

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 Ω . 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 ± 100 nA in the Low range and up to ± 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)

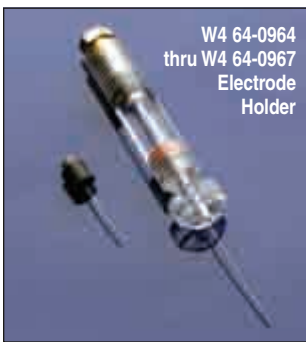
Electrode Holder

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 ± 200 V may be applied to the Breakaway input without damage to the probe input. Breakaway Current = applied voltage \div (electrode resistance + 2 M Ω).



Specifications

Electrometer Section:

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

Specifications (continued)

Input Offset	± 200 mV, referred to input
Electrode Resist. Test	1 mV/M Ω (Low Range) 10 mV/M Ω (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 Ω and 0 to 1000 M Ω (Low Range)
Ranges	0 to 10 M Ω and 0 to 100 M Ω (High Range)
Internal DC	0 to ± 100 nA (Low Range)
Current Source	0 to ± 1000 nA (High Range)
External Stimulus	Current is limited by electrode resistance up to maximums shown: ± 10 V \div electrode R or 0.5 μ A (Low Range) ± 10 V \div electrode R or 5 μ A (High Range)
Max. Stimulus Input	± 15 V
Stimulus Input Resist.	10 K Ω
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 Ω
Meter	3 $\frac{1}{2}$ digit LED, Full Scale Ranges: Amplifier Output: 200 mV, 2 V and 20 V Current: 200 nA and 2 μ 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.
W4 64-0042	2100	Replacement Headstage

Optional Accessories

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