
# Analog Stimulus Isolator

# 2200

# INSTRUCTION MANUAL

# FOR

# ANALOG STIMULUS ISOLATOR

# MODEL 2200

Serial #_____

Date_____

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**Version 6.0**

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# General Description

The *Model 2200 Analog Stimulus Isolator* is designed for a wide variety of applications. It provides opto-electrical isolation for stimuli generated by a wide range of signal sources. The signal is DC-coupled, and can take on any waveshape within its wide bandwidth. The input signal voltage, scaled according to the Range switch setting, can result in an output as large as 100V (or ±50V), and ±5mA. The output signal can be turned on and off by a digital Control Gate. If for any reason the instrument cannot follow the input signal, an Error indicator lights.

The isolated output section is battery-powered and optically-coupled to the input section, for the ultimate in clean isolation. The battery is adequate to provide full function for at least 8 hours of continuous use. An internal battery tester is provided. A charger is supplied, and an oven-night charge cycle is all that is required to ready the 2200 for another day's use. It is easy to swap a freshly charged pair of batteries if extended use is necessary.

There are several features to make this instrument highly useful in a computer-driven environment via the Control port. The instrument is well suited to accepting analog signals generated under computer control, isolating these signals from the noisy electrical environment associated with a computer, and coupling them to biological tissue. The error detection circuitry generates a TTL-level Control Error signal if the instrument is unable to deliver the required signal. It is also possible to detect a low battery condition at any time, without altering the isolation or interrupting an ongoing experiment.

**NOTE**

The instrument is not intended for clinical measurements using human subjects. A-M Systems, Inc. does not assume responsibility for injury or damage due to the misuse of this instrument.

# Warranty and Service

**LIMITED WARRANTY**

**What does this warranty cover?**

A-M Systems, LLC (hereinafter, "A-M Systems") warrants to the Purchaser that the Instrument, including cables, Headstage Probes and any other accessories shipped with the Instrument,(hereafter the "hardware") is free from defects in workmanship or material under normal use and service for the period of three (3) years. This warranty commences on the date of delivery of the hardware to the Purchaser.

**What are the obligations of A-M Systems under this warranty?**

During the warranty period, A-M Systems agrees to repair or replace, at its sole option, without charge to the Purchaser, any defective component part of the hardware. To obtain warranty service, the Purchaser must return the hardware to A-M Systems or an authorized A-M Systems distributor in an adequate shipping container. Any postage, shipping and insurance charges incurred in shipping the hardware to A-M Systems must be prepaid by the Purchaser and all risk for the hardware shall remain with purchaser until such time as A-M Systems takes receipt of the hardware. Upon receipt, A-M Systems will promptly repair or replace the defective unit, and then return the hardware (or its replacement) to the Purchaser, postage, shipping, and insurance prepaid. A-M Systems may use reconditioned or like new parts or units at its sole option, when repairing any hardware. Repaired products shall carry the same amount of outstanding warranty as from original purchase, or ninety (90) days which ever is greater. Any claim under the warranty must include a dated proof of purchase of the hardware covered by this warranty. In any event, A-M Systems liability for defective hardware is limited to repairing or replacing the hardware.

**What is not covered by this warranty?**

This warranty is contingent upon proper use and maintenance of the hardware by the Purchaser and does not cover batteries. Neglect, misuse whether intentional or otherwise, tampering with or altering the hardware, damage caused by accident, damage caused by unusual physical, electrical, chemical, or electromechanical stress, damage caused by failure of electrical power, or damage caused during transportation are not covered by this warranty.

**What are the limits of liability for A-M Systems under this warranty?**

A-M Systems shall not be liable for loss of data, lost profits or savings, or any special, incidental, consequential, indirect or other similar damages, whether arising from breach of contract, negligence, or other legal action, even if the company or its agent has been advised of the possibility of such damages, or for any claim brought against you by another party. THIS EQUIPMENT IS NOT INTENDED FOR CLINICAL MEASUREMENTS USING HUMAN SUBJECTS. A-M SYSTEMS DOES NOT ASSUME RESPONSIBILITY FOR INJURY OR DAMAGE DUE TO MISUSE OF THIS EQUIPMENT. Jurisdictions vary with regard to the enforceability of provisions excluding or limiting liability for incidental or consequential damages. Check the provision of your local jurisdiction to find out whether the above exclusion applies to you.

This warranty allocates risks of product failure between the Purchaser and A-M Systems. A-M Systems hardware pricing reflects this allocation of risk and the limitations of liability contained in this warranty. The agents, employees, distributors, and dealers of A-M Systems are not authorized to make modifications to this warranty, or additional warranties binding on the company. Accordingly, additional statements such as dealer advertising or presentations, whether oral or written, do not constitute warranties by A-M Systems and should not be relied upon. This warranty gives you specific legal rights. You may also have other rights which vary from one jurisdiction to another.

THE WARRANTY AND REMEDY PROVIDED ABOVE IS IN LIEU OF ALL OTHER WARRANTIES AND REMEDIES, WHETHER EXPRESS OR IMPLIED. A-M SYSTEMS DISCLAIMS THE WARRANTIES OF MERCHANTIBILITY AND FITNESS FOR A PARTICULAR USE, WITHOUT LIMITATION.

# Operating Instructions

The instrument is very simple to operate. First, check the battery condition: set the Power switch to off, and push the Battery Test button. The Test light should come on, indicating an adequate charge. Connect your input signal to the Signal In connector. Set the Polarity control to the predominant polarity of the waveform. Connect the Output to the stimulation electrode (or other load you wish to drive) and set the Range switch to the correct scale. If you wish to tum the output signal on or off by a separate controller (e.g. a timing signal), or be able to test the batteries via computer control during the course of an extended experiment, connect the control signal to the Control/Gate input. Now tum the Power switch to On.

The output may go to an unpredictable state if the battery charge is not maintained. It is the user's responsibility to ensure an adequate battery charge. Regular use of either front-panel or control-port battery testing is sufficient to guarantee proper battery charge.

The Error indicator should remain unlit in normal operation. The Error LED will light when the computer-interface battery test is in operation. Be aware, however, that the Error LED will not light if the batteries are dead! It is normal for the LED to turn on briefly when the front panel controls are switched.

To recharge the batteries, connect the battery charger to the rear Charger input, and set the Power switch to Charge. Note that if the switch is left in the Charge position without any incoming electrical power, the batteries will very slowly, but certainly, become discharged.

The Model 2200 can produce potentially dangerous voltages (up to 70V) at the output. The isolated output is not connected internally to safety (earth) ground in any way. Some part of the external circuit should be connected to safety ground. Use caution in handling any wires, connectors, or electrodes which may be directly or indirectly attached to the Model 2200 output. Some kinds of connectors (e.g. BNC connectors) have exposed metal parts which may float at dangerous potentials unless externally connected to safety ground. For greatest safety, turn the Model 2200 off before handling connections to the output.

## Signal Control

The voltage at the Signal In BNC defines the output waveform. The signal is DC coupled across the optical isolation barrier, so virtually any waveform can be used. It can be turned on and off with a digital Gate signal through the Control port

Set the Range control to achieve the type (voltage or current) and amplitude of output required. The output power is limited to 100V (±50V in bipolar mode) and ±5mA. For applications requiring the highest voltages (for example, trying to push “large” currents through high resistance electrodes), it may be necessary to set the Polarity switch to the dominant polarity of your signal. For most users, it should be necessary to set the Polarity switch to the dominant polarity of you signal. For most users, it should be adequate to leave the switch set to Bipolar, giving equal range for both positive- and negative-going signals. For the most challenging cases, you may double the output power by combining two units.

For users requiring the lowest possible offset voltage or current, itmaybe necessary to readjust the Offset. Use the small insulated screwdriver (supplied with the Model 2200) to zero the output while the input voltage is set to zero. It is best to do this with the Range switch set to the desired position.

## Battery Testing and Maintenance

There are two batteries: a small 9V “transistor” nickel-cadmium battery used to power the input section; and a larger gelled-electrolyte 12V battery used to power the output. Both are rechargeable. The internal batteries are designed to last at least 8 operating hours from a full charge, and up to 16 operating hours in a no-signal, no-error condition. Brand-new batteries often have a slightly reduced capacity, which improves after a few charge-discharge cycles.

There are two methods to test the state of the batteries. From the front panel, simply turn the Power to Off, and push the Battery/Test push-button. The Battery/OK LED will light if both battery voltages are sufficiently high. Warning: this light does not indicate how long the charge will remain high It is up to the user to maintain the battery charge properly.

To preserve maximum battery life, use the full battery capacity. Do not routinely discharge the battery beyond the point at which the Control-port battery test succeeds (this is a slightly lower threshold than the front-panel test); the gelled-electrolyte (12V) battery life will eventually deteriorate if you discharge it too far. At the other extreme, do not frequently discharge the batteries to a small fraction of their capacity: shallow discharging of the unit may lead to diminished charge life of the input-side (9V) battery. If this should occur, its charge life can be largely restored by removing the 9V

battery from the unit, and discharging the battery to 5 or 6V with a 330 ohm resistor. Now charge the battery again. It may be necessary to go through several discharge/ charge cycles to fully restore the battery's function. Do Not deeply discharge the 12V battery.

If battery charge life is a problem, there are two alternative "solutions". The simplest solution is to keep on hand a supply of one or more sets of fully charged replacement batteries in addition to the internal set. - It is easy to change the batteries: turn the Power switch Off, turn the unit upside-down, and unscrew the two recessed phillips-head bolts (see figure 1). While holding the unit together, turn the unit right-side up. The top side of the case comes off with an easy vertical pull. The 9V battery is in a battery holder on the horizontally-mounted circuit board; simply pry the discharged unit out (pull on the attached tab), and replace with another battery. Disconnect the wire from the larger 12V battery at the connector to the circuit board. Now pull the battery from the Velcro® pad that it is sitting on. Replace the battery, making sure that it is firmly pressed into the pad. Reconnect the new battery to the circuit board, making certain that the keyed connector is locked together with the correct orientation! If the connector does not go together easily, you may have it upside-down. Reinstall the top cover and tighten the two bolts. Pushing the Test push button should now light the Battery OK LED.

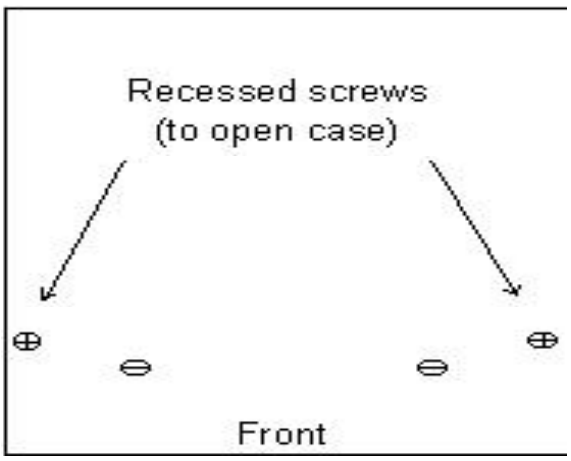


Figure 1. Bottom view of case: screw locations

If for some reason it is necessary to store the 2200 for more than a few months, it is recommended that the unit be kept at a low temperature(5-10°C). Before storing for longer than a year, it is advisable to remove the batteries from the unit; store the batteries separately.

# Control Port

Digital control is performed via the subminiature DB-9 connector on the instrument.

**Signal Description**

The output signal is turned on and off via the Gate line. The default (open circuit) condition is a logical “1”, allowing unimpeded signal transmission from input to output.

Output errors may be detected via the Error line. Normally at a logical “0”, this line goes high for at least 500ms if the output amplifier cannot drive the load satisfactorily. For example, this would occur if the amplifier were trying to drive a nonzero voltage into a short circuit, or drive a nonzero current into an open circuit; or if the output range were exceeded, such as trying to obtain 200V from the unit.

Since it is possible that either or both of the internal batteries will be too low to provide a readable Error signal, it is strongly recommended that a periodic battery check be done in order to ensure proper operation. The most conservative battery test is done via the front panel. Another test, adequate to ensure proper operation, is to set the Battery Test line high. Two things should occur on this event: the Battery OK line must go high, indicating that the 9V battery has an adequate charge; and the Error line must go high, indicating that the 12V battery is functional. Note that the Error line may stay high for up to 2 seconds as a result of this input.

Please note that the Control-port battery test is not guaranteed to work if the Error condition is already on.

**Pinout**

The pins are connected as follows. Note that while this is mechanically compatible with a 9-pin RS-232 connector, it is not electrically compatible. The 2200 is not smart enough to understand serial communications; and for some, the slow, erratic speed of serial communications would compromise performance.

| Control/Connector | Setting | Pin Name |
|---|---|---|
| 1 | O | Battery OK |
| 2 | O | Output Error |
| 3 | | Ground |
| 4 | I | Gate |
| 5 | O | Vcc (do not connect to any external power supply). |
| 6 | I | Battery/Test |
| 7 | | Ground |

| | |
|---|---|
| 8 | - |
| 9 | - |

+5V (nominal) is available for external uses, but caution is required: this power comes from the small (9V) battery. Current drain may reduce the rated charge life.

All signals are active-high. The accessory cable #20860 gives a connection to the Gate signal (and ground) only. The accessory cable #20865 allows control and reading of status lines via a standard parallel port:

| 2200 meaning | 2200 pin# | Parallel port pin# | Parallel-port pin name |
|---|---|---|---|
| Battery OK | 1 | 10 | Acknowledge |
| Output Error | 2 | 15 | I/O Error |
| Ground | 3,7 | 18-25 | Ground |
| Gate | 4 | 2 | Data O |
| Battery Test | 6 | 5 | Data 3 |

In addition, pins 11 (Busy) and 12 (Paper empty) of the parallel printer port are connected to ground. Some PC BIOS routines will not respond properly to parallel signals without this logical condition.

Do not connect the Battery Test signal permanently low: this would reduce battery charge life, and prevent real output errors from being detected. Do not connect anything to pin 5 of the DB-9 connector without consulting A-M Systems, or its representative.

# Examples and Applications

The first thing that should be done in any use of this instrument is to check the batteries using the internal battery test function. Set the Power switch set to Off, and push the Battery Test push-button. The Battery OK light should come on, indicating an adequate charge. If the test light does not come on, the batteries need to be recharged. The following applications assume that this simple test has been done first.

Single and direct (no use of the Control interface)

An example of a simple application (and basic instrument test) is using a function generator to provide the waveform.

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| Control/Connector | Setting |
|---|---|
| Output | Connect a 1kV resistor to the outpput. |
| | Connect a oscilloscope across the resistor. |
| Input | Connect the function generator, with a 1kHz sine wave of 1Vp-p |
| Sign | Bipolar |
| Range | 1V/V |
| Power | On |

You should observe the same waveform on both input and output. Rotating the DC offset control on the function generator should cause the DC level to change equally in input and output.

Change the Range control to 1mA/V. The waveform should stay the same. Now turn the Power off, disconnect the 1kV resistor, and turn the Power back on. The output waveform should be much larger (flattening against the power supply rails), and the error LED should light up as the 2200 fails to drive up to 6500mA into the high impedance of the oscilloscope input/load.

**Controller-Driven Application**

An example of a more complex application (and interface test) is using a computer to control the instrument. The waveform may be generated by computer (e.g. D/A board) or analog signal source. As before, it is assumed that battery test have been done.

| Control/Connector | Setting |
|---|---|
| Output | Connect a 1kV resistor to the outpput. |
| | Connect a oscilloscope across the resistor. |
| Input | Connect the function generator, with a 1kHz sine wave of 1Vp-p |
| Range | 1mA/V |
| Control | Connect to a computer or other source of logic signals (TTL compatible), capable of setting the logical Gate and Battery Test inputs, and reading the Battery OK and Output Error outputs. |
| Power | On |

As in the preceding test, you should observe the same wavefrom on both input and output. If the Battery Test level is changed to a logical ‘1’, both Battery Ok and Output Error output signals should go to a logical ‘1’. One or both of these will not go high if the batteries are low. The isolated output should continue without alteration while this test proceeds[2]. Within one second of the Battery Test input signal retruning to a ‘0’ state, the logical output signals should return to ‘0’. Now turn the Power off, disconnecting the 1kV resistor, and turn the Power back on. The output waveform should be much larger, switching between the power supply rails, and the Error LED should light up as the 2200 fails to drive up to 6500mA into the high impedance of the oscilloscope’s input. At the same time, the Output Error level should go to the ‘1’ state. If the Gate is st to a logical ‘0’, the isolated signal output will go to ground, and the Output Error will return to the ‘0’ state.

**Combining two 2200’s For Increased Output**

If you require up to twice the maximum output voltage, connect two 2200 units in series. If you require up to twice the maximum current of a single 2200, connect the 2200’s in parallel. The Gate may be connected (and driven) together, by the same timing source.

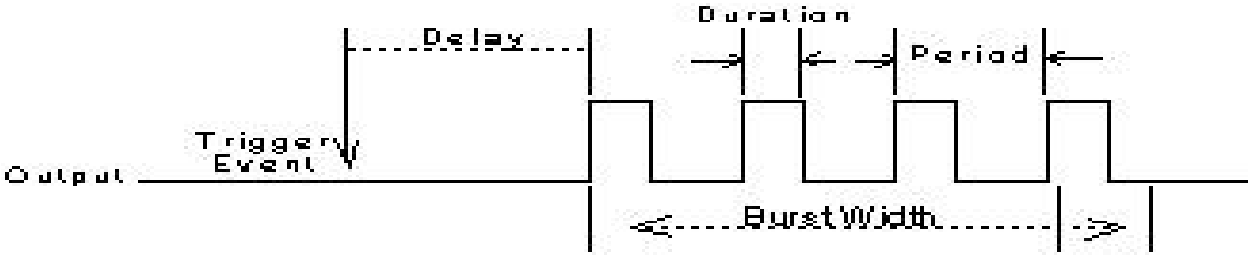


Figure 2. Extra voltage range through series connection

Figure 3. Extra voltage range through parallel connection

[2-] If the batteries are at the end of their charge life, it is possible that the additional load posed by this charge test could reduce the output power available.

The Battery Test lines may be connected together, just as the Output Error lines may be connected together. This simplifies battery testing, though any computer or other controller reading the Battery Test and Output Error will not be able to distinguish which device is signaling. Use the front-panel Test push buttons and LED's to determine which device has the low battery. Contact A-M Systems if it is necessary to connect more than two units together.

**Inverse Application**

This instrument may also be used to isolate a signal measurement/device from an earth-ground environment. Simply connect the Input to the measuring device, and connect the Output to your earth-ground system. CAUTION! Turn off all power before handling any ungrounded wiring, including the exposed cable outer shield connection going to the Input BNC. Do not connect the Control input in this application; its ground is associated with the Input side, and would eliminate the isolation.

# Problem Solving

If the instrument appears to be not working properly, check all of the control settings and connections. The following brief summary of typical problems for the user (along with the most common solutions) may help:

| | |
|---|---|
| No output (and the Error LED does not light). | • One or both of the batteries are uncharged (test batteries: recharge as required).<br>• The Gate input is held low (must be high, or disconnected, for output to occur). |
| Error LED on, even with no input. | • Low batteries (recharge). |
| Error LED lights when Gate is turned on | • Excessive drive: Unit is limited to 100V in a monopolar mode (+ or - Polarity); or ± 50V in Bipolar mode (reduce input drive check gain).<br>• Current mode: load is disconnected check wiring); or load impedance is too high for limited output voltage capability (cascade more than one unit).<br>• Voltage mode: output is short-circuited (check wiring); or load impedance is too low for limited current drive capability (parallel more than one unit).<br>• Battery charge is low (recharge). |

| | |
|---|---|
| | • Gate signal erroneously connected to Battery Test input. |
| Battery OK LED does not light when light when pressing Test. | • Power switch is not set to Off (set to Off)<br>• One or both of the batteries need recharging. |
| Battery OK LED does not light, but Battery OK and Error signals of port test positive. | • This indicates that the batteries are port almost fully discharged. The front panel battery test requires a slightly greater battery level to operate successfully. |
| Error LED lights when Battery Test signal is used. | • This is normal. |
| Excessive noise on the output. | • Charger is still plugged in (unplug/ disconnect).<br>• In the lowest current range: stray EMI coupled into the 2200 output through stray capacitance predominantly to the "black" output pin. (Operate the 2200 within a Faraday cage. Match or reduce stray capacitance to each output pin. Shorten output connections. Reverse output banana connector, inverting input signal polarity. |

If you suspect that the Model 2200 may have failed, we recommend checking the basic level of functionality.. If the instrument fails at this basic level, the instrument is defective and must be adjusted or repaired.

If this passes, either your experimental setup is incompatible or inconsistent; or there is a more subtle flaw in your instrument. Contact A-M Systems, Inc., or your dealer. Telephone numbers for A-M Systems, Inc., are listed on the front page of this manual. We will first attempt to solve the problem over the telephone, so have an exact description of your problem, the model number, and the serial number of the instrument available when you call. We are always ready to help our customers.

# Theory of Operation

The operation of the Model 2200 is summarized in the block diagram (see Fig. 4). The input signal is buffered, then enabled or disabled by an analog gate. When disabled, the output voltage at this stage is zero. A linear optoisolator system is used to couple the signal to the isolated section. The isolated signal is amplified (and possibly converted to a current) according to the Range setting.

The output amplifier is connected as a voltage-gain amplifier in voltage modes, with different feedback resistances depending on the setting. In the current mode, the same amplifier is used to fix a virtual ground within the instrument. The two currents connected to this virtual ground are the set current, determined by the range switch and input signal amplitude; and the load, driven by the amplifier output.

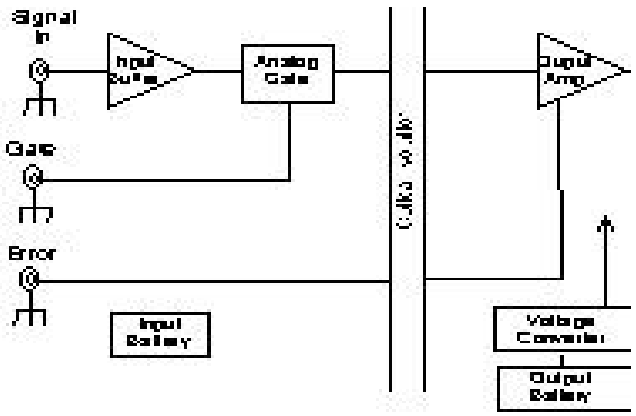


Figure 4: Instrument Block Diagram

With the Control Gate input signal open (disconnected), or set to a logical I by an external signal, the signal propagates normally as described above. If the Gate is set to a logical 0, the internal signal is connected to the input ground instead of the input signal.

Output errors are measured by sensing the output amplifier's differential input voltage. Under normal conditions, this voltage is negligible. If for any reason the amplifier fails to deliver the requested signal, the window comparator testing this voltage sends this message (via another optoisolator) to the input section, turning on a warning LED and setting the Error output to a TTL-high level.

Two sets of batteries are used to power the 2200. At no setting of the Power switch are the input and output sections connected together. In the Power/On mode, the batteries provide independent power to their respective side of the isolation barrier. In the PowerICharge mode, the batteries are disconnected from each side, and are reconnected to a built-in constant-current, voltage-limited battery charger. In the Power/ Off mode, the batteries are disconnected from each side, and are reconnected to a battery-test circuit through the Battery Test push button. Note that the tester only detects

the present state of the batteries, and does not indicate how long the charged batteries will be able to support the load. The batteries used in the 2200 vary more from unit to unit than from fullly-charged to nearly-discharged, making it impractical to measure the charge state. It is recommended that you, the user, keep track of battery usage to ensure that the battery does not become exhausted at a critical time. You may also use the Control port to automatically monitor battery condition (as well as Error state) during an experiment. The supplied software provides one way of achieving this end.

# Specifications

There are three classes of specifications. Class A specifications are tested in aU units, and are guaranteed. Class B specifications are inherent in the design-, they are indirectly tested, and are guaranteed. Class C specifications are typical operating values which are occasionally tested; these are given for your information but not guaranteed. The class for each specification is noted in the center column of the following sections. All specifications require that the batteries are adequately charged, and the instrument is fully warmed up (at least 15 minutes).

**Inputs**

| | | |
|---|---|---|
| Input resistancel | B | 1 MΩ ± 1% in parallel with less than 22pF□□ |
| Signal input to output delay | C | approx. 5µs for a load of more than 100 KΩ in parallel with 50pF |
| Maximum linear input | B | ± 10 V |
| Logical ‘0’ | B | <0.8 V |
| Logical ‘1’ | B | >2.4 V |
| Input equivalent circuit | C | >33 KΩ, in parallel with no more than 35pF |
| Gate polarity | A | active high (default is high = on) |
| Gate to output delay | C | approx 6µs |
| Gate timing jitter | C | <0.1µs |

| | | |
|---|---|---|
| Battery test polarity | A | active high (default is low = off) |
| Battery test to output delay | C | < 0.1 ms (turning on); <1 sec (turning off) |

**Outputs**

| | | |
|---|---|---|
| Maximum output capability | A | ± 50V (Bipolar Polarity); +100-10V ('+' Polarity); -100 + 10V ('-' Polarity). ± 5mA. Both limits apply to all Range settings. |
| Full scale output | B | ± 10V x Range setting |
| Gain | A | Within ± 0.3% of setting at dc. Accuracy is reduced for high output currents in voltage modes, to -2% at full output. |
| Transient response | A | <10 µs rise risetime into 1MΩ 10 KΩ in current modes) in parallel with less than 47 pF. Decreases to ≈ 4 µs with jumper J350 removed. |
| Bandwidth | B | within + 1-3 dB from dc to 40kHz (same load impedances as above). Increases to ~100kHz by removing jumper J350. |

Maximum slew rate (the effective bandwidth is reduced for large signals): with 10 KΩ and 20pF load. C

| RANGE | SLEW RATE (typ) |
|---|---|
| 10 V/V | 5 V/µs |
| 1 V/V | 0.6 V/µs |
| 1 mA/V | 0.4 mA/µs |
| 0.1 mA/V | 54 µA/µs |
| 10 µA/V | 5.6 µA/µs |
| 1 µA/V | 0.6 µA/µs |

**Note**: risetime in current modes is slower than in voltage modes if the wiring capacitance approaches or exceeds $4.5 \times 10^{6} R^{-1}$ pF (in ohms). Bandwidth is decreased by the same factor. This is a function of the load impedance driven by a costant current source, not a property specific to the Model 2200.

| | | |
|---|---|---|
| Offset | A | within ± 0.02% of full scale<br>+ 1nA offset in current modes)<br>at 25°C. |
| Drift | B | less than ± 0.01% of full scale<br>per °C from 10 to<br>30°C. |
| Output impedance | C | RANGE — OUTPUT RESISTANCE (typ)<br>10 V/V, 1 V/V — ≈50 ohms<br>1 mA/V — >1. GΩ (>$10^{10}$ )<br>10µA/V — >50 GΩ (>$10^{11}$ )<br>1µA/V — >50 GΩ (>$10^{12}$ ) |
| Noise, typical (voltage modes: open circuit load; current modes: 100kΩ load 10 Hz - 100 kHz bandwidth. J350 in place. | C | MODE — RMS — % FULL SCALE<br>10V/V — <10 mV — 0/01<br>1 V/V — <3 mV — 0.03<br>1 mA/V — <1µA — 0.01<br>0.1 mA/V — <100 nA — 0.01<br>10µA/V — <10nA — 0.01<br>1µA/V — <2nA — 0.02 |
| Isolation resistance | A | >200MΩ |
| Isolation capacitance | C | <20pF |
| Overload error response time | C | Flat to approx. 10ms duration.<br>Decreasing sensitivity for shorter pulses. |
| **Miscellaneous** | | |
| Battery load life (from full charge) Test | B | At least 8 hours (Control/Battery<br>on less than 100 seconds, total; average input voltage > -5V). |
| Battery charge time | B | No more than 14 hours |
| Battery charge life (unit off) | B | At least 2 months |
| Operating temperature range | | 10 - 30°C |
| Operating humidity | | 5 - 80% RH |

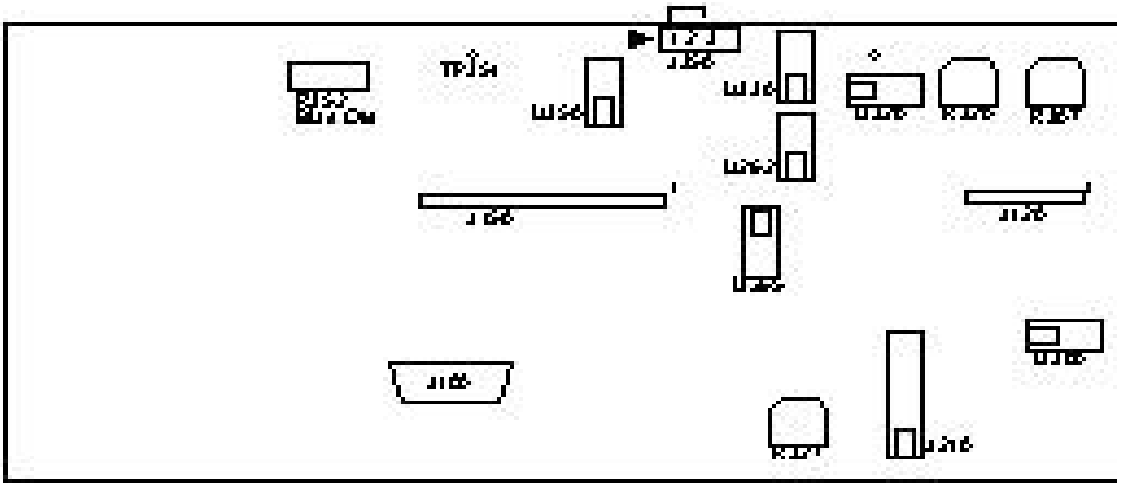

Figure 5. Input amplifier board: adjustment and test poiint locations

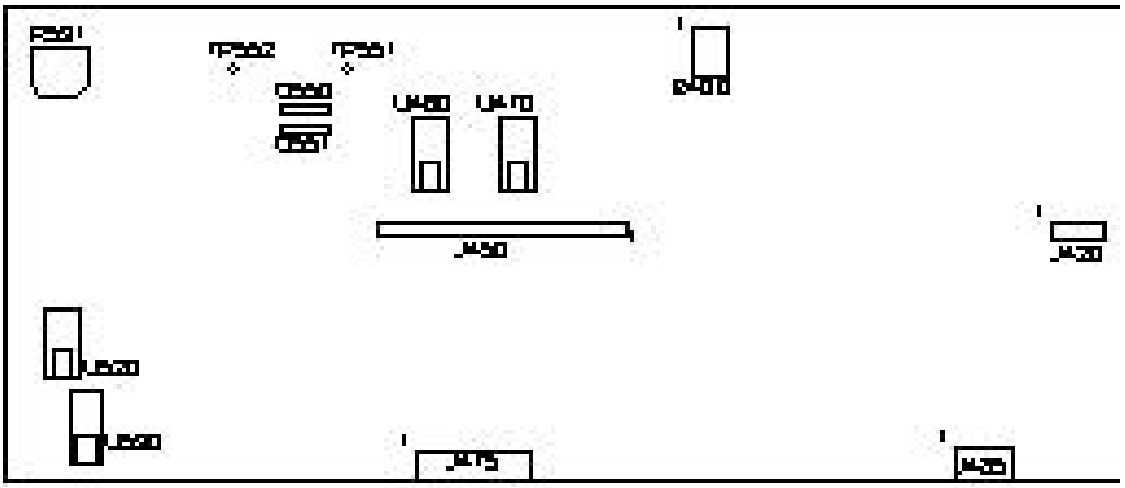

Figure 6. Output amplifier board: adjustment and test point locations

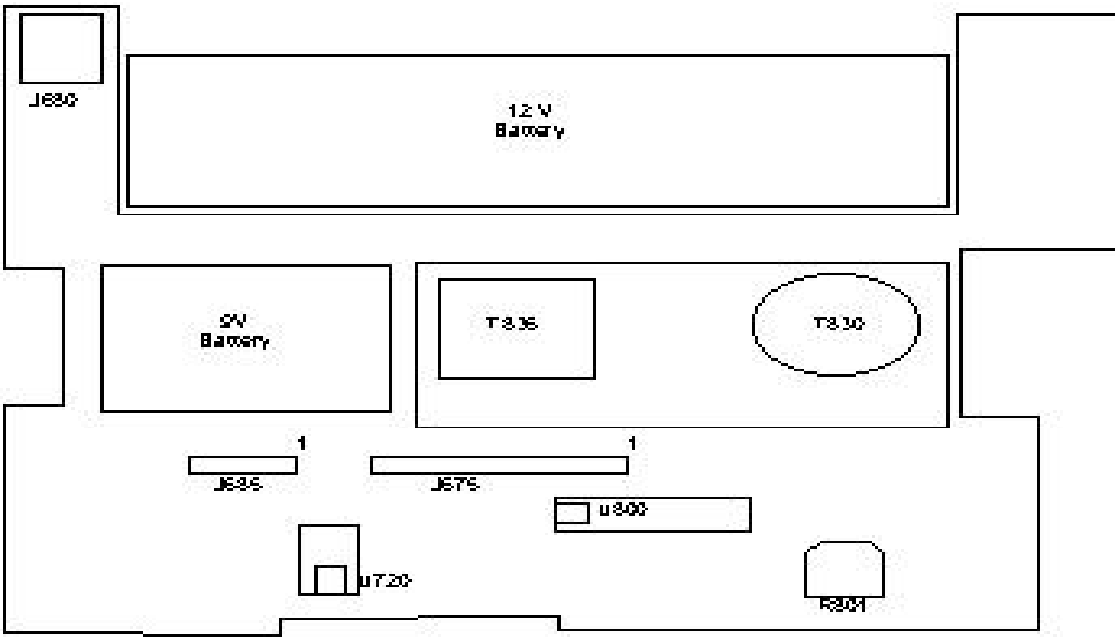


Figure7. Power suppy board: adjustment and test point locations

**Revision History**

| Rev | Date | Description |
|---|---|---|
| 7 | 6/30/06 | Initial Document Control release |
| 8 | 4/28/10 | DCR201200 Warranty and company name |