MicroProbes
for Life Science

Model BSI-1A
BIPHASIC STIMULUS ISOLATOR

Owner Manual

- OUTPUT WAVEFORM FOLLOWS INPUT (LINEAR)
- CONSTANT CURRENT AND CONSTANT VOLTAGE MODES
- PLUS AND MINUS 125 VOLTS COMPLIANCE
- BATTERY OPERATED
- GALVANICALLY ISOLATED

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Introduction

The Model BSI-1A Biphasic Stimulus Isolator is battery powered and users optimum packaging design to provide maximum isolation of stimulus signals. This instrument is a truly linear device which will convert any waveform from 0 to +/- 10 volts into a constant current or constant voltage stimulus. It has a constant current range from ±100 nanoamps to ±10 milliamps with a compliance voltage of up to ±125 volts and a constant voltage range between 0 and +125 volts. A four position front panel range switch allows optimum resolution for selecting precise stimulus amplitudes.

A calibrated front panel control knob allows the investigator to apply input signal levels which can then be attenuated to give continuously adjustable output levels. A separate output jack is provided for monitoring current levels through the electrode so that no connection need be made across the electrode which could interrupt the stimulus current path.
The Model BSI-1A is a completely self-contained portable instrument with adjustable handle for convenient placement near the preparation.

Description

The Model BSI-1A is a truly linear biphasic isolated stimulator and therefore, will accept any bipolar signal requiring no additional equipment for isolation. Any stimulus waveform can be isolated such as a sinewave, square wave, ramp, pulses, etc. The Model BSI-1A can produce either a constant current or constant voltage stimulus with continuous control of output level of between +100 nA to +10 mA and 0 to +125 volts respectively.

The output amplifier is short circuit protected, therefore output over loads or shorts will not damage the instrument. The unit utilizes standard battery types which can be purchased from most electronic wholesalers. Battery test jacks are provided on the rear panel for easy battery voltage check.

Installation

This instrument was thoroughly inspected both mechanically and electrically before leaving the factory. Please check for physical damage which may have occurred during shipment and file a report with the carrier if any damage is found.

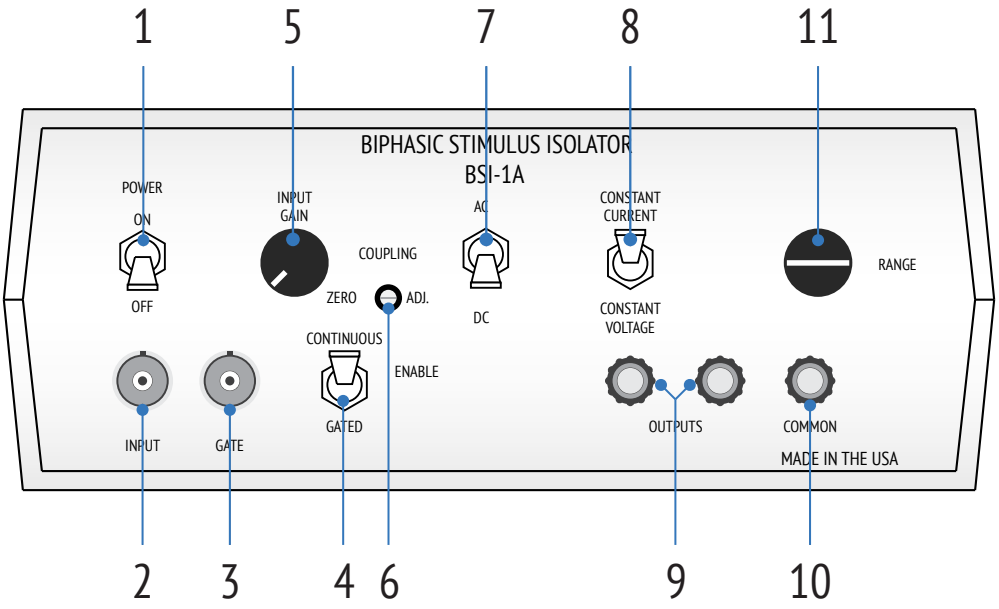
The power requirements for the Model BSI-1A are provided by 6 Ultralife 9 Volt Lithium batteries. Before using, ensure all voltages appear at the appropriate test jack at the rear of the instrument. Care has been taken to isolate the input circuitry from the output isolation stage and therefore, unless absolutely necessary, the output should not be grounded in order to maintain isolation to the preparation or subject.

Specifications

Constant Current	±100 nA to ±10 mA
Constant Voltage	0 to ±125 volts
Input Impedance	10 kOhms
Linearity	1% (input/output)
Noise	<0.5% of full output range
Compliance Voltage in Constant Current Mode	±125 volts
Maximum Output Current in Constant Voltage Mode	±25 mA
Isolation	Coupled through 1pF capacitor
Output to Ground Impedance	10^{11} ohms Shunted by 10 pf
Output Impedance	<0.05 ohms for loads up to ± 10 ma
Input Voltage Range	0 to ±10 volts (will accept any waveform)
Range Adjust	4 position switch and calibrated input attenuator knob (0-1.0)
Rise Time	2 microseconds with 1 MΩ source impedance
Slew Rate	5 volts per microsecond
Current Monitor Output	1 mV/uA
Power Supply	(4) 9 volt lithium batteries (Ultralife #U9VL) (life expectancy greater than 100 hours) (6) 3.6Volt C-cells

The BSI-1A is a linear output device and as such, it uses more current than pulse type output devices. The output amplifier stage draws 2.2 milliamps even when no signal is applied. This means that the high voltage batteries will operate for 81 hours continuously with no signal.
BE SURE TO SWITCH THE UNIT OFF WHEN NOT IN USE

Control Layout



1. On/Off switch
2. Input BNC
3. Gate pulse input BNC
4. Continuous, Enable or Gated Input Signal control Switch
5. Input Signal Attenuator control knob
6. Input DC offset adjustment
7. Input AC or DC Coupling Switch
8. Select Constant Current or Constant Voltage Output Switch
9. Output Signal Banana Jacks
10. Constant Voltage or Constant Current Monitor Output Banana Jack
11. Constant Voltage and Constant Current Output Range Switch

Introduction

Although the operation of the Model BSI-1A is straightforward, it is important to understand the controls, input and output requirements and limitations.

Battery Power (On/off Switch)

The full complement of batteries should last a minimum of 100 hours of operation. If at any time during stimulation the proper response is not observed during stimulation, the batteries should be checked. The instrument will operate normally when the batteries are within 75% of maximum rated value, although the output voltage compliance range may be slightly reduced.

All the battery clips are polarized; therefore, one should not experience any difficulty in assuring proper battery hook-up. To replace batteries lift each of the battery drawers with a thumb or fingernail and pull the drawer outward and fully out of the unit. While holder the battery drawer in on hand, press the battery towards the spring and lift it from the drawer. Install a new battery into each of the four battery drawers.

Input Signal

The input signal can be an analog or digital signal not greater than ±15 volts in amplitude. The input BNC connector is isolated from the output circuitry and is referred only to the input amplifiers and their power sources.

Input Attenuator

The calibrated INPUT GAIN knob allows the investigator to apply a signal of known amplitude and attenuate it from one down to zero. This feature is especially helpful if one wishes to drive the Model BSI-1A directly from a computer or other constant voltage source. The output current or voltage level for any attenuator setting would be, of course, a percentage of the range switch position. It is scaled from "0" to "1" with indicating marks in steps of "0.1".

D.C. Offset Test

Before connecting the output of the stimulator to an electrode, we recommend that the output D.C. level be checked with either a volt meter or oscilloscope to ensure a zero output. Zero D.C. output is especially important when stimulating in the constant current mode with high impedance electrodes, since very small currents can achieve fairly large voltage drops and in some cases, cause bubbling due to gas evolution. If an unacceptable DC output level is measured, using a jeweler screwdriver, turn the small plastic adjustment screw on the front panel.

A.C./Direct Operation Control

In the event of a circuit failure, the BSI-1A could deliver continuous net DC current. This could cause damage to electrodes and tissue by electrolysis and corrosion. To eliminate spurious net DC current passage as a result of DC biasing of the applied control signal or internal offsets not completely zeroed, set this switch in the AC position. Note that this AC couples the isolated control signal to the final output stage, not to the electrodes themselves. No bleed resistor is necessary.

Stimulus Mode Control

The stimulus mode control switch allows the Model BSI-1A to operate either as a constant current or a constant voltage stimulator by the appropriate positioning of this switch. In either mode the voltage or current will remain constant regardless of changes in electrode resistance. However, in the constant current mode one must realize the limitations with regard to the ±125 volts compliance i.e. the current should be less than V compliance voltage divided by the electrode's resistance.

$$I_{out} < \frac{V_{compliance}}{R_{electrode}}$$

Range Switch

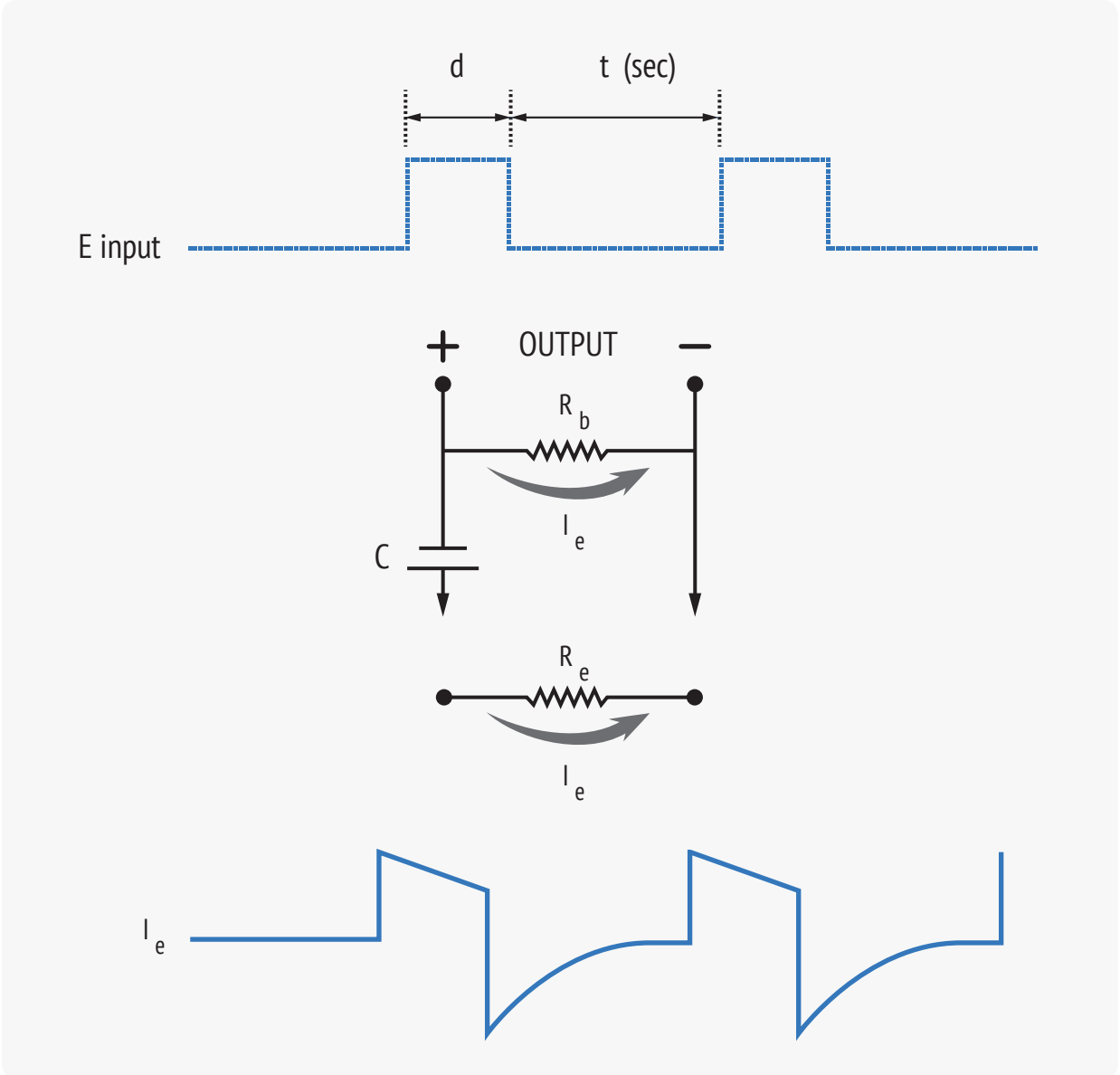
The four position range switch selects a proportional output level with respect to the input amplitude. The following table shows the ranges for each setting for constant current and constant voltage mode with the RANGE ATTENUATOR turned off.

CONSTANT VOLTAGE	
Output/Input Ratio	Range
.1 volt/volt	0 - +1 volt
1. volt/volt	0 - +10 volt
10 volt/volt	0 - +100 volt
100 volt/volt	0 - +1 max

CONSTANT CURRENT	
Output/Input Ratio	Range
1 uA/volt	0 - ±0.01 mA
10 uA/volt	0 - ±0.1 mA
100 uA/volt	0 - ±1 mA
1000 uA/volt	0 - ±10 mA

Sometimes only a monophasic input signal is available but a reasonably symmetrical biphasic output is desired to minimize electrode polarization artefact. This can be approached by capacitively coupling the output itself using a capacitor in series with the electrode. When in constant current mode, a bleed resistor across the output as shown in the figure below, is also required. The equations given will allow you to calculate the appropriate values. Note that for some conditions (long pulse duration and short interpulse interval), no combination of values is possible which does not seriously degrade output linearity.

Range Switch (Cont.)



$$\frac{R_b}{R_b + R_e} = \text{Output attenuation factor due to shunt current } I_b$$

$$\frac{t}{R_e + R_b} \geq C \geq \frac{d}{R_e}$$

The Range Attenuator would multiply the selected fraction times the input value, see the example below:

Input signal amplitude	+ 5 volt
Range attenuator	0.4
Range switch	10 l/volt - 1 volt/volt

The output would then be ±5 volts X 0.4 = ±2.0 volts
Therefore the output would be ±20 uA or 2 volts depending on the mode switch position.

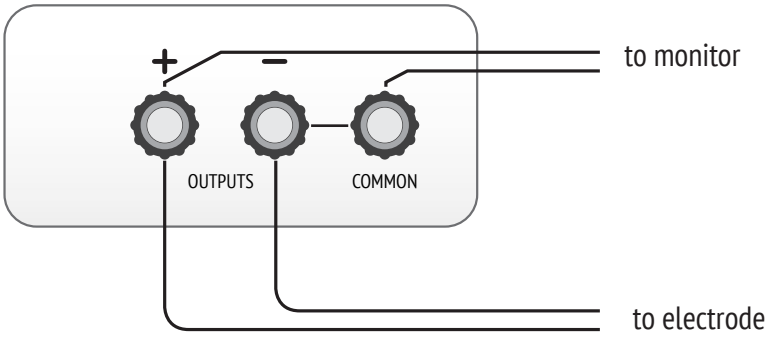
Because the noise level is 0.5% of the maximum output for any given range, it is strongly advised the lowest range possible be used initially when looking for threshold levels.

Always turn the range switch to off when connecting or disconnecting electrodes to prevent large voltage build up at the output when unloaded.

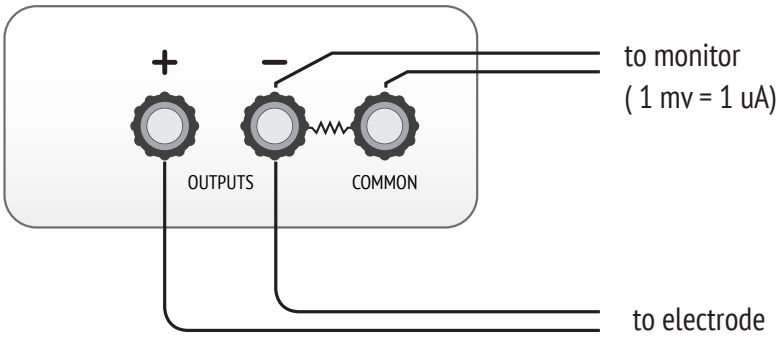
Output Connections

There are three output binding posts, a red and black pair labeled OUTPUT which are to be connected to the electrode leads, and a black one labeled COMMON for monitoring the voltage or current. The red output connector is positive and the black output connector is negative with respect to the input signal polarity. The diagrams below show the proper connections for stimulating and monitoring the two different modes of operation. Please note, however that when the stimulus is being monitored the input/output isolation may be reduced or even lost completely.

CONSTANT VOLTAGE MODE



CONSTANT CURRENT MODE



The output monitor for the constant current mode observes the voltage drop across an internal 1000 ohm shunt resistor and therefore, represents a calibration voltage of one millivolt per microamp.

When stimulating in the constant current mode, it is important to keep the electrode load wires to the stimulator as short as possible in order to reduce capacitive shutting which can distort the stimulus signal especially when using high impedance electrodes. This is especially important if microstimulation is done through metal microelectrodes.
Unless absolutely necessary it is advised that non-coaxial type cables be used in order to reduce capacitance. Stimulus signals with short duration are especially affected by capacitance since the current through the electrode will rise much more slowly than the current apparent at the monitor point, which includes the current going to change the cable capacitance.

Circuit Description

General

The Model BSI-1A was designed to handle a wide range of stimulus protocols. Since the Model BSI-1A is a linear biphasic device with a large stimulus output range with constant current and constant voltage capabilities, it may be used for stimulating three high or low impedance electrodes with any type of waveform in both the plus and minus direction. The utilization of optical coupling along with battery operation and careful circuit layout make it an ideal isolation source reducing leakage currents to a minimum.

The wide output voltage range of plus and minus 125 volts, assures constant current values for even high impedance electrodes, i.e. a 5 MOhm electrode with a constant current stimulating pulse of 20 microamps of current produces 100 volts drop. This is especially important when one is stimulating with narrow high amplitude pulses. The output amplifier has a very high slewing rate so that signal attenuation and distortion is minimized. The calibrated input attenuation knob allows one to apply a known voltage level and adjust the output stimulus level to the desired value.

Circuit Description

The newly redesigned BSI-1A uses pulse-width modulation (PWM) through a 1 picofarad capacitor with a voltage rating of 1kV. This provides the necessary isolation between the user and the specimen. Because it uses PWM, DC levels as well as the AC component of the waveform are transmitted across the galvanic barrier. High voltage (plus and minus 130 VDC) are generated from two switch mode power supplies (SMPS) that are powered from (6) 3.6-Volt C-cell batteries.

Maintenance and Calibration

Batteries

Labeled battery pin jacks are provided at the rear of the stimulator for easy checking of battery voltage levels. The 9 volt batteries must read at least 8.0 volts for proper operation.

The C-cells are in two compartments with each set powering a 130 Volt switch mode power supply (SMPS). The high voltages are present at the test points only when the system is powered on. If either of the two voltages are low, remove the C-cell batteries and test them. They should have no less than 3.4 Volts per cell. If they are below that or the test points don't show high voltage, replace them.

D.C. Offset Test

Please refer to Section **D.C. Offset Test** for proper instruction on testing the output.

Certification

Microprobes for Life Science certifies that all its instrument are tested and inspected thoroughly and found to meet all published specifications before shipment from the factory.

Warranty

All Microprobes for Life Science products are warranted against defects in materials and workmanship for one full year from the date of delivery. Products that prove to be defective during the warranty period will be repaired or replaced without charge provided they are returned to the factory. No other warranty is expressed or implied. We are not liable for consequential damages.

Service

Microprobes for Life Science will provide for servicing and calibration after the warranty period for a reasonable service charge. The instrument should be shipped to the factory postage prepaid. There is a minimum service charge of one hundred dollars ($100.00) and all instruments will be repaired, calibrated and returned promptly. Please enclose a cover letter with the instrument explaining deficiencies and identify by serial number in all correspondence pertaining to any instrument.

Contact Information

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