format compatible with spreadsheet files.
- Extracted data may be individual points or mean values.
- Extracted data may be imported into commercial graphics packages to produce publication quality graphs.
- Linear regression analysis of conductance vs. current can be performed on data within time bar to estimate pericellular pathway conductance.

Order #	Model	Product
W4 69-3145	–	Acquire & Analyze Data Acquisition and Analysis Software
W4 69-0954	MOD 08/A	Interface Module for VCC 600, VCC MC2, EC-800 and EC-825A amps
W4 64-1705	DB9EC800	Interface Cable for EC-800
W4 64-1706	DB15EC825A	Interface Cable for EC-825A

## Data Acquisition & Analysis System

HAI-118

*The HAI-118 is a fast, high-resolution data acquisition system suitable for most data recording needs in the research laboratory, including studies of epithelial tissue. The system consists of data acquisition hardware and a programmable software package used to record current, voltage, and conductance/resistance from 4 to 6 tissues.*



The HAI-118 includes hardware from iWorx and the popular LabScribe® software package. This system offers 8 analog input channels, 8 digital outputs, 4 digital inputs and 2 DACs. The hardware connects to PC compatible computers via USB, so setup is plug-and-play easy.

### DACs

The HAI-118 offers two  $\pm 0V$  DACs. Each DAC is independently programmable and can be synchronized with one another. Basic stimulus parameters for each DAC, such as pulse width, frequency, and amplitude can be changed on the fly using handy controls located in the LabScribe software tool bar. Standard protocols include pulse, train, and step waveform. Each standard protocol allows the quiescent state to be a holding voltage thereby making it ideal for voltage clamping applications.

### Resolution

A 16 bit A/D converter is used to sample data over the full input range. Typical noise on any input is less than 1 mV. This allows the recording of signals from 10 mV to 10 V without the need for additional external gain.

### Digital Input/Output

Eight digital output lines are available and the digital output connectors are industry standard BNC, eliminating the need for custom cables. Programming output lines is point-and-click and no complicated scripting language is required. Four digital input lines are also provided. One digital input line can be configured as an external trigger.

### Speed

The HAI-118 can collect 16 bit samples at 10kHz bandwidth on a single or up to eight channels simultaneously.

### USB Connection

Connection to the computer is accomplished over the popular USB port. This eliminates the need to install special interface cards and makes the HAI 118 compatible with notebook computers. The HAI 118 has a small footprint and in combination with a notebook requires very little bench space.

### Software Included

Powerful LabScribe® software is included with each HAI 118. LabScribe is provided with a site license at no additional charge and upgrades are free forever. The program will actually upgrade itself on any Internet connected machine.

## Data Acquisition & Analysis System

### HAI-118 (continued)

#### Supported Applications

**Epithelial Studies** - Output from Warner's EC-800 and EC-825A, as well the VCC Series epithelial voltage clamps can be fed directly into the HAI-118. The voltage clamp protocol in the LabScribe program's stimulator section makes recording of data of four to six epithelial channels possible.

**Oocyte Studies** - LabScribe's gain telegraph feature automatically calibrates the software to Warner's Oocyte Clamp so that the main display reads in current and voltage. The on-board stimulator includes a flexible voltage clamp protocol so an external stimulator is not required. Finally, the digital output capability of the HAI-118 also adds the ability to automate your oocyte rig. Organ and Tissue Bath Studies - LabScribe's smooth data recording interface and available 8 channels area perfect fit for tissue and organ bath studies. Real-time displays of force in grams as well as real-time annotations are ideal for these types of studies. In addition, the on board stimulator and digital outputs make automation of tasks like filling and draining baths or delivering drugs very straightforward. An available 8 channel high voltage field stimulator is directly controlled by the HAI-118 and LabScribe software.

**Electrophysiology Studies** - The high speed nature of the HAI-118 make it perfect for studies involving blood pressure and sympathetic nerve activity as well as all types of cardiac electrophysiology, even in rapid heartrate animals such as mice where extra speed is required.

LabScribe Data Acquisition Software The cornerstone of the HAI-118 data acquisition system is the LabScribe software. A single program, LabScribe detects what hardware it is connected to and self-configures. LabScribe is, by far, the easiest to use data recording and analysis solution available. It strikes the ideal balance between flexibility and simplicity. Just push the "Start" button, then use the AutoScale feature to center and expand your data; and you're recording! The 'click and play' approach of the software extends to a useful assortment of analyses, such as rate, integral, and conversion to real units. And, of course, built-in online help is always available.

#### LabScribe Software Features:

##### Simplified User Interface

- Only two mouse-clicks are required to record most data
- Only one mouse-click is required for most online functions
- Use of screen-time makes time calculations quick and simple

##### AutoScale

- Automatically ensures the optimal scaling of displayed data
- A simple click centers and expands the data in the display window to fill the available space
- You can toggle between Best View and a preset viewing range or you can zoom the time base or y axis scaling with a single click

##### Fast Scrolling

- LabScribe's display can smoothly scroll data at any speed
- Useful when high resolution data is compressed on the time axis to create a data overview.

#### Real Units

- LabScribe software allows you to calibrate the displayed data in any units that you choose
- Reading your data in mm Hg or grams or A takes the guesswork out of analysis

#### Real-time Annotation

- Keyboard input from the user may be time locked to the data to indicate drug delivery or stimulus points
- You can search and "Go To Annotations" anywhere in the data

#### Real-time Functions

- LabScribe currently supports 17 functions that are calculated and displayed in real-time, each is called from a single click in the Main window
- These include Periodic (rate, freq., period, max, min, mean), dV/dt, integral, Channel Math, Cardiac, EEG and Spirometry
- Functions can be applied to raw data in real-time or they can be called after the data has been recorded

#### Volt Meter Panel

- LabScribe can display a voltmeter status panel
- Values recorded on each channel are displayed in large type, easily visible from across the room
- Display DAC output on any channel
- Ability to revert back to Raw Data at any time
- LabScribe reports can

#### Journal

- LabScribe reports can be prepared and edited, all within the program's own Journal.
- No need to export to word processor or spreadsheet programs.
- The onboard journal also serves as a collecting place for the various measurements made in the Analysis window.
- The journal saves automatically with the file in .rtf format, which can be opened by any word processor.

#### Offline Functions

- Twenty-six offline calculations are also supported. These operate on a selection of data and return a value. While more are being added all the time, the current list includes area under the curve, max-min, slope at a point, slope of the line of best fit and the mean.

#### XY Plot

- In the Analysis window you can choose to overlay selected portions of your data or you can plot different channels against one another in an XY style plot.
- In XY mode, the available measurement functions adjust to the xy mode.



## Data Acquisition & Analysis System

### HAI-118 (continued)

#### LabScribe Software Features: (continued)

##### Export

- Recorded data may be exported in text (.txt), pictures (.png) or MatLab (.mat) format.
- This is ideal for post analysis in programs like Excel or MatLab and export picture formats make reports or poster presentations easy to create.
- Of course, you can always print data from any window in the program.

##### The Stimulator

- LabScribe has full support for the analog outputs on HAI hardware.
- The user can specify simple pulses or complex protocols involving trains and stepped voltage patterns.
- When used with HAI 118 hardware, LabScribe supports two simultaneous outputs.

##### Digital I/O

- When used with the HAI 118 the LabScribe software allows the user to configure eight digital inputs or outputs.
- Digital inputs can show frequency, period, duty cycle, time on or raw data
- Digital outputs can be assembled into control protocols for external devices

##### Settings

- Settings or templates for various experiments are stored in the program's settings menu
- This makes changing program settings to accommodate different experiments point-and-click easy

##### Broadcast

- A version (LS/16MC) of LabScribe is available that transmits recorded data in real-time over your local area network!
- Ideal for teaching or student labs where everyone can not get data first hand, this feature allows the network to share what the broadcast version sees

##### Gain Telegraph

- LabScribe will automatically calibrate and display the out put of Warner Instrument Voltage/Patch Clamp amplifiers
- This feature takes into account the changes in gain that may be applied from the voltage clamp

Software license allows copying on all departmental and student computers.

#### Specifications

Input:	
Number of Analog Inputs	8 single ended BNC
Input Impedance	1 M $\Omega$
Input Range	$\pm 10$ V
Noise	1 mV typical
Gain Telegraph	Software or hardware 8 bit
A/D Converter:	
Sample Speed	1 sample/sec - 100k sample/sec
Resolution	16 bit
Interface	USB
Trigger or Digital Input Lines	4, TTL
Output:	
Digital Output Lines	8 TTL
Digital Output Connector	BNC
DAC Performance:	
Number of DACs	2
DAC Resolution	12 bit
DAC Speed	100k sample/sec, Independent of sample speed
DAC Output Range	$\pm 10$ V
DAC Modes	Pulse, Train, Step, DC, Custom
Pulse Width	0.01 ms to 6500 ms (pulse mode)
Frequency	0.2 Hz to 50kHz (pulse Mode)
Trigger Modes	
	External Trigger, Data Threshold Trigger, User Trigger
Display	
	Real time user definable screen independent of sample rate. User definable scale units: Auto Scale, Full Scale or User Scale
Enclosure	
	Aluminum
Power	
	120/220 VAC, 60/50 HZ, CE compliant

Order #	Model	Product
W4 69-3130	IX118	Data acquisition system with hardware and Labscribe® software

# vibration isolation

## 2200 Series

### BenchMate Vibration-Free Platforms



- Unmatched price / performance
- Low profile Manual-Air or Automatic-Air designs
- VibraDamped construction
- Low natural frequency
- Excellent horizontal isolation
- SPILLPRUF spill management
- Class 10 Cleanroom Compatible - Class 10 available

These 2200 Series BenchMate Vibration-Free Platforms enhance the performance of precision tabletop equipment.

The 2210 Series is a Manual-Air design using an included hand pump (good for situations where an air source is not available). It requires periodic manual leveling.

The 2212 Series is an Automatic-Air design that requires an external air source for use (not included). It is a self-leveling unit and is recommended for regular use.

*These tables are not compatible with the Planar Lipid Bilayer workstation.*

#### Applications (Partial List)

- Atomic Force Microscopes
- Microhardness Testers
- Profimeters
- Balances
- Audio Equipment
- Precision Measuring and Testing Equipment

#### Specifications

##### Min. Load @ 20 psi

Vertical Natural Frequency:	2.3 Hz
Isolation Efficiency @ 5 Hz	52%
Isolation Efficiency @ 10 Hz	83%
Horizontal Natural Frequency:	2.9 Hz
Isolation Efficiency @ 5 Hz	40%
Isolation Efficiency @ 10 Hz	92%

##### Max. Load @ 80 psi

Vertical Natural Frequency:	2.1 Hz
Isolation Efficiency @ 5 Hz	70%
Isolation Efficiency @ 10 Hz	91%
Horizontal Natural Frequency:	1.8 Hz
Isolation Efficiency @ 5 Hz	81%
Isolation Efficiency @ 10 Hz	95%

##### Gross Load Capacity @ 80 psi:

W4 72-4728 to W4 72-4733	90.8 kg (200 lbs)
All Others	204 kg (450 lbs)

Finish	Ferromagnetic stainless steel, Ferromagnetic stainless steel with ¼-20 x 1" centers or Ferromagnetic stainless steel with M6 x 25mm on center
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Catalog No.	Depth x Width	Max. Capacity	Air Movement	Platform Top
W4 72-4755	16 x 19 in	up to 200 lbs	Manual Air	Ferromagnetic SS
W4 72-4756	16 x 19 in	up to 200 lbs	Automatic Air	Ferromagnetic SS
W4 64-0081	16 x 19 in	up to 200 lbs	Manual Air	Custom table for Bilayer Workstation, includes hand pump
W4 64-0082	16 x 19 in	up to 200 lbs	Automatic Air	Custom table for Bilayer Workstation
W4 72-4728	20 x 24 in	up to 200 lbs	Manual Air	Ferromagnetic SS
W4 72-4729	20 x 24 in	up to 200 lbs	Manual Air	Ferromagnetic SS SPILLPRUF with ¼-20 x 1" centers
W4 72-4730	20 x 24 in	up to 200 lbs	Manual Air	Ferromagnetic SS SPILLPRUF with M6 x 25mm centers
W4 72-4731	20 x 24 in	up to 200 lbs	Automatic Air	Ferromagnetic SS
W4 72-4732	20 x 24 in	up to 200 lbs	Automatic Air	Ferromagnetic SS SPILLPRUF with ¼-20 x 1" centers
W4 72-4733	20 x 24 in	up to 200 lbs	Automatic Air	Ferromagnetic SS SPILLPRUF with M6 x 25mm centers
W4 72-4734	24 x 30 in	up to 450 lbs	Automatic Air	Ferromagnetic SS
W4 72-4735	24 x 30 in	up to 450 lbs	Automatic Air	Ferromagnetic SS SPILLPRUF with ¼-20 x 1" centers
W4 72-4736	24 x 30 in	up to 450 lbs	Automatic Air	Ferromagnetic SS SPILLPRUF with M6 x 25mm center

## 5600 Series

# vibration isolation

### Lightweight VIBRALITE Breadboards



- Nominal broadband damping
- High natural frequency
- Magnetic
- Thickness: 1 inch or 2 inch nominal
- 1/8 inch Ferromagnetic stainless steel top and bottom skin
- Extruded structural aluminum core
- Flatness:  $\pm 0.004$  inch over 24 x 24 inch
- SPILLPRUF mounting holes English 1/4-20 x 1 inch or Metric M6 x 25 mm grid

These economical 5600 Series VIBRALITE breadboards feature a lightweight construction with 1/8 inch ferromagnetic stainless steel top and bottom skins with an aluminum core to reduce weight. They are an excellent economical choice. VIBRALITE breadboards are thinner and smaller than full-size optical tables, these "mini-tables" are built with the same precision tooling and high quality materials. Furnished with SPILLPRUF tapped mounting holes.

Optional, Level-Lok™ tie-downs fasten your breadboard to another surface, enabling you to level your work surface and lock it down. They are available in packages of 4 or 5 tie-downs.

Order #	W x D	Top
W4 72-4741	18 x 24 in	English SPILLPRUF 1/4-20 x 1 in
W4 72-4742	18 x 24 in	Metric (45 x 60 cm) SPILLPRUF M6 x 25 mm
W4 72-4743	24 x 48 in	English SPILLPRUF 1/4-20 x 1 in
W4 72-4744	24 x 48 in	Metric (45 x 120 cm) SPILLPRUF M6 x 25 mm
W4 72-4745	24 x 24 in.	English SPILLPRUF 1/4-20 x 1 in
W4 72-4746	24 x 24 in	Metric (60 x 60 cm) SPILLPRUF M6 x 25 mm
W4 72-4747	24 x 36 in	English SPILLPRUF 1/4-20 x 1 in
W4 72-4748	24 x 36 in	Metric (60 x 90 cm) SPILLPRUF M6 x 25 mm
W4 72-4749	24 x 48 in	English SPILLPRUF 1/4-20 x 1 in
W4 72-4750	24 x 48 in	Metric (60 x 120 cm) SPILLPRUF M6 x 25 mm
W4 72-4751	36 x 48 in	English SPILLPRUF 1/4-20 x 1 in
W4 72-4752	36 x 48 in	Metric (90 x 120 cm) SPILLPRUF M6 x 25 mm

#### Accessories

W4 72-4753	Level-Lok Tie-downs, qty. of 4
W4 72-4754	Level-Lok Tie-downs, qty. of 5

# 9100 Series

## LabMate VIBRAPLANE Workstations

# vibration isolation

The 9100 Series VIBRAPLANE Workstations are available for two load capacities, and is field convertible to the desired capacity. Faraday Cages are offered as accessories.



- Vertical vibration isolation
- Horizontal vibration isolation
- VibraDamped steel frame
- High performance automatic-air suspension
- Maintains a preset zero deflection level (regardless of load addition or removal)
- Choice of tabletops
- Choose from 12 sizes
- Ergonomic styling
- Class 10 Cleanroom Compatible - Class 10 available

### Applications (Partial List)

- Analytical Balances
- Cell Injection
- Confocal Microscopes
- Patch Clamping
- Optical Microscopes
- Wafer Probing
- Mask Aligning
- Atomic Force Microscopes

\*Guard rails and side rails must be purchased separately.  
Supplied in packages of 2.  
Warranty 1 year.

### Specifications

#### Minimum Load @ 20 psi

Vertical Natural Frequency:	1.9 Hz
Isolation Efficiency @ 5 Hz	70%
Isolation Efficiency @ 10 Hz	90%
Horizontal Natural Frequency:	2.2 Hz
Isolation Efficiency @ 5 Hz	64%
Isolation Efficiency @ 10 Hz	90%

#### Max. Load @ 80 psi

Vertical Natural Frequency:	1.5 Hz
Isolation Efficiency @ 5 Hz	85%
Isolation Efficiency @ 10 Hz	97%
Horizontal Natural Frequency:	1.2 Hz
Isolation Efficiency @ 5 Hz	91%
Isolation Efficiency @ 10 Hz	97%

#### Gross Load Capacity @ 80 psi:

9101	363 kg (800 lbs)
9102	590 kg (1300 lbs)

#### Finish:

Standard	Linear White Polyurethane
Class 10	White Epoxy Powder Coat

Note: Typical performance efficiencies are for microdisturbances

Labmate vibraplane workstations do not include any accessories; all must be purchased separately.

- Sliding shelf
- Padded Arm Rests
- Castors
- Guard Rails
- Side Rails
- Power Outlet Strip

LMVW Require a fork lift for transport when delivered, Aprox. 500 lbs.

Guard and side rails ship together (wooden pkg), Aprox 45 lbs (43 x 15 x 8 in)



# 9100 Series **vibration isolation**

## LabMate VIBRAPLANE Workstations (continued)

Order #	Load Capacity	Depth x Width	Tabletop
W4 72-4701	648 lbs	30 x 36 in	2" White Composite w/White Plastic Laminate
W4 72-4702	648 lbs	30 x 36 in	2" White Composite w/Stainless Steel Laminate
W4 72-4703	627 lbs	30 x 36 in	4" SPILLPRUF Honeycomb ¼-20 x1 in. centers
W4 72-4704	627 lbs	30 x 36 in	4" SPILLPRUF Honeycomb M6 x 25 mm centers
W4 72-4706	598 lbs	30 x 48 in	2" White Composite w/White Plastic Laminate
W4 72-4707	598 lbs	30 x 48 in	2" White Composite w/Stainless Steel Laminate
W4 72-4708	569 lbs	30 x 48 in	4" SPILLPRUF Honeycomb ¼-20 x1 in. centers
W4 72-4709	569 lbs	30 x 48 in	4" SPILLPRUF Honeycomb M6 x 25 mm centers
W4 72-4711	548 lbs	30 x 60 in	2" White Composite w/White Plastic Laminate
W4 72-4712	548 lbs	30 x 60 in	2" White Composite w/Stainless Steel Laminate
W4 72-4713	512 lbs	30 x 60 in	4" SPILLPRUF Honeycomb ¼-20 x 1 in. centers
W4 72-4714	512 lbs	30 x 60 in	4" SPILLPRUF Honeycomb M6 x 25 mm centers
W4 72-4716	679 lbs	24 x 36 in	2" White Composite w/White Plastic Laminate
W4 72-4717	679 lbs	24 x 36 in	2" White Composite w/Stainless Steel Laminate
W4 72-4719	558 lbs	36 x 48 in	2" White Composite w/White Plastic Laminate
W4 72-4720	558 lbs	36 x 48 in	2" White Composite w/Stainless Steel Laminate
W4 72-4721	523 lbs	36 x 48 in	4" SPILLPRUF Honeycomb ¼-20 x 1 in. centers
W4 72-4722	523 lbs	36 x 48 in	4" SPILLPRUF Honeycomb M6 x 25 mm centers
W4 72-4724	562 lbs	36 x 60 in	2" White Composite w/White Plastic Laminate
W4 72-4725	562 lbs	36 x 60 in	2" White Composite w/Stainless Steel Laminate
W4 72-4726	954 lbs	36 x 60 in	4" SPILLPRUF Honeycomb ¼-20 x 1 in. centers
W4 72-4727	954 lbs	36 x 60 in	4" SPILLPRUF Honeycomb M6 x 25 mm centers

Order #	Model	Product
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### Accessories

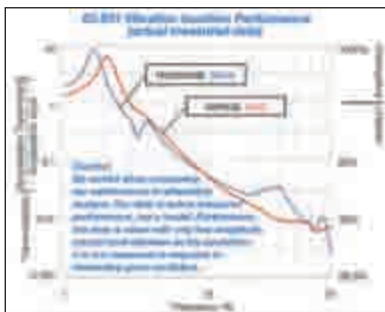
W4 64-1458	RC-4	Retractable Casters, set of 4
W4 64-1459-36	GR-36	Guard Rails, 36 inch length, front and rear
W4 64-1459-48	GR-48	Guard Rails, 48 inch length, front and rear
W4 64-1459-60	GR-60	Guard Rails, 60 inch length, front and rear
W4 64-1459-72	GR-72	Guard Rails, 72 inch length, front and rear
W4 64-1460	PA2	Padded Arm Rests, pkg. of two
W4 64-1461-10	SS-10	Sliding Shelf, 10 inch width, 31 inch length
W4 64-1461-12	SS-12	Sliding Shelf, 12 inch width, 31 inch length
W4 64-1461-14	SS-14	Sliding Shelf, 14 inch width, 31 inch length
W4 64-1462	PAC	Portable Air Compressor
W4 64-1463	EOS	Electrical Outlet Strip
W4 64-1607	SDR	Side Rails
W4 72-4737		24 x 36 in Kinetic Systems Faraday Cage*, Height 48 in
W4 72-4738		30 x 36 in Kinetic Systems Faraday Cage*, Height 48 in
W4 72-4739		30 x 48 in Kinetic Systems Faraday Cage*, Height 48 in
W4 72-7733		30 x 60 in Kinetic Systems Faraday Cage*, Height 48 in
W4 72-4740		36 x 48 in Kinetic Systems Faraday Cage*, Height 48 in
W4 72-7734		36 x 60 in Kinetic Systems Faraday Cage*, Height 48 in
W4 72-6021		36 in Side Rails for Kinetic Systems Faraday Cage
W4 72-6023		24 in Side Rails for Kinetic Systems Faraday Cage

\*Requires Side and Guard Rails

# vibration isolation

## 63-500 Series High-Performance Lab Tables

- Vertical and horizontal isolation
- Gimbal piston™ isolators
- Aluminum height control valves
- Internal piston travel restraint
- Rugged built-in leveling feet
- Choice of tabletops



The 63-500 Series High-Performance Lab Table provides an excellent vibration-free working surface for loads up to 350 lb (160 kg). Now with modular construction, these tables are recommended for use in such diverse applications as electrophysiology, cell injection, ultramicrotomy, photomicroscopy, scanning tunnel microscopy, and confocal laser scanning microscopy.

### Table Tops

#### Stainless Steel Laminate

Recommended for applications that require a strong magnetic attachment and will not involve repeated exposure of the top to corrosive liquids. This top does not have the precision flatness of our CleanTop II honeycomb top. Flatness is 0.030 in. ( 0.8 mm).

#### Plastic Laminate on Stainless Steel

An easy-to-clean alternative to stainless steel without sacrificing structural performance. A plastic laminate is added to the top surface, which reduces ferromagnetic attachment strength.

#### CleanTop II

Features a spill-proof, drilled and tapped mounting hole array. Tops are 4 in. (100 mm) thick and have 1/4–20 holes on 1 in. spacing or M6 holes on 25 mm spacing. The small cell-size steel honeycomb design provides stiffer damping than the stainless steel laminate. Guaranteed flat to 0.005 in. (0.13 mm).

### Accessories

#### Front and Rear Support Bars

These adjustable steel rails mount on the table's front and rear legs. They may be cantilevered and have slots in which shelves can be mounted. A front support bar is required for use with 60-4555 armrest pads. A front and rear support bar is required for use with sliding shelves. Support bars cannot be used in conjunction with the Faraday cage.

#### Armrest Pads

Available for both Faraday cage and non-Faraday cage applications. Adjustable leather forearm rests fasten to the Front



Support Bar or Perimeter Enclosure and can slide from side to side for added comfort. Sold in sets of two pads.

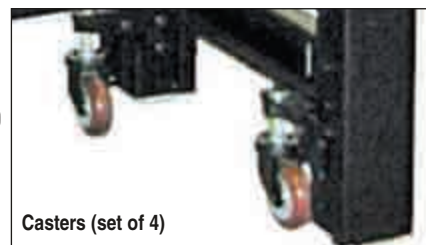


#### Sliding Shelves for Non-Faraday Cage Applications

Sliding shelves are made of wood with white plastic laminate covering all sides. Available in 6, 10, 14 and 20" widths. A metal bracket on the front edge of the shelf fits into the slot in the front support bar. Shelves slide freely from side to side and are easily lifted from the support bars. Built-in stops prevent shelves from sliding out of slots.

#### Casters

A set of four retractable casters with a total weight capacity of 1,000 lb (450 kg) can be mounted to the base of the table legs. Fits all tables.



Casters (set of 4)

#### Fixed Full-Perimeter Enclosures

A fixed, welded-steel structure that completely surrounds the table top to provide non-isolated support for the Faraday Cage and the sliding side shelf. Only accepts 8" wide Sliding Side Shelf.

#### Type II Faraday Cage

The Type II Faraday Cage offers improved access and simplified assembly. The "window-shade" type retracting front panel is easy to operate and causes reduced disturbance when adjusted. The front panel may be positioned anywhere between fully opened and fully closed, and stays in position without a fastener. The Type II Faraday cage requires the full-perimeter enclosure to mount to the 63-500 Series table.



Type II Faraday Cage

#### Sliding Shelf for Faraday Cage Applications

An 8" wide shelf that slides freely from side to side within the Faraday cage enclosure.

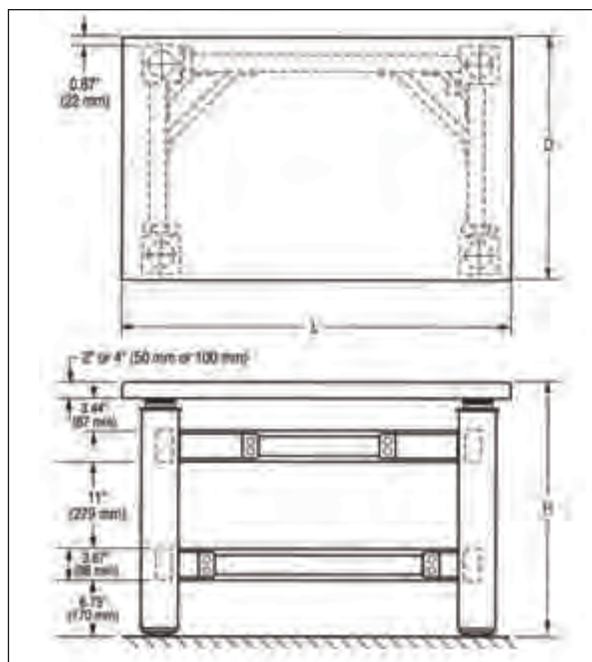
# vibration isolation

## 63-500 Series

### High-Performance Lab Tables

#### Specifications

Vertical natural frequency:		
High Input		1.2 Hz
Low Input		1.5-2.0 Hz
Isolation efficiency @ 5Hz		70-85%
Isolation efficiency @ 10Hz		90-97%
Horizontal natural frequency:		
High Input		1.0 Hz
Low Input		1.2-1.7 Hz
Isolation efficiency @ 5Hz		75-90%
Isolation efficiency @ 10Hz		90-97%
Gross load capacity	1400 lb (640 kg)	
Net load capacity	350 lb (160 kg)	
Finish	Black powder coat frame Stainless steel top	
Facilities required	80 PSI	



#### Tables

Description	25" x 36"	30" x 30"	30" x 36"	30" x 48"	36" x 48"
Stainless steel top	W4 60-4750	W4 60-4751	W4 60-4752	W4 60-4753	W4 60-4754
Plastic laminate top	W4 60-4755	W4 60-4756	W4 60-4757	W4 60-4758	W4 60-4759
Cleantop II, 1/4"-20 thread	---	---	---	W4 60-4760	W4 60-4761
Cleantop II, M6 thread	---	---	---	W4 60-4763	W4 60-4764

#### Accessories for Non-Faraday Cage Applications

Description	25" x 36"	30" x 30"	30" x 36"	30" x 48"	36" x 48"
Front support bar	W4 60-4536	W4 60-4535	W4 60-4536	W4 60-4537	W4 60-4537
Rear support bar	W4 60-4540	W4 60-4539	W4 60-4540	W4 60-4541	W4 60-4541
Armrest pads (set of 2)	W4 60-4567	W4 60-4567	W4 60-4567	W4 60-4567	W4 60-4567
Sliding shelf, 6" wide	W4 60-4543	W4 60-4547	W4 60-4547	W4 60-4547	W4 60-4551
Sliding shelf, 10" wide	W4 60-4544	W4 60-4548	W4 60-4548	W4 60-4548	W4 60-4552
Sliding shelf, 14" wide	W4 60-4545	W4 60-4549	W4 60-4549	W4 60-4549	W4 60-4553
Sliding shelf, 20" wide	W4 60-4546	W4 60-4550	W4 60-4550	W4 60-4550	W4 60-4554
Casters (set of 4)	W4 60-4798	W4 60-4798	W4 60-4798	W4 60-4798	W4 60-4798

#### Accessories for Faraday Cage Applications

Description	30" x 36"	30" x 48"	36" x 48"
Faraday Cage	W4 60-4799	W4 60-4800	W4 60-4801
Perimeter enclosure for stainless steel and laminated tops (required for cage)	W4 60-4804	W4 60-4806	W4 60-4808
Perimeter enclosure for Cleantop tops (required for cage)	W4 60-4805	W4 60-4807	W4 60-4809
Armrest pads (set of 2)	W4 60-4568	W4 60-4568	W4 60-4568
Hanging shelf	W4 60-4571	W4 60-4572	W4 60-4572
Sliding side shelf, 8" wide	W4 60-4811	W4 60-4811	W4 60-4815
Casters (set of 4)	W4 60-4798	W4 60-4798	W4 60-4798

## SIU-102

### Stimulus Isolation Unit – Bipolar High Current

*Designed for use with Warner's imaging chambers and dish inserts with field stimulation electrodes*



- Constant current and constant voltage modes
- Bipolar, pulse and DC modes
- Optical coupling is used to isolate the stimulator from pulse source
- Current up to 100 mA, voltage up to 100 V
- **For imaging applications only**

Designed for use with Warner imaging chambers having field stimulation electrodes, the SIU-102 features optical isolation at the input and transformer isolation at the output. Timing pulses can be controlled by any device capable of generating a TTL level positive pulse – a computer with data acquisition, for example.

Positive or negative pulses, positive or negative DC, and bipolar pulses are possible in constant current or constant voltage delivery modes. For bipolar delivery, a positive pulse during the input pulse is followed immediately by a negative pulse of equal duration and amplitude. Bipolar pulse widths from 100  $\mu$ s to 100 seconds per each polarity are possible.

Output amplitude is set using a range mode switch in conjunction with a ten-turn potentiometer to set a percentage of the selected range.

Indicator lights keep the user apprised of the following:

High voltage:	Lights red when output voltage above 30 volts
Compliance:	Lights when impedance across output is too high for current setting
T>100 Sec:	Lights when pulse width input is longer than 100 seconds in Bipolar mode
Ext. Trigger:	Lights when a valid input is applied to the Pulse In BNC

#### Specifications

Output Waveform	DC, Current Pulse or Voltage Pulse
Output Current Ranges	1, 10, and 100 mA
Output Voltage Ranges	10 and 100 V
Output Impedance	10 V Range: 1 k $\Omega$
Voltage Mode	100 V Range: 10 k $\Omega$
Output Compliance	100 V
Output Polarity	Selected by Mode Switch Red connector is positive in any positive mode: Red connector is negative in any negative mode
Amplitude Control	Multi-turn dial
Input Pulse Requirements	TTL level, positive pulse 3 V, 1 mA minimum Minimum
Pulse Width	100 $\mu$ s Maximum Pulse Width: 100 s (Bipolar Mode Only)
Input Connector	BNC
Output Connector	Banana Jacks
Power Requirements	90 to 270 VAC, 50/60 Hz, 10 VA
Physical Size, H x W x D	8.9 x 20 x 25.4 cm
Shipping Weight	3 kg
Warranty	Two years, parts and labor

Order #	Model	Product
<b>W4 64-1424</b>	SIU-102	Stimulus Isolation Unit
<b>W4 64-1425</b>	CC-102	Cable, male banana to 1 mm jacks (for use with Warner field stimulation chambers)



## DS4

## Bipolar Isolated Stimulator

Compatible with electrophysiology recording



- No interference with recordings
- No ground loops
- Bi-phasic constant current
- Gated operation allows multiple units
- Battery powered energy saver circuitry

The DS4 provides an isolated biphasic constant current stimulus in response to an external command voltage signal. Generally speaking, the command signal is a computer generated DAC signal via software.

The DS4 accepts a variety of voltage input ranges from  $\pm 1V$  to  $\pm 10V$  and produces a constant current output in 4 overlapping ranges from  $\pm 10_{\mu}A$  to  $\pm 10mA$ . The compliance voltage is  $\pm 48V$ .

In addition, the DS4's GATE input allows multiple DS4's to be connected to a single analog voltage source, with each DS4 capable of being independently enabled.

One problem with stimulators that use an external voltage source to define the stimulus waveform is that small offsets or noisy baseline signals from the DAC's can result in battery drain or low amplitude stimulation. The DS4 uses a special "inactivity sensor" to monitor the input voltage and disable the output if this voltage falls within 0.2% of the full scale value for a user selectable time period. This "inactivity sensor" reduces battery usage and damaging "leak currents" during infrequent stimulation, while at the same time maintaining low zero crossing distortion for repetitive waveforms.

The DS4 uses an external power supply to power the input control circuitry and inexpensive batteries to provide an opto-isolated voltage source.

## Specifications

Output	Biphasic constant current proportional to the input voltage	
Output Ranges	$\pm 10_{\mu}A$ ; $\pm 100_{\mu}A$ ; $\pm 1mA$ ; $\pm 10mA$ for a full scale input	
Output Duration	$>2_s$	
Compliance	$\pm 48V$ from 8x GP23A batteries	
Linearity	$\pm 3\%$ of full scale output for each output range	
Output Impedance	$>900M\Omega$	
Output Rise Time	$<5_s$ (1k $\Omega$ load), $<40_s$ (1M $\Omega$ load)	
Frequency Response	Expected DS4 output is maintained for frequencies up to 5kHz.	
<b>Inputs</b>		
IN Ranges	$\pm 1$ ; $\pm 2.5$ ; $\pm 5$ ; $\pm 10 V$ full scale (selected by an internal jumper) with a limit of $\pm 12V$ max without damage	
Input Impedance	1M $\Omega$	
GATE	Range: TTL; Gate OFF if Low; Gate ON if High or open circuit. Limit of $\pm 15V$ max. Input Impedance: 10k $\Omega$	
Inactivity Sensor	The output is disabled if the voltage input remains within $0\pm 0.2\%$ of the full scale value for a user selectable period of 100ms, 200ms, 1s or 2s. This time period can be adjusted with an internal jumper.	
Connections	Output - 2mm shrouded, touch-proof sockets (red and black) spaced at 0.75" Input - Front panel BNC socket Gate - Front panel BNC socket Battery Test - Six 2mm sockets Power - Socket for external power supply	
Controls:	Gate - On/Off toggle (off overrides BNC input) Output Range - 4 position rotary switch Power - On/Off toggle switch	
Indicators	Power ON - LED Green (lit when the power supply is connected and DS4 is switched On) Gate Enabled - LED Amber (lit when Gate is On and the Gate Input is held TTL high) Phase+ve - LED Amber (lit when input exceeds +0.2% of full scale voltage) Phase-ve - LED Amber (lit when input exceeds -0.2% of full scale voltage)	
Power	Included external power supply (input voltage 110V - 220V) providing $\pm 15V$ DC output 10 x 12V GP23A Batteries.	
Mounting	One or two stimulators may be mounted in a 19" rack using a specially fabricated frame (D121-11)	
Dimensions (w x h x d)	190 x 110 x 80 mm (7.5 x 4.3 x 3.1 in)	
Weight (approx.)	500g (1.1 lbs)	
<b>Order #</b>	<b>Model</b>	<b>Product</b>
<b>W4 65-0364</b>	DS4	Biphasic Stimulus Isolator

## DS2A and DS3

### Constant Voltage and Constant Current Isolated Stimulators

*A bettery operated stimulator useful for electrophysiology experiments*



#### Specifications

Maximum Output	99 V (High), 9 V (Low) selected by front panel switch; square wave pulse shape, typical rise
Voltage (DS2A)	Time < 1 $\mu$ sec fall time < 3 $\mu$ sec into resistive load
Output Ranges (DS3)	2 to 32 $\mu$ A, 20 to 320 $\mu$ A, 0.2 to 3.2 mA and 2 to 32 mA
Output Compliance (DS3)	90 V
Output Impedance (DS2A)	Dependent on position of amplitude control, 1.25 K max. at center position, 200 $\Omega$ at ends of travel
Pulse Width Controls*:	Two dials providing continuous adjustments over range 20 $\mu$ sec to 2 sec, as well as selection of input pulse width
1)	6-Position Switch for pulse widths 10 $\mu$ sec, 100 $\mu$ sec, 1 msec, 10 msec, 100 msec with $\pm 10\%$ accuracy or equal to input pulse width
2)	Multiplier continuously variable over range x2 to x20; pulse width is product of two dial settings
Trigger Isolation*	Optical coupling is employed between trigger source and stimulator circuitry; capacity coupling less than 3 pF
Single Shot*	Single shot push button provided
Batteries	Self contained batteries are used to provide isolated source of power; current is drawn only when delivering output pulse; max. current drain is 30 mA plus load current
Battery Type	11 x PP3 - (IEC-6R61) style 9V batteries
Dimensions:	
Panel Size	190 x 110 mm (7.5 x 4.3 in)
Depth	80 mm (3.15 in) over knobs
Weight	800 g (28.2 oz) with batteries installed

Order #	Model	Product
W4 65-0329	DS2A	Isolated Stimulator, Constant Voltage
W4 65-0550	DS3	Isolated Stimulator, Constant Current Output
W4 65-0337	D121-11	19 Inch Rack Mounting Frame, holds two DS2A/ DS3/DG2

\*Note: Fulfilled by both DS2A and DS3.

- Minimal interference with recordings
- No ground loops
- DS2A: 100 V maximum at up to 50 mA
- DS3: 2  $\mu$ A - 32 mA from 90 Volts
- Battery powered energy saver circuitry

Many experiments in electrophysiology use a brief pulse of current as a stimulus to excite nerve or muscle fibers. It is desirable that the source of this E.M.F. should be isolated both from ground and from the timing generator used to release the stimulus. The DS2A and DS3 fulfill these requirements by using self contained batteries as the source of power and optical coupling is employed to isolate the stimulator from the trigger source. Precise timing of stimulus application can be controlled by a PC or other stimulus generating device such as the DG2 Trigger Generator. The duration of the stimulator output is adjustable over the range of 20 microseconds to two seconds by controls on the stimulators or can be the same as the applied trigger pulse.

Current is drawn from the batteries only and instruments have non-conductive enclosure. A single shot button is provided, which operates at all times irrespective of the trigger input.

**DG2A****Train/Delay Generator**

*Designed for control of normal repetitive stimulation as well as for defining the Effective Refractory Period using a second, delayed pulse*



- Trigger timing generator
- Ideal for electrophysiology
- Perfect match for DS2A and DS3
- Internal battery

The DG2A is a compact, free-standing, battery powered instrument which can be used to generate trigger pulses required for repetitive stimulation. Also featuring DELAY controls, it is useful for determining nerve or axonal Effective Refractory Period (ERP) through the production of a delayed second pulse.

Various modes allow output pulses to be produced singularly (SINGLE), continuously (FREE-RUN & GATED) or in a burst (TRAIN), with the burst/train duration and pulse frequency determined by the front panel controls. In each of the modes (except FREE-RUN), outputs can be initiated either by the front panel push button, a TTL compatible trigger/gating pulse or a suitable foot switch.

The unit has control of train duration over three full decades, pulse repetition rate (or frequency) within that train over five decades and control of the delayed pulse over three decades. It has two BNC output sockets (i) the SYNC output produces a pulse to trigger recording devices or synchronize other equipment and (ii) the OUT output produces either a delayed version of the same or by toggle switch selection, pairs of delayed and non-delayed pulses (as would be necessary for ERP studies).

The unit is especially suitable for use with our DS2A Isolated Constant Voltage and DS3 Isolated Current Isolated Stimulators which have their own Pulse Duration controls.

The instrument is powered by an internal 9V battery (PP3 - 6R61 style) and replaces our DG2 Trigger Generator.

A mounting frame (part number W4 65-0337) is available so that two units of either DG2A, DS2A or DS3 can be mounted in 19" rack.

**Specifications**

The unit always produces a pulse to synchronize other equipment at SYNC and a pulse delayed from SYNC by DELAY controls.

**Modes:**

Modes:	Control Functions	Four position rotary switch
SINGLE	Input signal triggers a single Output pulse	
FREE-RUN	Continuous Output pulses as set by REPETITION controls	
GATED	Input signal enables unit to produce pulses as set by REPETITION controls	
TRAIN	Input signal Triggers unit to produce pulses as set by REPETITION controls for the time as set by the DURATION controls	

**Specifications (continued)****Input:**

Connector	BNC socket
Levels	TTL high (>1.5 V), TTL low (<0.8 V)
Polarity	Active High (GATE/TRAIN) and Positive edge (SINGLE) or Active Low and Negative edge by Internal Jumper
Internal Jumper	Enable "Active Low" - allowing for an Input that is Low during its active phase
Push-button	Has same function as a valid input signal
Indicator	"TOO FAST" Red LED that flashes if a Trigger is received while the unit is busy

**Duration:**

Total range	10 msec - 12 sec in three overlapping ranges
Control	Single turn control marked 1 - 12 sec with intermediate integer panel marks
Accuracy	±1% at '1' and '12' marks, ±5% at intermediate marks
Multiplier	x0.01 ; x0.1 ; x1
Internal Jumper	Enable "x10" - giving a 100 msec - 120 sec total range

**Repetition (Frequency):**

Total Range	0.01 - 1200 Hz in five overlapping ranges
Control	Single turn control marked 1 - 12 Hz with intermediate integer panel marks
Accuracy	±1% at '1' and '12' marks, ±5% at intermediate marks
Multiplier	x0.01 ; x0.1 ; x1 ; x10 ; x100

**Delay:**

Total Range	1 - 1200 msec in three overlapping ranges
Control	Single turn control marked 1 - 12 msec with intermediate integer panel marks
Accuracy	±1% at '1' and '12' marks, ±5% at intermediate marks
Multiplier:	x1 ; x10 ; x100
Internal Jumper	Enable "x10" - giving a 10 msec - 12 s total range
Indicator	"TOO LONG" Red LED that flashes if DELAY longer than can be produced for each pulse

Internal Jumper	Enable "x10" - giving a 10 msec - 12 s total range
Indicator	"TOO LONG" Red LED that flashes if DELAY longer than can be produced for each pulse

**Outputs – SYNC:**

Connector	BNC socket
Signal	Positive going, 200µs pulse, TTL compatible pulse (5 V amplitude)

**Outputs – OUT:**

Connector	BNC socket
Signal	Positive going, 200µs pulse, TTL compatible pulse (5 V amplitude)
Control	Selection of only the Delayed pulse (upwards) or both the Sync and Delayed pulses
Indicator	Amber LED that flashes for each OUT output pulse
Internal Jumper	Enable "Active Low" - giving an Output that is Low during its active phase

**Power:**

Control	ON/OFF toggle: OFF is down
Consumption	<2 mA
Internal	PP3 - (IEC-6LR61) style, alkaline preferred
Battery Life	250 Hours with EverReady 6LF22 or Duracell MN1604
Dimensions, H x W x D	110 x 188 x 60 mm (4.3 x 7.4 x 2.4 in)
Weight	490 g (17.3 oz) with battery installed

**Order # Product**

**W4 65-0641** Train Delay Generator DG2A

**W4 65-0337** 19 in Rack Mounting Frame, Holds 2 DG2 generators

*Note: No other accessories, other than a battery, are supplied.*

# NL900D and NL905 Rack (Case) with Power Supply

# neurolog™ system

## The NeuroLog™ System

The NeuroLog™ System is now widely accepted throughout the world by scientists who demand high quality, dependability and innovation in their research instrumentation.

Because the NeuroLog™ System is fully modular, it has the following well-recognized advantages over non-modular "multi-purpose" instruments.

- It is more flexible. Complex systems can be quickly assembled or modified.
- It is more efficient. Modules can be shared among several set-ups, expanding capabilities without duplication. Only those modules required for a particular task are tied up and occupy rack space.
- Fewer interface problems. Input and output levels, impedances, connectors, etc., of different modules in the system are compatible, minimizing the problems encountered in interconnecting pieces of equipment of diverse origin.
- It is less costly. Only those modules actually required are purchased. You do not pay for all those functions added to an instrument to make it "general purpose".
- Individual modules can be added to the system at any time, as the scope and orientation of your application changes.



- Intracellular Recording
- Extracellular Recording
- Spike Detection
- Electrical Stimulation
- Pulse & Train Generation
- Multi-channel EMG or EEG Recording
- Pressure or other Transducer Recordings
- High quality, dependable and efficient
- Modular — easy to install modules as you need them
- Fewer interface problems
- Less costly than general purpose instruments
- Built in logic circuit indicates excessive loading

The NeuroLog™ module frame and power supply are housed in a fully finished, enclosed case. The case has handles and integral rack mounting hardware so that it can be shifted directly between rack and bench top. The case contains 13 module bays plus power supply panel.

The NeuroLog™ case has an integral module retention system, consisting of a simple, slide action lever on the power supply panel. Therefore, fittings such as retained screws, D-locks, etc., on individual module front panels are unnecessary. This simple design enables easy, rapid, changes in module arrangements, and ultimately reduces the cost of the modules.

The NeuroLog™ power supply produces three voltages (+15 V, +5 V, and -15 V), stabilized against line and load variations. The voltage outputs are rated at 650 mA, 3.0A, and 650 mA, respectively. All three supplies have internal 'fold-over' current limiting; the 15V supplies, in addition, are protected with series fuses. Each supply has less than 15 mV line ripple at maximum load. The power supply transformer employs a sectionalized winding former for additional safety and complies with the requirements of IEC601 part 1 and BS5724. The power supply provides sufficient power for almost any mix of NeuroLog™ modules.

A unique feature of the NeuroLog™ power supply is a built-in logic circuit which indicates (by extinguishing the power supply indicator on the front panel) excessive loading of one or more of the three supply outputs. While it is expected that a power supply failure will never occur using NeuroLog™ modules, the fault indication is invaluable when testing custom circuits built in the NL50 Blank Module.

The NL905 Compact Case and Power unit is an enclosed case which will accept up to 4 single width NeuroLog System modules. This case is designed as a more compact counterpart to the full width NL900D.

## Specifications

Model	NL900D
Dimensions, H x W x D	133 x 483 x 317 mm (5.25 x 19 x 12.5 in), without feet
Weight	5.5 kg (12.1 lb), without modules

Order #	Model	Product
W4 65-0283	NL900D	Rack (Case) with Power Supply
W4 65-0283S	NL905	Small Rack (Case) with Power Supply



# NL50

## Blank Module

# neurolog™ system

*Each module has a split ring handle attached to its front panel. This handle serves as a cable run and as a handle for withdrawing or inserting the module into the case. All module outputs are short circuit proof. The extensive use of standard transistor-transistor logic (TTL, the standard logic in small computers) and standard linear integrated circuits ensures the lowest possible cost and highest possible compatibility with*

*other instruments. The output levels and impedances of the linear inputs and outputs are appropriate for general purpose oscilloscopes and low gain chart recorders, etc. The NeuroLog™ System is also compatible with the components most frequently used in special circuitry built by individual investigators to meet their own particular needs.*

### Module Interconnection

The general problem of module interconnection has been minimized in the NeuroLog™ System by a unique method of automatic connection of outputs and inputs of neighboring modules through the case edge connectors. Thus, for many linear arrangements of modules, only the input and output cables connecting the system to the preparation and to output devices such as oscilloscopes, recorders, etc., are required. Front panel controls are therefore not obscured by cables which merely connect each module to the next. More complex module arrangements will, however, require some front panel cable interconnection; between 5 and 10 cables of various lengths will be required for a typical 13-module system. No cables are supplied with the case, see NeuroLog™ accessories on page 206.

### Cables

Only microminiature coaxial connectors with a 'snap-on' action are used in the NeuroLog™ System, eliminating the nuisances caused by connectors such as the BNC and UHF types which have a 'twist-on' or 'screw-on' action. All external connections between modules are made through miniature, screened coaxial cable, which reduce cross-talk and transient pick-up, as well as eliminating the tangling of fine, unscreened wires and 1 mm (or 2 mm or 4 mm) plugs frequently used for patching in other modular systems.

A variety of assembled cables, plugs, sockets, BNC to NeuroLog™ adaptors and 'T' connectors are available from Harvard Apparatus, see NeuroLog™ accessories list page 206.

### NeuroLog™ Module Dimensions

Dimensions, H x W:

Front Panel (All modules)	122 x 30 mm (4.8 x 1.2 in)
Attached Printed Circuit Board	102 x 152 mm (4.0 x 6.0 in)



### NL50 Blank Module

The **NL50** Blank Module consists of an undrilled, finished front panel and an unassembled printed circuit board. The printed circuit board has a 76 mm (3 inch) by 102 mm (4 inch) area of drilled soldering pads on 2.54 mm (0.1 inch) centers, for mounting components and supporting solder connections. The gold-plated edge connector has pads labeled for the appropriate power supply voltages and back connections. Input and output jumpers and pin sockets are supplied with the same configuration used in factory constructed modules. The front panel can be labeled with white letraset and lacquered, to give an appearance very similar to other NeuroLog™ modules. The NL50 can be used to construct modules of your own design, compatible with the NL900 Case and power supply.

Order #	Model	Product
W4 65-0219	NL50	Blank Module

## NL102G

### DC Pre-Amplifier

- Electrode impedance check
- Calibrator
- Four current injection ranges ( $\pm 100$  nA,  $\pm 50$  nA,  $\pm 20$  nA,  $\pm 10$  nA) with four corresponding bridge balance ranges (100 M $\Omega$ , 200 M $\Omega$ , 500 M $\Omega$ , and 1000 M $\Omega$ )
- External gating of above facilities
- Bridge balance
- Back-off (DC Level) control
- Constant current capacitance compensation (neg. cap.) which largely eliminates readjustment, due to changes in input source resistance, common with voltage feedback circuits. The NL102G is now supplied with the hand held NL412 Pulse Box providing remote, push button overcompensation (ZAP!) control in order to assist membrane penetration
- Dye/clean (+ OFF -) toggle switch can be used for clearing blocked microelectrodes or depositing dyes through extracellular pipettes (max. current  $\pm 1.0$   $\mu$ A)
- x1 output amplifier has  $\pm 10$  V dynamic input signal range



The **NL102G** is a direct-coupled preamplifier is designed specifically for intracellular recording. With features such as capacity neutralization, current injection, low leakage current and low DC drift, it is particularly suitable for intracellular measurements through high impedance fluid-filled electrodes. The input stage is conveniently located at the end of a 2 meter cable for direct attachment to a micro electrode stepper.

The high impedance headstage of the NL102G is fitted in a metal tube at the end of a 2 meter cable. The Headstage is matched with the main amplifier module supplied with it. It is not interchangeable with other NL102G DC Preamplifier modules without recalibration (the serial numbers on the headstage and module match). The central 2 mm input socket (IN) is the capacity-compensated signal input through which current can be injected. The shield socket is the X1 output and may be used as a capacitance ground or shield at the electrode and preparation. The third socket is the system earth (ground) and connection should be made to the indifferent electrode only.

### Specifications

Input Resistance	10 <sup>11</sup> Ω
Voltage Gains	x1, x10 fixed
Input Voltage Range	±10 V, absolute max. of ±14 V
Gate Leakage Current	Adjustable to zero
Risetime	Zero Source Resistance: 1 μsec (20 MΩ source resistance); 15 μsec
Injection Current/ Bridge Balance	Selectable ranges: 100 nA/100 MΩ, 50 nA/200 MΩ, 20 nA/500 MΩ, and 10 nA/1000 MΩ
Zero Stability (Referred to Input)	±100 μV/day
Output Impedance	600 Ω
Capacity Neutralization	0 to 30 pF
Max. Noise Level	At 10 kHz bandwidth, referred to input (zero source resistance): 20 μV peak-to-peak (4 μV RMS); (10 MΩ source resistance): 180 μV peak-to-peak (36 μV RMS)
DC Level Range	±2 V (referred to input)
Output Voltage Range	±11 V
Electrode Impedance Check	x1 out      1 mV/MΩ x10 out     10 mV/MΩ
Calibrator	10 mV or 100 μV 150 Hz square wave
External Stimulus Input Range	±10 V corresponds to ±full scale current, depends on range selected
Amplification:	2 outputs available:
x1 Out	Voltage present at '+' input referred to GND including any potential dropped across electrode resistance by injection stimulus current applied. Max. voltage range of amplifier ±10 V
x10 Out	x10 signal present at '+' input referred to GND less voltage generated across electrode resistance R <sub>e</sub> when bridge balance control is correctly set for value of R <sub>e</sub>
Bridge Balance	Range ±10 V corresponds to 100 MΩ at 100 nA, 200 MΩ at 50 nA, 500 MΩ at 20 nA, and 1000 MΩ at 10 nA depending on setting of inject current selector (printed circuit board mounted)
DC Level Control	Enables x10 amplifier to back off up to ±2 V at input
Current Injection:	Stimulus currents can be injected into electrode system in either direction under following conditions:
1	Set by current inject control in magnitude, direction by front panel HYPER/DEP switch and gated ON or OFF by TTL gate pulses at front panel socket
2	Set in magnitude and direction by analog voltage applied at front panel socket signal range ±10 V; current injection can be combination of both control systems; full scale current injection conditions are printed circuit board selector at 100 nA, 50 nA, 20 nA or 10 nA
Monitor Out Socket	Allows connection of oscilloscope to monitor injection current (±10 V full scale injection current)
Other Injection Current Possibilities:	
1	Max. non-controlled current for dye injection to preparations or clearing of blocked electrodes; current is dependent on electrode resistance and can be up to ±1 μA max.; repeated reversal of selector switch usually cleans blocked electrodes
2	Impedance check measurement selected by front panel switch injects current (1 nA) through electrode giving signal at x1 output which is pulse wave of amplitude 1mV/MΩ or 10 mV/MΩ at x10 output

### Specifications (continued)

Capacity Compensation	NL102G has front panel control to adjust amplifier section to compensate for capacity to ground at electrode; adjustment is easily made by switching on impedance check signal and setting NEG CAP control for fast rise time square wave without excessive overshoot at output; range is sufficient to compensate for capacities up to 30pF; amplifier can be deliberately put into oscillatory mode by push button adjacent to NEG CAP control and is of use when penetrating cell membrane during electrode manipulation
Calibration	Square wave calibration signal built into NL102G for calibration through complete system; select it through front panel switch as one of two magnitudes: 10 mV or 100 μV. Can be gate controlled by TTL signal applied to front panel sockets; signal (approx. 150 Hz) is summed with bridge balance signal at input of x10 amplifier section

Order #	Model	Product
W4 65-0222	NL102G	DC Pre-Amplifier includes Headstage and NL412 Pulse Generator
W4 65-0223	NL102GH	Replacement Headset (Including Fitting)

# NL100AK and NL104A

# neurolog™ system



## NL100AK Headstage

The **NL100AK** Headstage is a differential input, low noise, high impedance buffer amplifier contained in a metal tube and supplied with a 2 meter long flexible cable. The NL100AK is supplied as standard with a removable 6.4 mm (0.25 inch) diameter stainless steel mounting rod. Power is supplied by the NL104A AC preamplifier via a 4 way lemo plug and socket. This headstage can also be used in conjunction with other NeuroLog™ amplifiers (NL103, NL104, NL107), please specify with order.

### Specifications

Input Resistance	100 MΩ
Gain	±1.0
Input Noise	< 2 μV (peak to peak) with inputs shorted; < 25 μV for a typical tungsten microelectrode in saline; < 30 μV with a MΩ resistor between inputs (bandwidth in all three cases, 10 Hz to 10 kHz)
Dimensions, L x OD	35.6 x 9.5 mm (1.4 x 0.375 in) diameter
Connections:	
+ IN	2 mm socket for non-inverting input accepts plugs supplied, as well as (optional) NL101 electrode chambers or NL08 micro-electrode adapters
- IN	1 mm socket for inverting input connection to reference electrode or via U connector (supplied) to ground socket (GND)
GND	Screen connected to mains earth

Order #	Model	Product
W4 65-0220	NL100AK	Headstage
W4 65-0396	NL08	Metal Microelectrode Adapter pin, 2 mm to 0.8 mm

## NL104A AC Preamplifier

The NL104A AC Preamplifier is a low noise, high input impedance, differential, preamplifier. It can be used alone for making recordings from low resistance (gross) electrodes, or with the NL100AK Headstage for microelectrode recordings. The NL104A features a wide dynamic balance adjustment for asymmetrical inputs (useful for balancing out interference and shock artifacts), a choice of two input time constants, 8 gain ranges and 3 high frequency filter settings. An internal 50Hz oscillator is provided for precisely balancing the input (input switch in the CM position).

### Specifications

Gain	100, 200, 500, 1 k, 2 k, 5 k, 10 k or 20 k
Input Resistance	10 MΩ
High Frequency Cutoff	Selectable for 100 Hz, 700 Hz, 6 kHz or W.B. (> 40 kHz)
Low Frequency Cutoff	0.1 Hz or 10 Hz
Common Mode Rejection Ratio	10,000:1 at 50 Hz
Input Noise	< 10 μV (peak to peak) with inputs shorted to ground and bandwidth of 0.1 Hz to 10 kHz
Dynamic Balance Adjustment	Gain for one input can be varied ±50% with respect to other
Output Voltage Range	±12 V max.

Order #	Model	Product
W4 65-0224	NL104A	AC Pre-Amplifier



# NL100RK, NL101 and NL04 **neurolog™ system**

- Allows stimulation and recording through the same electrode
- Stimulus can be controlled manually or from external device

## NL100RK Pre-Amplifier and Stimulus Relay

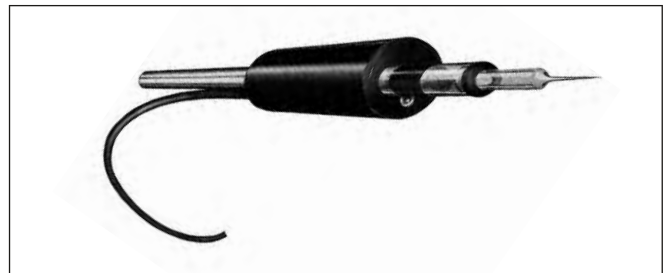
The **NL100RK** consists of an NL100AKS head-stage and the NL100C Stimulus Control module designed for use with the NL104A AC Pre-amplifier and allowing stimulation and recording through the same electrode. The NL100C allows a voltage of up to 100V to pass through the NL100AKS head-stage and recording electrode under the control of a three position switch on the NL100C front panel. The switch has "On", "Off" and "Ext" positions, allowing presentation of the stimulus to be controlled manually or via a gating pulse from an external device.

Order #	Model	Product
W4 65-0642	NL100RK	Pre-Amplifier and Stimulus Relay



## NL101 Electrode Chambers

**NL101** Electrode Chambers are compatible with all NeuroLog™ system headstages. They are available with two different plug sizes; Both of these are available in four sizes to fit glass capillaries. For example, NL101B3 will plug into a NL100AK or NL102G and hold a glass capillary with an outside diameter of 1.5 mm.



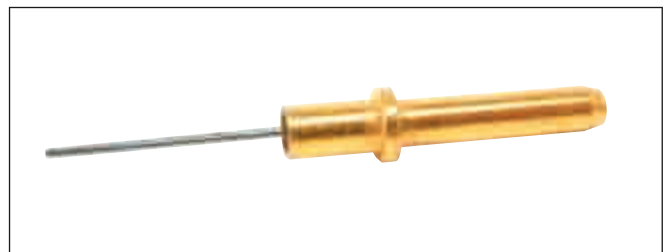
Order #	Model	Electrode Chamber OD	Plug Size	Color
W4 65-0221	NL101A	1 mm	1 mm	Yellow
W4 65-0389	NL101A	1.2 mm	1 mm	Green
W4 65-0390	NL101A	1.5 mm	1 mm	Blue
W4 65-0391	NL101A	2 mm	1 mm	Red
W4 65-0392	NL101B*	1 mm	2 mm	Yellow
W4 65-0393	NL101B*	1.2 mm	2 mm	Green
W4 65-0394	NL101B*	1.5 mm	2 mm	Blue
W4 65-0395	NL101B*	2 mm	2 mm	Red

\*Fits NL100AK and NL102G headstages.

## Tungsten Micro-Electrode Holder

The **NL04** Micro-Electrode Holder is a 26 gauge hypodermic needle tube soldered into a drilled out 2 mm pin. This holder is for use with NL100AK and NL100AKS headstages.

Order #	Model	Product
W4 65-0638	NL04	Tungsten Micro-Electrode Holder





## NL106 AC-DC Amplifier

The NL106 AC-DC Amplifier features attenuation or amplification which is continuously adjustable, using a locking ten-turn potentiometer, from 0 to x10, or 0 to x100. Its input controls are similar to those of conventional oscilloscope vertical amplifiers, allowing operation in AC or DC coupled, single-ended (inverting or non inverting) or differential modes. Up to  $\pm 2$  VDC at either input can be zeroed using the ten-turn DC OFFSET adjustment. The output voltage is shown by 4 light-emitting diodes: two red LED's show outputs in excess of 50 mV and 1.0 V; two green LED's show corresponding negative outputs. Thus, adjustment of gain and DC offset can be accomplished without an oscilloscope monitor. Low drift, low noise, and moderate input impedance make the NL106 suitable either as an amplifier for low impedance sources, or as variable gain stage following a preamplifier.

### Specifications

Input Voltage Range	$\pm 15$ V
Input Impedance	1 M $\Omega$
Gain	0 to X10 or 0 to X100 continuously variable by 10-turn potentiometer
Small Signal	$\pm 1$ V out >30 kHz Frequency Response
Low Frequency Cutoff	In AC Mode 2 Hz
Output Voltage Range	$\pm 12$ V
Output Impedance	600 $\Omega$
DC Offset Range	$\pm 2$ V at either input, 10-turn potentiometer adjustment
CMRR	> 2500; 1 at 50 Hz

Order #	Model	Product
W4 65-0225	NL106	AC-DC Amplifier

## NL108A Pressure Amplifier

The NL108A Pressure Amplifier module provides two gain settings, one appropriate for blood pressure measurement (1.0 V at the output corresponds to 100 mmHg pressure at the transducer) and the other for low pressure measurement such as intratracheal pressure (100 mV at the output equals 1 cm H<sub>2</sub>O at the transducer port). An internal voltage calibrate signal provides the appropriate deflection (1.0 V or 100 mV) for these two ranges. Other features include excellent DC stability, a push button switch for setting the zero pressure baseline on the recording instrument, and a sensitive zero offset control. Although the NL108A is designed to mate perfectly with our own pressure transducer, due to its internally adjustable gain and bridge excitation voltage, it can be used with a variety of other standard pressure transducers. Call Harvard Apparatus for additional information.

### Specifications

Input Voltage Range	$\pm 10$ V
Input Impedance	10 <sup>9</sup> , typical
Gain	1 V/100 mmHg or 100 mV/cmH <sub>2</sub> O, for pressure transducer having out put of 50 $\mu$ V/mmHg
DC Offset	$\pm 80$ cmH <sub>2</sub> O, $\pm 60$ mmHg, when switched to appropriate range
Bandwidth	DC to 150 Hz
O/P Voltage Range	$\pm 12$ V
O/P Impedance	600 $\Omega$ (nom) except 'zero out', where O/P is - S/C direct to ground
Bridge Supply	0 to 24 V DC (25 mA)

Order #	Model	Product
W4 65-0227	NL108A	Pressure Amplifier

## NL108T4 Pressure Transducer



Order #	Model	Product
W4 72-4222	NL108T4	Pressure Transducer, pkg. of 1
W4 72-4223	–	Replacement Dome for W4 72-4222, pkg. of 1
W4 72-4224	–	Replacement Dome for W4 72-4222, pkg. of 10
W4 65-0631	NL108L4	Lead for NL108T4 to NL108A

Suitable for both arterial and venous blood pressure monitoring, the NL108T4 can be attached via a lead (NL108L4) to the NL108A pressure amplifier, allowing continuous pressure monitoring. The NL108T4 is a highly accurate and rugged re-useable transducer, which is used in conjunction with disposable domes (NL108D4). These disposable domes are easy to fill and attach to the transducer body and are available in packs of 10 or individually (one dome is included with each transducer). The components of the transducer are electrically isolated from the transducer housing, which is in turn isolated from the saline solution by the silicone membrane of the dome. The transducer is gold plated, making it easier to clean.

The transducer is designed primarily for use during blood pressure monitoring, but equally well operates as a monitor for intracranial, gastrologic or intrauterine pressures, as well as urodynamic measurements.

### Specifications

Pressure range	20 to 300 mmHg
Max. Overpressure	10000 mmHg
Sensitivity	50 $\mu\text{V/V/cmHg}$
Resonance Frequency	300 Hz typical (transducer and dome)
Max Electrical Excitation	15 V DC or AC
Input Resistance	700 $\Omega$ (or equipment specified)
Output Resistance	1000 $\Omega$ (or equipment specified)
Non-Linearity and Hysteresis	max. 0.5% of full scale
Zero Balance	max. $\pm 30$ mmHg
Thermal Sensitivity	0.15%/°C
Thermal Zero Shift	max. 0.25 mmHg/°C
Operating/Storage Temperature Range	+10 to +50°C/-20 to +70°C
Insulation Resistance	min. 10 $\Omega$
Leakage Current	max. 1.5 $\mu\text{A}$ at 250 V, 50 Hz
High Voltage Resistance	10000 V between saline in dome and transducer leads
Weight	26 g (without cable)
Length of Cable	0.3 m



- Low cost alternative to isolated NL108TA
- Can be reused several times
- Available individually or in a package of 10

## NL108T2 Disposable Pressure Transducer

The **NL108T2** Pressure Transducer is a low cost alternative to the isolated unit NL108T1 which can be used with the NL108A Pressure Amplifier. Although the transducers are classed as 'disposable', it has been found that they can be used several times. The NL108T2 is connected by the NL108L2 lead, which is reusable. These transducers are for animal use only. Supplied individually or in a package of ten.

### Specifications

Pressure Range	-50 mmHg to +300 mmHg
Over-Pressure Tolerance	10000 mmHg
Bridge Resistance	
Input Resistance	1000 W nominal
Output Resistance	350 W nominal
Excitation Voltage	Up to 10 V DC or AC max. up to 5kHz
Zero Offset	±40 mmHg, max.
Maximum Inaccuracy	±2% of reading or 1 mmHg, whichever is greater
Thermal Coefficient of Sensitivity	±0.3 mmHg/°C
Thermal Coefficient of Zero	2 µA at 120 VAC, 60 Hz
Electrical Leakage	400 Ws, maximum across 50 W lead
Resonant Frequency	145 Hz with 30 cm pressure tubing, 43 Hz with 150 cm pressure tubing

Order #	Model	Product
W4 65-0229	NL108T2	Disposable Pressure Transducer, pkg. of 1
W4 65-0230	NL108T2/10	Disposable Pressure Transducer, pkg. of 10
W4 65-0231	NL108L2	Lead for NL108T2 to NL108A



(NL120 pictured)

## NL120S Audio Amplifier

The **NL120S** Audio Amplifier is a power amplifier for driving a 4 or 8 ohm loudspeaker. It has sufficient power amplification to raise a ±20 mV signal to moderate sound level. The module features an input selector for switching between two input signals, and the options of amplifying only positive or negative peaks, useful when baseline noise masks the sounds of nerve spikes of interest. The output is shaped to improve the low frequency response of small loudspeakers, and is power limited to minimize the nuisance caused by large transients such as shock artifacts.

### Specifications

Input Impedance	10 kΩ
Bandwidth	20 Hz to >15 kHz
Output Voltage Range	±1.5 V
Min. Load Resistance Across Output	3 Ω
Recommended Loud Speaker	W4 65-0323 (NL985)

Order #	Model	Product
W4 65-0236	NL120S	Audio Amplifier
W4 65-0323	NL985	Loudspeaker



# neurolog™ system

## NL125/6, NL134, NL135, NL136 and NL144



### NL125/6 Filter (High & Low Pass, 50/60Hz Notch)

The **NL125/6** filter module employs two active sections to control the high and low pass characteristics. The low frequency cutoff point can be set continuously from 0.5Hz to 5kHz with a single turn potentiometer, in four switched ranges. Similarly the high frequency cutoff can be set continuously from 5Hz to 50kHz in four switched ranges. DC and WB (wide band) switch positions bypass the lower and upper filter sections, respectively. An active notch filter is provided for the rejection of line frequency interference; this can be operator set at 50Hz or 60Hz, with a 20Hz notch width (-3dB points).

#### Specifications

Input Voltage Range	±10 V
Input Impedance	56 kΩ
Low Frequency Cutoff Range	DC, 0.5 Hz to 5 kHz continuously adjustable
High Frequency Cutoff Range	Wide band (> 50 kHz) and 5 Hz to 50 kHz, continuously adjustable
Gain Within Passband	x1
Attenuation Beyond Cutoff	40 dB/decade
Notch Attenuation	> 50 dB
Notch Width	20 Hz
Output Voltage Range	±10 V
Output Impedance	600 Ω

Order #	Model	Product
W4 65-0237	NL125/6	Filter (Low Cut, High Cut and 50 Hz Notch)

- NL134, NL135 and NL136 – Low Pass
- NL144 – High Pass

### 4-Channel Filters

The **NL134**, **NL135** and **NL136** are 4-channel, 2-pole (second order) low pass filters. Both the NL135 and NL136 have an AC power rejection notch filter module that is an ideal partner for the NL820A Isolated Amplifier System with its 2/4 channel AC or DC pre-amplifiers. The filter settings have been selected for most electrophysiological and clinical protocols but special frequencies can be factory set. Call Harvard Apparatus for details. The NL144\* is a high-pass version of this filter and does not have a notch filter.

\*Note: Has frequency settings of 0.1, 0.2, 0.3, 0.5, 1, 2, 3, 5, 10, 20, 30, 50, 100, 200 Hz and DC.

#### Specifications

Input Voltage Range	±15 V max, ±10 V operating
Input Impedance	120 kΩ
Filter Settings (-6 dB)	10, 20, 30, 50, 100, 200, 300, 500, 1k, 2k, 3k, 5k, 10k, 20k and WB
Cut-Off Accuracy	(±2% ±1.25 Hz < 630 Hz) or (±2% ±62.5 Hz > 630 Hz)
Gain Before Cut-Off	+1.0
Attn. Beyond Cut-Off	40 dB/decade, 12 dB/octave
Notch Attn/Width (-3 dB)	> 50 dB/20 Hz
Crosstalk // Noise	Better than -60 dB // < 100 μVrms

Order #	Model	Product
W4 65-0239	NL134	4-Channel Low-Pass Filter without Notch Filter
W4 65-0240	NL135	4-Channel Low-Pass Filter with 50 Hz Notch Filter
W4 65-0241	NL136	4-Channel Low-Pass Filter with 60 Hz Notch Filter
W4 65-0242	NL144	4-Channel High-Pass Filter* without Notch Filter



## NL143 Three Channel Difference Amplifier

The **NL143** Difference Amplifier allows the difference between two signals to be continuously monitored during the course of an experiment. The module has four inputs and three outputs, allowing three alternative “differences” to be recorded simultaneously from each module. Internal settings define the channels to be subtracted. The module also features a post-subtraction offset control which allows the output to be offset to a desired level e.g. for zeroing at the start of an experiment. While this module was originally designed to allow the differences between two biological parameters to be continuously monitored, it could also be used to remove unwanted offsets introduced into analogue signals originating from computer DAC interface cards.

Order #	Model	Product
W4 65-0643	NL143	Three Channel Difference Amplifier



## NL201 Spike Trigger

The **NL201** Spike Trigger is an amplitude discriminator for nerve spikes and other events, with an output that shows the levels superimposed on the signal. It produces separate output pulse trains for spikes which: (a) cross the Upper voltage threshold; (b) cross the Lower voltage threshold; (c) cross the Lower but not the Upper threshold. The window height potentiometer sets the DC level of the ‘window’ and the aperture potentiometer sets the separation between the two voltage thresholds of this window. Thus, slight changes in signal amplitude require adjustments of only one setting, and it is impossible to set the upper voltage threshold lower than the lower voltage threshold. The monitor output socket provides a display of the input signal with the lower and upper levels superimposed on it to enable easy setting of the discrimination levels. There is a choice of two internally selected input voltage ranges and a front panel switch selects either positive or negative slope and level triggering. This module is essential for converting spike trains (which are analogue signals) into trains of digital pulses; these can be analyzed using other modules (such as the NL700 Log Display) or used to synchronize displays, trigger averaging, etc. An internal jumper allows the input to be AC or DC coupled.

### Specifications

Input Voltage	±10 V max.
Input Impedance	1 MΩ
Input Time Constant	0.2 sec or DC
Lower Range (Height)	0 to 5 V
Aperture Range	0.2 to 5 V
Gain	x1 or x10 (internally)
Triggering	+ve or -ve slope
Threshold Calibration	±10%
Output - Upper	TTL, 230 μsec (±10%) pulse
Output - Lower	TTL, 200 μsec (±10%) pulse
Gate	TTL, 15 μsec (±10%) pulse
Monitor	Input plus upper and lower levels

Order #	Model	Product
W4 65-0243	NL201	Spike Trigger



- Monitors the difference between two signals continuously
- Monitor up to three pairs of signals

## NL301 Pulse Generator

The **NL301 Pulse Generator**, replaces the NL300, is a low cost module for producing trains of uniform TTL pulses. It can be operated continuously, switched off, or a single pulse can be triggered manually. A Gate input socket allows synchronous trains of pulses to be gated-on by an externally applied TTL high logic level. An internal jumper either excludes (as with the NL300) or produces an output pulse coincident with the start of the Gate signal.

Pulse frequency is continuously variable over more than three decades using a single 12:1 control and a three-position decade switch. Three fixed output pulse widths are available. The frequency range and pulse widths were chosen to make this module suitable as a timing source for electrical stimulation of the nervous system, without the necessity of additional modules for determining pulse widths.

The NL301 is also useful for a variety of other timing purposes where a widely variable rate is desirable, and precision is important but not critical. It has an on-board jumper that allows the user to select a frequency range 1/10 of that shown on the front panel. This allows a frequency range of < 0.1 to > 120 Hz.

### Specifications

Frequency	< 1 to > 1200 Hz
Control Marked	1 to 12 (0.5 to 12 possible)
Accuracy	±1% at '1' and '12' marks, ±5% at other scale marks
Multiplier	x1, x10, x100
Output Pulse Widths	50, 150 or 500 μsec (±10%)
Output Fan-Out	10 TTL inputs

Order #	Model	Product
W4 65-0247	NL301	Pulse Generator

## NL304 Period Generator

The **NL304 Period Generator** (replaces the NL303) contains a crystal oscillator and frequency dividers for producing a precise, stable frequency standard. It can be externally gated (Gate In) and synchronized with an external source (Reset input). The pulse train can be switched off and a single output pulse can be triggered manually. Eight decades of pulse rate are available. The NL304 is the basic 'clock' of the NeuroLog™ System: it provides the 'fine grain' (1 μsec increments) necessary for digital control of pulse width, cycle duration, delay, etc., using the NL603 Counters.

### Specifications

Output	TTL pulses
Period Accuracy	0.01%
Period Range	1 μsec to 10 min by 1 μsec, 10 μsec, 100 μsec, 1 msec, 10 msec, 100 msec, 1 sec, 10 sec, 30 sec and 60 sec Period switch and x1, x2, x5, and x10 MULT switch
Output Pulse Width	0.5 μsec

Order #	Model	Product
W4 65-0248	NL304	Period Generator



## NL410 Calibration Module

The **NL410** Calibration Module can be used for the precise calibration of the gain of an amplifier system or for adding a pulse of accurate amplitude and duration to a recording trace. The output of the Calibrator is isolated allowing for the user to choose the best method of preparation grounding to optimize recordings. Switches allow selection of 1 of 3 calibrated output levels with 1 of 2 calibrated triggered pulse widths of either polarity. The calibration level at the preset amplitude and polarity may also be enabled or pulsed manually from a front panel switch.

### Specifications

Trigger Level	+2 V on positive edge with 200 mV hysteresis
Trigger Input Limit	±15 V max.
Trigger Input Impedance	> 1 MΩ
Output Level	0.1 mV, 1 mV, 10 mV switch selectable
Output Level Accur.	±2%
Output Pulse Duration	1 or 10 msec (triggered) or under manual control
Pulse Duration Accur.	±2% (triggered)
Polarity	Positive or negative switch selectable
Output Impedance	2 Ω, 20 Ω, 200 Ω for output levels of 0.1 V, 1 V, 10 mV respectively
Output Isolation	> 50 V

Order #	Model	Product
W4 65-0252	NL410	Calibration Module

## NL510 Logic Gate

The **NL501** Logic Gate module contains two logic gates each with two inputs and complementary outputs. Both of these gates can be independently configured by PCB mounted switches as either 2-input AND gates or 2-input OR gates. The open circuited inputs are automatically held low for the OR function or high for the AND function and a further switch allows expansion of the second gate to take the output of the first as a third input. This enables a 4-input AND gate or a 4-input OR gate to be realized. A further possibility is a 3-input AND or OR gate where one of those inputs is a 2-input OR or AND function from the other gate. Provision is made for input 1 of gate 1 to be connected to the output of the module to the left and all 4 outputs are available for selection as the output to the module to the right. This is done by jumper plugs at the rear of the PCB.

### Specifications

Input	TTL
Outputs	TTL
Output Fan-Out	10 TTL inputs

Order #	Model	Product
W4 65-0253	NL501	Logic Gate



## NL405 Width Delay



The **NL405** Width Delay is a digitally controlled pulse duration generator and is used to produce precise pulses of adjustable duration with high accuracy and repeatability. The NL405 produces TTL logic output pulses (of both polarities) that have a duration set using three decades of thumbwheels and a seven (7) position range switch. It also features a press to start button, LED indication of an output and a separate logic output signal at the end of the defined WIDTH time. It was designed as a replacement for the NL401 and in most places where the NL403 would have been used.

The NL405 can be triggered off either positive or negative-going edges of the input pulses and the NL405 is capable of 100% duty cycles. An external push to make switch can be used when -ve edge triggering is selected. In the "FIXED WIDTH" mode, the NL405 produces an Output pulse as specified by the front panel controls; In the "RE-TRIGGER" mode, any valid Input trigger arriving whilst the Output is active will restart the timing and therefore extending the Output pulse duration. As long time periods can be generated (999 seconds is over 16 minutes) any change in position of the rotary range switch will stop the current Output and inhibit further input triggers for 450 ms.

The "DELAYED" Output socket provides a short duration pulse (set internally) that is produced at the end of the timed WIDTH pulse. This provides a trigger-out after the set Delay time.

The NL405 can be used for digital control of pulse duration or for introduction of a delay to a trigger pulse. The logarithmic or exponential nature of the many biological responses make the very wide continuous adjustment (from  $\mu$ s to minutes) particularly beneficial.

Rear connections to the motherboard allow Input and Output interconnections between this and other logic modules without the need of front panel cables.

### Specifications

Input:	TTL pulse, 1 TTL load
Trigger Edge	Positive or Negative, selected from front panel
Manual	Push-button, operation on push
Output (Width):	TTL, Output will drive 10 loads
Polarity	Both active-high and active-low sockets
Range	1 $\mu$ s - 999 s
Control	001 - 999
Multiplier	1 $\mu$ s, 10 $\mu$ s, 100 $\mu$ s, 1 ms, 10 ms, 100 ms, 1 s
Accuracy	$\pm 0.5\%$
Delay from Trigger In	<200 ns
Indicator	Amber LED on for approximately 100 ms for each pulse
Output (Delay):	TTL, Output will drive 10 loads
Polarity	Active-high
Duration	0.5 $\mu$ s, 1.5 $\mu$ s, 5 $\mu$ s $\pm 20\%$ 50 $\mu$ s, 150 $\mu$ s, 500 $\mu$ s $\pm 10\%$ , by on-board jumpers
Output:	
Mode	Fixed Width or Re-Triggered, selected from front panel
Reset/Inhibit	450 ms $\pm 20\%$ , after change of rotary range control

Order #	Model	Product
W4 65-0630	NL405	Width Delay

## NL412 Pulse Generator



The **NL412 PULSE** is a small, handheld, general purpose pulse generator which can be used to “start” experiments, command the “gate” of a train of pulses or be used with an NL102G to “Buzz” electrodes. The NL412 is self-powered by a standard internal 9 V battery and is fitted with a 2 m lead terminating in the standard Lemo connector.

### Start

On pressing the button the NL412 generates an active high pulse which will trigger remote modules.

### Gating

The front panel control on the NL412 provides control for output pulse durations over the range of 1 to 10 ms. Setting this control allows different durations of trains of pulses when the NL412 is combined with a Pulse Generator such as the NL301.

### Use with NL102G

When used with a NL102G (that incorporates external “Buzz” control circuitry) the duration of the “Buzz” is set by the front panel control.

### Technical Note - NL102G use

During intracellular micro-electrode recording, cell penetration is often facilitated by use of a Buzz button, a feature included on the front panel of the NL102G DC pre-amplifier. Pressing the Buzz button fully activates the capacitance compensation circuitry, causing the amplifier voltage to oscillate. This oscillation often aids passage of the electrode into the intracellular milieu. In certain situations, it may be necessary to operate the Buzz button in combination with microelectrode manipulation, making the front panel location of the Buzz button less convenient for the user. To make the Buzz feature more accessible, a remote NL412 Pulse box has been developed by Digitimer Ltd. This small handheld unit provides control over Buzz duration (1-10ms) and has a single push button for Buzz pulse delivery.

The NL412 is connected via its own 2m long Lemo cable to a modified version of the NL102G, incorporating an external Buzz control input socket. Existing users of NL102G modules can have the modification made at Digitimer Ltd.

### Specifications

Button LED (not release)	Only produces an output pulse on “Press” (not release) Amber - illuminates for approximately 250 ms after each press
Pulse Duration:	
Range	1 to 10 ms
Accuracy	Better than 20% at all scale markings
Output:	
Level	9 V, with new battery.
Rise and Fall Times	< 100 $\mu$ s
Battery	Standard 9 V, 6LR61 style. (Non-alkaline supplied) - we recommend the Duracell Ultra MN1604 alkaline battery
Power Consumption	< 5 $\mu$ A (static)
Cable	2 m (nom) with standard Lemo connector fitted
Dimensions, H x W x D	105 x 61 x x 28 mm plus 15 mm on “d” for knob
Weight	< 170 g including battery

Order #	Model	Product
<b>W4 72-4220</b>	NL412	Pulse Generator



## NL505 Flip-Flop

The **NL505** Flip-Flop can be operated either as a “set-reset” flip-flop or as a “toggled” complementing flip-flop. This makes it useful in setting up conditional and “single-shot” stimuli, and testing logic outputs for the presence of pulses, logic levels etc.

It has three inputs, Set, Complement and Clear, and two outputs (Q and Q') all of which drive or are driven from TTL logic (ie +5V and 0V).

A LED indicator is illuminated when the Q output is at a high level.

The table below shows the relationship between inputs and outputs.

Complement	Set	Clear	Q	Q'	Function
0	0	0	Q0	Q'0	Static Condition
X	0	1	0	1	Clear Output
X	1	0	1	0	Set Output
X	1	1	1	1	*see below
^	0	0	Q0	Q'0	Complement

Where a 1 is a logic high (+5V)

0 is a logic low (0V) or unconnected inputs

X is irrelevant

Q0 is the previous output

^ is a positive going pulse

\* This is a non-stable situation, it will only remain whilst Set and Clear are both held high.

N.B. The Set and Clear inputs override the Complement input, that is why the output is only affected by the complement input when both of these are low.

Order #	Model	Product
W4 65-0254	NL505	Flip Flop

## NL506 Analog Switch

The **NL506** Analog Switch contains a single pole change-over switch, the state of which is controlled by a logic signal. This signal can be generated externally or by the internal Flip-Flop that can be toggled by a logic input. A front panel switch allows direct selection of the switch state which is indicated by an LED. The switch is bi-directional allowing it to be used as a 1-input 2-output or a 2-input 1-output device. Also, as the switch is analog; it can handle signals up to ±15 volts as well as being of low enough impedance to handle TTL signals.

*Note: The analog switch is robust but has a current limit, especially when the NeuroLog™ power supply is off. Only signals originating from within the same NL900 should be coupled to the NL506.*

### Specifications

Analog Switch:	
Range	±15 V
Impedance Per Socket	1 MΩ
ON Resistance	< 35 Ω
OFF Leakage	< 50 nA
Switching Time	< 200 nsec
Break-Before-Make Delay	< 10 nsec
Indicator	Amber LED indicates switch position
Switches	SET/-RESET toggle forces selection of analog switch; also presets internal Flip-Flop; in mid position, IN/FF switch selects control signal for analog switch
Flip-Flop	Is preset by SET/-RESET toggle switch and toggled by negative (-ve) going edge of logic input signal
Input Allowed Signal	±15 V max.
Input Logic Threshold	+1.4 V approx. (suits TTL)
Input Impedance	10 kΩ approx.

Order #	Model	Product
W4 65-0255	NL506	Analog Switch



## NL510A Pulse Buffer

The **NL510A** Pulse Buffer converts TTL logic pulses into 0 to 10V pulses, which can be used to drive the NL800A STIMULUS ISOLATOR. The output pulses in the ISOLATOR DRIVE mode are offset to match the input characteristics of the NL800A. Output amplitude is adjusted with a precision 10-turn potentiometer and turns counting dial. The mode switch has an OFF position, a useful feature when more than one stimulator is used. The NL510A can be used as a voltage stimulator, relay driver, solenoid drive, oscilloscope beam brightener, etc.

### Specifications

Output Voltage Range	0 to 10.0 V
Output Resistance	< 10 Ω
Output Current	50 mA
Output Rise & Fall Times	< 1 μsec

Order #	Model	Product
W4 65-0256	NL510A	Pulse Buffer

## NL530 4-Channel Conditioner

The **NL530** Conditioner module is designed to give Gain and Offset setup controls when interfacing signals to the Analog-to-Digital Converters (ADCs) of PCs.

The module contains four channels. Each has independently adjustable filter settings and front panel Gain and Offset presets. There is also a master ADC offset control to allow unipolar ADCs to be used with bipolar signals. ADC boards have precise input ranges (outside of which damage may occur) and this module features on-board preset controls to set all channels to 'CLIP' or limit at independently set positive and negative (or zero) levels.

### Specifications

#### Each Independent Channel

##### Input:

Absolute Max.	±100 V
Impedance	20 kΩ
Gain	x0.1, x0.2, x0.5, x1, x2, x5, x10
Variable Gain	x1 (CAL) to x2.5 (nominal)
Offset Control	±1 V or ±5 V
Filters	100 Hz, 1 kHz, 10 kHz, none
Bandwidth	DC to 100 kHz
Crosstalk	< -56 dB between channels

##### Output:

Range	±11 V min.
Impedance	< 5 Ω (for up to 10 mA load)

#### Common To All Channels

##### Clip Limits:

Positive	+4 V to +11 V min
Negative	-11 V to 0 V
ADC Offset	Zero (0 volts) or +2.5 V

Output	[Input x Gain] + [(ADC + variable) offsets]
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Order #	Model	Product
W4 65-0259	NL530	4-Channel Conditioner



# NL512

## Biphasic Pulse Buffer

# neurolog™ system



The **NL512** Biphasic-Pulse Buffer is the interface between any bipolar signal and two of the NeuroLog™ NL800A ISOLATORS so that bipolar, isolated, constant current signals can be used for stimulation. This is “current out for voltage in”.

The NL512 features a high input impedance and four input ranges to allow a number of different modules, or an external signal (such as from the ADC in a PC), to be used for the input signal. A GATE input allows multiple units to be connected to a single analogue source with each channel being digitally enabled separately. The switch, in the OFF position, disables the module.

The NL800A ISOLATOR features no battery usage except for when a stimulus is being presented which is achieved by using an input opto-coupler. This does suffer from having a low impedance and a DC offset which is different for each unit but the NL512 removes these problems.

The NL512 provides easily adjustable internal finger controls for the DC offset of each of the NL800A's.

An on-board jumper allows the unit to be driven by one of four different ranges for Full Scale current output from the NL800's. These are  $\pm 10V$ ,  $\pm 5V$ ,  $\pm 2.5V$  and  $\pm 1V$ . The 1 mm jumper system on the board allows the unit to be driven from the unit on its immediate left, if required, via the Motherboard in the NL900 Rack and Power Supply.

### Specifications

#### IN

Input Voltage Range:	$\pm 15V$ max
For Full Scale Output	$\pm 10V$ ; $\pm 5V$ ; $\pm 2.5V$ or $\pm 1V$ by on-board jumper selection
Input Impedance	1 MW
Frequency Response	> 1 MHz; this will usually be limited to less than this by the NL800

#### Gate:

Logic Levels	TTL compatible
Function	ON (unit working) - TTL high (> 2.8 V or no connection) OFF (unit disabled) - TTL low (< 0.8 V)

Input Voltage Range:	$\pm 15V$ max
Input Impedance	$\sim 85k\Omega$
Response Time	< 5 $\mu s$

ON/OFF Switch	This overrides the GATE input to disable the module when set to OFF
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#### OUT

Output DC Offset for NL800	< 0.7 to > 2.3 V - Separately set for each phase
Output Voltage Range	0 to +10 V
Output Current for NL800	Up to 20 mA
Output Impedance	< 10 W
Rear connections	To the NL900 motherboard allow an input interconnection for IN or GATE and the module to the immediate left without the need of a front panel cable

Order #	Model	Product
W4 72-4221	NL512	Biphasic Pulse Buffer



## NL601 Pulse Integrator

The **NL601** Pulse Integrator has a digital counter which produces an analog output proportional to the count. A pulse at the input socket increments the counter towards a full scale count of 255, 2550 or 25500 which is pre-selectable by the front panel scale switch. The counter will continue to increment on input pulses until the unit is reset. This can be done manually (with the on, off/reset switch) or by applying a pulse to the reset socket. Alternatively, with the unit set to internal-reset, when the counter reaches full scale the unit will automatically reset. There is one other reset function, the external reset/latch function. On a reset pulse the output will be held at the previous count level until the next reset pulse. In effect the counter is reset but the output is held at its value at the time of the pulse. The NL601 has two outputs, the first is a simple pulse out when the counter reaches full scale count the output goes high until the counters are reset. The second is the analog output. Adjustable between 1 volt and 11 volts for full scale count (using the front panel output adjuster pot) the output will increase by 1/255 (for a full scale count of 255) for every pulse in and will stay at maximum voltage for every pulse after 255 until the unit is reset.

### Specifications

Inputs	TTL pulses
Pulse Out	TTL
Analog Out	Adjustable between 1 V and 11 V for full scale via front panel pot
Output Steps	255
Pre-Scaler	None, 10, or 100

Order #	Model	Product
W4 65-0260	NL601	Pulse Integrator

## NL603 Counter

The **NL603** Counter is a 2-digit preset decade counter with a 2-digit light emitting diode decimal readout. The counters can be externally reset and gated; they can be operated in one of three modes: Preset-Reset in which the counters are reset to zero when the count equals the preset switch settings; Preset-Stop in which the count is stopped when the preset number is reached; and FREE RUN, in which the preset number does not affect the count. A pulse occurs at the output when the count equals the preset number (Free Run and Preset-Reset modes); a high logic level appears at the output during counting in the Preset-Stop mode. Up to 3 NL603 Counters can be cascaded to give arbitrarily large counts. Carry, reset and preset logic signals are automatically relayed to adjacent Counters through rack edge connectors when the Counters are cascaded. NL603 modules can be used for digital control of pulse width, cycle duration, pulse delay (phase), number of pulses in trains, etc. Precision obtainable when used with the NL304 Period Generator is better than 0.01% in minimum steps of 1 µsec. The LED display of the NL603 enables it to be used to count responses, number of stimuli delivered, etc., in addition to controlling pulse trains.

### Specifications

Inputs	TTL pulses
Output Fan-Out	10 TTL inputs
Output Pulse Width	(Free Run and Preset-Reset modes) 0.5 µsec (nominal)
Max. Counting Rate	5 MHz

Order #	Model	Product
W4 65-0261	NL603	Counter

# NL703 and NL800A **neurolog™** system



## NL703 EMG Integrator

The **NL703** EMG Integrator module was designed to produce an analogue signal to represent muscle activity. The unit will accept signals up to  $\pm 1$  V which it full-wave rectifies and applies to a 'leaky integrator'. The output of the integrator is buffered and the overall gain is set at unity. The time constant of the integrator is set by a 6-position rotary switch. A toggle switch is also provided so that the direct signal can be viewed.

### Specifications

Input	Max. signal that can be processed without distortion is $\pm 1$ V
Input Overload	Input is protected up to $\pm 75$ V
Time Constants	Setable to 20, 50, 100, 200, 500 and 1000 msec; accuracy better than 10%
Integrate/Direct	Either Integrated signal or input signal is selectable by this switch; if Direct is selected, Integrator is reset to zero
Output	Output produces signal which has gain of unity from input but integrated with respect to time at time constant selected
Output Impedance	600 $\Omega$ in integrate; connected to INPUT socket in Direct

Order #	Model	Product
W4 65-0266	NL703	EMG Integrator



## NL800A Stimulus Isolator-Constant Current

The **NL800A** Stimulus Isolator is a battery powered, light-coupled isolated stimulator. It has a constant current output, with very high output impedance, making it suitable for stimulation through microelectrodes as well as with gross electrodes. Can be driven by the NL510A Pulse Buffer or NL512 Biphasic Buffer. When used with the NL510A, output current is set by the 10-turn AMPLITUDE control on the NL510A itself. Alternatively, the NL512 allows biphasic analogue waveforms (e.g. from a PC) to be converted into a biphasic stimulus when used in conjunction with two NL800A units. In both cases, output pulses have the same timing as input pulses. Features of the NL800A are its very small physical size (for mounting close to the preparation), low battery consumption, excellent isolation ( $< 1$  pF output to input or ground coupling), and fast rise time.

### Specifications

Input Requirements	10 V at 30 mA (nominal) for full scale output
Output Current Range	0 to 10 mA in 4 overlapping decade ranges
Output Risetime	$< 5$ $\mu$ sec (1 k $\Omega$ load); $< 20$ $\mu$ sec (typical tungsten micro-electrode load); $< 40$ $\mu$ sec for 1 M $\Omega$ resistor across output
Output Resistance	$> 900$ M $\Omega$
Input-Output Capacitive Coupling	$< 1$ pF
Accuracy and Linearity	$\pm 3\%$ of full scale output for each output range
Dimensions	38 x 54 x 98 mm (1.50 x 2.13 x 3.5 in) excluding knob

Order #	Model	Product
W4 65-0276	NL800A	Stimulus Isolator, Constant Current
W4 65-0363	NL800BATT	Set of Five Batteries for NL800A



## NL844 4-Channel Pre-Amplifier

The **NL844** pre-amplifier is specifically designed to operate in conjunction with the NL820A Isolator. Its low noise and high impedance differential inputs make it particularly suitable for use as a headstage pre-amplifier close to the preparation, ideal for isolated EMG, EEG or ECG applications. It features 4 pairs of colour coded 1.5mm DIN “touch proof” sockets for electrode connection as well as a COM input. The unit can be operated in 1, 2, 3 or 4 channel modes with unused channels switched off using the rear panel toggle switches. This unit is particularly suited for use where there are very large stimulus artefacts, for example when used close to a magnetic stimulator coil. The input circuit automatically adjusts to the DC input conditions plus a non-linear filter modifies its time constant if the differential input signal exceeds its normal  $\pm 0\text{mV}$  working range. Therefore, fast, short artefacts do not block the subsequent stages. This results in an amplifier with a very fast recovery time from stimulus artefact pulses.

## Specifications

Gain	x100, x1,000, x10,000 (operated in channel pairs)
Low Frequency Cut	3, 10, 30 Hz (operated in channel pairs)
High Frequency Cut	With NL820A > 35 kHz -3dB
Input Impedance	100 M $\Omega$
Input Channels	4
Common Mode	10,000:1 (-80 dB) (with NL820A -120 dB)
Noise	5 $\mu\text{V}$ RMS full bandwidth
Lead Length	2.5 m

Order #	Model	Product
<b>W4 65-0362</b>	NL844	4-Channel Pre-Amplifier



Order #	Model	Product
<b>Cables</b>		
W4 65-0386	NL951-15cm	Cable With Male Connectors (Lemo Type F00250) on Both Ends, 15 cm L
W4 65-0387	NL951-30cm	Cable With Male Connectors (Lemo Type F00250) on Both Ends, 30 cm L
W4 65-0388	NL951-45cm	Cable With Male Connectors (Lemo Type F00250) on Both Ends, 45 cm L
W4 65-0284	NL951-1m	Cable With Male Connectors (Lemo Type F00250) on Both Ends, 1 m L
W4 65-0385	NL951-2m	Cable With Male Connectors (Lemo Type F00250) on Both Ends, 2 m L
W4 65-0285	NL952	Cable With Male Connector at One End and Tinned Leads at Other End, 2 m L
W4 65-0286	NL953	4-Way Cable With One Plug (Mates with NL103/NL107), 2 m L
W4 65-0287	NL953K	4-Way Cable With One Plug (Mates with NL104A/NL108A), 2 m L
W4 65-0288	NL975	Two-Way With 2 x 4 mm Plugs (for NL120), 1 m L
<b>Extension Cables</b>		
W4 65-0289	NL950	One-Way With Plug (Standard NeuroLog™ Style), 10 cm L
W4 65-0290	NL954	4-Way Extension Cable for NL100A/NL103/NL107, 2 m L
W4 65-0291	NL954K	4-Way Extension Cable for NL100AK/ NL104A/NL108A/NL850A, 2 m L
W4 65-0292	NL955	6-Way Extension Cable for NL102 (With Split Socket), 2 m L
W4 65-0293	NL955K	6-Way Extension Cable for NL102 (Standard Keyway), 2 m L
W4 65-0294	NL956K	6-Way Extension Cable for NL102G, 2 m L
<b>Plugs</b>		
W4 65-0295	NL962	Lemo 1-Pole (Standard NeuroLog™ Plug)
W4 65-0296	NL963	Lemo 4-Pole for NL103/NL107
W4 65-0297	NL963K	Lemo 4-Pole for NL104A/NL108A
W4 65-0298	NL967K	Lemo 6-Pole for NL102G
W4 65-0299	NL968K	Lemo 2-Pole for NL410
W4 65-0300	NL969P	Lemo 9-Pole Insulated for NL820A

Order #	Model	Product
<b>Panel-Mounted Sockets</b>		
W4 65-0301	NL944	Lemo 4-Pole, as on NL103 and NL107
W4 65-0302	NL944K	Lemo 4-Pole, as on NL104A, NL108A
W4 65-0303	NL964	Lemo RA00250 (Standard NeuroLog™ Socket)
W4 65-0304	NL969S	Lemo 9-Pole Insulated, as on NL820A
<b>Cable Mounted Sockets</b>		
W4 65-0305	NL965	4-Pole (Matches NL100A)
W4 65-0306	NL965K	4-Pole (Matches NL100AK/NL850A)
W4 65-0307	NL966K	6-Pole (Matches NL102GH)
<b>Adapters</b>		
W4 65-0308	NL957	4-Way for NL100AK to NL103, 2 m L
W4 65-0309	NL957K	4-Way Adapter for NL100A to NL104A, 2 m L
W4 65-0310	NL960	BNC Plug to Lemo Socket
W4 65-0311	NL961	Lemo One-Pole 'T' Connector
W4 65-0312	NL969T	'T' Connector for Two NL822/832
<b>Accessory Kit</b>		
W4 65-0313	NL973A	NL100AK Headstage Accessory Kit
W4 65-0314	NL976	NL102G Headstage Accessory Kit
<b>Blank NeuroLog™ Front Panels for Current Royal Blue NL900D's</b>		
W4 65-0632	NL910D-1	Single Width Panel
W4 65-0633	NL910D-2	Double Width Panel
W4 65-0634	NL910D-4	Quad Width Panel
W4 65-0635	NL910D-6	Hex Width Panel
W4 65-0636	NL910D-8	Octal Width Panel
W4 65-0637	NL911D-1	Single Width Panel with Handle and Panel Screws, No PCB Mounts
<i>Blank Panels for older NL900™ Models are available. Please contact Customer Service for availability.</i>		
<b>Other Items</b>		
W4 65-0320	NL970/10	Stacking Plugs, 1 mm D, pkg. of 10
W4 65-0321	NL972/10	Gold Plugs, 2 mm D, pkg. of 10
W4 65-0322	NL980	Edge Connector Extender Cable; Allows Access to Both Sides of Working Module for Trimmer Adjustments, Calibration and Servicing
W4 65-0323	NL985	Loudspeaker for NL120S
W4 65-0325	NL1MAN	NeuroLog™ Operators Manual (Supplied with NL900 but also Sold Separately)

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