



***Digital Stimulus Isolator***

**2300**

**INSTRUCTION MANUAL**  
**FOR**  
**DIGITAL STIMULUS ISOLATOR**  
**MODEL 2300**

Serial # \_\_\_\_\_

Date \_\_\_\_\_

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*Each Stimulus Isolator is delivered complete with:*

*Battery Charger*

**NOTE**

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



# General Description



The Model 2300 Digital Stimulus Isolator is designed for a wide variety of stimulus applications. It provides opto-electrical isolation for TTL-compatible digital signals controlling the timing of preset levels. These levels are set by calibrated ten-turn potentiometers. Scaled according to the *Range* switch setting, these levels can result in an output up to 65V or 65mA. Up to five different output levels can be produced: (+ and -) Pulse; (+ and -) Baseline, and Zero, depending on the *Control* logic levels. 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 overnight charge cycle is all that is required to ready the 2300 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 digital timing 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 accept responsibility for injury or damage due to the misuse of this instrument***

WARNING the Model 2300 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 2300 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 2300 off before handling connections to the output.**

# Operating Instructions

The instrument is very simple to operate. First check the battery condition: set the *Power* switch set to Off, and push the Battery/Test push-button. The test light should come on, indicating an adequate charge. Connect your controlling signal(s) to the *Control* connector. Connect the *Output* to the stimulation electrode (or other load you wish to drive) and set the *Range* switch to the correct scale. Now turn the *Power* switch to On.

The Error indicator should remain unlit during normal operation. The Error LED will light when the computer interface battery test is in operation. Be aware, however, that the Error LED cannot light if the batteries are completely dead! The LED may 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 charger should be disconnected during normal operation to minimize power line noise.

## Output Levels

Set the *Range* control to achieve the type (voltage or current) and amplitude of output required. The output power is limited to 100V and 10mA. For the most challenging cases, you may double the output power by combining two units.

Set the *Level/Pulse* and *Level/Baseline* potentiometers to the desired levels. The Pulse potentiometer multiplies the *Range* by a factor between 0 (in the fully counterclockwise position) and 1.00 (in the fully clockwise position). Note, however, the maximum output capabilities as noted above. The Baseline potentiometer multiplies the *Range* by a factor between 0 and 0.10. For the greatest accuracy, use the smallest *Range* setting possible for the output that you need. For example, if you need to develop a pulse with an amplitude of 80 $\mu$ A, use the 100 $\mu$ A *Range* setting and *Level* of 0.80, rather than 1mA *Range* and *Level* of 0.08.

Five output levels may be generated: (+ and -) Pulse; (+ and -) Baseline, and Zero. The *Control* signals are DC coupled across the optical isolation barrier, so virtually any timing is possible. Three logic levels are required if it is necessary to produce all five of these levels; only one logic level is required (for example) to switch between Zero and +Pulse. Creating a biphasic pulse requires at least two logic control signals.

## Timing Sources

There are many possible sources of timing signals. If all you require is a simple pulse, you can use a single TTL-compatible pulse set to the desired output timing parameters. This pulse can be connected to the Pulse/Baseline or On/Off logic line, depending on whether you want a nonzero baseline or not. For more complex waveforms, including biphasic waveforms, you will need at least two bits of information. These can be derived from a multi-channel timing generator, or from a computer.

## Battery Testing and Maintenance

There are two batteries inside the unit: a small 9V rechargeable NiMH 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 on a full charge. 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 an adequate proper battery charge.

To preserve maximum battery life, use the full battery capacity. Do not routinely discharge the battery completely, as 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 9V battery

If battery charge life is a problem, 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 a 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 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 up the Battery OK LED.

If for some reason it is necessary to store the 2300 for more than a few months, it is recommended that the unit (or at least the batteries) be kept at a low temperature (<15°C). Before storing for longer than a year, it is advisable to remove the batteries from the unit; store the batteries separately in a cool location.

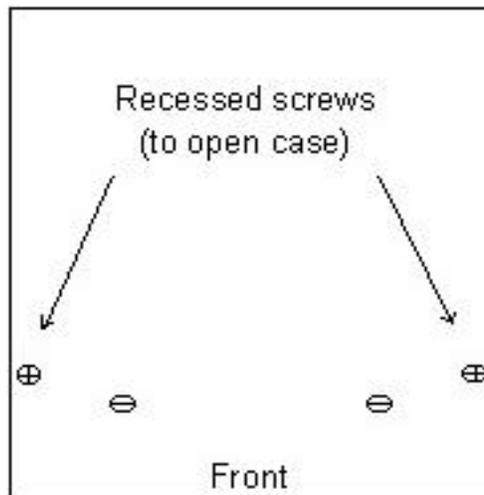


Figure 1. Bottom view of case: screw locations

## Control Port

Digital control is performed via the subminiature DB-9 connector on the instrument. Signal output control, battery testing, and output error detection can be controlled via this port. The pinout follows in the next section.

## Signal Description

The output levels are controlled by three logic lines. The default (open circuit) condition is a logical "0" for the On/Off line (the output is normally Off), and a logical "1" for the Sign and Pulse/Baseline bits (+Pulse).

Output Level	On/Off	Pulse/Baseline	+Sign/ -Sign
Default (Zero)	0	1	1
Zero	0	any	any
-Baseline	1	0	0
+ Baseline	1	0	1
-Pulse	1	1	0
+ Pulse	1	1	1

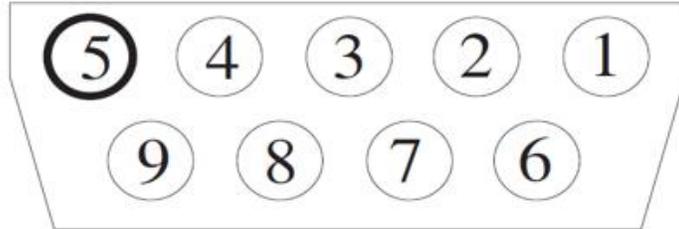
Output errors may be detected via the Error line. Normally at a logical "0", this line goes high for at least 500ms if the output amplifier cannot drive the load satisfactorily or if the output range were exceeded, such as trying to obtain 200V from the unit.

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 using the front panel test button be done in order to ensure proper operation. 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.

Please note that the *Control*-port battery test will not 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 2300 is not smart enough to understand serial communication; and for most, the slow, erratic speed of serial communications; and for most, the slow, erratic speed of serial communications would compromise performance.



<i>Pin Number</i>	<i>In/Out</i>	<i>Pin Name</i>
1	O	Battery OK
2	O	Output Error
3		Ground
4	I	On/Off
5	O	VCC (do not connect to any other device)
6	I	Battery Test
7		Ground
8	I	+/- Sign
9	I	Pulse/baseline

All signals are active-high.

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 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 passed first.

## Monophasic Output Pulse

An example of a simple application (and basic instrument test) is using a pulse generator, function generator, or other source of TTL-compatible voltages to provide an On/Off signal.

<i>Control/Connector</i>	<i>Setting</i>
Output	Connect a 10kohm resistor to the output
Control	Connect a TTL compatible 100Hz square wave to On/Off pin 4
Range	10V
Level	0.50
Power	On

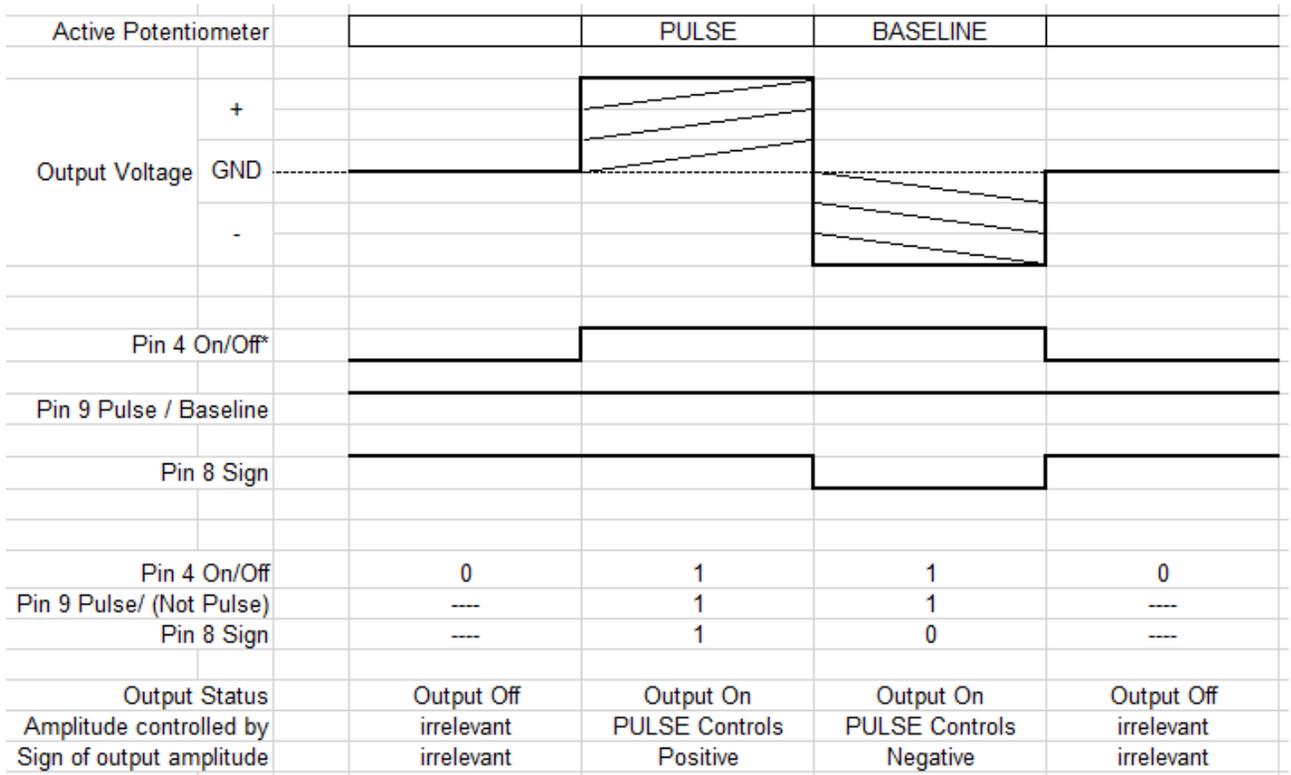
You should observe the same timing in both input and output waveforms, and output should have a 0.0 to 5.0 output. Variations in the input levels should have no effect on the output, as long as the voltages meet TTL-logic requirements.

Change the Range control to 1mA. The waveform should stay the same. Now turn the Power off, disconnect the 10kohm resistor, and turn the Power back on. The output waveform should be much larger, and the Error LED should light up as the 2300 fails to drive up to 500mA into high impedance of the oscilloscope input/load.

# Controller-Driven Application

The following diagram details the timing signals operation in generating an output from the Model 2300. Full control (determining if the output is on or off; determining if the PULSE knob or the BASELINE knob sets the signal amplitude; and determining the sign\polarity of the output signal) requires three TTL control signal lines.

In the example below, when Pin 4 is pulled high, there is a non-zero output generated. Pin 9, the Pulse\Baseline, is held high, meaning that only the PULSE knob is determining the amplitude of that output. The sign\polarity of that output is determined by Pin 8.



## Combing Two 2300's For Increased Output

If you require up to twice the maximum output voltage, connect two 2300 units in a series. If you require up to twice the maximum current of a single 2300, connect the 2300's in parallel. The Gate inputs may be connected (and driven) together, by the same timing source.

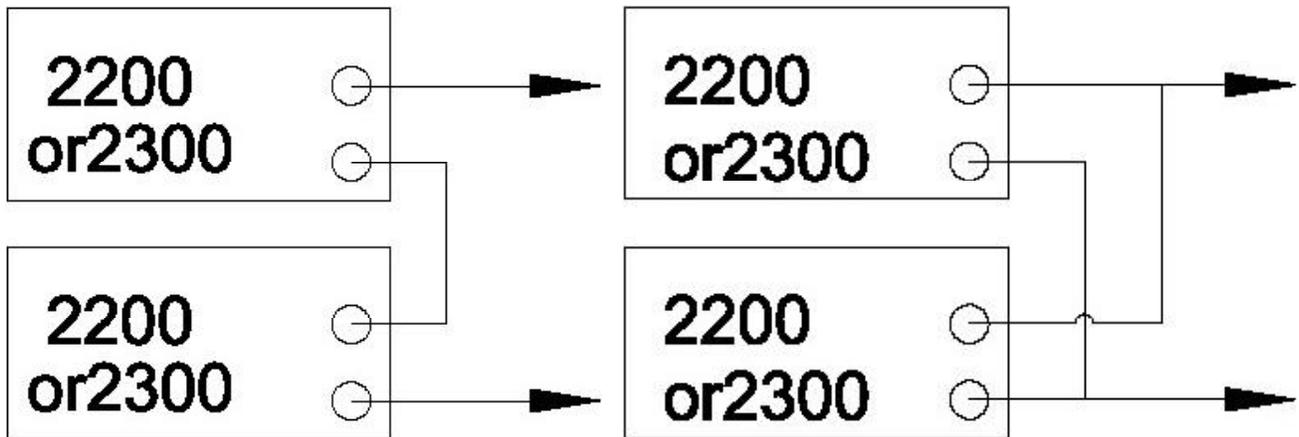


Figure 2. Extra voltage range through series connection

Figure 3. Extra current range through parallel connection

## 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).
- The On/Off Control input is held low (must be high for an output to occur).

Battery OK LED does not light when pressing Test.

- Power switch is not set to Off (set to Off).
- 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 almost fully discharged. The front panel battery test requires a slightly greater battery level to operate successfully.

Error LED on, even with no input

- Low batteries (recharge).

Error LED lights when Gate is turned on

- Excessive drive: Unit is limited to  $\pm 50V$  (reduce input drive or gain).
- Current mode: load is disconnected (check wiring); or load impedance is too high for limited output voltage capability (cascade more than one unit).
- Battery charge is low (recharge)
- On/Off signal erroneously connected to Battery Test input (change connection).

Error LED lights when Battery Test signal is used

- This is normal.

Excessive noise on the output

- Charger is still plugged in (unplug/disconnect).
- In the lowest current range: stray electrical interference can degrade noise performance if it mostly couples into the output pin. (Try operating the 2300 within a Faraday (electrostatic shielding) cage. Match or reduce the stray capacitance to each output pin. Shorted the output

connections. If these are inadequate, reverse the output banana connector, and invert the Sign logic signal).

Large, brief glitch on transition

- The pulse amplitude is set nearly zero, but the Baseline amplitude is set nearly to its maximum. (Reduce the Baseline setting, or reverse the roles of Pulse and Baseline amplitudes).

If you suspect the Model 2300 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 recalibrated or repaired.

# Theory of Operation

The logic control inputs are multiplexed with a D/A converter, optically coupled over a single analog channel to the output side, and demultiplexed with a A/D converter to provide the logic control to the output side. The pulse and baseline levels originate in the output side. An analog switch, controlled by the demultiplexed control signals, connects the appropriate level to the output amplifier.

The output amplifier scales the switched level (possibly converting the voltage to a current) according to the *Range* 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

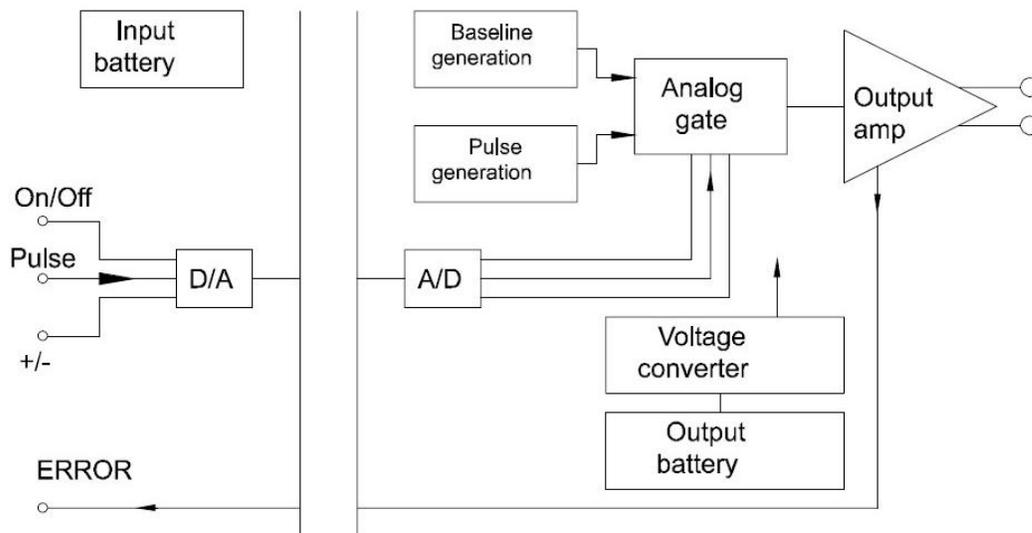


Figure 4. Instrument block diagram

Output errors are detected by sensing the output amplifier's differential input voltage. Under normal conditions, this voltage is negligible. If for any reason this amplifier fails to deliver the requested signal, a 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 2300. 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.

# Specifications

There are three classes of specifications. Class A specifications are tested in all 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 typical values, 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).

## Input

(Gate and Battery Test)

Logical '0'	B	<0.8 V
Logical '1'	B	>2.4 V
Input equivalent circuit	C	>400kohms in parallel with no more than 35pf
On/Off	A	active high (default is low = off)
Pulse/baseline	A	active high (default is high = pulse)
Sign +/-	A	active high (default is high = +)
Control to output delay	C	approx 6µs
Control 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

(Battery OK and Error)

Logical '0'	B	0 to 0.5 V (sense circuit current <300µA)
Logical '1'	B	2.4 to 4.2 V
Maximum output capability	A	±50 V or ±5mA. Both limits apply to all Range settings.

Accuracy	A	within $\pm(0.25\%$ of setting + 0.15% of range) at dc. Accuracy is reduced for high output currents in voltage modes due to output impedance.
Transient response (pulse amplitude dial set to 2.50)	A	<10 $\mu$ s risetime with <4% overshoot in the 100 V range) into 20kW in parallel with less than 47 pF.
Slew rate	C	At least 2V/ $\mu$ s

**Note:** Risetime in current modes is slower than in voltage modes if the wiring capacitance approaches or exceeds  $4.5 \times 10^6 R^{-1} pF$  (R in ohms). This is an inevitable consequence of driving an RC circuit with an true constant-current source.

Offset	A	within $\pm 0.0025\%$ of full scale (plus additional $\pm nA$ offset in current modes) at 25°C.	
Output impedance	C	MODE	OUTPUT RESISTANCE (typ)
		100V, 10V	$\gg 50$ ohms
		10 mA	>1.GW (>10 <sup>10</sup> )
		1mA	>50GW (>10 <sup>11</sup> )
		100 $\mu$ A	>50GW (>10 <sup>12</sup> )
		10 $\mu$ a	>50GW (>10 <sup>12</sup> )
Noise, typical (voltage modes: open circuit load; current modes: 100kV load) 10 Hz - 100 kHz	C	MODE	RMS % FULL SCALE
		100V	<1mV 0.001
		10 V	<1mV 0.01
		10 $\mu$ A	<5nA 0.05
		100 $\mu$ A	<5nA 0.005
		1mA	<5nA 0.0005
		10m	<30na 0.0003
Isolation resistance	A	$\gg 200$ Mohms	
Isolation capacitance	C	<20pF	

Overload error	C	Flat to approx. 10ms response time duration. Decreasing sensitivity for shorter pulses.
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**Miscellaneous**

Battery load life (from full charge)	B	At least 8 hours (Control/Battery Test On less than 100 seconds, total)
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Battery charge time	B	No more than 14 hours
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Battery charge life (unit off)	B	At least 2 months
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Operating temperature range		10-30°C
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Operating humidity		5-80% RH
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Storage temperature range		0-40°C
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Dimensions		6.35 cmH x 15.4 cmW x 15.9 cmD
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Weight		1.15kg
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# Warranty and Service

## LIMITED WARRANTY

### **What does this warranty cover?**

A-M Systems, LLC (hereinafter, “A-M Systems”) warrants to the Purchaser that the Instruments manufactured by A-M Systems (hereinafter the “hardware”), and sold after January 1, 2020, is free from defects in workmanship or material under normal use and service for the lifetime of the hardware. Headstages manufactured by A-M Systems and sold after January 1, 2020, will be repaired under warranty only once per year. This warranty commences on the date of delivery of the hardware to the Purchaser. “Lifetime” is defined as the time all components in the instrument can still be purchased from mainstream, common, electronic component distributors such as Digi-Key Electronics, Newark, or Mouser Electronics.

For hardware sold prior to January 1, 2020, the warranty in effect at time of purchase applies, with the maximum warranty period of three (3) years for new purchases, and one (1) year for those that have been repaired by A-M Systems. For headstages manufactured by A-M Systems and sold prior to January 1, 2020, the maximum warranty period is one (1) year.

### **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 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 with postage, shipping, and insurance prepaid by the Purchaser. 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. 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

## LIMITED WARRANTY, cont

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. Further, no guarantee is made regarding software compatibility with future updated operating systems. Products may not be returned to A-M Systems for service, whether under warranty or otherwise, which are contaminated by infectious agents, radioactive compounds or other materials constituting a health hazard to employees of A-M Systems

### **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 MERCHANTABILITY AND FITNESS FOR A PARTICULAR USE, WITHOUT LIMITATION.

**Revision History**

<b>Rev</b>	<b>Date</b>	<b>Description</b>
8	6/30/06	Initial Document Control release
9	4/28/10	DCR 201200 Warranty and company name
10	9/19/16	DCR 202468 Remove Calibration instructions
11	1/18/19	DCR 202615. Review content, add content rev control.
12	3/19/20	DCR 203316. Update Warranty