2400A

Extracellular Preamplifier

Operating Manual

JKang
环境解决方案专家

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Warning: This instrument is not designed or intended for use in human applications or human experimentation

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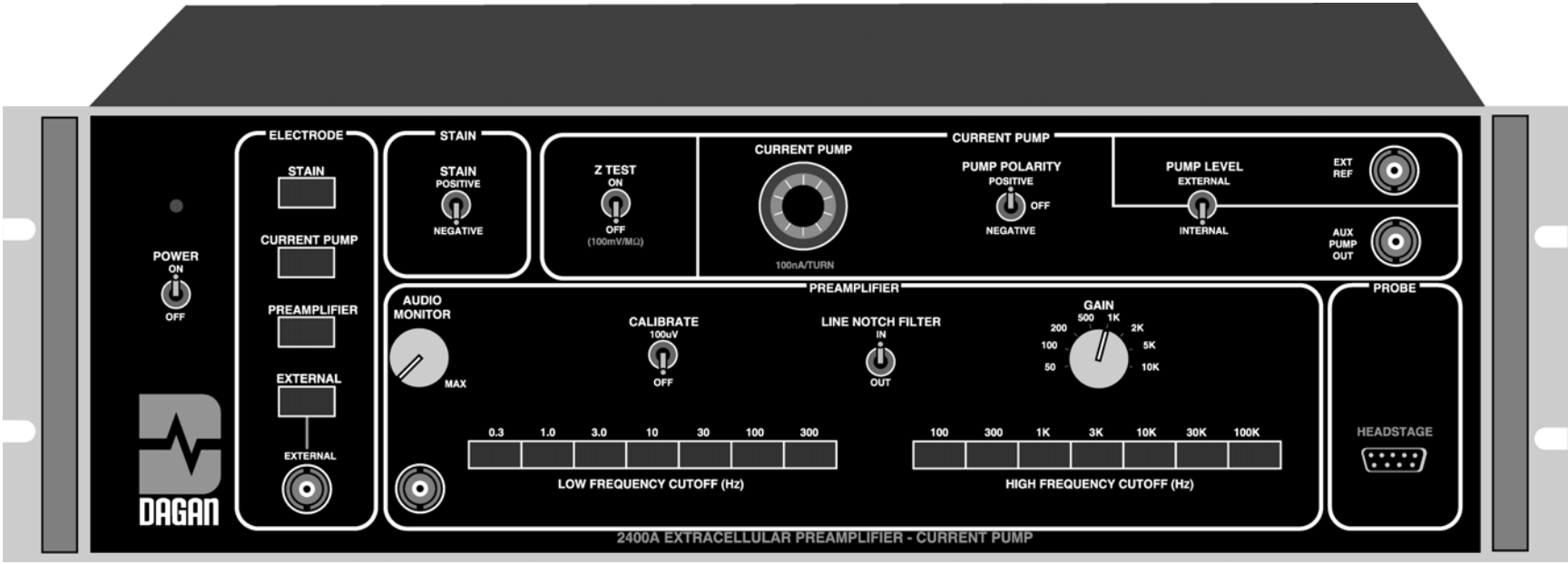
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2400A EXTRACELLULAR PREAMPLIFIER - CURRENT PUMP

I GENERAL INFORMATION

A. INTRODUCTION

The DAGAN Model 2400 EXTRACELLULAR PREAMPLIFIER CURRENT PUMP is a low noise preamplifier system for extracellular recording with both glass and metal microelectrodes or micropipettes.

The high input impedance assures faithful reproduction from electrodes ranging into the hundreds of megohms. In addition to producing low noise voltage preamplification, the 2400 is unique in that it also provides an audio amplifier for audible monitoring of the preamplifier output and two types of current injection to the microelectrode. One type is used for high current cell staining and the second is a precise ideal constant current source capable of both front panel and external analog programming control of magnitude and polarity. It is potentially useful for cell staining, iontophoretic drug injection and as a stimulating current (polarize or depolarize). In addition the Model 2400Z uses the CURRENT PUMP for microelectrode resistance measurements.

The 2400 also provides optimum bandwidth tailoring for maximum signal to noise ratio by incorporating both active high pass and low pass push button switch selection filters. And to reject AC line noise, an independently, operated LINE NOTCH FILTER provides a 200 to 1 reduction in 60 Hertz interference. When powering the 2400 from standard AC power lines, no batteries are ever needed to achieve the low noise performance.

The 2400 is packaged within an attractive, heavy-duty cabinet for either rack or bench mounting. When used by itself or as a component of a larger system, this instrument will truly become an indispensable laboratory tool.

B. INSTRUMENT & ACCESSORIES

The Model 2400A is shipped with the following standard accessories:

Rack adapter (handles/bracket assemblies).
Probe mounting rod for micromanipulator

C. SPECIFICATIONS

PREAMPLIFIER

NEUTRALIZATION: 15 turn control located on probe. Range is 0 to 100 pF.

INPUT IMPEDANCE: Greater than 10,000 Megohms
INPUT CONNECTOR: Miniature co-axial slip-on
OUTPUT: 10 ohms impedance. 20 volt peak to peak,
BNC connector
GAIN: 50; 100; 200; 500; 1,000; 2,000; 5,000; or 10,000 ± 1%
OVERLOAD RECOVERY: Recovery is very fast, usually
one-half to a few milliseconds except for just after
STAIN. Recovery is then 20 to 40 seconds.
NOISE: Due to Amplifier and Source Resistance; (takes
into account current and voltage noise)
CALIBRATE GENERATOR: 100 uV ± 1%, Peak to Peak Square Wave. 150 Hz

LINE NOTCH FILTER: Standard 60 Hz. (optional 50 Hz.) The rejection ratio is 200 to or, 46 dB.
HIGH FREQUENCY FILTER: Active 20 dB/decade, push button switch selection 3 dB points are; 100, 300, 1K. 3K, 10K, 30K and 100K Hz.
LOW FREQUENCY FILTER: Active 20 dB/decade, push button switch selection 3 dB points are 0.3, 1.0, 3.0, 10, 30, 100, and 300 Hz.

AUDIO MONITOR: An internal audio power amplifier monitors the PREAMPLIFIER output. Sound level is controlled by the MONITOR control. Output is through a phone jack located on rear panel. An 8 ohm speaker, or external computer type powered amplifier is recommended.

CURRENT PUMP

PUMP LEVEL:

(1) EXTERNAL: An analog voltage between minus 10 to plus 10 volts into the EXT REF BNC jack generates a current between minus 1000 nA to plus 1000 nA.
(2) INTERNAL: The INTERNAL position enables the 10 digital dial current setting. The dial is read out in nA, and has a range of 0 to 1000 nA. Polarity is determined by the PUMP POLARITY switch.

Z TEST: A signal 2 Hz 100mV per megohm

STAIN

A POSITIVE (for Metal electrodes) or NEGATIVE (for Glass electrodes) voltage of 15 volts limited by 10,000 ohms is fed into the electrode.

ELECTRODE (PROBE MODE)

A four station push button switch selects the mode of operation by connecting the probe input connector to the four functions via a reed relay located in the probe. The four functions are:

(1) STAIN: The high level STAIN current is fed to the microelectrode.

(2) CURRENT PUMP: The CURRENT PUMP section of the instrument is connected through the probe to the electrode. The CURRENT PUMP is always available through the AUX PUMP OUT BNC jack.

(3) PREAMPLIFIER: The probe and audio monitor amplifiers are connected to the electrode.

(4) EXTERNAL: The electrode is connected to the EXTERNAL BNC sack. This position gives direct access to the electrode for passage of any voltage or current.

GENERAL

POWER: 115v AC, 60 Hz, 6 Watts (optional 230v AC, 50 Hz, 4 Watts)

DIMENSIONS:

MAINFRAME: 43.2 cm W (17") X 34.3 cm D (13k") X 13.3cm H (5 1/4”) (for Rack mounting, handle and brackets make width 48.3 cm (19").

PROBE: 5.7 cm (2Y4") X 3.2 cm (PA") X 2.5 cm (1") less mounting plate. Detachable rod is 0.63 cm dia. (1/4 ") X 7.6 cm long (3"). Probe to Mainframe cable is 7 conductor, low noise shielded, 3 meters long (10').

WEIGHT: 10Kg. (20 pounds)

D OPTIONS/ Input Connectors

2400 OPTIONAL HEADSTAGES

2410A Standard Capacitive Neutralized Single ended probe and cable with connector.
2430A Optional Differential probe for the 2400A System

Input Adapters and Connectors

8012 Additional co-axial input connector

HB120 and HB180 Glass Microelectrode Holders for BNC option input

1mm pins for Tip Jack Option (Order# P657-5 (set of 5))

II DIRECTIONS FOR USE

A. INSTALLATION

1. LINE VOLTAGES AND FREQUENCY

The serial number label on the instrument rear panel also contains the line voltage and frequency. A voltage marked 115v AC indicates the power supply is wired for voltages from 100 to 125v AC.
A 230v AC marking indicates a 200 to 250v AC range. The power supply will operate from 50 or 60 Hz without modification. The frequency indicated on the label identifies the frequency of the line notch filter.

2. RACK MOUNTING

The 2400 is shipped with its rack adapters (handles and brackets) in place. It is designed for use with a standard 19" rack.

3. BENCH USE

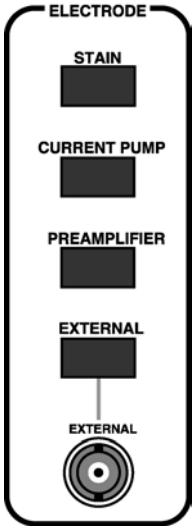
If desired, the rack adapters may be removed to allow for more space on the bench.

4. CLEANING

Use a soft cloth and mild soap to maintain the dead front appearance of the front panel.

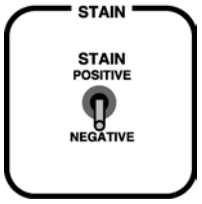
B. OPERATION

ELECTRODE



The ELECTRODE control switches provide a unique combination of microelectrode terminations~ A push of the button changes the 2400 system from (1) a high current stain generator for marking recording sites to a, (2) controlled positive or negative ideal current source up to 1000nA to (3) a low noise neutralized preamplifier to your microelectrode for any future need that you may encounter. All this without ever touching the probe or the microelectrode.

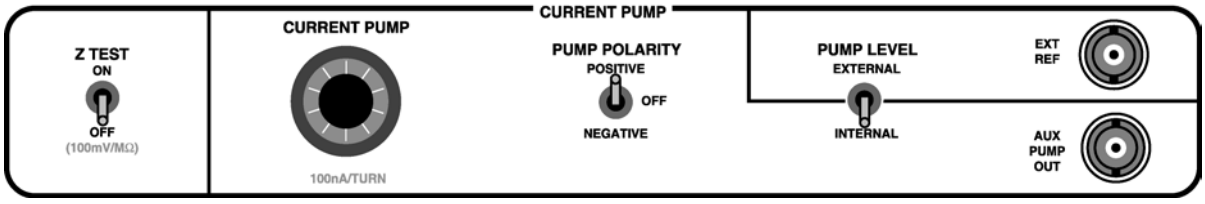
STAIN



Your microelectrode recording site can be marked for easy visual identification by using either the STAIN switch or the controlled but smaller currents from the CURRENT PUMP. The STAIN generator provides a high level resistive limited current with polarity selections for use with both metal and glass electrodes.

The 2400 also provides for any future stain requirements you may have by giving you direct access to the electrode via the EXTERNAL BNC CONNECTOR.

CURRENT PUMP



The CURRENT PUMP provides a precisely regulated current from 0 to plus or minus 1000 nA for injection of dyes or drugs from the microelectrode by iontophoresis. The currents can be injected through the probe into the microelectrode by pushing the ELECTRODE switch to the CURRENT PUMP position.

If the need should arise for the CURRENT PUMP to be terminated in an electrode other than the recording electrode, its output current is always available at the AUX PUMP OUT BNC connector. With the PUMP LEVEL switch set to the INTERNAL position, the current magnitude is set by the ten-turn digital readout dial. The polarity is set by the PUMP POLARITY switch. The OFF position of this switch programs the ideal current generator to zero nA output, this is a quick means of going from the dialed CURRENT PUMP level to zero nA.

Supplying an external bipolar analog signal into the EXT REF BNC jack with the PUMP LEVEL switch set to EXTERNAL allows the ideal current source to be programmed externally by the magnitude and polarity of the reference signal. (Interfaces directly with the D/A converter output on any computer.)

a) CURRENT PUMP COMPLIANCE
The combination of the microelectrode resistance and the current level setting of the CURRENT PUMP dial should fall into the darkened area on the graph at left if linear operation of the CURRENT PUMP is to be assured. The product of the CURRENT PUMP output (digital dial reading if using the INTERNAL position of the PUMP Level switch) and the microelectrode resistance
should be less than 14 volts. For situations requiring higher compliances than 14 volts the DAGAN model 6400 Current Generator system (40 volts compliance) is recommended.

b) EXTERNAL PUMP REFERENCE
Using a BNC connector, inject a DC analog voltage within -10 to +10 volts into the EXT REF jack. The input resistance of the CURRENT

PUMP External Reference input is one meghom. An output current of 1nA for each 10mV of reference voltage will be available either through the probe or the AUX PUMP OUT BNC connector.

c) AUXILIARY PUMP OUTPUT (AUX PUMP OUT) USE
The output of the current generator may be obtained at any time from this connector. Current injection through the probe (by placing the ELECTRODE switch to CURRENT PUMP) and concurrently through the AUX PUMP OUT connector will result in division of current between these two loads and thus should not be used experimentally.

MEASUREMENT OF MICROELECTRODE RESISTANCE

A front panel mounted push button switch may be operated at any time (the ELECTRODE switch must also be placed to the CURRENT PUMP position) to instantaneously provide a visual indication of the microelectrode resistance via the PREAMPLIFIER OUTPUT BNC connector. A 2 Hertz waveform will appear on the oscilloscope monitoring the OUTPUT. Each 100mV of peak-to-peak amplitude indicates a microelectrode resistance of one megohm (i.e.,100mV/megohm). Thus, a 20 megohm microelectrode resistance will appear as a 2 volt peak-to-peak signal.

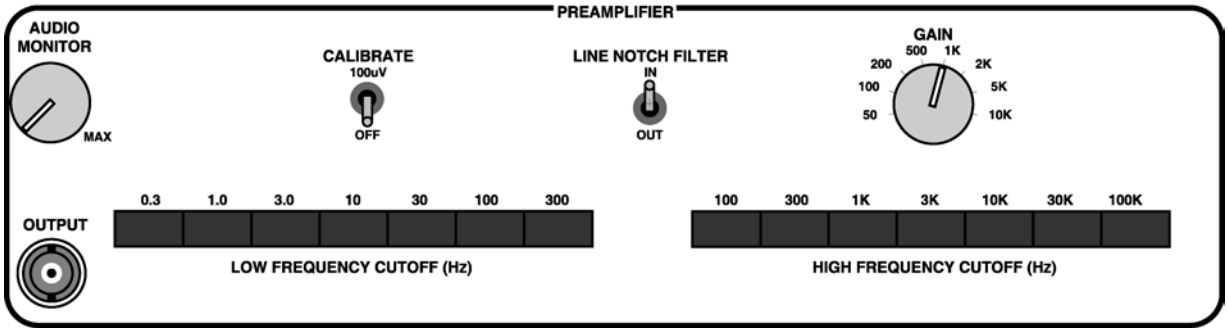
Since the CURRENT PUMP is connected to the microelectrode for this check, it will pump or inject its programmed DC current into the microelectrode until the resistance test pushbutton is depressed. At this time a 2 Hertz 100nA peak-to-peak square wave is injected into the microelectrode via the probe. Since it is a regulated current signal, a voltage corresponding to this current flow through the microelectrode resistance will reflect the magnitude of this resistance.

When using the CURRENT PUMP for the resistance check the AUX PUMP OUT BNC front panel connector should not be used since this would divert a portion of the test current away from the microelectrode and result in an incorrect reading.

Some risetime effects will be noticed since the CURRENT PUMP output is internally "loaded" with a capacitance of l000pF. Thus, for a 10 megohm microelectrode or test resistor, a RC time constant (63% of risetime) of 10ms will result.

In instruments equipped for microelectrode resistance measurements (2400Z), the CALIBRATE generator will be modified to a 2 Hz output. The model 2400 is normally supplied with a 150 Hz CALIBRATE generator.

PREAMPLIFIER



The heart of the 2400 system is its versatile preamplifier section made up of a high gain, low noise neutralized preamplifier, active filters, and an audio amplifier. The neutralized input capacitance allows risetime signals to be viewed with high microelectrode resistances.
Since extracellular and microiontophoretic recording can involve microelectrode resistances into the tens of megohms, current noise (in addition to voltage noise) becomes an important consideration. The 2400 system preamplifier is designed for use with both high and low impedance electrodes. In all situations it will provide noise levels close to the Johnson noise theoretical minimum (produced by the microelectrode resistance).

The voltage gain of the preamplifier section is very high (switch selection of 50; 100; 200; 500; 1,000; 2,000; 5,000; or 10,000). No other additional amplification should ever be needed between the microelectrode and the recording instrumentation.

A full complement of active filters means that frequency response can be tailored to provide maximum signal to noise ratio. The seven frequencies for both the high and low frequency cutoff filters were chosen to provide for a complete range of recording bandwidths. Selection is made by convenient, fast action, push button switches. By switching on the twin-tee active LINE NOTCH FILTER, interference problems caused by 60 (or 50) hertz power lines are eliminated.

The internal audio power amplifier fulfills the requirement for audio monitoring of the preamplifier output. The audio level is determined by the MONITOR control and a separate 8 ohm speaker (available as

an option) plugs into the instrument back panel to provide sound where you want it.

A Calibrate switch allows a precise signal to be passed from the preamplifier to calibrate recording or viewing instrumentation.

a) USE OF HIGH AND LOW CUTOFF FILTERS
The active filter network provided in the 2400 is virtually a complete instrument in itself. The sharp 40 db/decade rolloffs in response on both the low and high cutoff filters provide clean segmenting of the frequency spectrum into a well defined bandwidth. This capability will optimize your signal level with respect to the white noise background.

The primary sources of this noise are typically within the preamplifier and also the microelectrode resistance. Careful attention to design, component selection, testing, and layout in the 2400 system have all but eliminated the preamplifier as a major noise contributor.
Noise generated by the microelectrode resistance (Johnson Noise) can also be controlled to some degree by manipulating the bandwidth or frequency response of the preamplifier's output. Since Johnson Noise is frequency dependent (in ideal situations also linear with frequency) it may be controlled by limiting the lower and primarily the upper limits of the preamplifier frequency response. As can be seen in the defining equation of Johnson Noise, a factor of four decrease in bandwidth will reduce the background noise by a factor of two.
E = Square root of: 4KTBR

where: E = Johnson Noise (rms)
B = Bandwidth
R = Resistance
K = Boltzman's constant (1.38 x 10E23)
T Temperature in degrees Kelvin
Multiplying the value E by a factor of five will provide a good indication of the peak-to-peak voltage level of the expected noise with a 99% probability.

b) MONITOR AMPLIFIER
The power level of the MONITOR amplifier is purposely kept low (1/2 watt) so that interference problems are minimized. To take

maximum advantage of the audio drive available the speaker should be located within five to ten feet of the listening area. An 8 ohm large (efficient) speaker, or a computer type powered speaker is recommended.

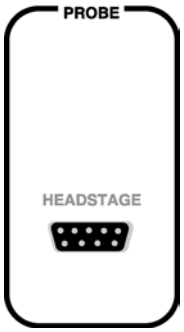
It is potentially possible to overdrive the MONITOR amplifier if large (several volts at the OUTPUT BNC connector) signals are used. To prevent this from occurring and introducing possible interference into the preamplifier input, never use a MONITOR level so high as to cause oscillation and distortion in its output.

If the MONITOR amplifier provision is not used the output binding post on the rear panel should not be terminated and the MONITOR control should be at its minimum position.

c) CALIBRATE SWITCH
A Calibrate switch sends a 100mV square ware signal through the output so that any recording equipment can be set up.

A rear panel mounted BNC PULSE TEST 10:1 allows you to inject a calibration signal through the 2400A (after the GAIN) to check external recording equipment. For example, a one volt signal would be seen as a 100mV signal at the OUTPUT BNC.

PROBE



An ultra low noise experimental setup and the absence of capacitive loading effects are made possible by the use of a probe head stage containing the first preamplifier gain block and also all circuitry needed for the other microelectrode terminations.

Capacitive neutralization is at your fingertips with a high resolution neutralization control located on the probe. This feature gives you the capability to fine tune signal risetimes when your microelectrode's resistances are greater than a few megohms.
A low noise shielded probe cable is so flexible that the lightweight probe head stage will always stay where you want it. The ten foot cable and rugged chassis connector make for fast and simple connection to your experimental setup. A slide-on miniature co-axial input connector mates with a wide variety of female connectors made by several manufacturers. Two different mating connectors are supplied with the 2400 initially. A removable three inch long rod allows the probe to be mounted directly in your micromanipulator. A flat removable probe mounting plate is furnished for setups that necessitate permanent mounting of the probe to a variety of surfaces and equipment.

a) CAPACITIVE NEUTRALIZATION CONTROL
The neutralization control is a 15 turn trimpot located at the mounting rod end of the probe. It controls the amount of positive feedback supplied to the input of the first gain stage of the preamplifier. It effectively neutralizes up to 100pF of stray input or microelectrode capacitance by correcting for the degradation in signal risetime caused by these capacitances in conjunction with the microelectrode resistance. The algebraic product of the micro-electrode resistance and the stray capacitance is equal to one "time constant" or about the length of time in seconds it will take the signal's leading edge to rise to 63% of its total amplitude. Thus decreasing this capacitance by neutralization (canceling it with the

negative neutralization capacitance fed back to the probe input) will result in a much faster risetime.
The neutralization control is preadjusted at the factory and in many cases will never need additional attention. For very high microelectrode resistances (above 10 megohms) or experimental setups with a large amount of stray (or a co-axial cable) capacitance, slight adjustments from time to time will be desirable. Adjustments can be accomplished both when the 2400 is terminated in (1) a microelectrode or in (2) a test resistor.

(1) It may be adjusted during an experiment by simply introducing a square wave between the 2400 grounding lead (shield of co-axial input cable or mounting rod or bracket) and the experiment ground reference wire. Rotate the trimpot until the leading edge of the square wave is vertical and displays no more RC time constant (exponential) effects.

Actual signals may also be used if it is inconvenient to introduce a square wave in the above manner. But because of the lack of a clear rise time (or vertical leading edge) in most situations the best approach will be to rotate the neutralization trimpot until oscillations start, then back off one-half turn. This should be very satisfactory in the majority of cases.

(2) The neutralization control may be adjusted to compensate for fixed added input capacitance (such as a short length of co-axial cable from the micro-electrode internal to the 2400 probe input connector) in the following manner: Terminate the probe input to ground through a 10 megohm resistor (carbon composition type may be used). Now rotate the control until oscillations are visible at the PREAMPLIFIER output BNC connector. Back off one-half turn. This is also a good method of calibrating the neutralization control if it is normally not used but you desire optimum neutralization.

(b) PROBE INPUT PARAMETERS (PREAMPLIFIER MODE ONLY)
When operating in the PREAMPLIFIER mode, care should be exercised with regard to static voltage discharge to the probe input. Although the input is designed around a very rugged dual junction FET amplifier and is isolated from the input through a 10K resistor, extreme abuse (several hundred volts) may cause some damage. The input stage is DC coupled to the microelectrode in the PREAMPLIFIER mode (it is disconnected via a reed relay in all other modes) and is operated at a gain of 10. For this reason, input DC offsets should be less than one volt for linear recording. The use of a

DC coupled input stage allows extremely fast preamplifier recovery if overloads or open circuits occur.

c) PROBE INPUT CONNECTORS
The 2400A comes with BNC connector, Mini Coaxial, 1mm Tip Jacks, or Phone Jack

BNC (standard in 2005)
Mates with Dagan HB120 and HB180 microelectrode holders for glass pipettes.

Mini Coaxial (standard before 2005)-
The 2400's input connector mates with the DAGAN part number 8012 Mini Coaxial connector with 15 cm of miniature coaxial cable attached. Coaxial cable typically has a distributed capacitance of 48pF per foot, so its length should be kept to a minimum (few inches).

1 mm Tip Jacks
Mates with standard Tip Jack connectors (Order# P657-5 (set of 5))

Phone Jack
Mates with earphone mono connecters.

d) SYSTEM GROUNDING
Either the probe or the mainframe cabinet may be grounded to your experiment for the reference connection. The probe is preferable for the lowest noise setup; however, experimentation with grounding may provide a better noise level in unique situations. For all common experimental setups the probe is grounded by either tying into the shield of the co-axial input cable or connection to the probe mounting rod screw. The mounting rod or plate may also serve as the 2400 system's ground connection to your experiment.

Any number of 2400's or any other amplifier using a real ground reference may be used at the same time on the same experiment without cross-talk or mutual interference.
The mainframe may be grounded via either of the front panel BNC connector bodies or alternatively by the binding post located on the rear panel.

e) PHYSICAL PROBE PLACEMENT
Because of the neutralized input design of the first gain stage of the PREAMPLIFIER, the 2400 has a "single ended" input (one side of the

differential FET amplifier connected to ground). To achieve maximum advantage of the low noise preamplifier input, the probe should be located as close as possible to the microelectrode. The usual procedure is to use a 4 to 6 inch piece of small diameter co-axial cable to connect the microelectrode internal to the 2400 probe input connector.

To aid in mechanical mounting of the probe, either the mounting plate (secured to probe by the 4 cover screws) or the mounting rod may be used. The cover is glued in place to seal the probe from moisture and thus will not come off even if the four mounting screws are removed. At least one screw is needed to insure electrical connection of the cover to the probe and thereby provide shielding.

C MODEL B

2400B EXTERNAL DC POWER AND BATTERY OPERATION

The 2400B is capable of running on external DC or battery power as well as AC line power. Instruments so equipped can be identified by the "B" at the end of the system model number, 2400, on the rear panel serial number label.

It should be emphasized that external DC or battery operation is simply an added convenience for some situations, and that batteries are not required to achieve the low noise amplification specified for the 2400 system.

An added toggle switch located on the rear panel selects either external (EXT) or AC line operation (INT). Also, two additional binding posts are added to the rear panel for external DC power input. They are labeled +15 and -15 volts. The external +15V supply should be capable of supplying 120mA, and the -15V supply should be capable of supplying 4OmA. For battery operation we recommend either four Eveready type 717 batteries (7.5 volts each) or four Eveready type 715 batteries. The 717's will provide about 10 hours of use and the 715's will provide about 150 hours of use.

The power switch and its pilot light are not used during EXT (external) operation. The audio MONITOR output to the speaker or the monitoring oscilloscope will indicate that the 2400 is operating on EXT. The rear panel toggle switch may be switched to the INT position to disconnect the DC supplies or batteries.

D. SERVICING

Dagan Corporation prefers that we be allowed to perform any major service work that should arise. The three year warranty period will provide service at no charge to your during this period.

Listed below are some minor problems you may be able to correct yourself and not void the warranty, if you should find self servicing to be desirable or expedient.

MAIN FRAME COVER REMOVAL

Remove the two screws on the top cover and slide it backwards.

PRINTED CIRCUIT CARD REMOVAL
Unscrew the desired PC board locking screws. Unsnap the connectors and pull them upwards. Slide the card back slightly and remove.

FUSE
The 2400 has a fused power supply. The fuse is located inside the cabinet adjacent to the power transformer. It is easily snapped out for inspection if the power switch pilot light should fail to function. It is a slow-blow 1/2 amp. 250 volt 3AG type.

E. GUARANTEE

The 2400 system is warranted to be free from defects caused by materials, workmanship, and construction for a period of one year from date of purchase. During this period, Dagan Corporation will service your instrument at no charge. A letter or phone call to us can usually provide enough data to confirm the problem and we will then immediately air ship you the plug-in replacement cards. If the problem is more serious, or if you prefer that we replace any faulty cards, return the instrument to us and we guarantee it will be repaired immediately and shipped back to you.

We know that you are only able to depend on and get maximum use from your instrument if service is prompt, courteous, and correct.

9/1/08