KM-SM-20V3-5I7-03
Modular Power Supply

Instruction Manual

Contains Operating and Servicing Information

KEITHLEY

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Keithley Instruments, Inc. warrants the following items for 90 days from the date of shipment: probes, cables, rechargeable batteries, diskettes, and documentation.

During the warranty period, we will, at our option, either repair or replace any product that proves to be defective.

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Modular Precision Readback Power Supply
Instruction Manual

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Manual Print History

The print history shown below lists the printing dates of all Revisions and Addenda created for this manual. The Revision Level letter increases alphabetically as the manual undergoes subsequent updates. Addenda, which are released between Revisions, contain important change information that the user should incorporate immediately into the manual. Addenda are numbered sequentially. When a new Revision is created, all Addenda associated with the previous Revision of the manual are incorporated into the new Revision of the manual. Each new Revision includes a revised copy of this print history page.

Revision A (Document Number KMSM03-901-01)..... December 1995

Safety Precautions

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 the operating information carefully before using the product.

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.**

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.

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.

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.

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 main. When connecting sources to switching cards, install protective devices to limit fault current and voltage to the 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 #18 AWG or larger wire.

The  symbol on an instrument or accessory indicates that 1000V or more may be present on the terminals. Refer to the product manual for detailed operating information.

Instrumentation and accessories should not be connected to humans.

Maintenance should be performed by qualified service personnel. Before performing any maintenance, disconnect the line cord and all test cables.

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4 Calibration

1

Specifications

DC Voltage (23° ±5°C)

Output voltage: 0 to +20VDC
Output accuracy: ±(0.05% +10mV)
Programming resolution: 10mV
Readback accuracy: ±(0.05% +10mV)
Readback resolution: 1mV

Current (23° ±5°C)

Output current: See graph in Figure 1-1.
Compliance accuracy: ±(0.16% +5mA)
Programmed compliance resolution: 1.25mA
Readback accuracy:
  5A range: ±(0.2% +200μA)
  5mA range: ±(0.2% +1μA)
Readback resolution:
  5A range: 100μA
  5mA range: 0.1μA
Minimum current in constant current mode: 6mA

Digital voltmeter input (23° ±5°C)

Maximum input voltage: +20VDC
Overload voltage: +30VDC with respect to earth
Reading accuracy: ±(0.05% +10mV)
Reading resolution: 1mV

Speed (command sent and reading received)

Measure voltage readback: 75ms max.
Measure current (5A range): 75ms max.
Measure current (5mA range): 200ms max.
Measure voltmeter reading: 75ms max.

General

Response time: <15ms from 10% to 90%
Isolation (low – earth): 22VDC max. (not intended to be operated in parallel)
Programming: GPIB, IEEE-488.1
Remote sense: Automatic, 2V max. drop
Calibration interval: 1 year
Operating temperature: 0° to 35°C max.
Storage temperature: 0° to 50°C max.
Humidity: <80% @ 35°C non-condensing
Power consumption: 275VA max.
Dimensions: 267mm × 305mm × 102mm (10.5 in. × 12 in. × 4 in.)
Weight: 12 lbs
Input power: 110 to 125VAC at 60Hz
Warranty: 1 year parts and labor on materials and workmanship.

Accessories

KM-DM-2×16-03 rack mount display with 2×16 LCD and attached 9-foot cable

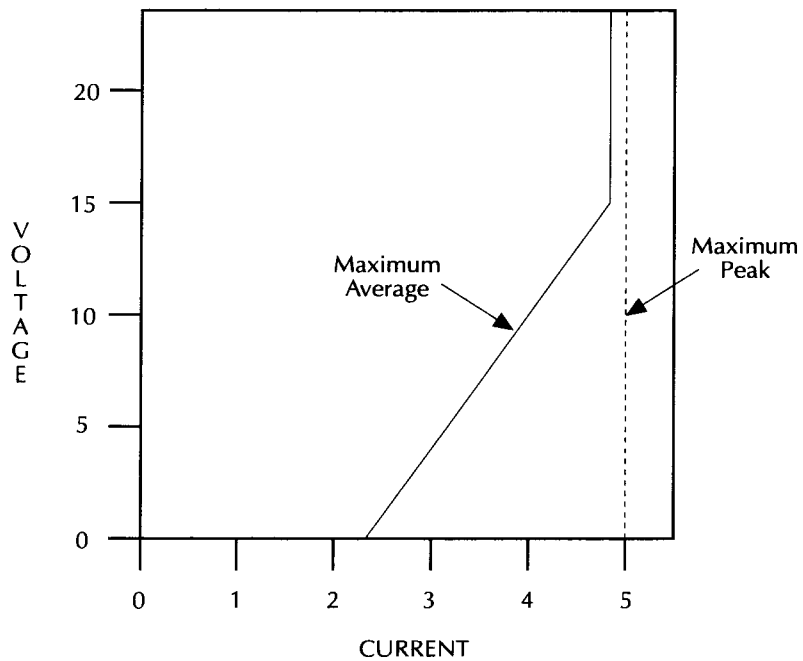

Figure 1-1
Output current

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Installation

Module mounting

Figure 2-1 gives the dimensions of the module. Use these dimensions when deciding on the module mounting location.

Make sure the power supply's fan has adequate clearance to provide proper ventilation to internal components.

The heat sink becomes warm while the power supply is in use. Make sure the heat sink has adequate clearance so the power supply and components installed receive proper cooling.

Make sure the wiring connectors on the power supply have adequate space. Leave enough room so the wiring does not get crimped coming out of the power supply.

Wiring connections for normal operation

Figure 2-2 shows a detailed example of the wiring connections needed for normal operation.

The connections to the SM-03 shown in Figure 2-2 are made to the eight pin connectors located on the front of the power supply as shown in Figure 2-3.

GPIB (IEEE-488.1 bus) and the optional remote display unit are the other wiring connections made to the power supply. Figure 2-4 shows the connectors on the power supply for these wiring connections.

Remote display

The remote display, shown in Figure 2-5, is an optional display device that connects directly to the power supply by a 9-foot cable. Figure 2-4 shows the connection for the display.

This display provides measured voltage and current readings, the output status, and whether current limits are in effect or whether protection is tripped. This two-line display unit requires only 2.5 inches (63.50mm) of panel height, so space requirements are minimal.

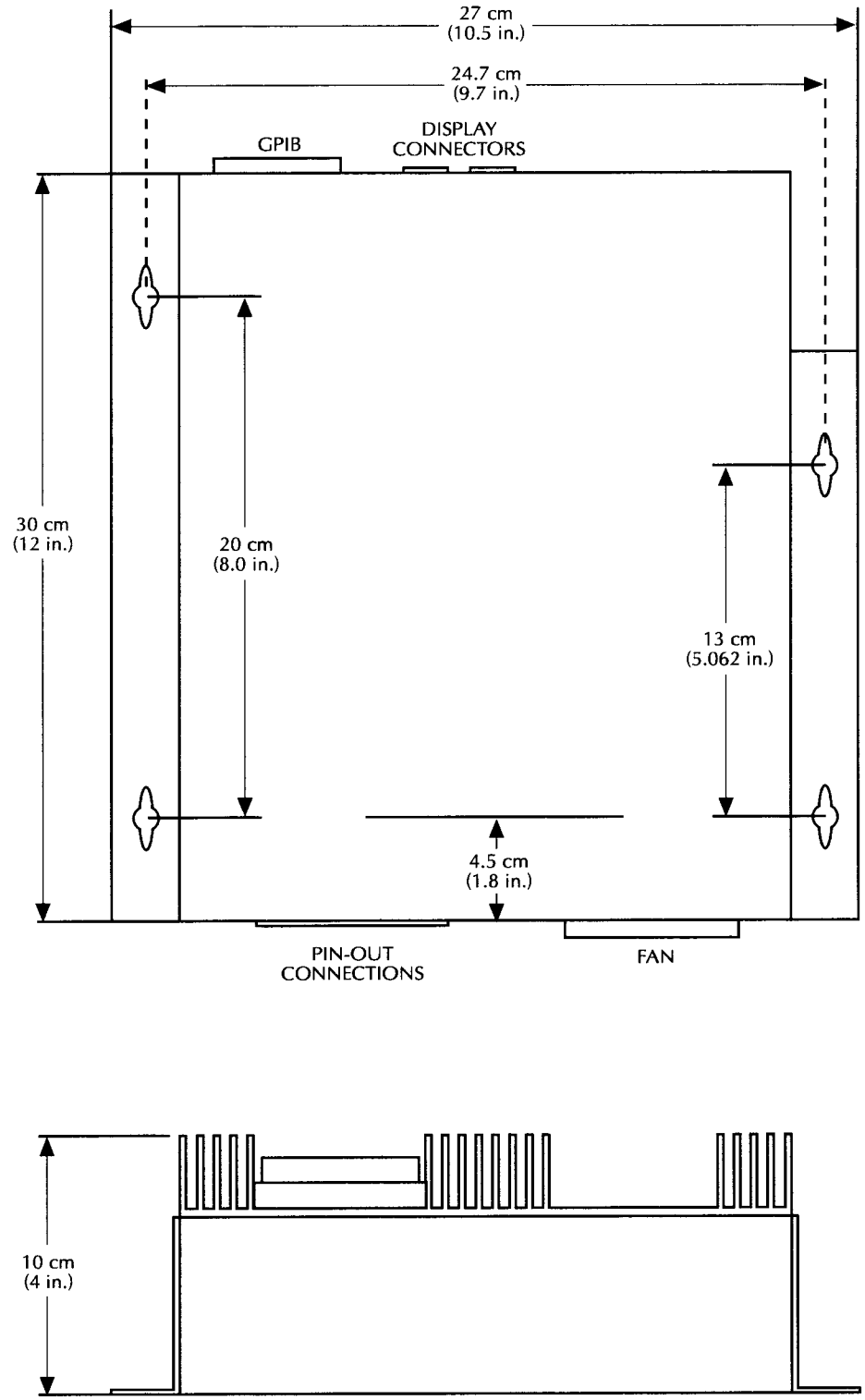

Figure 2-1
Mounting dimensions

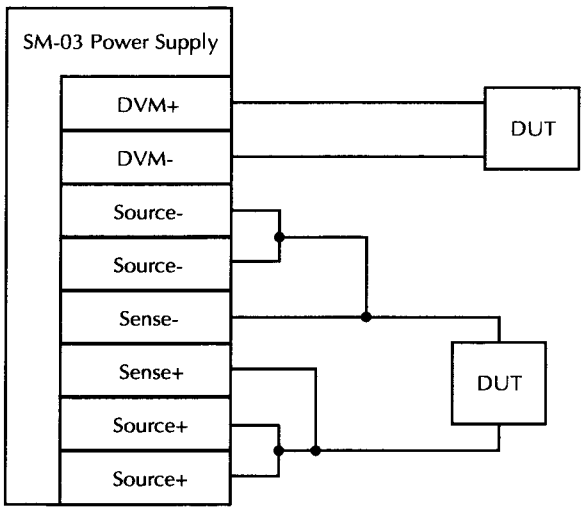

Figure 2-2
Pin-out connections

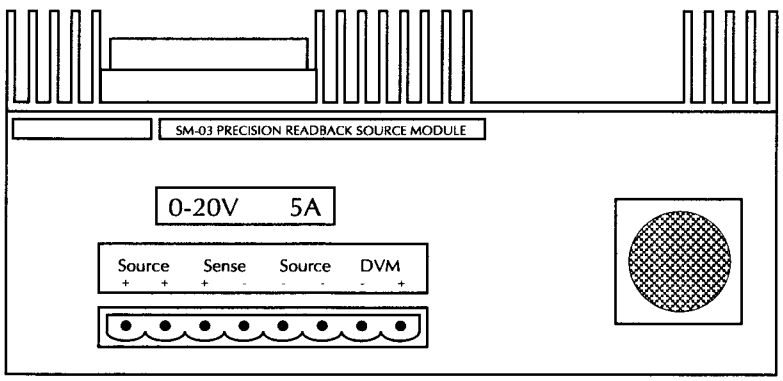

Figure 2-3
SM-03 front panel

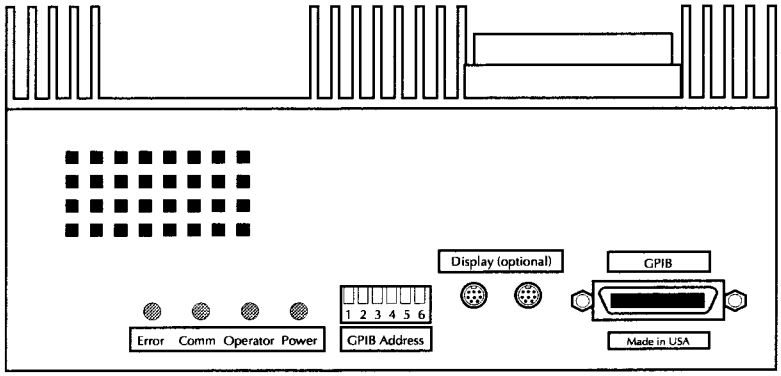

Figure 2-4
SM-03 rear panel

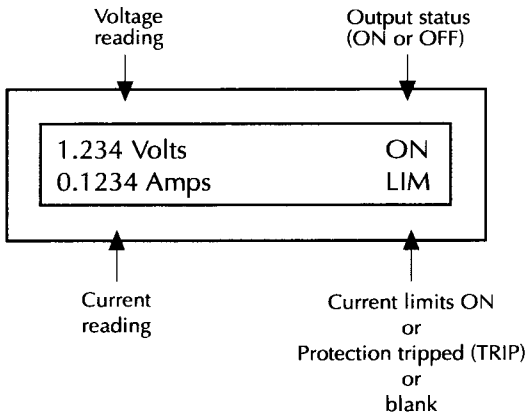

Figure 2-5
Remote display

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Operation

GPIB interface

The GPIB is the operational interface of the SM-03 module. This unit supports serial poll and multiple commands per program message. The module provides a response message for a query command sent within a program message. Any response message left unread in the output buffer is overwritten when a new response message is sent.

Data throughput is approximately 90 microseconds per byte in either direction. Multiple commands affecting the source execute at 50 milliseconds per command.

Setting the GPIB address

Figure 3-1 shows the GPIB address switch. If this switch must be configured, make sure it is done before powering up the module.

For example, to set the GPIB address to 13 (decimal), move switches 1, 3, and 4 to the up position and switches 2 and 5 to the down position.

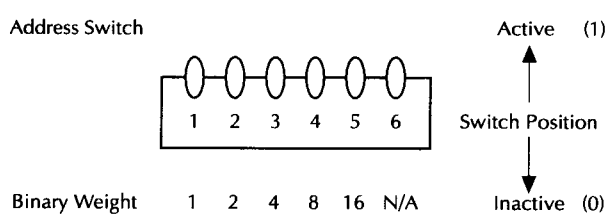

Figure 3-1
GPIB address switch

Programming

A program message contains one or more commands and is limited to 30 characters per command.

No spaces are permitted in a program message except between a command letter and its argument. The unit will only support one query per message.

Multiple commands are separated by a semicolon and executed sequentially in the order they appear from left to right.

The program message must be terminated with a line feed character. The power supply then processes commands from the bus once the line feed character is read. The GPIB interface driver normally inserts this character at the end of the string. For example, the CEC "send" command automatically appends the line feed character to the end of the string passed to the function.

Some bus controllers do not automatically send a line feed character, such as the controller cards from National. To get a line feed character into the string being sent, append \n to the command(s) being sent out. For example, if the program line states ibwrt(V5.0), change it to ibwrt(V5.0\n).

Commands are not case sensitive. Most commands can be followed by a question mark (?) to return the programmed value. All commands and responses are in ASCII format.

Command set

An Set Current: n=0.000 to 5.000.

A? Returns last programmed current value.

Vn Set Voltage: n=0.000 to 20.000.

V? Returns last programmed voltage value.

On Set Output: n=0 or 1: 0=Off, 1=On.

O? Returns present output state. This may be different from last On command sent. For example, from a power-up state, send the following commands:

O? 0 returned

O1 turn on output

O? 1 returned

P1 turn on current limit protection

O? 0 returned if current limit ever exceeded and output was turned off

Pn Set Protection: n=0 (off) or 1 (on). If the set current is ever exceeded, the output will be turned off.

P? Returns present protection state. 0=Off, 1=On, 3=Tripped.

I? Returns 3xx/rev/sernum where xx=the hex value of the error status (see E command), rev=the instrument firmware version, sernum=instrument serial number. Example readback: 300/A1.0/585699

Sn SRQ Mask: n=hexadecimal representation of the serial poll bits and is used to enable the positive transition of one or more serial poll bits to cause a service request:
b0=LSB=DataRdy, b1=Error, b2=OperateOn, b3=CurrentLimitOn, b5=ReadyForCmd, b6=RQS

Mn Starts and returns a measurement (n=0 to 3). 0=volts, 2=milliamps, 3=Digital Voltmeter Input. This command sets serial poll bit 0 to a 1 when the measurement is complete and ready to be read.

E? Error Status: Returns a hexadecimal representation of the Error Byte. b0=LSB=BusCmd, b1=Calibration, b2=RomCheckSum, b3=OverPowerShutdown, b4=PowerUp, b5=EEpromSumcheck, b6=rxOflo. Reading the error status clears the condition until it occurs again.

Cnv Calibrate: n=step 0 to 6, v=actual value: step 0=VoltMeas, 1=CurrMeas, 2=mAmeas, 3=DvmMeas, 4=VoltSourced, 5=currSourced, 6=save to EEPROM.

Non-volatile storage

The calibration constants, serial number, and ROM checksum are stored in the EEPROM. At power-up, this data is tested against their respective checksums and reported in the error status, which is accessible using the I or E command. The calibration constants are also verified during a Device Clear GPIB command and when they are stored during calibration command C6.

A calibration error (b1) means the calibration data saved in the EEPROM does not match its associated checksum.

A ROM error (b2) occurs when the calculated program memory sum check does not equal the value stored in the non-volatile EEPROM.

An EEPROM error (b5) indicates the serial number and/or the number compared against the program memory calculated checksum do not agree with their associated checksums.

Serial poll and service request (SRQ)

The serial poll bits represent the real-time status of the unit. A one-level return indicates a true condition.

Bit Number	Bit Weight	Meaning when the bit is set
0 (lsb)	1	The response to a measurement command (Mn) is loaded into the output buffer and is ready to be read by the controller.
1	2	The unit has an error to report in the error byte. Use the E command to read the error. Reading the error byte clears the error condition.
2	4	The output is turned on.
3	8	The output is in current limit.
5	32	The unit is ready to accept a program message.
6	64	The unit is requesting a serial poll per the SRQ mask.

The Service Request (SRQ) is a signal within the GPIB interface that can be used to interrupt the controller if a device on the GPIB requires attention. The SRQ is used in conjunction with the serial poll to provide an explanation of the interrupt. The S command is used to enable a state change from false to true of any of the serial poll bits to cause an SRQ.

For example, S28 will cause an SRQ whenever the unit is ready for a program message and/or the output goes into current limit.

Programming procedures

The following example illustrates some of the programming rules:

1. Serial poll the unit until bit 5 is true, indicating it is ready to receive a program message.
2. Send the following test:

   ```
   V12;a.2;o1;m0?< >;
   ```

   (where < > represents the line feed character.)

   This test sets the output voltage to 12.000, sets the maximum output current to 200 milliamps, turns the output to ON, and measures the source voltage.
3. Read the measured value into the computer by addressing the unit to talk. Optionally, serial poll the unit until the Data Ready Bit is true if the controller could be busy while the reading is being prepared in the power supply unit.

Programming errors

Each command in a program message will execute sequentially. An erroneous command and all subsequent commands in a message will be discarded.

BusCmd errors are the result of unrecognized command letters and arguments out of range.

RxOflo errors occur when a program message exceeds 30 characters. It is also used when a program message is received before the unit is ready to accept it. If multiple commands are to be sent, put them all into one program message of 30 or less characters. For example, send:

```
V12;A1.5;O1;M3?
```

You can also send the message one command at a time, making sure to wait between commands for the "unit ready" bit (b5) in the SRQ byte. For example, send:

```
V12
```

Wait for bit 5 on the SRQ status to go high.

```
A1.5
```

Wait for bit 5 on the SRQ status to go high.

```
O1
```

Wait for bit 5 on the SRQ status to go high.

```
M3?
```

4

Calibration

Introduction

Calibration may be done partially or completely. An uncalibrated SM-03 power supply and a DMM with the ranges and accuracies listed below is needed. Keithley Models 2001 and 2002 meet all of these requirements.

Range	Accuracy
20V	0.0025% + 500μV
2A	0.025% + 1mA
20mA	0.025% + 0.1μA

Ambient temperature is 18° to 28°C (64° to 82°F).

Voltage calibration (source and measure)

Connect the SM-03 and DMM as shown in Figure 4-1. Always calibrate at 90% of full scale or greater. 19.0 volts is recommended.

Table 4-1 provides the steps required to properly calibrate the voltage source and measurement capabilities of the SM-03.

Current calibration (source and measure)

Connect the source and DMM as shown in Figure 4-2. Calibrate at 1.9 amps for both the amps output and the amps measure.

Table 4-2 provides the steps required to properly calibrate the current source and measurement capabilities of the SM-03.

Table 4-1
Voltage calibration table

Step	Command	Description
1	`V19;A1;O1; < >`	Set DMM to 20V range. Set SM-03 output to 19V. Set SM-03 output to 1A. Turn ON SM-03 output.
2	`C4xx.xxxx`	**Calibrate Output** Calibrate SM-03 output by reading voltage on DMM (xx.xxxx) and entering it into the calibration source argument.
3	`3COxx.xxxx`	**Calibrate Measure** Calibrate SM-03 measure by reading voltage on the DMM (xx.xxxx) and entering it into the calibration measure argument.
4	`4C3xx.xxxx`	**Calibrate DVM Input** Calibrate SM-03 DVM input by reading voltage on DMM (xx.xxxx) and entering it into the calibration DVM measure argument.
5	`C6`	Store the new calibration constants

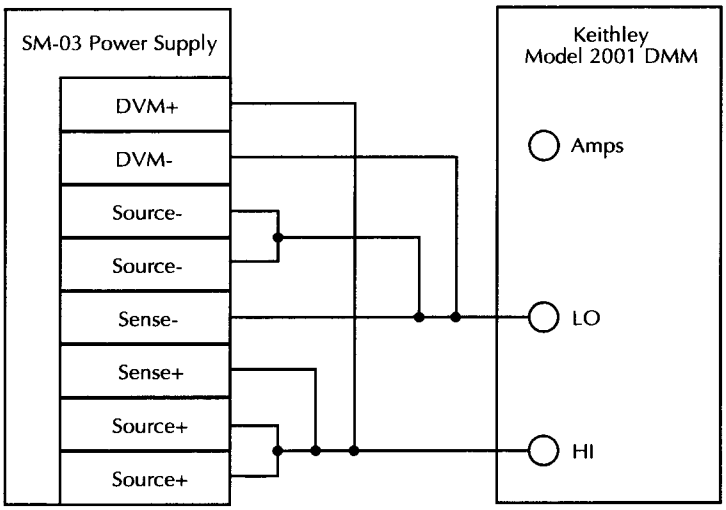

Figure 4-1
Voltage calibration connections

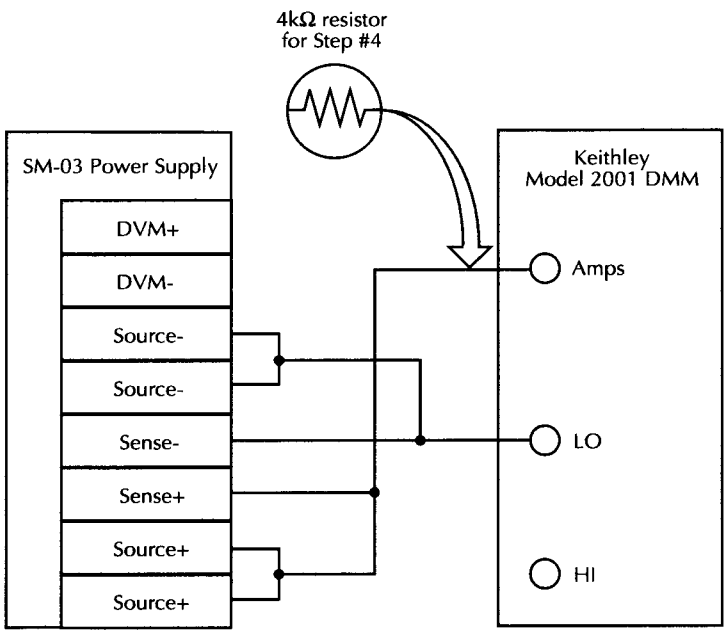

Figure 4-2
Current calibration connections

Table 4-2
Current calibration table

Step	Command	Description
1	V19;A1.9;O1; < >	Set DMM to 2A range. Set SM-03 output to 19V. Set SM-03 output to 1.9A. Turn ON SM-03 output.
2	C5x.xxxx	**Calibrate Output** Calibrate SM-03 output by reading current on DMM (x.xxxx) and entering it into the calibration source argument.
3	C1x.xxxx	**Calibrate Measure** Calibrate SM-03 measure by reading current on the DMM (xx.xxxx) and entering it into the calibration measure argument.
4a		**5mA Current Measure Calibration** Insert a 4kΩ resistor as shown in Figure 4-2.
4b		Change DMM to 20mA range.
4c	C2x.xxxx	Calibrate SM-03 milliamp measure by reading current on DMM (x.xxxx) and entering it into the calibration DVM measure argument. (For 4.5mA, enter C24.5000 not C20.0045.)
5	C6	Store the new calibration constants.

KEITHLEY

Service Form

Model No. _____ **Serial No.** _____ **Date** _____

Name and Telephone No. _____

Company _____

List all control settings, describe problem and check boxes that apply to problem. _____

_____

_____

- ❑ Intermittent
- ❑ IEEE failure
- ❑ Front panel operational
- ❑ Analog output follows display
- ❑ Obvious problem on power-up
- ❑ All ranges or functions are bad
- ❑ Particular range or function bad; specify _____
- ❑ Batteries and fuses are OK
- ❑ Checked all cables

Display or output (check one)

- ❑ Drifts
- ❑ Unstable
- ❑ Overload
- ❑ Unable to zero
- ❑ Will not read applied input

- ❑ Calibration only
- ❑ Data required
- ❑ Certificate of calibration required

(attach any additional sheets as necessary)

Show a block diagram of your measurement system including all instruments connected (whether power is turned on or not). Also, describe signal source.

Where is the measurement being performed? (factory, controlled laboratory, out-of-doors, etc.)

_____

_____

What power line voltage is used? _____ Ambient temperature? _____ °F

Relative humidity? _____ Other? _____

Any additional information. (If special modifications have been made by the user, please describe.)

_____

_____

Be sure to include your name and phone number on this service form.