



**PB-503A**  
**Circuit Design Trainer**

**User Manual**

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## Symbols and Terms

The following symbols may appear on the product or in the documentation.



Caution Symbol (ISO 7000-0434) – Statements or instructions that must be consulted in order to find out the nature of the potential hazard and any actions which must be taken.

### CAUTION

A statement calling attention to an operating procedure, practice, or condition, which if not followed correctly, could result in damage to or destruction of parts or the entire product.

### WARNING

A statement calling attention to an operation procedure, practice, or condition, which if not followed correctly, could result in injury or death to personnel



Power on. This is the AC mains connect/disconnect switch on the trainer.



Power off. This is the AC mains connect/disconnect switch on the trainer.



This symbol is used to denote an AC signal



This symbol is used to denote the chassis ground



This symbol is used to denote the earth ground

## Definitions

**POLLUTION (P)** – addition of foreign matter solid, liquid or gaseous (ionized gases), that may product a reduction of dielectric strength or surface resistivity.

- Degree 2 (P2) – only non-conductive pollution occurs except that occasionally a temporary conductivity caused by condensation is expected.

**MEASUREMENT CATEGORY (CAT)** – classification of testing and measuring circuit according to the type of mains circuits to which they are intended to be connected.

- CAT II – measuring circuits connected to utilization points of the low-voltage mains installation.

## General Safety Information

To avoid personal injury and/or product damage, review and comply with the following safety precautions. These precautions apply to both operating and maintenance personnel and must be followed during all phases of operation, service, and repair of this meter. Before applying power be sure to:

- Read and understand the safety and operational information in this manual.
- Apply all the listed safety precautions.
- Verify that the voltage selector on the back of the unit is set to the correct line voltage. Operating the instrument at an incorrect line voltage will void the warranty.
- Make all connections before applying power.
- Do not operate the instrument in ways not specified by this manual or by Global Specialties.

Failure to comply with these precautions or with warnings elsewhere in this manual violates the safety standards of design, manufacture, and intended use of the instrument. Global Specialties assumes no liability for a customer's failure to comply with these requirements.

### Dry Conditions



**WARNING** Hands, shoes, floor, and work bench must be dry. Avoid making measurements with dampness, or other environmental conditions that might affect safety.

### Cleaning



**CAUTION** Use a soft cotton cloth lightly moistened with a mild solution of detergent and water. Do not allow any portion to be submerged at any time. Dry thoroughly before attempting to make measurements. Do not use solvents or expose to solvent fumes as they may cause deterioration or damage.

### Do not Operate:

- In the presence of noxious, corrosive, flammable fumes, gases, vapors, chemicals, or finely-divided particulates.
- In environments where there is a danger of any liquid being spilled on the meter.
- In air temperatures exceeding the specified operating temperatures.
- In atmospheric pressures outside the specified altitude limits or where the surrounding gas is not air.

Only for use in pollution degree 2 environments where non-conductive pollution occurs except occasionally when a temporary conductivity caused by condensation is expected.

#### Electrical Power



**CAUTION** This instrument is intended to be powered from a CATEGORY II mains power environment. The mains power should be 115 VAC or 230 VAC ( $\pm 10\%$ ) at 50/60 Hz. Use only the power cord supplied with the instrument and ensure it is appropriate for your country of use. Slide the switch on the back of the trainer to select the appropriate input making sure the correct fuse is installed. This trainer consumes less than 50 W.

#### Fuse Replacement



**WARNING** Set the power switch to the OFF or 0 position and disconnect the power cord before inspecting or replacing the fuse. Open the black fuse holder (located at the back of the trainer below the input power receptacle) with a small, flat-head screwdriver. Remove the old fuse, replace it with a new one, and reinstall the fuse holder. Use only 5 x 20 mm type T 1.5 A / 250 V or 0.75 A / 250 V Fuses.

#### Ground the Instrument



**CAUTION** To minimize shock hazard, the instrument case must be connected to an electrical safety ground. This instrument, and the chassis, is grounded through the ground conductor of the supplied, three-conductor AC power cable per IEC 60320-1. Do not alter or bypass the ground connection. Failure to use a properly-grounded approved outlet and the recommended three-conductor AC line power cable may result in injury or death. Unless otherwise stated, a ground connection on the instrument's front is for a reference of potential only and is not to be used as a safety ground.

#### Indoor Use:

This instrument is intended to be used in an indoor pollution degree 2 environment. The operating temperature range is 0 °C to 40 °C and the operating humidity range is up to 80% relative humidity with no condensation allowed. Measurement results may be outside specifications if the instrument is used in non-office-type environments. Such environments may include rapid temperature or humidity changes, sunlight, vibration and/or mechanical shocks, acoustic noise, electrical noise, strong electric

fields, or strong magnetic fields.

### Do not Operate:

*If the instrument is damaged, appears to be damaged, or if any liquid, chemical, or other material gets on or inside the instrument, remove the instrument's power cord, remove the instrument from service, label it as not to be operated, and return the instrument to Global Specialties for repair. Notify Global Specialties of the nature of any contamination of the instrument.*

### Not for Critical Applications:

*This instrument is not authorized for use in contact with the human body or for use as a component in a life-support device or system.*

### Do not Touch Live Circuits

### Do not Attempt Servicing:

**WARNING** *Instrument covers must not be removed by operating personnel. Component replacement and internal adjustments must be made by qualified service-trained maintenance personnel who are aware of the hazards involved when the instrument's covers and shields are removed.*



*Under certain conditions, even with the power cord removed, dangerous voltages may exist when the covers are removed. To avoid injuries, always disconnect the power cord from the instrument, remove all other connections (for example, test leads, probes, etc.), discharge all circuits, and verify there are no hazardous voltages present on any conductors by measurements with a properly-operating voltage-sensing device before touching any internal parts. Verify the voltage-sensing device is working properly before and after making the measurements by testing with known-operating voltage sources and test voltages. Do not attempt any service or adjustment unless another person capable of rendering first aid and resuscitation is present. Hazardous voltages may be present in unexpected locations in circuitry being tested when a fault condition in the circuit exists.*

## Use Correctly Sized Wires



**CAUTION** Use only standard 4 mm banana plugs when connecting to power supplies.

Solid core wires no larger than 20 AWG must be used for connections to the solderless breadboards.

## Compliance and Certifications

### CE Compliance

This product meets the essential requirements of the applicable European Directives as follows:

2014/30/EU: Electromagnetic Directive (EMC)

2014/35/EU: Low Voltage Directive (LVD)

Standard IEC 61010-1



2011/65/EU + AMD2015/863: Reduction of Hazardous Substances Directive (RoHS 2)

ANNEX III Exemption 6(c)

### Disposal



(Applicable in the European Union and other European countries with separate collection systems). This product is subject to Directive 2012/19/EU of the European Parliament and the Council of the European Union on waste electrical and electronic equipment (WEEE), and in jurisdictions adopting that Directive, is marked as being put on the market after August 13, 2005, and should not be disposed of as unsorted municipal waste.

Please utilize your local WEEE collection facilities in the disposition of this product.

### Introduction

*The PB-503A Circuit Design Trainer is a versatile, time-saving tool for circuit designers, engineering technicians, students, and hobbyists. A large breadboard area and a wide choice of built-in circuit accessories allow rapid and accurate construction of virtually any type of analog or digital circuit.*

*Circuit power is provided by three power supplies, two variable and one fixed. The circuit breadboard area includes over 2500 contact points. A multiple-waveform digital function generator supplies sine, triangle, and square wave output for analog circuits. A built-in speaker may be used for analog output.*

*Outputs also include a TTL-level square wave generator, two debounced pushbutton switches, and a bank of eight logic switches. Eight logic indicators may be used to display high and low logic levels. Two built-in potentiometers and two SPDT switches are provided for circuit control and adjustment. Connections to external test equipment or signal sources may be made using the two BNC connectors on the front panel.*

*The PB-503A eliminates the clutter and confusion that often results when constructing sophisticated circuits. Alligator clips and similar connectors are seldom needed. Solderless breadboards on the PB-503A allow insertion of components or wires of up to 20 gauge.*

*A detailed panel layout and description of the PB-503A is given in the section "Description of Individual Features".*

### Features & Applications

*The PB-503A Circuit Design Trainer is a robust electronics trainer suitable for all levels of electronics instruction and design. Utilizing the PB-503A, students will learn valuable hands-on breadboarding techniques and build a solid foundation in circuit experimentation, construction and analysis. Experienced designers will find the PB-503A an invaluable instrument, providing a reliable platform for the most advanced and demanding design applications. The PB-503A can be used to construct basic series and parallel circuits to the most complicated multi-stage microcomputer circuits, incorporating the latest in industrial technology. Use the PB-503A to construct a wide variety of experiments, including but not limited to:*

- Opto-Device Circuits
- Clocks
- Multivibrators



- Oscillator Circuits
- Timers
- Function Generator Circuits
- Logic Circuits
- Gates
- Counters
- Flip-Flops
- Analog-to-Digital Converters
- Digital-to-Analog Converters
- Medium Scale Integration Circuits
- Phase Lock Loops
- Operational Amplifiers

## Courseware

Courseware is available separately through our website or as part of the PB-503ALAB package. The PB-503ALAB package offers comprehensive course instruction covering the following areas:

<b>Electronic Fundamentals</b>	<b>Digital Electronics</b>
Fundamentals of Electricity	Number Systems & Codes
Ohm's Law	Binary, Decimal, Hexadecimal, Octal & ASCII
Series Circuits	Logic Gates & Boolean Algebra
Parallel Circuits	Combinational Logic Circuits
Combinational Circuits	Flip-Flops
Current Control	Digital Arithmetic
Closed, open, shorts	Counters & Registers
Switches	Integrated Circuit Logic Families

Thevenin's Theorem	TTL Logic
Wheatstone Bridge	MOSFETS
Capacitors	CMOS
Inductors	Interfacing CMOS & TTL
Phase Shift Circuits	Medium Scale Integration
Impedance	Decoders
Resonant Circuits	Encoders
Transformers	Data Conversion & Acquisition
Rectifiers & Filtering	Microcomputer Concepts
Integrated Circuits	
Transistor Amplifiers	
Oscillators	
Power Control Circuits	

## Description of Individual Features

In order to properly use the full capabilities of the PB-503A, it is highly recommended that the user become familiar with the panel layout and the features of the components. See Figure 1.

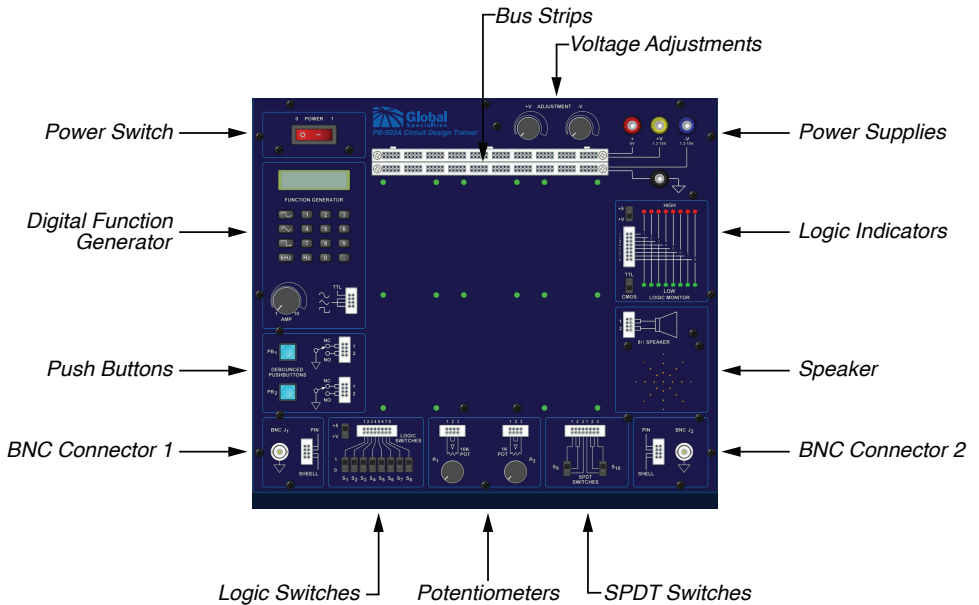


Figure 1 PB-503A Components

## AC Line Input

The PB-503A can run off of 115 or 230 VAC. The unit comes standard with a 250 V / 1.5 A type T fuse for the 115 VAC setting. In order to use with 230 VAC, please slide the switch on back to 230 V and replace the fuse with a 250 V / 0.75 A type T fuse.

### Power Supplies

By combining the three DC power supplies on the PB-503A, the user may work with virtually any type of integrated circuit or discrete component. The fixed 5 V / 1A supply has become an industry standard for powering digital IC's. Integrated circuits which require +5 V, +12 V, and -5 V are easily accommodated by the PB-503A. The variable supply output voltages may be changed by adjusting the knobs at the top on the front panel. The positive and negative outputs are variable from +1.3 at 150 mA to +15 V 500 mA and -1.3 at 150 mA to -15 V at 500 mA. Both variable supply outputs are referenced to circuit common. This creates a split supply which is often used with differential and operational amplifiers (op amps).

### Digital Function Generator

The multi-waveform digital function generator provides continuously variable frequency signals from 0.1 Hz (for extra-low frequency work) to radio frequency signals of 100 kHz. The frequency is selected in two ranges, with a LED screen to easily view the current settings. The generator can be set in increments of 0.1 Hz or 0.1 kHz in their respective ranges as desired. The sine wave output is factory adjusted for minimum distortion. The triangle waveform is adjusted for best linearity. The standard square wave and TTL level outputs are both set at a 50% duty cycle. The low output impedance of the sine, square, and triangle waveforms (600  $\Omega$ ) assures maximum coupling of the output signal to the device being driven. All outputs can withstand a continuous short circuit to ground. The signal amplitude can be adjusted from 0 to 20 Vpp with an open circuit and 0 to 10 Vpp with a 600  $\Omega$  load.

### Logic Indicators

Sixteen LEDs, eight red and eight green, make up eight Logic Indicators that will display logic high and low conditions based on either TTL or CMOS thresholds, selectable by the user. Operating voltage can also be selected by the user to be either at +5 V, or +1.3 V to 15 V at the setting of the +V supply. This selection should be the same as the operating circuitry that is to be monitored. The red LEDs will light when the voltages at the inputs are 2.2 V or higher when in the TTL position, or 70% of the operating voltage or higher when in the CMOS position. The green LEDs will light when the voltages at the inputs are 0.8 V or less when in the TTL position, or 30% of the operating voltage or less when in the CMOS position. An unconnected input, or an input not at a valid logic level, will cause both LEDs to be off. Note that the thresholds determined by the TTL positions are only accurate when the +5 volt range is selected. The 100 k $\Omega$  input impedance ensures minimal loading effects of the circuit under test.

### *Debounced Pushbuttons (Pulsers)*

*The PB-503A uses clocked flip-flops to provide debounced pushbutton switch functions. The pushbutton circuitry has open-collector outputs which can sink up to 250 mA each. This type of debouncing gives the user a sharp, glitch-free trigger source which assures reliable operation in digital circuits. Each pushbutton has a normally-open and a normally-closed output. If necessary, a pull-up resistor can connect any pulser output to any of the positive voltage sources.*

### *Potentiometers*

*Two potentiometers are provided on the trainer. The resistance values chosen (1 k $\Omega$  and 10 k $\Omega$ ) may be used in common circuit applications such as volume controls, DC offset controls for op amps, and timing circuit controls. All leads for both potentiometers are available and uncommitted.*

### *BNC Connectors*

*The PB-503A may be connected to other pieces of equipment via two BNC connectors. This allows the use of shielded cable to minimize noise and interference.*

### *Switches*

*Two single pole, double throw (SPDT) switches are provided for general switching functions. All leads are available and clearly marked on the PB-503A for easy connection. Eight switches are configured as Logic Switches to provide a convenient source of digital outputs. These switches will provide logic levels of zero V (ground) for a logic low, and logic high levels of either +5 V or +1.3 to +15 V at the voltage setting of the +V supply. The high level is determined by the setting of the +5/+V switch. This arrangement makes connecting special digital circuitry such as an eight-bit input port quick and easy, and allows compatibility with virtually any logic family.*



**CAUTION** *Integrated circuits can be destroyed if a voltage is applied to their inputs that is higher than the operating voltage of the ICs. Always insure that the setting of the +5/+V high-level switch is in the correct position before making connections to any device.*

## Specifications

All specifications apply to the unit after a temperature stabilization time of 20 minutes over an ambient range of  $20^{\circ}\text{C} \pm 5^{\circ}\text{C}$

Description	Specification
AC Line Input	115 VAC @ 60Hz or 230 VAC @ 50 Hz (switchable)
Power Supplies	<p><i>Fixed DC:</i> +5 VDC 1.0 A max, current limited Ripple <math>&lt; \pm 5</math> mV</p> <p><i>Variable DC:</i> +1.3 VDC <math>\pm 0.05</math> V @ 150 mA to +15 VDC @ 500 mA Ripple <math>&lt; \pm 5</math> mV</p> <p><i>Variable DC:</i> -1.3 VDC <math>\pm 0.05</math> V @ 150 mA to -15 VDC @ 500mA Ripple <math>&lt; \pm 5</math> mV</p>
Binding Posts	(4) Ground, +5VDC, Variable $\pm$ VDC Power Supply Outputs
Pulsers	(2) Pushbutton-operated, open-collector output pulsers. Each with 1 normally-open, 1 normally-closed output. Each output can sink up to 250 mA.
Digital Function Generator	<p><i>Frequency Range:</i> 0.1 Hz to 100 kHz in two ranges <i>Output Voltage:</i> 0 to +10Vpp into 600 <math>\Omega</math> Load (20Vpp in open circuit), short circuit protected</p> <p><i>Output Impedance:</i> 600 <math>\Omega</math> except TTL</p> <p><i>Output waveforms:</i> Sine, Square, Triangle &amp; TTL</p> <p><i>Sine Wave Distortion:</i> <math>&lt; 3\%</math> @ 1 kHz typical</p> <p><i>TTL Pulse:</i> Rise &amp; fall time <math>&lt; 25</math> ns, drives 100 TTL Loads</p> <p><i>Square Wave:</i> Rise and fall times <math>&lt; 0.5</math> <math>\mu</math>s</p>
Logic Switches	<p>(8) Logic Switches select Logic High and Logic Low <i>Logic Low Level:</i> Ground</p> <p><i>Logic High Level:</i> Switchable between +5 V and the variable positive power supplies.</p>

<i>Description</i>	<i>Specification</i>
Switches	(2) Single Pull Double Throw (SPDT) - uncommitted
Logic Indicators	<p><b>LEDs:</b> 16 LEDs; (8) red to indicate logic high and (8) green to indicate logic low</p> <p><b>Logic High Threshold:</b> 2.2 V (nominal) in TTL/+5 V mode, 70% (nominal) of selected operating voltage in CMOS mode</p> <p><b>Logic Low Threshold:</b> 0.8V (nominal) in TTL/+5 V mode, 30% (nominal) of selected operating voltage in CMOS mode</p>
Connectors	(2) BNC - uncommitted
Potentiometers	(2) 1 k $\Omega$ and 10 k $\Omega$ - uncommitted
Speaker	8 $\Omega$ , 0.25 W - uncommitted
Breadboards	Removable breadboard Plate (PB-3) with 2520 tie-points with 200 additional bus strip tie-points internally connected to power supply outputs and ground
Weight	7 lbs
Dimensions	326 mm x 260 mm x 155 mm

## Checking out the PB-503A

The PB-503A may be checked out for proper operation by making a few simple measurements and connections. Begin by connecting the AC line cord to a suitable receptacle. The AC power indicator should light when the power switch is turned on. Using a DC voltmeter, check for +5 V between the ground terminal and the +5 volt terminal. Repeat the measurement for the positive (+) variable supply terminal and the negative (-) variable supply terminal. Check the variability of each supply by turning the appropriate adjustment knob.

To test the logic indicators, switch the +5/+V operating voltage switch to the +5 position. The TTL/CMOS threshold switch can be in either position. With no input to the logic indicators, all LEDs should be turned off. Connect one end of a jumper wire to the + 5 V terminal and the other end to logic indicator 1; the red LED of logic indicator 1 should light. Repeat this test for logic indicators 2 through 8. Disconnect the jumper from the +5 volt terminal and connect it to the ground terminal. Connect the other end to logic indicator 1; the green LED of logic indicator 1 should light. Repeat this test for logic indicators 2 through 8.

The digital function generator may be tested by connecting its output to one of the speaker inputs. Connect the other speaker input to the ground terminal (or one of the connectors on the ground bus strip). Set the frequency to 60 Hz and select the square wave. Move the amplitude control upward until you hear a tone coming from the speaker. Step through any range of frequencies up to 20 kHz (this upper limit may vary as it depends on the user's own hearing) and the pitch should change. Push the waveform buttons to select sine, square, and triangle. A changing but clearly audible tone should be heard in each position.

If an oscilloscope is available, you may check the digital function generator for proper waveform and frequency using standard measurement techniques.

The debounced pushbuttons can be checked by connecting one side of a resistor (20 $\Omega$  to 100 k $\Omega$ ) to +5 volts and the other side to PB1-1, the NC point. Then connect PB1-1 to LED-1 with the Logic Indicator +5/+V switch in the +5 position, the red LED should light when PB1 is pressed and the green LED should light when PB1 is released. Next, move the connections from PB1-1 to PB1-2, the NO point. Now the red LED should be lit when PB1 is not pressed, and the green LED should be lit when PB1 is pressed. Repeat these steps to test PB2.

The logic switches can be tested by connecting the output of logic switches 1 through 8 to the input of logic indicators 1 through 8. Switch the logic switch +5V/+V high level switch to +5, and switch the logic indicator +5/+V operating voltage switch to



+5. Select the CMOS position on the logic indicator TTL/CMOS threshold select switch. Now the logic indicators should reflect the conditions of the logic switches, that is, red LEDs will indicate switches in the high (logic "1") position and green LEDs will indicate switches in the low (logic "0") position. Move each switch between its high and low position to verify proper functioning. Switch the logic switch +5/+V high level switch to +V and the logic indicator +5/+V operating voltage switch to +V; the relationship between the switch positions and the logic indicator display should remain the same, regardless of the setting of the 1.3 - 15 volts +V supply.

By using an ohmmeter, you can check the potentiometers. To do so, select an appropriate range for measuring 10 k $\Omega$  and connect the ohmmeter leads to R1-1 and R1-2. With R1 rotated fully counterclockwise a reading of 0  $\Omega$  ohms should be observed. As the potentiometer is rotated clockwise, the resistance reading will be seen to increase linearly up to 10 k $\Omega$   $\pm$  20%. Now move the ohmmeter lead from R1-1 to R1-3; with R1 fully clockwise the ohmmeter will read zero ohms, and the resistance will increase linearly to the full value noted previously as the potentiometer is rotated counterclockwise. Select an ohmmeter range appropriate for 1 k $\Omega$  and repeat these steps on R2 to verify its function.

To test SPDT switch S9, put S9 in the up position and connect an ohmmeter to S9-1 and S9-2. The ohmmeter should read 0  $\Omega$ . When the switch is brought to the down position, an open circuit should be indicated. Move the ohmmeter lead from S9-1 to S9-3 and observe a short circuit with S9 down, and an open with S9 up. These steps can be repeated on S10 to test its functions.

## Breadboarding Techniques

*This section contains information which may prove useful when constructing circuits using the PB-503A. While there are no hard and fast rules for breadboarding, the following tips may save time and trouble.*

*Unless a circuit is being prepared for a demonstration or display, avoid cutting component leads very short. While short wires and leads may look neat, the clipped components will only fit into a limited "span" of connector sockets, limiting the use of the component. It is perfectly permissible to use untrimmed components while exploring different circuit possibilities. The only time short leads may be necessary is when operating at higher frequencies and experiencing mysterious malfunctions. Sometimes the only way to correct high frequency circuit problems is to shorten all circuit connections.*

*Be cautious when using components which have been removed from a tape reel used in automatic insertion equipment. Suppliers of surplus components often sell components which are taped together in small batches. Removing the components from the tape does not always remove the adhesive from the leads of the components. Placing a formerly taped component into a socket connector may result in a poor electrical connection and, worse still, leave tape adhesive in the socket. Avoid this problem by either carefully cleaning taped component leads, clipping the taped portion of the lead off, or avoiding the use of taped components altogether.*

*Be especially careful when inserting integrated circuits into the breadboard sockets. Unless the IC pins are straight, it is very easy to crush the pin into a zigzag shape or fold the pins underneath the body of the IC. Either way the result is a bad connection or no connection at all.*

*Always use solid wire for breadboard connections. When stripping the wire ends, be careful not to strip more than about three-eighths of an inch of insulation from the wire. Too much bare wire may result in unintentional connections near the wire end.*

*After you have built up a few circuits, you will have a good collection of pre-stripped jumper wires. Save them. By reusing these wires, you can save even more time and effort in assembling future circuits. Pre-formed wires in various sizes are also available from Global Specialties (please visit web site for available options and accessories).*

## Warranty Information

### *Limited Three-Year Warranty*

*Global Specialties (a brand of Cal Test Electronics) warrants these products to be free from defective material or workmanship for a period of 3 years from the date of original purchase. Under this warranty, Global Specialties is limited to repairing the defective device when returned to the factory, shipping charges prepaid, within the warranty period.*

*Units returned to Global Specialties that have been subject to abuse, misuse, damage, or accident, or have been connected, installed, or adjusted contrary to the instructions furnished by Global Specialties, or that have been repaired by unauthorized persons, will not be covered by this warranty.*

*Global Specialties reserves the right to discontinue models, change specifications, price, or design of this device at any time without notice and without incurring any obligation whatsoever.*

*The purchaser agrees to assume all liabilities for any damages and/or bodily injury which may result from the use or misuse of this device by the purchaser, his employees, or agents.*

*This warranty is in lieu of all other representations or warranties expressed or implied and no agent or representative of Global Specialties is authorized to assume any other obligation in connection with the sale and purchase of this device.*

## *Service*

*If you have a need for calibration or repair services, technical, or sales support, please contact us:*

*Global Specialties  
(A brand of Cal Test Electronic, Inc.)  
22820 Savi Ranch Parkway Yorba Linda, CA 92887  
800-572-1028 or 714-221-9330  
[globalspecialties.com](http://globalspecialties.com)*

