

KEITHLEY

Model 7708 40-Channel Differential Multiplexer with Automatic CJC User's Guide

PA-744 Rev. C / 8-03

A GREATER MEASURE OF CONFIDENCE

The following safety precautions should be observed before using this product and any associated instrumentation. Although some instruments and accessories would normally be used with non-hazardous voltages, there are situations where hazardous conditions may be present.

This product is intended for use by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read and follow all installation, operation, and maintenance information carefully before using the product. Refer to the manual for complete product specifications.

If the product is used in a manner not specified, the protection provided by the product may be impaired.

The types of product users are:

Responsible body is the individual or group responsible for the use and maintenance of equipment, for ensuring that the equipment is operated within its specifications and operating limits, and for ensuring that operators are adequately trained.

Operators use the product for its intended function. They must be trained in electrical safety procedures and proper use of the instrument. They must be protected from electric shock and contact with hazardous live circuits.

Maintenance personnel perform routine procedures on the product to keep it operating properly, for example, setting the line voltage or replacing consumable materials. Maintenance procedures are described in the manual. The procedures explicitly state if the operator may perform them. Otherwise, they should be performed only by service personnel.

Service personnel are trained to work on live circuits, and perform safe installations and repairs of products. Only properly trained service personnel may perform installation and service procedures.

Keithley products are designed for use with electrical signals that are rated Measurement Category I and Measurement Category II, as described in the International Electrotechnical Commission (IEC) Standard IEC 60664. Most measurement, control, and data I/O signals are Measurement Category I and must not be directly connected to mains voltage or to voltage sources with high transient over-voltages. Measurement Category II connections require protection for high transient over-voltages often associated with local AC mains connections. Assume all measurement, control, and data I/O connections are for connection to Category I sources unless otherwise marked or described in the Manual.

Exercise extreme caution when a shock hazard is present. Lethal voltage may be present on cable connector jacks or test fixtures. The American National Standards Institute (ANSI) states that a shock hazard exists when voltage levels greater than 30V RMS, 42.4V peak, or 60VDC are present. **A good safety practice is to expect that hazardous voltage is present in any unknown circuit before measuring.**

Operators of this product must be protected from electric shock at all times. The responsible body must ensure that operators are prevented access and/or insulated from every connection point. In some cases, connections must be exposed to potential human contact. Product operators in these circumstances must be trained to protect themselves from the risk of electric shock. If the circuit is capable of operating at or above 1000 volts, **no conductive part of the circuit may be exposed.**

Do not connect switching cards directly to unlimited power circuits. They are intended to be used with impedance limited sources. NEVER connect switching cards directly to AC mains. When connecting sources to switching cards, install protective devices to limit fault current and voltage to the card.

Before operating an instrument, make sure the line cord is connected to a properly grounded power receptacle. Inspect the connecting cables, test leads, and jumpers for possible wear, cracks, or breaks before each use.

When installing equipment where access to the main power cord is restricted, such as rack mounting, a separate main input power disconnect device must be provided, in close proximity to the equipment and within easy reach of the operator.

For maximum safety, do not touch the product, test cables, or any other instruments while power is applied to the circuit under test. ALWAYS remove power from the entire test system and discharge any capacitors before: connecting or disconnecting cables or jumpers, installing or removing switching cards, or making internal changes, such as installing or removing jumpers.

Do not touch any object that could provide a current path to the common side of the circuit under test or power line (earth) ground. Always make measurements with dry hands while standing on a dry, insulated surface capable of withstanding the voltage being measured.

The instrument and accessories must be used in accordance with its specifications and operating instructions or the safety of the equipment may be impaired.

Do not exceed the maximum signal levels of the instruments and accessories, as defined in the specifications and operating information, and as shown on the instrument or test fixture panels, or switching card.

When fuses are used in a product, replace with same type and rating for continued protection against fire hazard.

Chassis connections must only be used as shield connections for measuring circuits, NOT as safety earth ground connections.

If you are using a test fixture, keep the lid closed while power is applied to the device under test. Safe operation requires the use of a lid interlock.

If a  screw is present, connect it to safety earth ground using the wire recommended in the user documentation.

The  symbol on an instrument indicates that the user should refer to the operating instructions located in the manual.

The  symbol on an instrument shows that it can source or measure 1000 volts or more, including the combined effect of normal and common mode voltages. Use standard safety precautions to avoid personal contact with these voltages.

The  symbol indicates a connection terminal to the equipment frame.

The **WARNING** heading in a manual explains dangers that might result in personal injury or death. Always read the associated information very carefully before performing the indicated procedure.

The **CAUTION** heading in a manual explains hazards that could damage the instrument. Such damage may invalidate the warranty.

Instrumentation and accessories shall not be connected to humans.

Before performing any maintenance, disconnect the line cord and all test cables.

To maintain protection from electric shock and fire, replacement components in mains circuits, including the power transformer, test leads, and input jacks, must be purchased from Keithley Instruments. Standard fuses, with applicable national safety approvals, may be used if the rating and type are the same. Other components that are not safety related may be purchased from other suppliers as long as they are equivalent to the original component. (Note that selected parts should be purchased only through Keithley Instruments to maintain accuracy and functionality of the product.) If you are unsure about the applicability of a replacement component, call a Keithley Instruments office for information.

To clean an instrument, use a damp cloth or mild, water based cleaner. Clean the exterior of the instrument only. Do not apply cleaner directly to the instrument or allow liquids to enter or spill on the instrument. Products that consist of a circuit board with no case or chassis (e.g., data acquisition board for installation into a computer) should never require cleaning if handled according to instructions. If the board becomes contaminated and operation is affected, the board should be returned to the factory for proper cleaning/servicing.

Introduction

The Model 7708 is a 40-channel differential multiplexer card with the following features:

- DC and AC voltage measurement
- 2-wire or 4-wire Ω measurement (automatically pairs switches for four wire measurements — $n + 20$)
- Temperature applications (RTD, thermistor, thermocouple)
- Built-in cold junction reference
- Screw terminal connections
- Designed specifically for use with Keithley's Model 2700, 2701, and 2750 system DMMs.

NOTE All references to the Model 27xx apply to the Models 2700, 2701, and 2750.

WARNING Before operating the Model 27xx with an accessory card, verify that the card is properly installed and the mounting screws are tightly fastened. If the mounting screws are not properly connected, an electrical shock hazard may be present.

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Specifications

The specifications for the Model 7708 switching card are located at the end of this User's Guide.

Operating instructions

Switching card operation is covered in the Model 27xx User's Manual. The Model 7708 operates the same as the Model 7700 switching card with the following differences:

- The Model 7708 has 40 channels; the Model 7700 has 20 channels.
- The Model 7708 does not have any amps channels; the Model 7700 has two amps channels.

Amps measurements

The 7708 module does not support amps measurements. System channel operation cannot be used to close channels while an amps function (DCI or ICI) is selected.

If an amps function (DCI or ACI) is selected and you attempt to close a system channel, the message "NO AMPS CHAN" will be displayed briefly. For remote programming, error -222 (Parameter data out of range) is generated. Example:

```
SYST: PRES           ' Restores system preset defaults.
SENS: FUNC `CURR:DC' ' Selects DCI function.
ROUT: CLOS (@101)   ' Attempts to close system channel 101 – Generates error -222.
```

If a system channel is already closed and you attempt to select the DCI or ACI function, the message "INVALID FUNC" will be displayed briefly. For remote programming, error -221 (Settings conflict) is generated. Example:

```
SYST: PRES           ' Restores system preset defaults.
ROUT: CLOS (@101)   ' Close system channel 101.
SENS: FUNC `CURR:DC' ' Attempts to select DCI function – Generates error -221.
```

Making amps measurements – In order to perform amps measurements, you must use the front panel inputs of the 27xx main-frame. You can still use the 7708 module for other aspects of the test (such as controlling a bias supply for DUT), but you must use multiple channel operation to close channels. Example:

NOTE In order to use the front panel inputs, make sure the INPUT switch is in the out (F) position.

```
SYST: PRES           ' Restores system preset defaults.
ROUT: MULT: CLOS (@101) ' Closes channel 101.
SENS: FUNC `CURR:DC'   ' Selects DCI function – Legal operation.
```


Channel 41 (2W/4W Configuration), Channel 42 (Sense Isolation), and Channel 43 (Input Isolation) are normally automatically configured by the Model 27xx. However, by using the :ROUT:MULT: commands (refer to Section 2 of the Model 27xx User's Manual), they can be manually configured.

NOTE Connect 4-wire sense leads using channels 21–40.

To disconnect channels 21–40 from channels 1–20, send:
:ROUT:MULT:CLOS (@141) (note opposite logic).

When automatically configured for 4-wire measurements (including 4-wire Ω , RTD temperature, Ratio, and Channel average) the channels are paired as follows:

- CH1 and CH21
- CH2 and CH22
- CH3 and CH23
- CH4 and CH24
- CH5 and CH25
- CH6 and CH26
- CH7 and CH27
- CH8 and CH28
- CH9 and CH29
- CH10 and CH30
- CH11 and CH31
- CH12 and CH32
- CH13 and CH33
- CH14 and CH34
- CH15 and CH35
- CH16 and CH36
- CH17 and CH37
- CH18 and CH38
- CH19 and CH39
- CH20 and CH40

Card connections

WARNING The information in this section is intended for qualified service personnel. Do not attempt to perform this procedure unless qualified to do so.

Figure 2 shows how to access the screw terminals on the Model 7708. Channel designations for the screw terminals are contained in Figure 3.

WARNING Do not exceed the maximum specifications for the Model 7708 module. Refer to the end of this packing list for specifications.

Figure 2
Screw terminal access

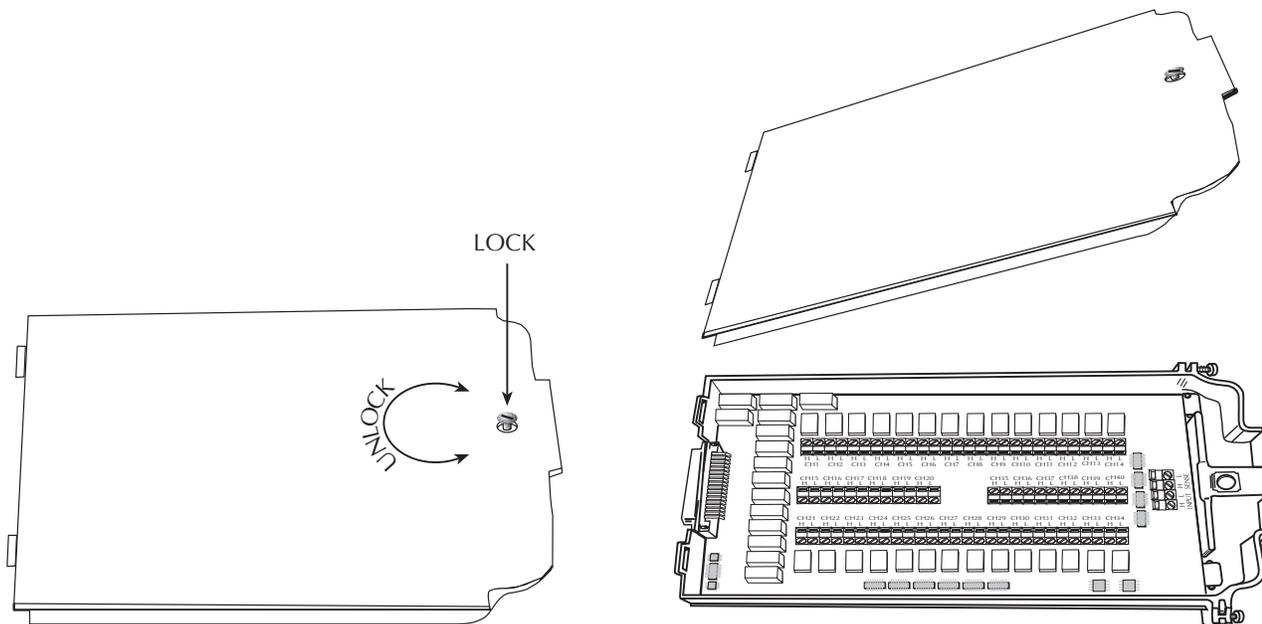
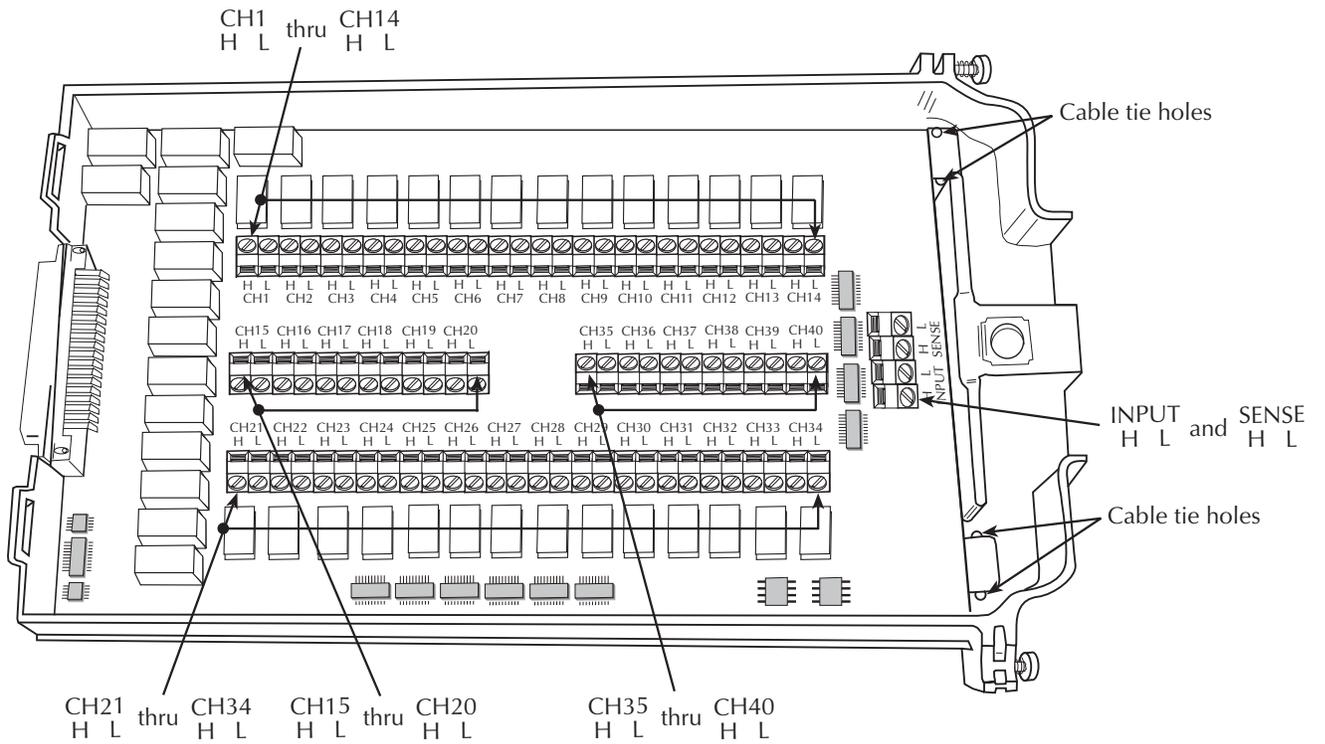


Figure 3
Model 7708 screw terminal channel designs



Wiring procedure

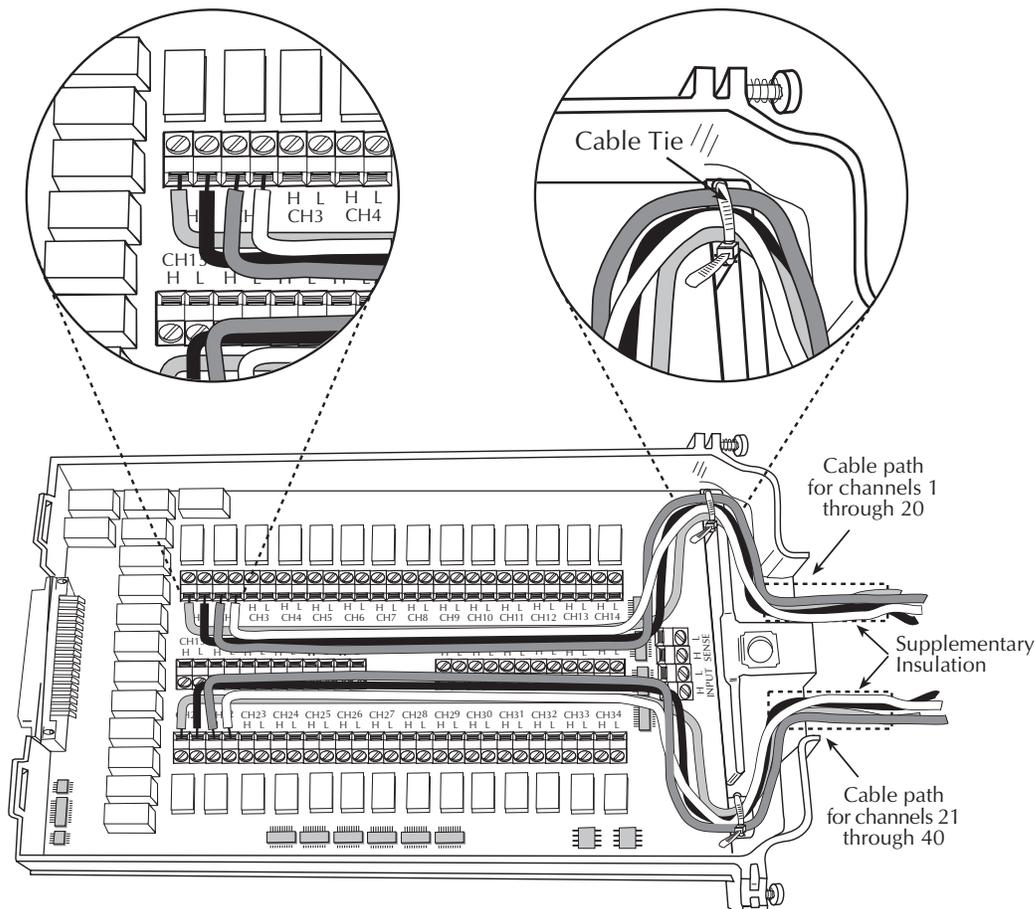
WARNING The information in this section is intended for qualified service personnel. Do not attempt to perform this procedure unless qualified to do so.

Use the following procedure to wire the Model 7708 module. Make all connections using the correct wire size (up to 20 AWG). Also, make sure to add supplementary insulation around the harness for voltages above 42V peak (see [Figure 4](#)).

WARNING All wiring and supplementary insulation must be rated for the maximum voltage in the system. For example, if 1000V is applied to the front terminals of the Model 27xx, the plug-in module wiring must be rated for 1000V.

1. Make sure all power is discharged from the Model 7708 module.
2. Access the screw terminals (see [Figure 2](#)).
3. Using a small flat-blade screwdriver, loosen terminal screws and install wires as desired. ([Figure 4](#) shows connections to channels 1 and 2.)
4. Route wire along wire-path and secure with cable ties as shown.
5. Fill in a copy of the connection log ([Table 1](#)) and affix it to the module cover.
6. Close and lock cover.

Figure 4
Wire dressing



Typical connections

The following examples show typical wiring connections for the following types of measurements:

- Thermocouple connections, see [Figure 5](#)
- Ω 2-wire and thermistor connections, see [Figure 6](#)
- Ω 4-wire and RTD connections, see [Figure 7](#)
- Voltage (AC or DC), see [Figure 8](#)

Figure 5

Thermocouple connections

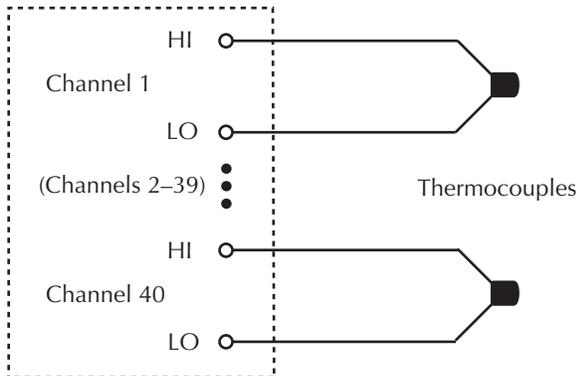


Figure 6

Ω 2-wire and thermistor connections

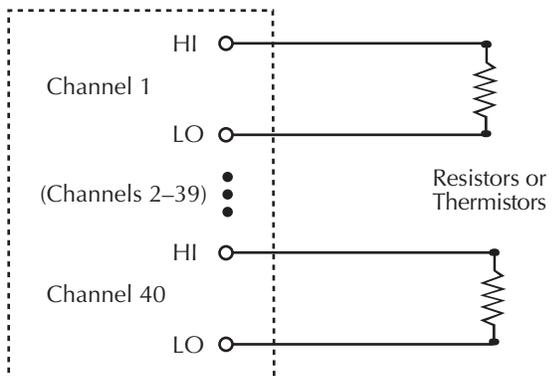


Figure 7
Ω4-wire and RTD connections

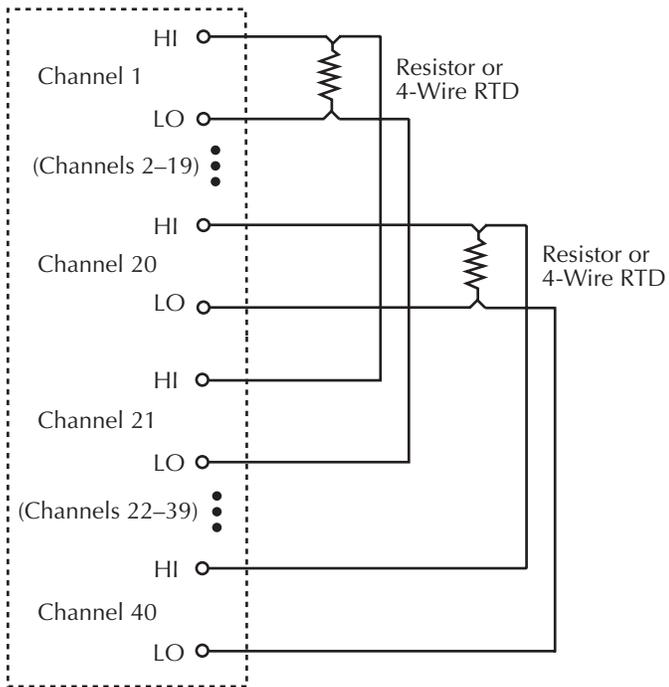
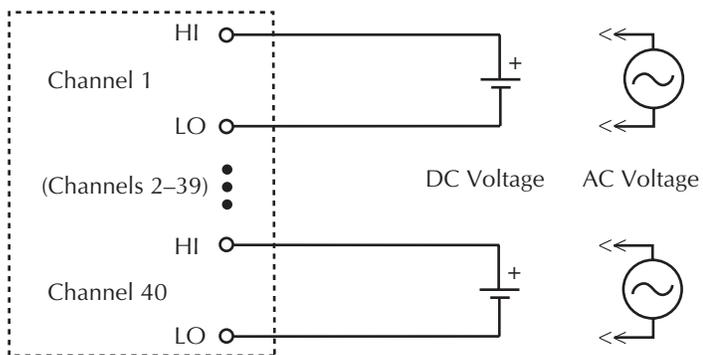


Figure 8
Voltage connections (DC or AC)



Connection log

Make a copy of [Table 1](#) and affix it to the cover of the Model 7708. Use this to record connection information and channel descriptions as needed.

Table 1
Connection log Model 7708

Channel		Color	Description	Description	Color	Channel
INPUT	H					
	L					
SENSE	H					
	L					
CH1	H				H	CH21
	L				L	
CH2	H				H	CH22
	L				L	
CH3	H				H	CH23
	L				L	
CH4	H				H	CH24
	L				L	
CH5	H				H	CH25
	L				L	
CH6	H				H	CH26
	L				L	
CH7	H				H	CH27
	L				L	
CH8	H				H	CH28
	L				L	
CH9	H				H	CH29
	L				L	
CH10	H				H	CH30
	L				L	
CH11	H				H	CH31
	L				L	
CH12	H				H	CH32
	L				L	
CH13	H				H	CH33
	L				L	
CH14	H				H	CH34
	L				L	
CH15	H				H	CH35
	L				L	
CH16	H				H	CH36
	L				L	
CH17	H				H	CH37
	L				L	
CH18	H				H	CH38
	L				L	
CH19	H				H	CH39
	L				L	
CH20	H				H	CH40
	L				L	

Performance verification

The performance of the Model 7708 card is tested by verifying measurement accuracy through the card. If verification limits are met through the front panel terminals of the Model 27xx, they should also be met through the card.

WARNING The information in this section is intended only for qualified service personnel. Do not attempt these procedures unless you are qualified to do so.

NOTES *Measurement accuracy through the Model 7708 card should only be verified after instrument accuracy has already been verified through the front panel terminals of the Model 27xx. The procedures to verify accuracy from the front panel inputs are provided in the Model 2700 Service Manual.*

If the Model 7708 card is still under warranty and is the cause of measurement inaccuracy, contact your Keithley representative or the factory to determine the correct course of action.

Model 7708 verification test procedures include:

- DC volts
- AC volts
- Resistance
- Temperature
- Frequency
- Ratio and average

Verification test requirements

Be sure that you perform the verification tests:

- Under the proper environmental conditions.
- After the specified warm-up period.
- Using the correct line voltage.
- After restoring factory defaults.
- With the INPUTS switch in the REAR (in) position.

Also, make sure to use the proper calibration equipment (Table 2) and the reading limits provided with the verification procedures.

Environmental conditions

Conduct your performance verification procedures in a test environment that has:

- An ambient temperature of 18° to 28°C (65° to 82°F).
- A relative humidity of less than 80% unless otherwise noted.

Warm-up period

Allow the Model 27xx to warm up for at least two hours before conducting the verification procedures.

If the instrument has been subjected to temperature extremes (those outside the ranges stated above), allow additional time for the instrument's internal temperature to stabilize. Typically, allow one extra hour to stabilize a unit that is 10°C (18°F) outside the specified temperature range.

Also, allow the test equipment to warm up for the minimum time specified by the manufacturer.

Line power

The Model 27xx requires a line voltage of 100V/120V/220V/240V, $\pm 10\%$ and a line frequency of 47.5Hz to 63Hz. Note that the line frequency is automatically sensed at power-up, but the line voltage must be manually set to either 100V/120V or 220V/240V as described in Section 3 of the Model 27xx Service Manual.

Factory defaults

Before performing the verification procedures, restore the instrument to its factory defaults as follows:

1. Press SHIFT and then SETUP. The instrument will display the following prompt:
RESTORE: FACT.
2. Using either range key, select FACT, then restore the factory default conditions by pressing ENTER.

INPUTs switch

In order to connect the Model 7708 card to the meter of the Model 27xx, the INPUTs switch must be in the REAR (in) position. The INPUTS switch is located on the front panel of the Model 27xx multimeter near the input terminals.

Test considerations

When performing the verification procedures:

- Be sure to restore factory defaults as outlined above.
- Make sure that the equipment is properly warmed up and connected to the correct input terminals. Also make sure that the INPUTS switch is in the REAR (in) position.
- Do not use autoranging for any verification tests because autorange hysteresis may cause the Model 27xx to be on an incorrect range. For each test signal, you must manually set the correct range for the Model 27xx using the range keys.
- Make sure the calibrator is in operate before you verify each measurement.
- Always let the source signal settle before taking a reading.

WARNING Observe the following safety precautions when performing these tests:

- Some of the procedures in this section may expose you to dangerous voltages. Use standard safety precautions when such dangerous voltages are encountered to avoid personal injury or death caused by electric shock.
- The maximum common-mode voltage (voltage between any plug-in module terminal and chassis ground) is 300V DC or 300V RMS. Exceeding this value may cause a breakdown in insulation, creating a shock hazard.

Verification limits

The verification limits stated in this section have been calculated using only the Model 27xx one-year accuracy specifications, and they do not include test equipment uncertainty. If a particular measurement falls slightly outside the allowable range, recalculate new limits based on both Model 27xx specifications and pertinent calibration equipment specifications.

Example reading limit calculation

The following is an example of how reading limits have been calculated. Assume you are testing the 10V DC range using a 10V input value. Using the Model 27xx one-year accuracy specification for 10V DC of $\pm (30\text{ppm of reading} + 5\text{ppm of range})$, the calculated limits are:

$$\text{Reading limits} = 10\text{V} \pm [(10\text{V} \times 30\text{ppm}) + (10\text{V} \times 5\text{ppm})]$$

$$\text{Reading limits} = 10\text{V} \pm (0.0003 + 0.00005)$$

$$\text{Reading limits} = 10\text{V} \pm 0.00035\text{V}$$

$$\text{Reading limits} = 9.99965\text{V to } 10.00035\text{V}$$

Calculating resistance reading limits

Resistance reading limits must be recalculated based on the actual calibration resistance values supplied by the equipment manufacturer. Calculations are performed in the same manner as shown in the preceding example, except, of course, that you should use the actual calibration resistance values instead of the nominal values when performing your calculations.

For example, assume that you are testing the 10k Ω range using an actual 10.03k Ω calibration resistance value. Using Model 27xx one-year 10k Ω range accuracy of $\pm (100\text{ppm of reading} + 6\text{ppm of range})$, the calculated reading limits are:

$$\text{Reading limits} = 10.03\text{k}\Omega \pm [(10.03\text{k}\Omega \times 100\text{ppm}) + (10\text{k}\Omega \times 6\text{ppm})]$$

$$\text{Reading limits} = 10.02894\text{k}\Omega \text{ to } 10.03106\text{k}\Omega$$

Recommended test equipment

Table 2 summarizes recommended verification equipment. You can use alternate equipment as long as that equipment has specifications at least as good as those listed in Table 2. Keep in mind, however, that calibrator uncertainty will add to the uncertainty of each measurement.

Table 2

Recommended verification equipment

Fluke 5700A Calibrator:		
DC voltage	AC voltage (1kHz, 50kHz)	Resistance
100mV: $\pm 14\text{ppm}$ 1.0V: $\pm 7\text{ppm}$ 10V: $\pm 5\text{ppm}$ 100V: $\pm 7\text{ppm}$ 1000V: $\pm 9\text{ppm}$	100mV: $\pm 200\text{ppm}$ 1.0V: $\pm 82\text{ppm}$ 10V: $\pm 82\text{ppm}$ 100V: $\pm 90\text{ppm}$ 700V: $\pm 85\text{ppm}$	100 Ω : $\pm 17\text{ppm}$ 1k Ω : $\pm 12\text{ppm}$ 10k Ω : $\pm 11\text{ppm}$ 100k Ω : $\pm 13\text{ppm}$ 1M Ω : $\pm 18\text{ppm}$ 10M Ω : $\pm 37\text{ppm}$ 100M Ω : $\pm 120\text{ppm}$
Fluke 5725A Amplifier: AC Voltage, 50kHz: 700V, $\pm 375\text{ppm}$		
Keithley 3930A or 3940 Frequency Synthesizer: 1V RMS, 10V RMS, 1kHz, $\pm 5\text{ppm}$, steady state and burst modulation		
General Radio 1433-T Precision Decade Resistance Box: 10 Ω to 400 Ω , $\pm 0.02\%$		
Miscellaneous Equipment: Double banana plug to double banana plug shielded cables (2) BNC to double banana plug shielded cable		

NOTE: The Fluke 5725A amplifier is necessary only if you wish to verify the 750V AC range at 50kHz. Verification at 220V and 50kHz using only the 5700A calibrator is adequate for most applications.

Performance verification procedures

NOTE The following procedures check one channel (CH1) or one channel pair (CH1 and CH21) of the Model 7708 card. To check other channels (or channel pairs), modify the procedures by connecting the verification equipment to the appropriate channel (or channel pair) and then closing that channel.

Verifying DC voltage

Check DC voltage accuracy by applying accurate voltages from the DC voltage calibrator to the Model 7708 input terminals and verifying that the displayed readings fall within specified limits.

CAUTION Do not exceed 300V DC between plug-in module INPUT H and L terminals or between any adjacent channels.

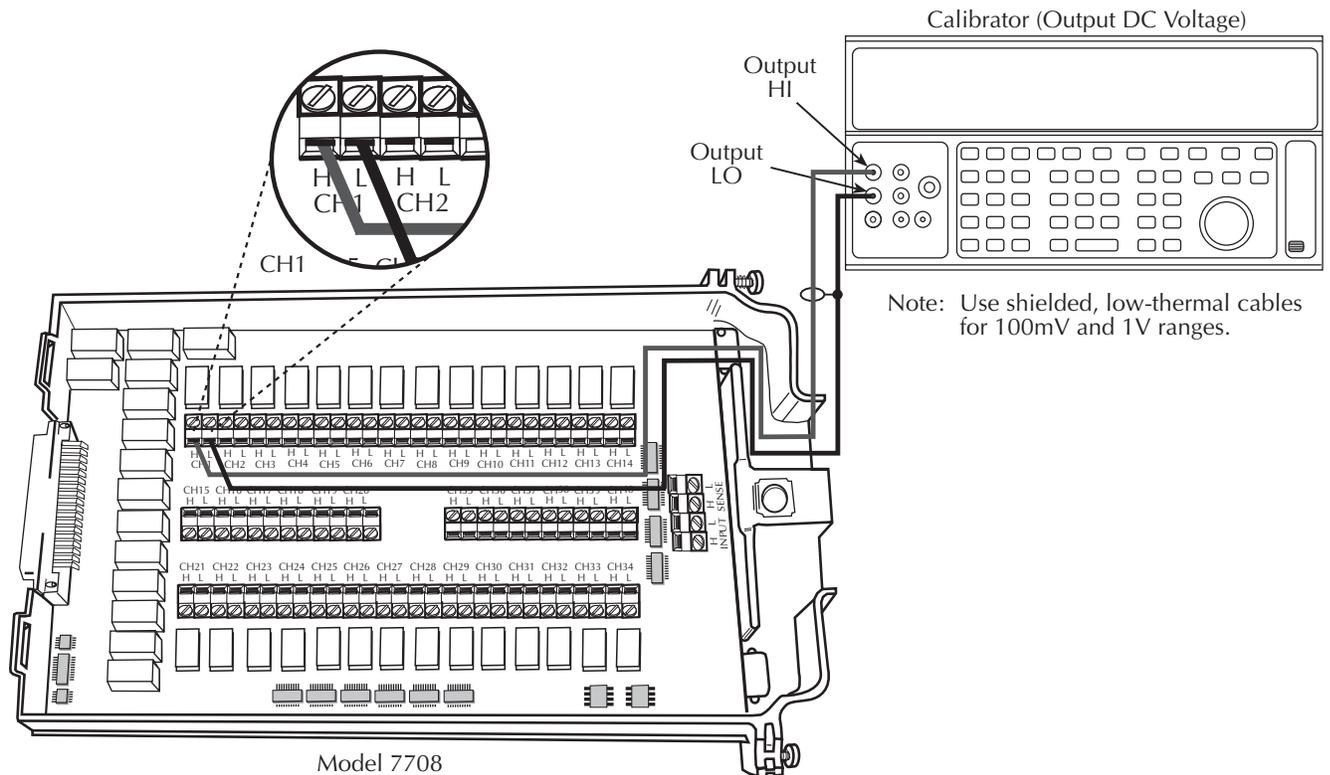
Follow these steps to verify DC voltage accuracy:

1. Connect the Model 7708 CH1 H and L INPUT terminals to the DC voltage calibrator as shown in Figure 9.

NOTE Use shielded, low-thermal connections when testing the 100mV and 1V ranges to avoid errors caused by noise or thermal effects. Connect the shield to the calibrator's output LO terminal.

Figure 9

Connections for DC volts verification



2. Install the Model 7708 in Slot 1 of the Model 27xx, turn on the power, and allow the unit to warm up for two hours before proceeding. Be sure the front panel INPUTS switch is set to the REAR position.

3. Select the DC volts function by pressing the DCV key, and set the Model 27xx to the 100mV range. Close Channel 1 by pressing the CLOSE key and then keying in 101.
4. Set the calibrator output to 0.00000mV DC, and allow the reading to settle.
5. Enable the Model 27xx REL mode. Leave REL enabled for the remainder of the DC volts verification tests.
6. Source positive and negative and full-scale voltages for each of the ranges listed in Table 3. For each voltage setting, be sure that the reading is within stated limits.
7. Press the OPEN key to open Channel 1.

Table 3

DCV reading limits

Range	Applied DC voltage*	Reading limits (1 year, 18° to 28°C)
100mV	100.0000mV	99.9925 to 100.0075mV
1V	1.000000V	0.999962 to 1.000038V
10V	10.00000V	9.99965 to 10.00035V
100V	100.0000V	99.9946 to 100.0054V
1000V	300.000V	299.976 to 300.024V

*Source positive and negative values for each range.

Verifying AC voltage

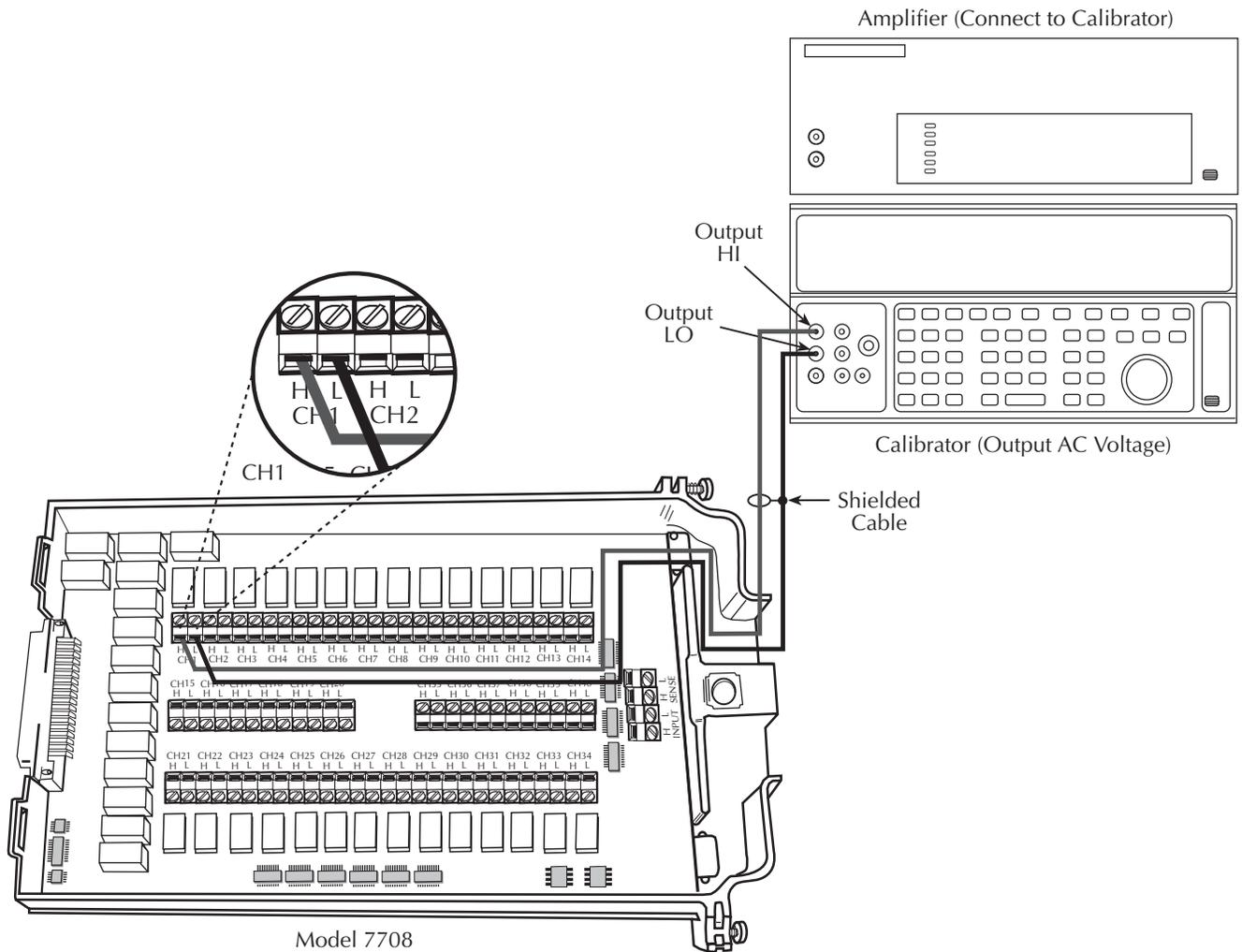
Check AC voltage accuracy by applying accurate AC voltages at specific frequencies from the AC voltage calibrator to the Model 7708 inputs and verifying that the displayed readings fall within specified ranges.

CAUTION Do not exceed 300V RMS between plug-in module INPUT H and L terminals or between adjacent channels, or 8×10^7 V•Hz input, because instrument damage may occur.

Follow these steps to verify AC voltage accuracy:

1. Connect the Model 7708 CH1 H and L INPUT terminals to the AC voltage calibrator as shown in Figure 10.
2. Install the Model 7708 in Slot 1 of the Model 27xx, turn on the power, and allow the unit to warm up for two hours before proceeding. Be sure the front panel INPUTS switch is set to the REAR position.
3. Select the AC volts function by pressing the ACV key. Close Channel 1 by pressing the CLOSE key and then keying in 101.

Figure 10
Connections for AC volts verification



4. Set the Model 27xx for the 100mV range; make sure that REL is disabled.
5. Source 1kHz and 50kHz AC voltages for each of the ranges summarized in Table 4, and make sure that the respective Model 27xx readings fall within stated limits.
6. Press the OPEN key to open Channel 1.

Table 4
ACV reading limits

ACV range	Applied AC voltage	1kHz reading limits (1 year, 18°C to 28°C)	50kHz reading limits (1 year, 18°C to 28°C)
100mV	100.0000mV	99.910 to 100.090mV	99.830 to 100.170mV
1V	1.000000V	0.99910 to 1.00090V	0.99830 to 1.00170V
10V	10.00000V	9.9910 to 10.0090V	9.98300 to 10.0170V
100V	100.0000V	99.910 to 100.090V	99.830 to 100.170V
750V	300.000V*	299.60 to 300.40V	299.27 to 300.73V

* If the 5725A amplifier is not available, change the 300V @ 50kHz step to 220V @ 50kHz. Reading limits for 220V @ 50kHz = 219.36 to 220.64V.

Verifying resistance

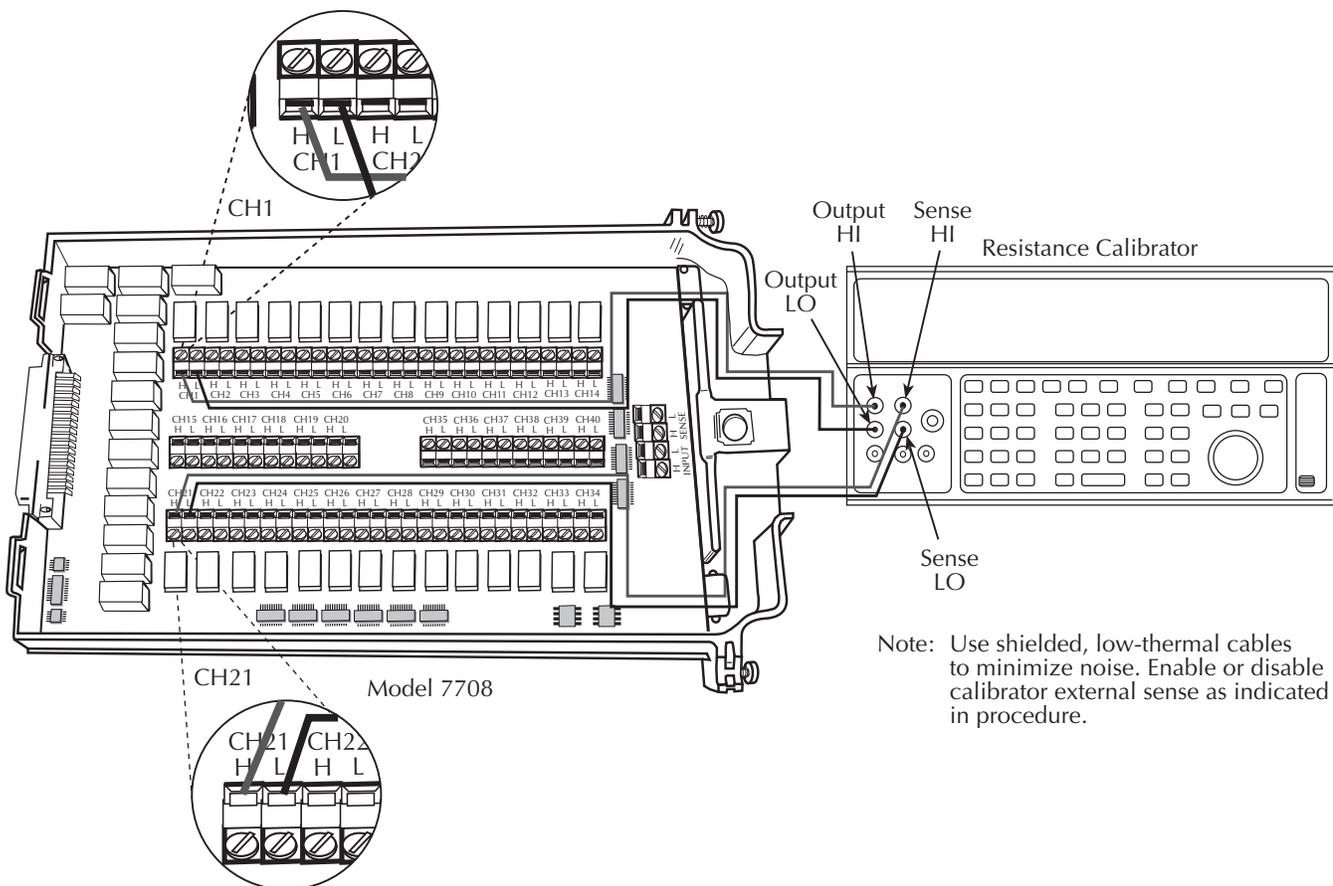
Check resistance by connecting accurate resistance values to the Model 7708 and verifying that its resistance readings are within the specified limits.

CAUTION Do not apply more than 300V between plug-in module INPUT or SENSE H and L terminal, or between any adjacent channels, or instrument damage could occur.

Follow these steps to verify resistance accuracy:

1. Using shielded Teflon or equivalent cables in a 4-wire configuration, connect the Model 7708 CH1 H and L INPUT terminals, and CH21 H and L SENSE terminals to the calibrator as shown in Figure 11.
2. Install the Model 7708 in Slot 1 of the Model 27xx, turn on the power, and allow the unit to warm up for two hours before proceeding. Be sure the front panel INPUTS switch is set to the REAR position.
3. Set the calibrator for 4-wire resistance with external sense on.
4. Select the Model 27xx 4-wire resistance function by pressing the $\Omega 4$ key. Close Channel 1 by pressing the CLOSE key and keying in 101.

Figure 11
Connections for resistance verification (100 Ω to 10M Ω) ranges)



5. Set the Model 27xx for the 100Ω range, and make sure the FILTER is on. Enable OCOMP (offset-compensated ohms) for the 100Ω range test. (Press SHIFT then OCOMP.)
6. Recalculate reading limits based on actual calibrator resistance values.
7. Source the nominal full-scale resistance values for the 100Ω-10MΩ ranges summarized in Table 5, and verify that the readings are within calculated limits.

Table 5

Limits for resistance verification

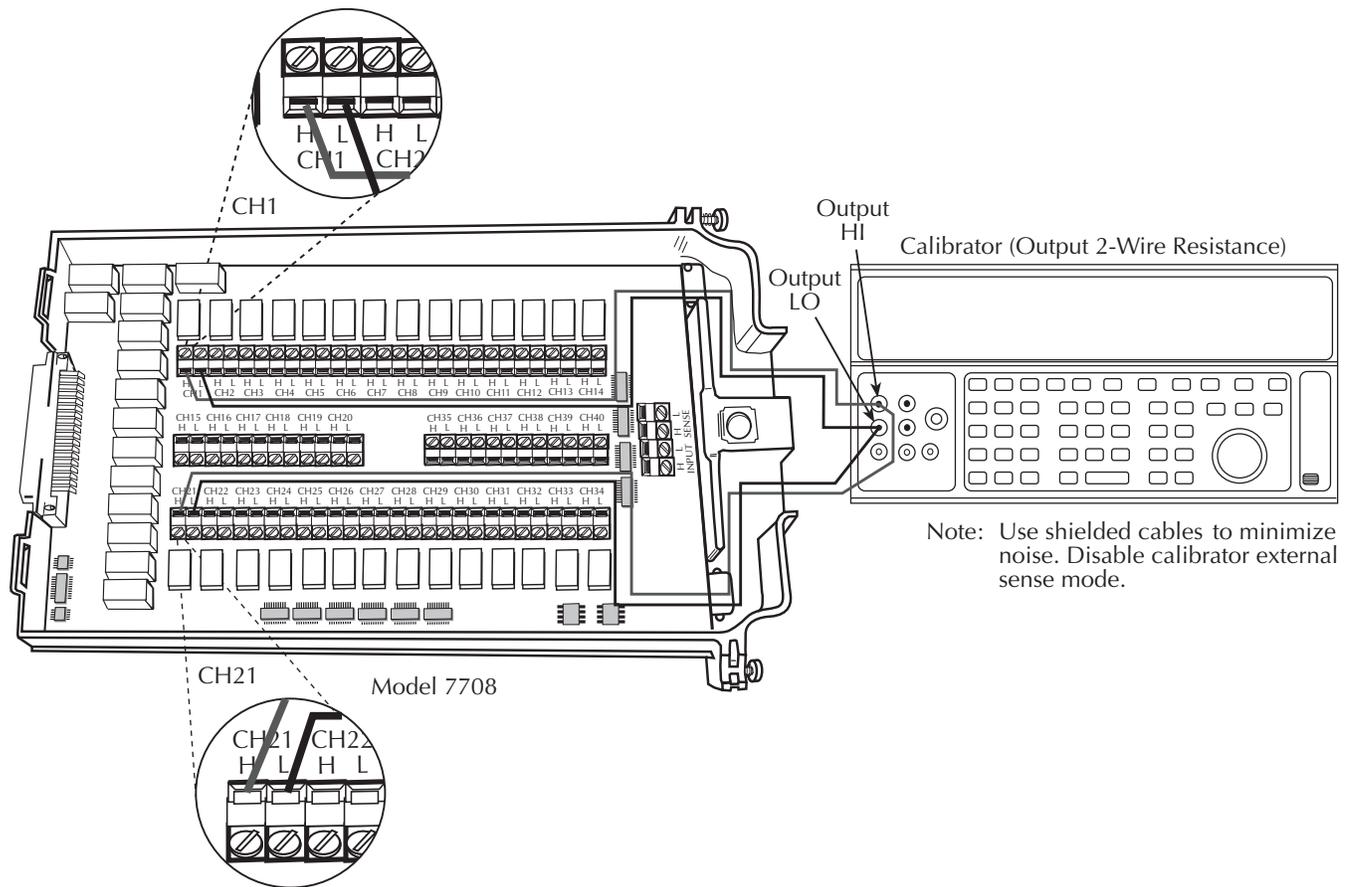
Ω Range	Nominal resistance	Nominal reading limits (1 year, 18°C to 28°C)	Recalculated limits**
100Ω*	100Ω	99.9880 to 100.0120Ω	_____ to _____ Ω
1kΩ	1kΩ	0.999894 to 1.000106kΩ	_____ to _____ kΩ
10kΩ	10kΩ	9.99894 to 10.00106kΩ	_____ to _____ kΩ
100kΩ	100kΩ	99.9890 to 100.0110kΩ	_____ to _____ kΩ
1MΩ	1MΩ	0.999890 to 1.000110MΩ	_____ to _____ MΩ
10MΩ	10MΩ	9.99590 to 10.00410MΩ	_____ to _____ MΩ
100MΩ	100MΩ	99.5770 to 100.4230MΩ	_____ to _____ MΩ

* Enable OCOMP for 100Ω range.

** Calculate limits based on actual calibration resistance values and Model 27xx one-year resistance accuracy specifications. See *Verification limits*.

8. Connect the Model 7708 CH1 and CH21 terminals to the calibrator as shown in Figure 12.
9. Disable external sense on the calibrator.
10. Set the Model 27xx for the 100MΩ range.
11. Source a nominal 100MΩ resistance value, and verify that the reading is within calculated limits for the 100MΩ range.
12. Press the OPEN key to open Channel 1.

Figure 12
Connections for resistance verification (100MΩ range)



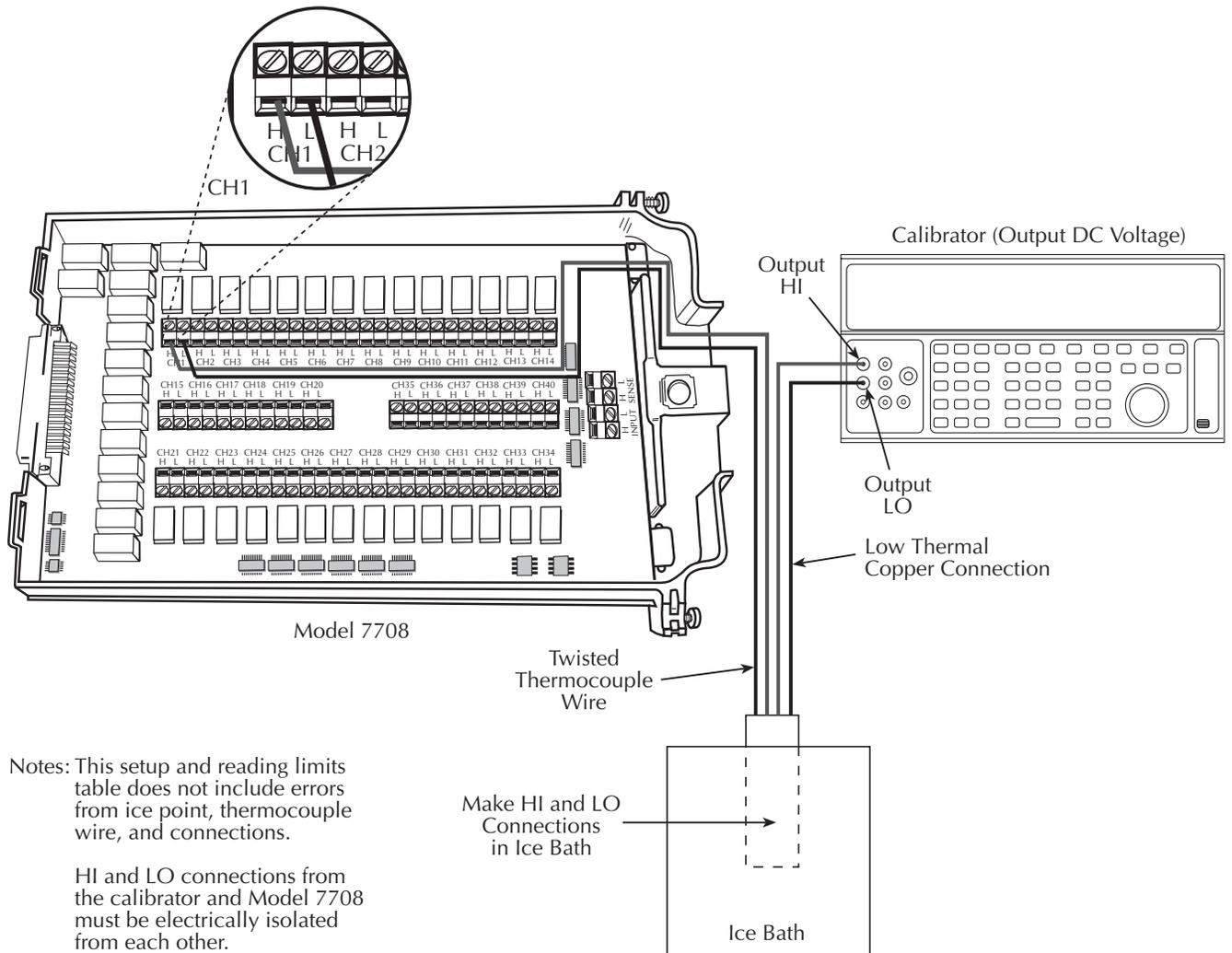
Verifying temperature

Thermocouple, thermistor, and RTD temperature readings are derived from DC volts and resistance measurements, respectively. For that reason, it is not necessary to independently verify the accuracy of temperature measurements. As long as the DC volts and resistance functions meet or exceed specifications, temperature function accuracy is automatically verified. However, temperature verification procedures are provided below for those who wish to separately verify temperature accuracy.

Thermocouple temperature

1. Connect the DC voltage calibrator output terminals and ice point reference to the Model 7708 CH1 H and L INPUT terminals using low-thermal shielded connections, as shown in Figure 13.
2. Install the Model 7708 in Slot 1 of the Model 27xx, turn on the power, and allow the unit to warm up for two hours before proceeding. Be sure the front panel INPUTS switch is set to the REAR position.
3. Select the temperature function by pressing the TEMP key. Close Channel 1 by pressing the CLOSE key and keying in 101.

Figure 13
Connections for thermocouple temperature verification



4. Configure the Model 27xx for °C units, type K temperature sensor, and internal reference junction as follows:
 - a. Press SHIFT then SENSOR, and note the unit displays the temperature units: UNITS: C. (If necessary, use the cursor and range keys to select °C units.)
 - b. Press ENTER. The unit then displays the sensor type: SENS: TCOUPLE.
 - c. Make sure that TCOUPLE is displayed, then press ENTER. The unit displays the thermocouple type: TYPE: J.
 - d. Select a type K temperature sensor, then press ENTER. The unit then displays the reference junction type: JUNC: SIM.
 - e. Select INT reference junction, then press ENTER.
5. Source each of the voltages summarized in [Table 6](#) and verify that the temperature readings are within limits. Be sure to select the appropriate thermocouple type for each group of readings. (See step 3 above.) Open Channel 1 after the test is completed.

Table 6

Thermocouple temperature verification reading limits

Thermocouple type	Applied DC voltage*	Reading limits (1 year, 18°C to 28°C)
J	-7.659mV	-192.33 to -187.67°C
	0mV	-1.0 to +1.0°C
	42.280mV	749.0 to 751.0°C
K	-5.730mV	-192.33 to -187.67°C
	0mV	-1.0 to +1.0°C
	54.138mV	1349.0 to 1351.0°C

*Voltages shown are based on ITS-90 standard.

RTD temperature

1. Connect the precision decade resistance box (listed in [Table 2](#)) to the Model 7708 CH1 and CH21 H and L terminals using four-wire connections. (See [Figure 11](#) for similar connecting scheme.)
2. Install the Model 7708 in Slot 1 of the Model 27xx, turn on the power, and allow the unit to warm up for two hours before proceeding. Be sure the front panel INPUTS switch is set to the REAR position.
3. Select the temperature function by pressing the TEMP key. Close Channel 1 by pressing the CLOSE key and keying in 101.
4. Configure the Model 27xx temperature function for °C units and RTD temperature sensor ($\alpha=0.00385$) as follows:
 - a. Press SHIFT then SENSOR, and note the unit displays the temperature units: UNITS: C.
 - b. Press ENTER, and note the unit displays the sensor type: SENS: TCOUPLE.
 - c. Using the cursor and range keys, set the display as follows: SENS: 4W-RTD.
 - d. Press ENTER, and note the unit displays: TYPE: PT100.
 - e. Using the cursor and range keys, set the unit for the following display: TYPE: PT385.
 - f. Press ENTER to complete the temperature configuration process.
5. Set the decade resistance box to each of the values shown in [Table 7](#), and verify that the temperature readings are within the required limits. Open Channel 1 when finished.

Table 7

Plug-in module four-wire RTD temperature verification reading limits

Applied resistance*	Reading limits (1 year, 18°C to 28°C)
22.80Ω	-190.06 to -189.94°C
100.00Ω	-0.06 to +0.06°C
313.59Ω	599.94 to 600.06°C

*Based on $\alpha = 0.00385$. See text.

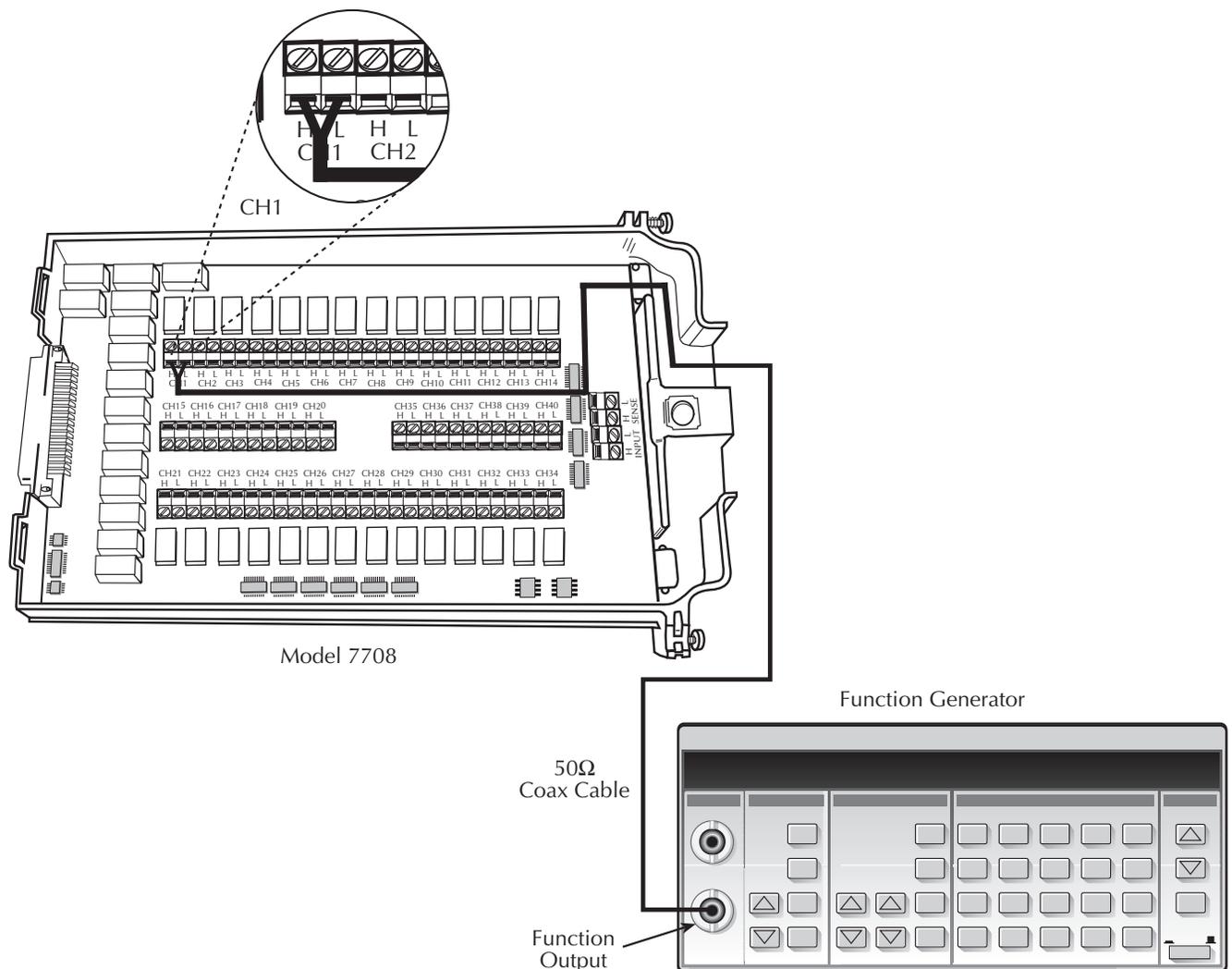
Verifying frequency

Follow the steps below to verify the Model 27xx frequency function:

1. Connect the function generator to the Model 7708 CH1 H and L INPUT terminals. (See [Figure 14.](#))
2. Install the Model 7708 in Slot 1 of the Model 27xx, then turn on the power, and allow the unit to warm up for one hour before proceeding. Be sure the front panel INPUTS switch is set to the REAR position.
3. Set the function generator to output a 1kHz, 1V RMS sine wave.
4. Select the Model 27xx frequency function by pressing the **FREQ** key. Close Channel 1 by pressing the **CLOSE** key and keying in 101.
5. Verify that the Model 27xx frequency reading is between 0.9999kHz and 1.0001kHz.

Figure 14

Connections for frequency verification



Verifying ratio and average

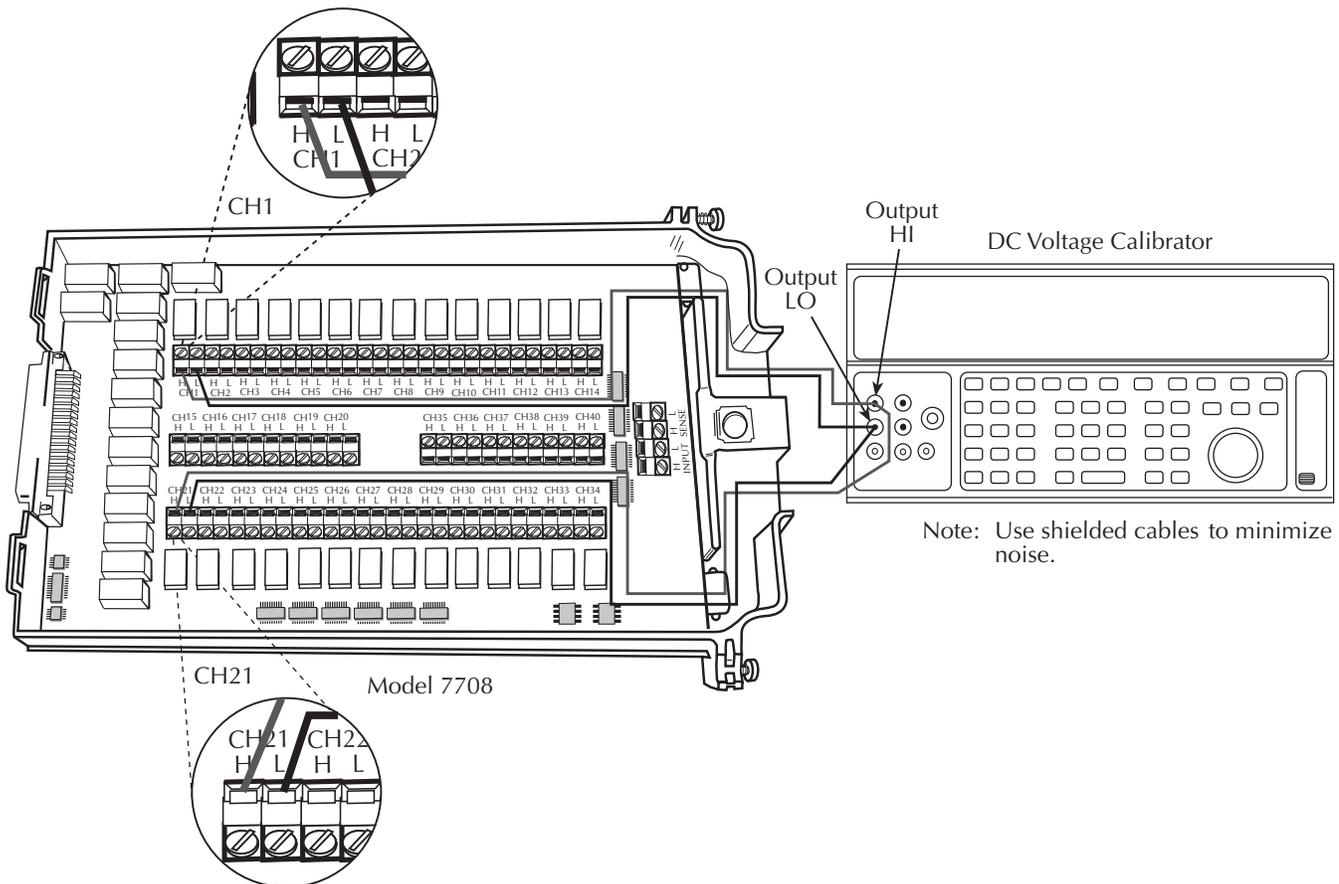
Follow the procedure below to verify ratio and average.

CAUTION Exceeding 300V between plug-in module INPUT or SENSE H and L terminals may cause instrument damage.

1. Connect the Model 7708 CH1 and CH21 H and L terminals to the DC calibrator, as shown in [Figure 15](#).
2. Install the Model 7708 in Slot 1 of the Model 27xx, turn on the power, and allow the unit to warm up for two hours before proceeding. Be sure the front panel INPUTS switch is set to the REAR position.
3. Select the Model 27xx DCV function and the 1V range. Close Channel 1 by pressing the CLOSE key and keying in 101.
4. Select the Model 27xx RATIO function (press SHIFT then RATIO).
5. Set the calibrator output to 1.00000V DC, and allow the reading to settle.
6. Verify that the ratio reading is between 0.9999926 and 1.000074.
7. Press OPEN to open Channel 1.

Figure 15

Connections for ratio and average verification



Calibration

The following procedures calibrate the temperature sensors on the Model 7708 plug-in modules.

WARNING The information in this section is intended only for qualified service personnel. Do not attempt these procedures unless you are qualified to do so.

Recommended test equipment

In order to calibrate the Model 7708, you will need equipment summarized in [Table 8](#).

Table 8

Recommended equipment for Model 7708 calibration

Digital Thermometer: 18 to 23°C, ±0.1°C
Keithley 7797 Calibration/Extender Board

Extender board connections

The Model 7708 being calibrated should be connected to the 7797 Calibration/Extender Board, and the extender board should then be installed in scanner Slot #1. Note that the module being calibrated will be external to the Model 27xx to avoid card heating during calibration.

Model 7708 calibration

NOTE Before calibrating the Model 7708, make sure that power has been removed from the card for at least two hours to allow card circuitry to cool down. After turning on the power during the calibration procedure, complete the procedure as quickly as possible to minimize card heating that could affect calibration accuracy. Allow the Model 27xx to warm up for at least two hours.

Front panel Model 7708 calibration

1. Connect the Model 7708 to the Model 7797 Calibration/Extender Board (see “Extender board connections” above).
2. With the power off, install the Model 7708/7797 combination in Slot 1 and select the rear inputs with the INPUTS switch. Allow three minutes for thermal equilibrium.
3. Accurately measure and record the cold temperature of the Model 7708 card surface at the center of the card with a digital thermometer.
4. Press in and hold the Model 27xx OPEN key while turning on the power.
5. Press SHIFT then TEST, then display TEST:CALIB with the up or down range key. Press ENTER, select RUN, then enter the appropriate calibration code (default: 0027xx).
6. With NEW CODE? displayed, use the up or down range key to display N, then press ENTER.
7. Using the up or down range key, select CARD at the CAL:RUN prompt, then press ENTER.
8. Set the display value to the cold calibration temperature (°C) you measured in Step 3, then press ENTER to complete Model 7708 calibration.

Remote Model 7708 calibration

1. Connect the Model 7708 to the 7797 Calibration/Extender Board (see “Extender board connections” above).
2. With the power off, install the Model 7708/7797 combination in Slot 1, and select the rear inputs with the INPUTS switch. Allow three minutes for thermal equilibrium.
3. Accurately measure and record the cold temperature of the Model 7708 card surface at the center of the card.
4. Press in and hold the Model 27xx OPEN key while turning on the power.
5. Enable calibration by sending the :CODE command. For example, the default command is:
:CAL:PROT:CODE 'KI0027xx'
6. Initiate calibration by sending the following command:
:CAL:PROT:CARD1:INIT
7. Calibrate the Model 7708 with the following command:
:CAL:PROT:CARD1:STEP0 <temp>
Here <temp> is the cold calibration temperature (°C) measured in Step 3.
8. Send the following commands to save calibration and lock out calibration:
:CAL:PROT:CARD1:SAVE
:CAL:PROT:CARD1:LOCK

Replaceable parts

This section contains replacement parts information and the component layout drawing for the Model 7708.

Parts list

Replaceable parts for the Model 7708 are listed in [Table 9](#).

Table 9
Model 7708 parts list

Circuit Designation	Description	Keithley Part No.
C1, C3, C4, C7, C9-C11, C14, C200, C201, C203-C213	CAP, 0.1 μ F, 20%, 50V, CERAMIC	C-418-1
C2, C6, C17-C20, C23-C25, C202	CAP, 47pF, 5%, 100V, CERAMIC	C-465-47P
C5	CAP, 4.7 μ F, 10%, 35V, TANTALUM	C-476-4.7
C16	CAP, 220 μ F, 20%, 10V, TANTALUM	C-558-220
CR1-CR14, CR15-CR42, CR45, CR48-CR56	DIODE, DUAL SWITCHING, BAV99L	RF-82
CR43, CR44, CR46, CR47	DIODE, SWITCHING, MMBD914	RF-83
CR101-CR104	DIODE, DUAL HIGH SPEED	RF-147
J1015	CONN, RT ANGLE DUAL ROM RECEIPT	CS-1065-1
K1-K41	LATCHING RELAY, SINGLE COIL	RL-225
K42, K43	NON-LATCHING RELAY	RL-242
Q4, Q6	DIGITAL TRANS, DUAL PNP	TG-386
Q5	N-CHANNEL/P-CHANNEL POWER MOSFET	TG-360
Q7	DIGITAL TRANS, DUAL PNP	TG-385
Q25, Q27, Q29, Q31, Q33, Q35, Q37, Q39, Q41, Q43, Q45, Q47, Q49, Q51	TRANS, PNP SILICON	TG-388
Q26, Q28, Q30, Q32, Q34, Q36, Q38, Q40, Q42, Q44, Q46, Q48, Q50, Q52	TRANS, NPN SILICON	TG-389
R1	RES, 69.8k Ω , 1%, 1W, THICK FILM	R-418-69.8K
R2, R3, R5, R6, R108-R110, R12	RES, 1k Ω , 1%, 100mW, THICK FILM	R-418-1K
R4	RES, 10k Ω , 1%, 100mW, THICK FILM	R-418-10K
R7-R13	RES ARRAY, 4 x 4.3k Ω , 5%, 100mW	TF-276-4.3K
R14, R55	RES, 137 Ω , 1%, 125mW, METAL FILM	R-391-137
R200-R202	RES, 470 Ω , 5%, 125mW, METAL FILM	R-375-470
R203-R205	RES, 4.7k Ω , 5%, 125mW, METAL FILM	R-375-4.7K
R206, R207	RES, 1k Ω , 5%, 125mW, METAL FILM	R-375-1K
TE1, TE3, TE106, TE112, TE113	CONN, 4-PIN, JOLO BB-125-04	TE-115-4
TE2, TE4, TE101-T3103, TE107-TE109	CONN, 8-PIN	TE-115-8
U1-U3, U6, U8	IC, 8-STAGE SHIFT/STORE, MC14094BD	IC-772
U7, U25	IC, POS NAND GATES/INV, 74HCT14	IC-656
U9, U10	IC, DUAL OPTO	IC-1358
U11, U12	IC, 8-CHAN ANA MULTIPLEXER, DG408DY	IC-844
U13, U31-U38	IC, CENTIGRADE TEMP SENSOR, LM35DM	IC-906
U14	IC, RETRIG., MULTIVIB, 74HC123AM	IC-788
U16	IC, 2.5V, CASCADABLE SERIAL EEPROM	LSI-212
U24	IC, QUAD 2 IN AND, 74HCT08	IC-837
	TOP COVER HEAT STAKE ASSEMBLY	7700-302A
	BOTTOM CARD COVER	7702-301C
	COMPRESSION SPRING	SP-7-3

Ordering information

To place an order, or to obtain information concerning replacement parts, contact your Keithley representative or the factory (see inside front cover for addresses). When ordering parts, be sure to include the following information:

- Card model number (Model 7708)
- Card serial number
- Part description
- Component designation (if applicable)
- Keithley part number

Factory service

If the instrument is to be returned to Keithley Instruments for repair, perform the following:

- Call the Repair Department at 1-888-KEITHLEY for a Return Material Authorization (RMA) number.
- Complete the service form at the back of this manual, and include it with the instrument.
- Carefully pack the instrument in the original packing carton.
- Write ATTENTION REPAIR DEPARTMENT and the RMA number on the shipping label.

Component layout

The component layout for the Model 7708 is shown at the end of this packing list.

7708 40-Channel Differential Multiplexer w/Automatic CJC

GENERAL

40 CHANNELS: 40 channels of 2-pole relay input. All channels configurable to 4-pole.

RELAY TYPE: Latching electromechanical.

ACTUATION TIME: <3ms.

Specified for Model 2700, firmware revision BO2 or later.

CAPABILITIES

CHANNELS 1–40: Multiplex one of 40 2-pole or one of 20 4-pole signals into DMM. Configuration supports dual 1×20 independent multiplexers.

INPUTS

MAXIMUM SIGNAL LEVEL:

Channels (1–40): 300V DC or rms, 1A switched, 60W, 125VA maximum.

SAFETY: Conforms to European Union Directive 73/23/EEC EN61010-1, CAT I.

CONTACT LIFE (typ): >10⁵ operations at max signal level.
>10⁸ operations cold switching.

CONTACT RESISTANCE: <2Ω at end of contact life.

CONTACT POTENTIAL: <±500nV typical per contact, 1μV max.
<±500nV typical per contact pair, 1μV max.

OFFSET CURRENT: <100pA.

CONNECTOR TYPE: Screw terminal, #20 AWG wire size.

ISOLATION BETWEEN ANY TWO TERMINALS: >10⁹Ω, <200pF

ISOLATION BETWEEN ANY TERMINAL AND EARTH: >10⁹Ω, <400pF

CROSS TALK (1MHz, 50Ω Load): <–40dB.

INSERTION LOSS (50Ω Source, 50Ω Load): <0.35dB below 1MHz.
<3dB below 2MHz.

COMMON MODE VOLTAGE: 300V between any terminal and chassis.

T/C COLD JUNCTION: 1.0°C (18°–28°C Mainframe Temp)
1.5°C (0°–18°C & 28°–50°C Mainframe Temp).

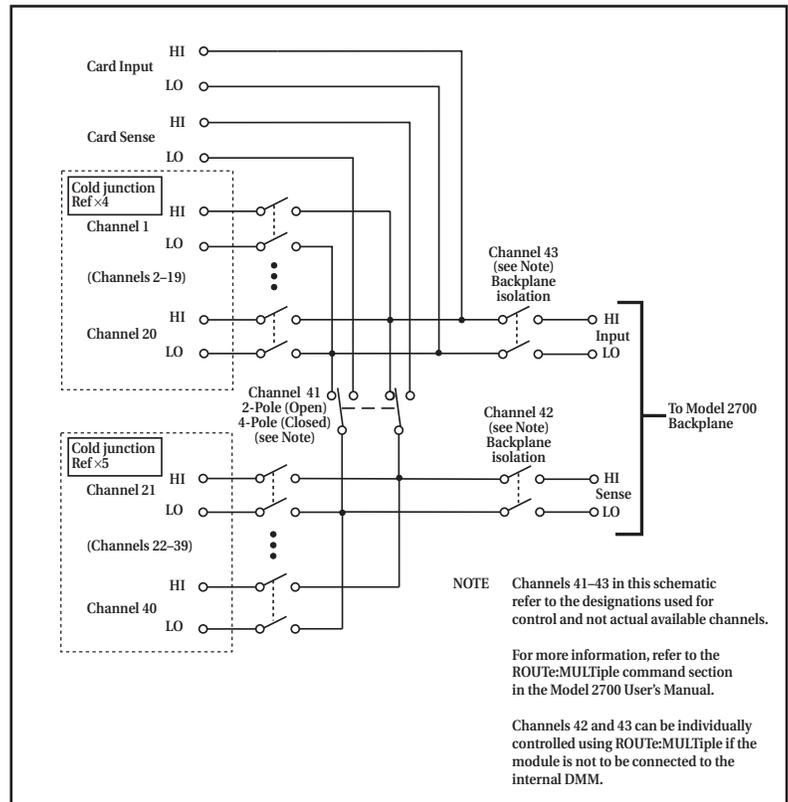
ENVIRONMENTAL:

OPERATING ENVIRONMENT: Specified for 0°C to 50°C.
Specified to 80% R.H. at 35°C.

STORAGE ENVIRONMENT: –25°C to 65°C.

WEIGHT: 0.52kg (1.16 lb).

Specifications are subject to change without notice.



Specifications are subject to change without notice.

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