



A360LA

High Voltage Stimulus Isolator



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INSTRUCTION MANUAL

Serial No. _____

Please read this manual completely before using the A360LA stimulus isolator.

Be sure to use as directed and to comply with all warnings and cautions.

110305

World Precision Instruments



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DECLARATION OF CONFORMITY

We: World Precision Instruments, Inc.
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As manufacturers of the apparatus listed, declare under sole responsibility that the product(s):

Title: A360LA Stimulus Isolator

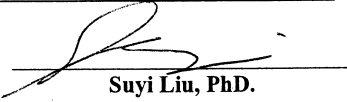
to which this declaration relates is/are in conformity with the following standards or other normative documents:

- Safety:** EN 61010-1:2001
- EMC:** EN 61326:1998
 EN 55011 Class A Group 1
 EN 61000-4-2 through EN 61000-4-6 inclusive
 EN 61000-4-8
 EN 61000-4-11

and therefore conform(s) with the protection requirements of Council Directive 89/336/EEC relating to electromagnetic compatibility and Council Directive 73/23/EEC relating to safety requirements.

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AC recharging power supply and set of international connectors included with each A360LA.

Warranty

WPI (World Precision Instruments, Inc.) warrants to the original purchaser that this equipment, including its components and parts, shall be free from defects in material and workmanship for a period of one year* from the date of receipt. WPI's obligation under this warranty shall be limited to repair or replacement, at WPI's option, of the equipment or defective components or parts upon receipt thereof f.o.b. WPI, Sarasota, Florida U.S.A. Return of a repaired instrument shall be f.o.b. Sarasota.

The above warranty is contingent upon normal usage and does not cover products which have been modified without WPI's approval or which have been subjected to unusual physical or electrical stress or on which the original identification marks have been removed or altered. The above warranty will not apply if adjustment, repair or parts replacement is required because of accident, neglect, misuse, failure of electric power, air conditioning, humidity control, or causes other than normal and ordinary usage.

To the extent that any of its equipment is furnished by a manufacturer other than WPI, the foregoing warranty shall be applicable only to the extent of the warranty furnished by such other manufacturer. This warranty will not apply to appearance terms, such as knobs, handles, dials or the like.

WPI makes no warranty of any kind, express or implied or statutory, including without limitation any warranties of merchantability and/or fitness for a particular purpose. WPI shall not be liable for any damages, whether direct, indirect, special or consequential arising from a failure of this product to operate in the manner desired by the user. WPI shall not be liable for any damage to data or property that may be caused directly or indirectly by use of this product.

Claims and Returns

- Inspect all shipments upon receipt. Missing cartons or obvious damage to cartons should be noted on the delivery receipt before signing. Concealed loss or damage should be reported at once to the carrier and an inspection requested. All claims for shortage or damage must be made within 10 days after receipt of shipment. Claims for lost shipments must be made within 30 days of invoice or other notification of shipment. Please save damaged or pilfered cartons until claim settles. In some instances, photographic documentation may be required. Some items are time sensitive; WPI assumes no extended warranty or any liability for use beyond the date specified on the container.
- WPI cannot be held responsible for items damaged in shipment en route to us. Please enclose merchandise in its original shipping container to avoid damage from handling. We recommend that you insure merchandise when shipping. The customer is responsible for paying shipping expenses including adequate insurance on all items returned.
- Do not return any goods to WPI without obtaining prior approval and instructions (RMA#) from our returns department. Goods returned unauthorized or by collect freight may be refused. The RMA# must be clearly displayed on the outside of the box, or the package will not be accepted. Please contact the RMA department for a request form.
- Goods returned for repair must be reasonably clean and free of hazardous materials.
- A handling fee is charged for goods returned for exchange or credit. This fee may add up to 25% of the sale price depending on the condition of the item. Goods ordered in error are also subject to the handling fee.
- Equipment which was built as a special order cannot be returned.
- Always refer to the RMA# when contacting WPI to obtain a status of your returned item.
- For any other issues regarding a claim or return, please contact the RMA department.

Warning: This equipment is not designed or intended for use on humans.

** Electrodes, batteries and other consumable parts are warranted for 30 days only from the date on which the customer receives these items.*

11. References

Lilly, J.C., Hughes, J.R., Alvord, E.C., Jr. and Galkin, T.W. "Brief noninjurious electric waveform for stimulation of the brain" *Science* (1955) 121, 468-469.

Doty, R.W. and Bartlett, J. R.; "Stimulation of the Brain Via Metallic Electrodes", *Electrical Research Techniques*, Academic Press (1981) Chapter 4.

Silverman, G., Ball, G.G. and Cohn, C.K., "A new automatic constant current stimulator and its biological applications". *IEEE Trans. On Biomed. Engin.* (1975) BME-25, 207-211.

L.A. Geddes, *Electrodes and the Measurement of bioelectric Events*. John Wiley and Sons Pub. (1972).

Ances, B.M., *et al.* "Acute carotid occlusion alters the activation flow coupling response to forepaw stimulation in a rat model" (2000) *Stroke* 31: 4

1. Introduction

The World Precision Instruments A360LA is a highly versatile stimulus isolator. It is designed to apply an electrical stimulus, focused on a target, through isolated electrodes and can be used in tandem with other instruments such as pulse generators, oscilloscopes and other research instrumentation.

The A360LA features include:

- TTL trigger input.
- High current resolution — 0.1% full scale.
- High voltage compliance up to 130 V.
- Output polarity reversible.
- Low output noise.
- High dynamic range (1 μ A to 10 mA).
- Powered by rechargeable batteries.
- Long overall battery life.
- Replaceable battery pack.
- Universal charging adapter included.
- Compact, easy to handle and transport.
- Logical and intuitive front panel mounted controls.
- Easily accessible front mounted terminals.
- Low noise

Stimulus isolation is essential to assure accurate localization of electrical stimuli and to prevent current flowing from the stimulation site to ground.

The A360LA Stimulus Isolator is battery operated, ensuring better stability and a lower noise figure than most AC powered isolators.

Although used most often as a stimulus isolator, a precision isolated current source as generated by the A360LA is useful in a wide variety of research tasks.

The A360LA Stimulus Isolator can be pulsed or gated by any World Precision Instruments stimulator, standard pulse generator or a digital to analog output from a data acquisition system which can provide the necessary voltage threshold level specified in this manual.

2. Warning

- High voltage produced by this unit can cause dangerous electric shock.
- This device is not approved for clinical use.
- This equipment is not intended for use on humans.
- Do not drop the instrument or subject it to adverse shock.
- Do not handle bare high voltage wires or connectors while power is turned on.
- Use only the charge adapter and connectors specified for the A360LA.
- Do not disassemble this product. Electric shock can cause injury. Electric current is still present even after the unit has been unplugged. Contact the manufacturer should battery replacement ever become necessary.
- Do not allow this unit to become wet.
- Do not use this product near inflammable gasses or liquids.
- When unplugging the adapter do not pull from receptacle by the wire.
- Do not continue to use this unit if it becomes damaged in any way.
- **Disconnect battery charger before use.**
- **This equipment is not designed or intended for use on humans.**

3. Caution

- Do not use if the AC adapter cord is damaged
- Be sure the unit is properly ventilated. Do not cover during operation.
- Unplug the AC adapter when cleaning this unit or when product is not in use or being charged.
- When using the AC adapter be sure to insert the plug securely into the outlet.
- Clean only with a damp cloth and mild detergent. Do not use chemical solvents or abrasives.
- Keep loose metal or bare wire away from the unit while in operation in order to prevent a short circuit.
- As with any electrical product use common sense and reasonable safety precautions to assure safe, satisfactory operation and long instrument life.
- Length of output leads should not exceed 3 meters (10 feet).

Problem — Battery duty cycle seems too short even after a full charge, or Battery Indicator turns yellow shortly after a full charge.

Possible Solution — The battery pack may have reached the end of its useful life span. The A360LA must be returned to WPI for battery replacement. Please see the warranty section of this manual for item return notes, address and phone numbers.

10. Specifications

Input Triggering	Momentary switch, DC or externally generated current pulse (TTL)
External Command Voltage	3.5V minimum at 2.6 mA. (8.5V max. DC)
Output Current Ranges	10 mA, 1.0 mA and 100 μ A
Current Amplitude Error	0.5% of full scale, maximum; 1.0% linearity over full scale
Current Resolution/Repeatability	0.1% of full scale, typically
Minimum Current Ranges	10 mA Range = 0.1 mA, 1 mA Range = 10 μ A, 100 μ A Range = 1 μ A
Maximum Tissue Resistance	10 mA Range = 12 K Ω , 1 mA Range = 120 K Ω , 100 μ A Range = 1.2 M Ω
Output Voltage (Compliance)	100 V min. Typically 130 V.
Output Polarity	Positive or negative, reversible, switch-selectable
Current Rise Time	2 μ s, typically (1 K Ω load), 5 μ s @ 10 K Ω
Current Fall Time	5 μ s, typically (1 K Ω load), 8 μ s @ 10 K Ω
Maximum Input Frequency	50 KHz (20 μ s) @1K Ω ; 30KHz @ 10K Ω
Impedance, Output to Ground	10 ¹² Ω shunted by < 12pF
Current Leakage (maximum)	\pm 10 nA \pm 0.01% of full scale
Output Noise (maximum)	<0.1 μ A RMS (10 mA), <50 nA (1 mA), range independent
Isolation	Optocoupler, minimum breakdown voltage 2500 Volts AC
Power	Two 6V 1.2 Ahr sealed lead acid batteries
Charge Time	4 hours, typical
Charger	Universal AC input (100-240 VAC, 50-60 Hz), included
Operation Time on Full Charge	24 hours at 10 mA output at 10% duty cycle, 48 hours at idle (zero output)
Dimensions	4.5 x 3.5 x 5.5in. (11 x 9 x 14 cm)
Weight	4 lb (1.8 Kg)

and fall time of the stimulus pulse. Conversely, lower impedance keeps rise and fall time of the pulse to a minimum thus the pulse profile becomes sharp. An increase in resistance or impedance of the electrode will become more apparent as the pulse frequency increases. This is due to the product of capacitance X resistance/impedance of the total circuit. In certain applications the choice of the electrode is limited by its nature. For example when deep insertion is employed. In such cases the user may have to compensate for electrode resistance or impedance, especially when the pulse repetition rate is high (above 4KHz).

Whenever possible, the user should choose a low impedance electrode, especially if the pulse rate is going to be high.

Isolators will have their own inherent limitations on DC resistance and the AC effects of rise and fall times.

Electrolysis: Electrolysis can occur in any electrolytic solution where ionic breakdown has occurred. In a stimulus application, electrolysis generally occurs when the tissue is incorrectly attached electrically. This is almost always an indication of improperly connected electrodes or excessive tissue resistance. Electricity will take the path of least resistance and if the current is flowing through the solution, usually a very high resistance and beyond the capacity of the isolator to control the current flow. The isolator will put out the highest voltage available and effluent will appear at the electrode tips. Tissue resistances beyond the limits detailed in the specifications, will usually result in some degree of electrolysis and the compliance alarm will sound.

Leakage: Two immediate forms of isolator leakage are apparent, one is from the device's circuitry and the other is from "pickup" on the leads leading to the tissue or target. Lead pickup is sometimes mistaken for the actual current / voltage leakage of the isolator. See the notes below on EM suppression. The stimulus isolator leakage can be minimized by setting the output device to a low output threshold or by counterbalancing it with an offset voltage.

EM (electromagnetic) interference: Electromagnetic noise (EM) is found everywhere and is the bane of researchers making electrical measurements worldwide. For EM reduction in stimulation, the user should keep the leads (wires) as short as possible (this will also reduce pickup "leakage" in the leads). Keeping the experiment in a well grounded faraday cage and practicing good laboratory grounding techniques can also help keep the EM noise to a minimum. In some cases, the sources of the EM radiation will need to be eliminated or suppressed, if it cannot be moved farther away from the experiment. Fluorescent lights, transformers and power supplies are known sources of 50/60 Hz, while "switching" power supplies can generate radiation anywhere from below 1 Hz to 300 KHz and above. Computers have a larger EM noise signature that can affect things in the MHz range and beyond. Local AM radio stations, wristwatches, cell phones, pagers have been known to interfere with research environments. Even a simple static charge on a researchers hand can saturate a high impedance amplifier. In some cases special RF (radio frequency) traps are need to be used for some EM suppression. Electronic compliance's like CE are suitable for general-purpose EM radiation standards. Research tools that approach or exceed the picoamp and microvolt ranges need greater isolation and exceptional care.

4. Controls

POWER ON/OFF

The on-off switch connects/disconnects power from the battery pack to the A360LA Stimulus Isolator. The charger connector at the rear of the unit is disconnected when the power switch is turned on. Batteries will not charge if the adapter is connected to the unit and the power switch is turned on.

Notes:

! Disconnect the adapter from the instrument while in use so as to insure electrical isolation from ground.

! Turning the power "ON" or "OFF" while the polarity switch is not in the "OFF" position can cause an artifact to be delivered. To avoid this place the polarity switch in the "OFF" position before powering the isolator or connecting the electrodes.

! Turn power switch off when the instrument is not in use so as to preserve battery power.

DC/TEST

DC current can be manually activated by moving the DC/Test switch to either "ON" or "MOM" (momentary). With the AUDIO switch in the "ON" position, moving the DC/Test switch to either "ON" or "MOM", will result in an audible tone if the battery supply voltage is adequate.

INPUT

An external command voltage of more than 2.4 volts or a Transistor-Transistor Logic (TTL) compliant pulse applied to this BNC connector will result in current flow from the OUTPUT terminal. **Note: Do not apply a continuous DC input voltage greater than +8.5 volts, damage to the circuitry may result.**

AUDIO

When the audio switch is in the "ON" position, a low frequency tone will sound if DC/TEST or an external INPUT voltage is applied.

A high frequency audible signal will sound, independently of the AUDIO switch selector if the output exceeds the compliance voltage of the instrument (100V). This is referred to as the compliance alarm. This signal indicates that the isolator cannot supply the desired current for the resistance across the output terminals. The compliance alarm tone will override the AUDIO tone.

Note: The compliance alarm tone cannot be disabled.



RANGE

This selector switch selects the maximum current, 10, 1 or 0.1 milliamperes that can be delivered from the OUTPUT terminals.

POLARITY

The polarity-reversing switch sets the positive pole to either the black output terminal or the red output terminal. When set to the off position, the terminals are disconnected from the internal circuit.

Note: The Polarity switch must be in the "OFF" position to eliminate power cycling artifacts.

% OF RANGE

The dial reading indicates current amplitude as a percentage of the selected current range that is set with the RANGE switch.

The percent of range is set by a multi-turn precision potentiometer with a readable dial that displays the potentiometer setting as a number between 000 and 999. Thus the dial displays percent of range, 000 being 0% and 999 being 99.9%. A locking mechanism found below the percentage dial will hold the selected setting. RANGE is indicated by the position of the RANGE switch.

For example; a dial setting of 75.0 on the % OF RANGE control and a setting of 10mA on the RANGE control will set the A360LA to deliver a current of 7.5 milliamperes.

Output Connectors

Caution: Voltage at the output connectors can exceed 100 volts. Although current is limited, an unpleasant shock can be delivered.

The output connectors will accept either standard banana plugs or plain wires. The polarity of the output current is determined by the position of the Polarity Switch, (see above). It is recommended that the red connector be connected to the stimulus electrode and the black connector be connected to the bulk or reference electrode.

If external monitoring equipment (oscilloscope, data recorder, etc.) is connected to the A360LA output, the ground or common lead of the equipment should be connected to the black output connector of the A360LA.

Instrument Case

The instrument case is not electrically connected to the isolator circuit. In some instances, the user may wish to connect the case to ground by attaching a ground wire to the chassis connector on the rear panel.

7. Maintenance and Care

The A360LA Stimulus Isolator requires little maintenance. With proper care, it will afford users an extended and trouble-free period of service.

Normal Care Procedures:

- Keep batteries sufficiently charged.
- Do not store unit with a discharged battery pack for extended periods of time as this will result in shortened battery life.
- Keep the case clean, use only damp cloth and mild detergent if necessary. Do not use chemicals or abrasives.
- Should battery replacement become necessary, contact WPI for instructions (see company contact information on back cover).
- Before each use, inspect power cables from the adaptor to the A360LA. Also check the condition of the lead terminals and be sure there is no evidence of liquid intrusion or battery leakage.
- Do not expose the unit to corrosives or extreme operating temperatures.
- Do not disassemble the device. There are no user-serviceable parts inside this unit.

8. Modifications

The A360LA can be modified to deliver a lower current range of 0 to 1 μ A. This allows a resolution of approximately 10 nA. This special modification requires the A360LA to be returned to WPI for refitting. The A360LA cannot be modified to produce currents higher than 10 mA.

The volume of the audible tone produced by the A360LA can be specified at time of ordering the device. Thereafter the volume can be adjusted. This modification also requires the A360LA to be returned to WPI for adjustment.

9. Troubleshooting the A360LA

Problem — Erratic or inconsistent output currents.

Possible Solution — Be sure the electrodes are securely connected and that the battery is sufficiently charged.

Problem — Inconsistent Current Flow. This can result from a number of causes. Some of the most common causes are addressed here.

Possible Solutions —

Electrodes: The best choice of electrodes to use for stimulation can vary with application. The most commonly employed electrode characteristics include a low resistance (DC), low impedance (AC) electrochemically reversible metal electrode. Low resistance reduces heat build up within the electrode. Heat build up can increase impedance or resistance, which reduces the current flow needed to stimulate the tissue, and will increase the rise

Notes on Electrolysis

Electrolysis can be minimized by maintaining low electrode current density. This can be accomplished by the utilization of larger electrode surface area and/or lower current. (Also see Section 9 on Troubleshooting for additional information on Electrolysis).

6. Quick Instrument Tests

Equipment required for tests: A set of precision resistors such as **DRL** and a precision Digital Voltmeter (DVM) that has recent calibration.

Output and Range Testing: Measure the exact resistance of the test resistors. Place a 1 K 0.1% resistor across the output terminals and the test leads of the voltmeter. Set the range to 1 mA and range percentage to 50.0%. Turn the power switch on, audio on, polarity to positive. When the momentary switch is activated a low tone will be heard and the DVM will read 0.50 volts (1000 ohms * 0.000 5A = 0.50 V). On the 100 µA scale the voltage will be 0.050 V and on the 10 mA scale the voltage will be 5.00 V.

Resistor	100 ohm	1000 ohm	10,000 ohm
10mA scale 50%	0.50 V ± 0.0025 V	5.00 V ± 0.025 V	50.0 V ± 0.25 V
1mA scale 50%	0.05 V ± 0.00025 V	0.50 V ± 0.0025 V	5.00 V ± 0.025 V
100µA scale 50%	0.005 V ± 0.000025 V	0.05 V ± 0.00025 V	0.50 V ± 0.0025 V

Audio tests: Toggle the audio switch to off while the momentary switch is on and the tone will stop. With the momentary switch on, remove the resistor pack and the compliance alarm will sound, indicating that the compliance voltage has been reached and the set current is no longer flowing. **Warning: A high voltage of 125 V or more is present across the terminals.**

Waveform, an Example

To view brief pulses of current on an oscilloscope it is first necessary to convert the current to a voltage. Connect a resistor of 1K Ohm across the OUTPUT terminals. Connect the two OUTPUT terminals to the input of an oscilloscope. Oscilloscope settings: 20 mV per cm, vertical sensitivity, DC coupled and 1 millisecond per cm sweep speed. Using a WPI stimulator or any convenient pulse generator, apply a series of 1 millisecond pulses of +5 volt amplitude at a frequency of 200 Hz to the input of the A360LA. Set the controls as follows: DC/TEST to OFF, RANGE to 1 mA, AUDIO to OFF, POLARITY to RED +. Dial % OF RANGE to 10.0 (10% of 1 mA = 0.1 mA) and turn the POWER switch to ON. When the oscilloscope is synchronized, a series of 100 mV pulses (5 cm on the scope) should be observed. Note the shape and speed of the rising and falling edges. They should be fast and smooth. The true speed of a current pulse generator can be best seen using low values of shunt resistance, as in the example discussed above. As the load resistance increases to 10 K Ohms and larger, the effect of shunt capacity will be to slow the rising and falling edges of the resultant voltage waveform.

5. Operation

Note: For longest overall battery life it is recommended that the battery pack be charged for 6 hours prior to initial use. Thereafter, it will take approximately 6 hours to fully recharge a completely discharged battery pack. For more detailed information see "Battery Charging" section on page 6.

Important Information for the Proper Use and Care of the Batteries

Storing the unit for extended periods of time with a discharged battery pack will effectively shorten overall battery life. Place the A360LA on charge periodically to preserve battery life.

The battery charging circuit prevents overcharging. Leaving the unit on charge for more than 6 hours will not harm the batteries; however, leaving batteries on charge for extended period of times is not recommended.

The batteries that power the A360LA are a sealed lead acid type designed not to leak and to render a long, trouble free service life. Though very rare, some severe operating conditions may adversely affect the battery pack. If for any reason you suspect the integrity of the battery pack has been compromised, take all due precautions so as to prevent any consequential damage. Discontinue use of the instrument, securely pack the unit and return to WPI as soon as possible for inspection and any necessary repairs.

(See section 7, page 9 for additional battery care information.)

Expected Battery Life

The battery pack in the A360LA has a capacity of 2.4 Ampere-hours. With a full charge, and assuming a 10% duty cycle (stimulation on for 10%, off for 90% while power switch is in "ON" position), the A360LA should operate for about 20 hours at 10mA output and about 40 hours at 1 mA before recharging is necessary. Typically, actual duty cycles are much less than 10%. At a duty cycle of 1%, the A360LA will operate for about 40 hours regardless of the output current.

The sealed lead acid batteries supplied with the A360LA can be expected to perform adequately for five years or more. Should replacement be necessary, see Maintenance, page 7.

Battery Status Indicator

The battery status indicator located at the top left corner of the front panel will emit light in one of three different colors while the A360LA is operating.

A **green** light indicates that the battery has at least 50% capacity. The light will change to **yellow** when battery capacity drops below 50%, and will change to **red** when remaining capacity drops below 20%. If the battery becomes completely exhausted the indicator light will not illuminate.

The indicator will flash at a slow rate to indicate batteries are being charged. (Also see the trouble shooting section of this manual.)

For longest battery service life, recharge the battery when the indicator light begins to glow yellow.

Charging the Batteries

An AC adapter is included with each A360LA and is used to charge the battery pack. The adapter will operate from a line voltage between 100 and 240 volts AC.

Depending on your location and the configuration of your mains receptacle, the connector assembly may require changing. Select the proper connector assembly; slide the existing connector assembly off of the adapter unit and slide the proper connector into place. Plug the charger into an outlet and connect the charger output cable to the "CHARGER" input jack on the rear of the A360LA.

The "POWER" switch must be in the OFF position for charging to take place. The battery status indicator on the front of the unit will flash at a slow rate to indicate charging is in progress.

The batteries can be recharged at any time, and leaving the charger connected will not harm the batteries. Leaving the charger connected for extended periods of time, however, is not recommended. When the A360LA will not be used for an extended period of time, disconnect the charger adapter from the instrument and remove from the mains receptacle. This helps protect the instrument from damage resulting from power surges and/or lightning strikes.

The Charging Adapter

The charging adapter does not run the A360LA stimulus isolator. When the power switch on the A360LA is toggled to the "ON" position, the charging adapter is disconnected from the internal circuitry, and the A360LA becomes dependent on the battery pack for its power.

It is recommended that the adapter be disconnected from the A360LA when the power switch is in the "ON" position so as to insure proper stimulus isolation and to eliminate stimulus artifacts from the AC power source.

The charging adapter supplied has interchangeable receptacle or mains adapters. The receptacle adapters are replaced by depressing the release button and sliding the plug adapter off the adapter head. Slide the selected plug adapter onto the charge adapter head until a definite click is felt.

The receptacle adapters allow charging the A360LA while located within the United States or abroad. The charging adapter will operate utilizing 100 volt AC or 240 volt AC, from 47 to 63 Hz.

Current

This instrument is a precise source of current. Operating times are controlled by voltage command pulses generated externally or by manual operation of the DC/TEST switch. The A360LA Stimulus Isolator will accurately dispense current from the OUTPUT terminals. The selected current RANGE and the setting of the % OF RANGE digital indicator dial determine the output current amplitude.

The user can verify the accuracy of the setting on the % OF RANGE dial by connecting a milliampmeter in line (series) with the OUTPUT connector and the test subject and manually toggling the DC/TEST switch. The direction of current flow is determined by which OUTPUT connector has been designated as the anode, *i.e.*, RED + or BLACK + on the POLARITY switch.

AUDIO monitoring of the applied stimulus can be switched ON or OFF at the user's option.

Current amplitude is "constant," that is, current amplitude is load resistance independent, provided that the $I \times R$ (load) product does not exceed the available compliance voltage. (See Specifications for these limits.)

An audible alarm (the compliance alarm) will always sound, independent of the AUDIO switch, if $I \times R$ exceeds the compliance voltage. Thus, the user can be sure that the amplitude of the current will be as dialed unless the compliance alarm is heard. The user then will know that (a) too much current has been dialed for a given load or (b) inter-electrode resistance is too high or the electrode circuit is path open.

Voltage

A360LA can be used as a precise voltage source by placing a precision resistor load across the OUTPUT terminals.

Precision resistors such as 100, 1000 and 10,000 Ohms when placed across the OUTPUT terminals convert the precision current levels to accurate voltage levels by ohms law. For example, 1 milliamperes flowing through 1000 Ohms will produce 1 volt across the OUTPUT terminal pair. Thus, the A360LA can be used as a low noise source of accurate DC voltage pulses.

To maintain less than 1% error the user must avoid shunting the OUTPUT resistor with a load resistance less than 100 times the resistance value. A Resistor Load Kit (WPI order # **DRL**) is available from WPI and allows users to conveniently create and view voltage waveforms. A precision voltmeter should be used in conjunction with the circuit to make minor adjustments, due to resistance tolerances

Stimulation

A360LA can produce high voltage at the OUTPUT terminals. Take care to avoid accidental electrical shock to the user or to the subject.

DANGER: Misuse of this device can result in injury or death. Follow all precautions and instructions carefully to avoid hazardous conditions.

Always toggle the POLARITY switch to OFF while connecting electrodes and to prevent stimulation artifacts. The maximum current the A360LA is designed to deliver is 10 milliamperes. For most experiments, this is more than adequate. A360LA can apply as much as 140 volts to the electrodes. Large electrodes and proper preparation as well as the use of brief pulses will minimize power dissipation and avoid the possibility of tissue burning. In virtually all stimulation methods, current flows across a metal/fluid electrolyte interface.

Electrode polarization and possible electrolysis of the fluid can occur as a consequence of this stimulation interface. The use of a "constant current" source with a high voltage range can tolerate the changing electrode resistance caused by electrode polarization and still maintain the proper current amplitude.

Noise Reduction

Attaching a shield to the chassis banana connector can reduce 60-50 Hz noise. The rear banana connector is isolated from the instrument outputs and can be connected to ground, earth or a Faraday cage.