



User's Manual

Model 110CS Current Source



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CHAPTER 1

INTRODUCTION

1.0 GENERAL

Lake Shore Cryotronics, Inc. designed and manufactures the Model 110CS in the USA. This chapter covers a general description in Paragraph 1.1, handling liquid helium and liquid nitrogen in Paragraph 1.2, electrostatic discharge in Paragraph 1.3, safety summary in Paragraph 1.4, and safety symbols in Paragraph 1.5.

We welcome comments on this manual. Although we try to keep it error-free, some may occur. To report an error, describe it briefly and include the appropriate paragraph, figure, table, and page number. Send comments to Lake Shore Cryotronics, Attn: Technical Publications, 575 McCorkle Blvd., Westerville, Ohio 43082-8888. This manual is subject to change without notice.

1.1 MODEL 110CS GENERAL DESCRIPTION

The Model 110CS is an ideal current source for quick, accurate, stable outputs for sensor excitation or other applications. Compliance voltage of 11 volts assures constant current under a wide range of load conditions. The instrument features:

- 1 μ A to 100 mA Output Current.
- Front panel OUTPUT switch to easily reverse polarity.
- Red CMPL light to alert user when compliance limit is reached.
- Capability for external resistor programming from 1 μ A to 100 mA.
- Selectable output current in 1X and 3X increments.

The Model 110CS has a compliance voltage of 11 Volts, allowing it to be used as an excitation source in a variety of diode sensor applications. It also features a compliance LED visually indicates the unit is operating within specification.

Table 1-1. Model 110CS Specifications

OUTPUT:

Output Current (10 μ A factory preset):

Externally programmable from 1 μ A to 10 mA

Accuracy at 10 μ A (programming resistor determines accuracy): 0.05% of output

Temperature Coefficient (% output / $^{\circ}$ C ambient):

<0.01% of output per $^{\circ}$ C

Compliance Voltage: 11 volts. CMPL light turns on when the output voltage reaches 11 volts

Line Regulation: <0.01% change in output for 10% change in line voltages within specified range (see Power below)

Load Regulation: <0.01% change in output current from 1% to 100% of compliance voltage

AC Current Ripple: <0.01% of scale +1 nA (RMS) in a properly shielded system

GENERAL:

Ambient Temperature Range: 15–35 $^{\circ}$ C (59–95 $^{\circ}$ F)

Power: 90–125 or 210–250 VAC, 50 or 60 Hz, 3 VA

Size: 106 \times 41 \times 164 mm (4.2 \times 1.6 \times 6.5 inches)

Weight: 0.5 kilograms (1.1 pounds)

NOTES:

1. Electrical specifications given are for a unit operating at the factory at current output of 10 μ A; a different output current may affect some specifications.
2. Product Specifications are subject to change without notice.

1.2 HANDLING LIQUID HELIUM AND LIQUID NITROGEN

Helium and Nitrogen are colorless, odorless, and tasteless gases. They liquefy when properly cooled. Liquid Helium (LHe) and liquid nitrogen (LN₂) may be used in conjunction with the Model 110CS. Although not explosive, there are certain safety considerations in the handling of LHe and LN₂.

1.2.1 Handling Cryogenic Storage Dewars

Operate all cryogenic containers (dewars) in accordance with manufacturer instructions. Safety instructions are normally posted on the side of each dewar. Keep cryogenic dewars in a well-ventilated place, protected from the weather, and away from heat sources.

1.2.2 LHe and LN₂ Safety Precautions

Transfer LHe and LN₂ and operate storage dewar controls in accordance with manufacturer/supplier instructions. During transfer, follow all safety precautions written on the storage dewar and recommended by the manufacturer.

WARNING: Liquid helium is a potential asphyxiant and can cause rapid suffocation without warning. Store and use in an adequately ventilated area. DO NOT vent the container in confined spaces. DO NOT enter confined spaces where gas may be present unless area is well-ventilated. If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.

WARNING: Liquid helium can cause severe frostbite to exposed body parts. DO NOT touch frosted pipes or valves. For frostbite, consult a physician immediately. If a physician is unavailable, warm the affected parts with water that is near body temperature.

Two essential safety aspects of handling LHe are adequate ventilation and eye and skin protection. Although helium and nitrogen gases are non-toxic, they are dangerous because they replace air in a normal breathing atmosphere. Liquid helium is an even greater threat because a small amount of liquid evaporates to create a large amount of gas. Store and operate cryogenic dewars in open, well-ventilated areas.

When transferring LHe and LN₂, protect eyes and skin from accidental contact with liquid or the cold gas issuing from it. Protect eyes with full face shield or chemical splash goggles; safety glasses (even with side shields) are inadequate. Always wear special cryogenic gloves (Tempshield Cryo-Gloves® or equivalent) when handling anything that is, or may have been, in contact with the liquid or cold gas, or with cold pipes or equipment. Wear long sleeve shirts and cuffless trousers long enough to prevent liquid from entering shoes.

1.2.3 Recommended First Aid

Post an appropriate Material Safety Data Sheet (MSDS) obtained from the manufacturer/distributor at every site that stores and uses LHe and LN₂. The MSDS specifies symptoms of overexposure and first aid.

If a person exhibits symptoms of asphyxia such as headache, drowsiness, dizziness, excitation, excessive salivation, vomiting, or unconsciousness, remove to fresh air. If breathing is difficult, give oxygen. If breathing stops, give artificial respiration. Call a physician immediately.

If exposure to cryogenic liquids or cold gases occurs, restore tissue to normal body temperature (98.6°F) by bathing it in warm water not exceeding 105 °F (40 °C). DO NOT rub the frozen part, either before or after rewarming. Protect the injured tissue from further damage and infection and call a physician immediately. Flush exposed eyes thoroughly with warm water for at least 15 minutes. In case of massive exposure, remove clothing while showering with warm water. The patient should not drink alcohol or smoke. Keep warm and rest. Call a physician immediately.

1.3 ELECTROSTATIC DISCHARGE

Electrostatic Discharge (ESD) may damage electronic parts, assemblies, and equipment. ESD is a transfer of electrostatic charge between bodies at different electrostatic potentials caused by direct contact or induced by an electrostatic field. The low-energy source that most commonly destroys Electrostatic Discharge Sensitive (ESDS) devices is the human body, which generates and retains static electricity. Simply walking across a carpet in low humidity may generate up to 35,000 volts of static electricity.

Current technology trends toward greater complexity, increased packaging density, and thinner dielectrics between active elements, which results in electronic devices with even more ESD sensitivity. Some electronic parts are more ESDS than others. ESD levels of only a few hundred volts may damage electronic components such as semiconductors, thick and thin film resistors, and piezoelectric crystals during testing, handling, repair, or assembly. Discharge voltages below 4000 volts cannot be seen, felt, or heard.

1.3.1 Identifying ESDS Components

Below are some industry symbols used to label components as ESDS:



1.3.2 Handling ESDS Components

Observe all precautions necessary to prevent damage to ESDS components before installation. Bring the device and everything that contacts it to ground potential by providing a conductive surface and discharge paths. At a minimum, observe these precautions:

1. De-energize or disconnect all power and signal sources and loads used with unit.
2. Place unit on a grounded conductive work surface.
3. Ground technician through a conductive wrist strap (or other device) using 1 M Ω series resistor to protect operator.
4. Ground any tools, such as soldering equipment, that will contact unit. Contact with operator's hands provides a sufficient ground for tools that are otherwise electrically isolated.
5. Place ESDS devices and assemblies removed from a unit on a conductive work surface or in a conductive container. An operator inserting or removing a device or assembly from a container must maintain contact with a conductive portion of the container. Use only plastic bags approved for storage of ESD material.
6. Do not handle ESDS devices unnecessarily or remove from the packages until actually used or tested.

1.4 SAFETY SUMMARY

Observe these general safety precautions during all phases of instrument operation, service, and repair. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended instrument use. Lake Shore assumes no liability for Customer failure to comply with these requirements.

Ground The Instrument. To minimize shock hazard, connect instrument chassis and cabinet to an electrical ground. The instrument comes with a 3-conductor AC power cable. Plug it into an approved three-contact electrical outlet or use a three-contact adapter with the green ground wire firmly secured to an electrical ground (safety ground) at the power outlet. The power cable jack and mating plug meet Underwriters Laboratories (UL) and International Electrotechnical Commission (IEC) safety standards.

Do Not Operate In An Explosive Atmosphere. Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

Keep Away From Live Circuits. Operating personnel must not remove instrument covers. Refer component replacement and internal adjustments to qualified maintenance personnel. Do not replace components with power cable connected. To avoid injuries, always disconnect power and discharge circuits before touching them.

Do Not Substitute Parts Or Modify Instrument. Do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to an authorized Lake Shore Cryotronics, Inc. representative for service and repair to ensure that safety features are maintained.

1.5 SAFETY SYMBOLS



Direct current (power line).



Alternating current (power line).



Alternating or direct current (power line).



Three-phase alternating current (power line).



Earth (ground) terminal.



Protective conductor terminal.



Frame or chassis terminal.



On (supply).



Off (supply).



Equipment protected throughout by double insulation or reinforced insulation (equivalent to Class II of IEC 536 - see Annex H).



Caution: High voltages; danger of electric shock. Background color: Yellow; Symbol and outline: Black.



Caution or Warning - See instrument documentation. Background color: Yellow; Symbol and outline: Black.



Fuse.

CHAPTER 2

INSTALLATION

2.0 GENERAL

This chapter covers inspection and unpacking in Paragraph 2.1, repackaging for shipment in Paragraph 2.2, power and ground requirements in Paragraph 2.3, load connection in Paragraph 2.4, sensor installation recommendations in Paragraph 2.5, and rack mounting in Paragraph 2.6.

2.1 INSPECTION AND UNPACKING

Inspect shipping containers for external damage. Make all claims for damage (apparent or concealed) or partial loss of shipment in writing to Lake Shore within five (5) days from receipt of goods. If damage or loss is apparent, please notify the shipping agent immediately.

Open the shipping containers. Use the packing list included with the system to verify receipt of the instrument, sensor, accessories, and manual. Inspect for damage. Inventory all components supplied before discarding any shipping materials. If there is freight damage to the instrument, file proper claims promptly with the carrier and insurance company and notify Lake Shore. Notify Lake Shore immediately of any missing parts. Lake Shore cannot be responsible for any missing parts unless notified within 60 days of shipment. See the standard Lake Shore Warranty on the A Page (immediately behind the title page).

2.2 REPACKAGING FOR SHIPMENT

To return the Model 110CS or accessories for repair or replacement, obtain a Return Goods Authorization (RGA) number from Technical Service in the United States, or from the authorized sales/service representative from which the product was purchased. Instruments may not be accepted without a RGA number. When returning an instrument for service, Lake Shore must have the following information before attempting any repair.

1. Instrument model and serial number.
2. User name, company, address, and phone number.
3. Malfunction symptoms.
4. Description of system.
5. Returned Goods Authorization (RGA) number.

Repack the system in its original container (if available). Affix shipping labels and FRAGILE warnings. Write RGA number on the outside of the container or on the packing slip. If not available, consult Lake Shore for shipping and packing instructions.

2.3 POWER AND GROUND REQUIREMENTS

The Model 110CS requires a power source of 90 to 125 or 210 to 250 VAC, 50 or 60 Hz, single phase, 3 VA maximum. It ships with a line cord (P/N 115-006) for 120 VAC operation. Connect to rear panel power plug. Turn the unit on by pressing the red POWER button on the front panel.

WARNING: To prevent electrical fire or shock hazards, do not expose this instrument to rain or excess moisture.

CAUTION: Verify correct voltage configuration by checking the Line Voltage Selection Block on the Model 110CS rear panel do not use the current source at other than its marked voltage. To change voltage configuration, see Chapter 4.

To protect operating personnel, properly ground instrument panels and cabinets in accordance with local codes. The 3-conductor power cable, when plugged into an appropriate receptacle, grounds the instrument. Shield sensor cables whenever possible. Attach the shields to the connector shield pin.

2.4 LOAD CONNECTION

Connect the load (temperature sensor) to the (+) and (-) OUT terminals on the Terminal Block on the rear panel. Use proper shielding techniques to minimize line frequency AC noise on the leads. This is more critical at low currents with high resistance.

2.5 SENSOR INSTALLATION RECOMMENDATIONS

Although the Model 110CS acts as a current source for any application, it can provide the 10 μ A excitation current for Lake Shore 400-Series, 500-Series, and TG-120 Diode Sensors. Refer to the Lake Shore Temperature Measurement and Control Catalog for installation details and sensor specifications. Call Lake Shore for copies of application notes or sensor installation questions. Although a sensor is not provided with the Model 110CS, below are general recommendations on sensor installation:

1. Do not ground the sensor.
2. Shield leads and connect shield wire to SHIELD on screw terminal connector only. Do not connect shield at other end of cable.
3. Keep leads as short as possible.
4. Use twisted-pair wire. Use Lake Shore Duo-Twist™ wire (or equivalent) for 2-wire, or Quad-Twist™ wire (or equivalent) for 4-wire applications.
5. Thermally anchor lead wires.

2.5.1 Connecting Leads To The Sensor

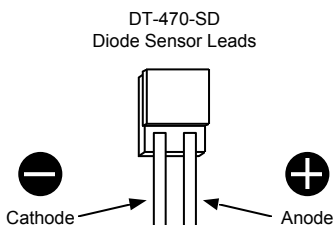
Excessive heat flow through connecting leads to any temperature sensor may differ the temperature between the active sensing element and the sample to which the sensor mounts. This reflects as a real temperature offset between what is measured and the true sample temperature. Eliminate such temperature errors with proper selection and installation of connecting leads.

To minimize heat flow through the leads, select leads of small diameter and low thermal conductivity. Phosphor-bronze or Manganin wire is commonly used in sizes 32 or 36 AWG. These wires have a fairly low thermal conductivity, yet electrical resistance is not large enough to create measurement problems.

Thermally anchor lead wires at several temperatures between room temperature and cryogenic temperatures to guarantee no heat conduction through the leads to the sensor.

2.5.2 Sensor Mounting

Before installing a diode sensor, identify which lead is the anode and which is the cathode. When viewed with the base down and the leads towards the observer, the anode is on the right and the cathode is on the left. The Lake Shore DT-470-SD silicon diode sensor lead configuration is shown to the right.



For other sensors, read accompanying literature or consult the manufacturer to positively identify sensor leads. Lead identification should remain clear even after sensor installation. Record the sensor serial number and location.

On the DT-470-SD, the base is the largest flat surface. It is sapphire with gold metalization over a nickel buffer layer. The base is electrically isolated from the sensing element and leads; make all thermal contact to the sensor through the base. A thin braze joint around the sides of the SD package electrically connect to the sensing element. Avoid contact to the sides with any electrically conductive material.

When installing the sensor, make sure there are no electrical shorts or current leakage paths between the leads or between the leads and ground. If IMI-7031 varnish or epoxy is used, it may soften varnish-type lead insulations so that high resistance shunts appear between wires if *sufficient time for curing is not allowed*.

Slide Teflon[®] spaghetti tubing over bare leads when the possibility of shorting exists. Avoid putting stress on the device leads and allow for thermal contractions that occur during cooling which could fracture a solder joint or lead if installed under tension at room temperature.

For temporary mounting in cold temperature applications, apply a thin layer of Apiezon[®] N Grease between the sensor and sample to enhance thermal contact under slight pressure. The preferred method for mounting the DT-470-SD sensor is the Lake Shore CO Adapter.

CAUTION: Lake Shore will not warranty replace any device damaged by user-designed clamps or solder mounting.

For semi-permanent mountings, use Stycast epoxy instead of Apiezon[®] N Grease. **NOTE:** Do not apply Stycast epoxy over the DT-470-SD package, as sensor stress may shift the readings. In all cases, periodically inspect the sensor mounting to verify good thermal contact to the mounting surface is maintained.

2.5.3 Measurement Errors Due To AC Noise

Poorly shielded leads or improperly grounded measurement systems can introduce AC noise into the sensor leads. In diode sensors, the AC noise shifts the DC voltage measurement due to the diode non-linear current/voltage characteristics. When this occurs, measured DC voltage is too low and the corresponding temperature reading is high. The measurement error can approach several tenths of a kelvin. To determine if this problem exists, perform either procedure below.

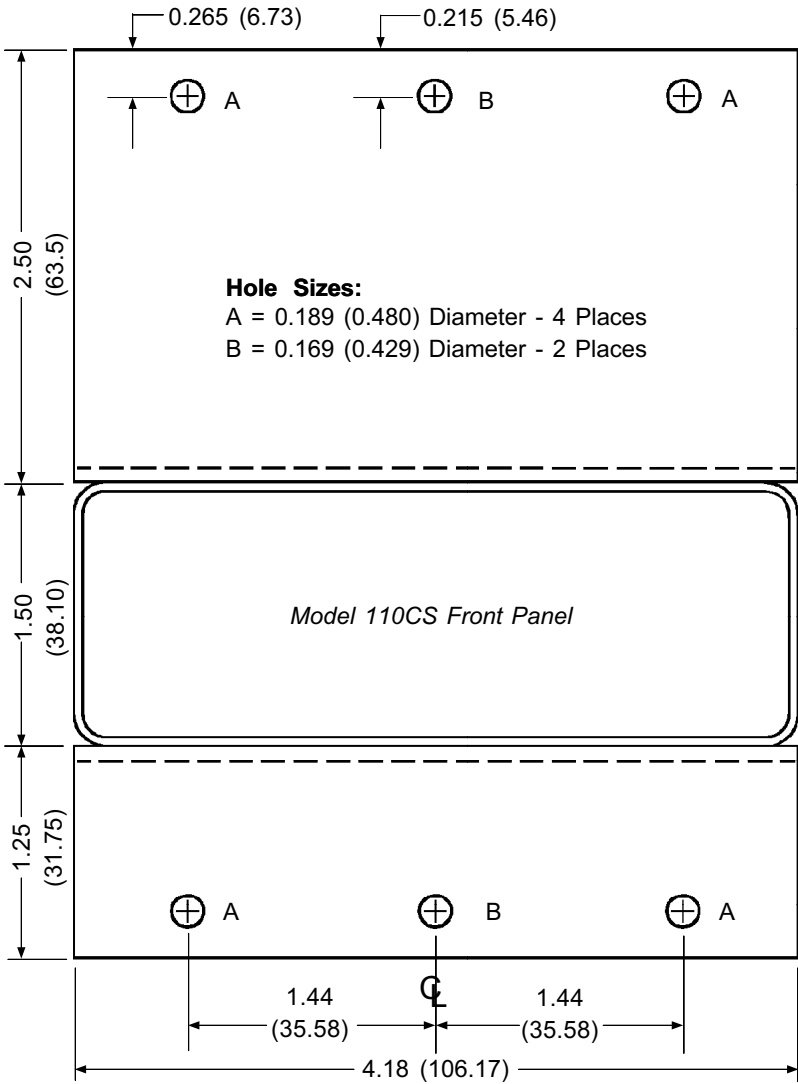
1. Place a capacitor across the diode to shunt induced AC currents. Capacitor size depends on the noise frequency. If noise is related to power line frequency, use a 10 μF capacitor. If AC-coupled digital noise is suspected (digital circuits or interfaces), use a 0.1 to 1 μF capacitor. In either case, if measured DC voltage increases, there is induced noise in the measurement system.
2. Measure AC voltage across the diode with an AC voltmeter or oscilloscope. Most voltmeters do not have the frequency response to measure noise associated with digital circuits or interfaces (which operate in the MHz range). For a thorough discussion of this potential problem, and the magnitude of error which may result, request the paper "Measurement System-Induced Errors In Diode Thermometry," J.K. Krause and B.C. Dodrill, Rev. Sci. Instr. 57 (4), 661, April, 1986 from Lake Shore.

To greatly reduce potential AC noise, connect twisted leads (pairs) between the measurement instruments and the diode sensors. Use 32 or 36 AWG Lake Shore Duo-Twist[™] Cryogenic Wire, which features phosphor bronze wire twisted at 3.15 twists per centimeter (8 twists per inch). See the Lake Shore Product Catalog or contact Lake Shore for further information.

2.6 RACK MOUNTING

The Model 110 can install in a standard size 1/4 panel EIA rack space. If you ordered a 2090 rack mounting adapter, follow the installation instructions below. See Figure 2-1.

1. Remove front feet on bottom of unit and attach lower rack piece by threading two of the four screws provided into the front feet holes.
2. Locate the two mounting hole access covers on the top of the unit. Attach the other rack with the remaining screws.



C-110-2-1.eps

Figure 2-1. Model 2090 Rack Mounting

CHAPTER 3

OPERATION

3.0 GENERAL

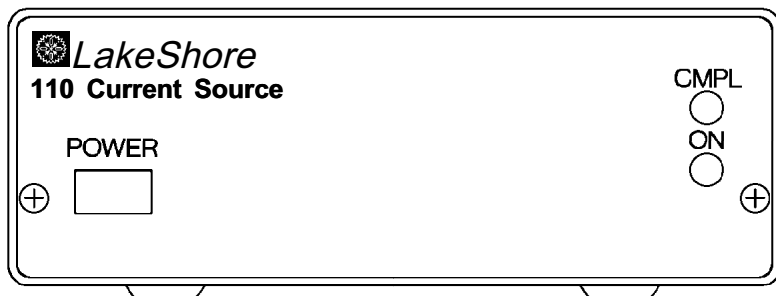
This chapter describes front panel features and functions in Paragraph 3.1, rear panel features and functions in Paragraph 3.2, instructions for selecting output current value fixed ranges are provided in Paragraph 3.3, and program mode is discussed in Paragraph 3.4.

3.1 FRONT PANEL FEATURES AND FUNCTIONS

POWER: Push to turn power to unit On. Push again to turn power Off.

CMPL (COMPLIANCE) LED: Compliance voltage is the maximum voltage that can be developed across the output terminals while maintaining the specified output current. If output current reaches 11 volts, the light flashes.

ON LED: Illuminates when power to unit is On.



C-110-3-1.eps

Figure 3-1. Model 110CS Front Panel

3.2 REAR PANEL FEATURES AND FUNCTIONS

Terminal Block: 5-position terminal block for easy connection of:

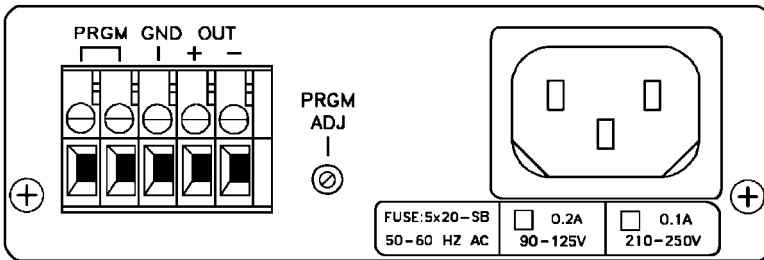
PRGMProgramming Resistor.

GNDShielding Ground.

+ and - OUT.....Output Current.

PRGM ADJ (Program Adjust): Trim Potentiometer. Adjusts output current value $\pm 5\%$.

The Line Voltage Selection Block indicates the fuse rating and selected line voltage. The as ordered setting is marked at the factory, but can be modified using the procedure provided in Paragraph 4.2.



P-110-3-2.bmp

Figure 3-2. Model 110CS Rear Panel

3.4 SELECTING OUTPUT CURRENT VALUE

1. Connect the desired resistor to the **PRGM** output terminals located on the rear panel.

NOTE: The output current (I) in relation to the programming resistor (R) in ohms is: $I = 1000 / (100 + R)$ milliamperes. In Table 3-1, the calculated **R** and the closest standard 1% resistance values are given for various currents.

2. Turn On Model 110CS by pressing red front panel **POWER** button.
3. Adjust the **PRGM ADJ** trimmer located on the rear panel to compensate for variations in the programming resistor tolerance.

Table 3-1 Output Currents and Corresponding 1% Programming Resistances

Approximate Current *	Calculated R (Ohms)	Closest Standard 1% Resistance Value (Ohms)
1 μ A	999,900	1 M Ω
3 μ A	333,233	322 K Ω
10 μ A	99,900	100 K Ω
30 μ A	33,233	33.2 K Ω
100 μ A	9,900	10 K Ω
300 μ A	3,233	3.24 K Ω
1 mA	900	909 Ω
3 mA	233	232 Ω
10 mA	0	0 Ω

* Use rear panel **PRGM ADJ** trimmer to adjust output current $\pm 5\%$.

The **PRGM** (programming) terminals have an internal 100 ohm resistor in series that limits current to 10 mA in the event of a short circuit across the **PRGM** terminals. In this mode, the total output current flows through the programming resistor. Use a resistor with a power rating at least 10 times the power actually dissipated. A ¼ watt resistor suffices.

The programming resistor temperature coefficient affects output current thermal stability. To maintain the 0.01%/°C temperature coefficient specification, use a programming resistor with a temperature coefficient of 10 PPM/°C or better.

Programming resistor accuracy determines output current accuracy. For example, if a 1 M Ω 1% resistor is used to program a 1 μ A output current, output current accuracy cannot be more than $\pm 1\%$. (In this case, the built-in 100 Ω only contributes 0.01% difference.) The **PRGM ADJ** trimmer can compensate for variations in programming resistor tolerance and the internal 100 Ω resistor.

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CHAPTER 4

SERVICE

4.0 GENERAL

This chapter covers Model 110CS maintenance, with fuse replacement covered in Paragraph 4.1, line voltage configuration in Paragraph 4.2, and PRGM mode calibration in Paragraph 4.3.

4.1 FUSE REPLACEMENT

WARNING: To prevent shock hazard, turn off instrument and disconnect it from AC line power and all test equipment before replacing fuse.

1. Turn POWER switch Off and disconnect power cord from unit. Disconnect all test equipment from unit.
2. Remove 2 screws securing rear panel to bottom of enclosure. Gently pull away rear panel and remove enclosure cover by sliding it to the back.
3. Remove fuse with a fuse puller. The fuse is located behind the transformer as shown in Figure 4.1.
4. Replace with a 0.2 A fuse for 110 V (115 VAC) operation or a 0.1 A fuse for 220 V (230 VAC) operation. Use slow blow fuses.

CAUTION: Replace fuse with the same type and rating as specified by the line voltage selected.

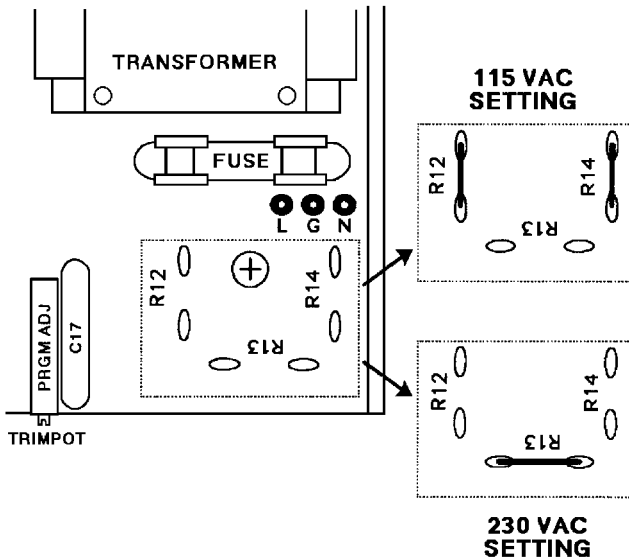
5. Replace enclosure cover, rear panel, and all screws.

4.2 LINE VOLTAGE CONFIGURATION

The rear-panel, 3-pronged line power connector permits Model 110CS operation at either 110 or 220 VAC. The configuration is indicated on rear panel in the Line Voltage Selection Block. Use the procedure below to change line voltage.

WARNING: To prevent shock hazard, turn off instrument and disconnect it from AC line power and all test equipment before changing line voltage configuration.

1. Turn power switch OFF and disconnect the power cord from the unit. Disconnect all test equipment from unit.
2. Remove 2 screws securing rear panel to bottom of enclosure. Gently pull away rear panel and remove enclosure cover by sliding it to the back.
3. Modify jumper configuration to desired line voltage (see Figure 4-1).
4. Replace fuse to match new voltage requirements.
5. Replace enclosure cover, rear panel and all screws



P-110-4-1.bmp

Figure 4-1. Fuse Replacement and Jumper Configurations

∞ NOTES ∞

Lake Shore

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