The Model 7706 can be used with Keithley Models 2700, 2701, and 2750. All references to the Model 2700 also apply to the Models 2701 and 2750.
WARRANTY

Keithley Instruments, Inc. warrants this product to be free from defects in material and workmanship for a period of 1 year from date of shipment.

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.

To exercise this warranty, write or call your local Keithley representative, or contact Keithley headquarters in Cleveland, Ohio. You will be given prompt assistance and return instructions. Send the product, transportation prepaid, to the indicated service facility. Repairs will be made and the product returned, transportation prepaid. Repaired or replaced products are warranted for the balance of the original warranty period, or at least 90 days.

LIMITATION OF WARRANTY

This warranty does not apply to defects resulting from product modification without Keithley’s express written consent, or misuse of any product or part. This warranty also does not apply to fuses, software, non-rechargeable batteries, damage from battery leakage, or problems arising from normal wear or failure to follow instructions.

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR USE. THE REMEDIES PROVIDED HEREIN ARE BUYER’S SOLE AND EXCLUSIVE REMEDIES.

NEITHER KEITHLEY INSTRUMENTS, INC. NOR ANY OF ITS EMPLOYEES SHALL BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF THE USE OF ITS INSTRUMENTS AND SOFTWARE EVEN IF KEITHLEY INSTRUMENTS, INC., HAS BEEN ADVISED IN ADVANCE OF THE POSSIBILITY OF SUCH DAMAGES. SUCH EXCLUDED DAMAGES SHALL INCLUDE, BUT ARE NOT LIMITED TO: COSTS OF REMOVAL AND INSTALLATION, LOSSES SUSTAINED AS THE RESULT OF INJURY TO ANY PERSON, OR DAMAGE TO PROPERTY.
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 Installation Category I and Installation Category II, as described in the International Electrotechnical Commission (IEC) Standard IEC 60664. Most measurement, control, and data I/O signals are Installation Category I and must not be directly connected to mains voltage or to voltage sources with high transient over-voltages. Installation 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 ☻ or ☼ 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 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

This packing sheet contains information specific to the Model 7706 module. If you have any questions after reviewing this information, please contact your local Keithley representative or call one of our Applications Engineers at 1-800-348-3735 (U.S. and Canada only). This document is arranged as follows:

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<td>Front panel Model 7706 temperature calibration</td>
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<td>Remote Model 7706 temperature calibration</td>
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Connection

The Model 7706 is a 20-channel differential multiplexer card with the following features:

- 20 channels of analog input with 300V, 1A capacity; 60W, 125VA maximum
- 16 channels of digital output for output control
- One event counter/Totalizer
- Two analog outputs (±12V @ 5mA with 16-bit programmability)
- 2-wire or 4-wire Ω measurement (automatically pairs switches for four wire measurements — n + 10)
- Temperature applications (RTD, thermistor, thermocouple)
- Built-in automatic cold junction reference (CJC)
- Screw terminal connections
- Designed specifically for use with Keithley’s Model 2700 Multimeter/Data Acquisition System

Card configuration—schematic

Figure 1 shows a simplified schematic diagram of the Model 7706 module. As shown, the Model 7706 has channels that are grouped into two banks of ten channels (twenty channels total). Backplane isolation is provided for each bank. Each bank also includes separate cold junction reference points. The first bank contains channels 1 through 10 while the second bank contains channels 11 through 20. Each channel of the 20-channel multiplexer card is wired with separate inputs for HI/LO providing fully isolated inputs.

NOTE

Although the Model 7706 relays are the latching type (relays hold their state even after power has been removed), all relay states are set to open a few seconds after either a power cycle or an *RST command is issued.

Connections to DMM functions are provided through the card backplane connector for the following:

    INPUT connections
    SENSE (4-Wire) connections

Channels 21–22 (digital output), 23–24 (analog output), and 25 (Totalizer) are controlled either over the bus or from the front panel. The grounds for these channels are non-isolated. Detailed information on each channel is contained later in this section.

Channel 26 (2W/4W Configuration), Channel 27 (Sense Isolation), and Channel 28 (Input Isolation) are normally automatically configured by the 2700. However, by using the :ROUT:MULT: commands (refer to Section 2 of the 2700 User’s Manual), they can be manually configured.
NOTES

Connect 4-wire sense leads using channels 11–20.

To disconnect channels 11–20 from channels 1–10, send:
:ROUT:MULT:CLOSE (@126) (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 CH11
- CH2 and CH12
- CH3 and CH13
- CH4 and CH14
- CH5 and CH15
- CH6 and CH16
- CH7 and CH17
- CH8 and CH18
- CH9 and CH19
- CH10 and CH20

**Card configuration—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 7706. Channel designations for the screw terminals are contained in Figure 3.

**Figure 2**
* Screw terminal access

**WARNING**

Do not exceed the maximum specifications for the Model 7706 module. Refer to the end of this packing list for specifications.
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 7706 module. Make all connections using correct wire size (up to 22 AWG). Also, make sure to add supplementary insulation around the harness for voltages above 42V peak (see Figure 4).
**WARNING**

All wiring must be rated for the maximum voltage in the system. For example, if 1000V is applied to the front terminals of the Model 2700, the plug-in module wiring must be rated for 1000V.

1. Make sure all power is discharged from the Model 7706 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 all channels).
4. Route wire along wire-path and secure with cable ties as shown (see Figure 4).
5. Fill in a copy of the connection log (Table 1) and affix it to the module cover.
6. Close and lock cover.

**WARNING**

The Model 7706 module provides connections for both high voltage analog measurements as well as digital earth based circuits. Make sure to install and maintain double insulation between the analog and digital circuit wiring using supplementary insulation as required (see Figure 4).

*Figure 4*

*Wire dressing—fully wired module*

Note: Secure wiring to 7706 by using cable ties through cable tie holes.
**Typical connections (channels 1–20)**

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

- Thermocouple connections, see Figure 5
- Ω2-Wire and thermistor connections, see Figure 6
- Ω4-Wire and RTD connections, see Figure 7
- Voltage (AC or DC), see Figure 8

*Figure 5*

**Thermocouple connections**

*Figure 6*

**Ω2-Wire and thermistor connections**
Figure 7
Ω4-Wire and RTD connections

Channel 1
HI
LO
(Channels 2–9)
HI
LO
Channel 10
HI
LO
Channel 11
HI
LO
(Channels 12–19)
HI
LO
Channel 20
HI
LO
RTD
Ω4-Wire

Figure 8
Voltage connections (DC or AC)

Channel 1
HI
LO
(Channels 2–19)
HI
LO
Channel 20
HI
LO
DC Voltage
AC Voltage
Digital outputs (channels 21–22)

Use the Model 7706 digital outputs to control indicators, fixtures, switches, solenoids, loads, relays, etc. Figure 9 shows a simplified schematic of the digital output.

Figure 9
Simplified schematic of digital output

Setting the digital output in 8-bit (byte)

To set the digital output, send the decimal equivalent of the binary pattern desired. Keep in mind that on each port, bit 7 is the most significant bit (MSB) and bit 0 is the least significant bit (LSB). This makes the pin 1 screw terminal of each digital port (TE2 and TE1) the LSB, and pin 10 the MSB.

NOTES

TE2 is Channel 21 and TE1 is Channel 22.

Pins 5 and 6 on each digital port are ground.

To find the decimal equivalent of the binary pattern, first determine the pattern mapped to the screw terminals on the desired digital output (refer to the example contained in Figure 10). Setting a bit to a logic ‘1’ effectively sets the screw terminal to +5V, while setting it to a logic ‘0’ sets the screw terminal to 0V. Then, for each screw terminal (or bit position), multiply the binary value (either a 1 or a 0) by the decimal weight (see Figure 10). The sum of the products is the decimal equivalent value of the binary pattern. This decimal value can be either sent over the bus (as in the example) or by using the front panel of the Model 2700. To send it over the front panel: under the SHIFT->CARD menu, key in the decimal value (138) for the menu item “DIGOUT1: XXX”. Refer to Figure 11 for a sample on Channel 22.
Figure 10
Sample digital output for Channel 21

Channel 21

<table>
<thead>
<tr>
<th>Bit Position</th>
<th>Binary Value</th>
<th>Decimal weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>B7 B6 B5 B4</td>
<td>0/1 0/1 0/1 0/1</td>
<td>(2^7) (2^6) (2^5) (2^4)</td>
</tr>
<tr>
<td>B3 B2 B1 B0</td>
<td>0/1 0/1 0/1 0/1</td>
<td>(2^3) (2^2) (2^1) (2^0)</td>
</tr>
</tbody>
</table>

Multiply the binary values by the decimal weight:

128 64 32 16 8 4 2 1

Add the products together:

128 + 64 + 32 + 16 + 8 + 4 + 2 + 0 = 138 (this is the NRf value in the command)

Therefore, the command to send is:

OUTP:DIG:BYTE 138,(@121)

Output 8 bit digital output (NRf value of 138 (specifies which terminals are 1 / 0))

Example:
Figure 11
Sample digital output for Channel 22

<table>
<thead>
<tr>
<th>Bit Position</th>
<th>Binary Value</th>
<th>螺丝端子编号</th>
<th>Bit Position</th>
<th>Binary Value</th>
<th>权重</th>
</tr>
</thead>
<tbody>
<tr>
<td>B7 B6 B5 B4</td>
<td>0/1 0/1 0/1 0/1</td>
<td></td>
<td>B3 B2 B1 B0</td>
<td>0/1 0/1 0/1 0/1</td>
<td></td>
</tr>
<tr>
<td>$2^7 (2^6) (2^5) (2^4)$</td>
<td>$2^3 (2^2) (2^1) (2^0)$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>128 64 32 16</td>
<td>8 4 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Multiply the binary values by the decimal weight

<table>
<thead>
<tr>
<th>Binary Value</th>
<th>Equivalent decimal weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel 22</td>
<td>137 (this is the NRf value in the command)</td>
</tr>
</tbody>
</table>

Example:

| Channel 22 |
|---|---|
| 1 0 0 0 | 1 0 0 1 |

<table>
<thead>
<tr>
<th>Multiply the binary values by the decimal weight</th>
<th>1 0 0 0</th>
<th>1 0 0 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>128 64 32 16</td>
<td>8 4 2 1</td>
<td></td>
</tr>
</tbody>
</table>

Therefore, the command to send is:

```
OUTP:DIG:BYTE 137, (@122)
```

Channel 22 of the Model 7706 in slot 1
NRf value of 137 (specifies which terminals are 1 / 0)
8 bit
Digital
Output
Setting the digital outputs in 16-bit (word)

**NOTE**

Setting the digital output in 16-bit (word) can be accomplished only over the bus (no front panel operation).

To set the digital outputs in 16-bit, send the decimal equivalent of the binary pattern desired (similar to 8-bit). The binary pattern will be twice as long as the 8-bit pattern (requiring both digital output ports). Keep in mind that bit 15 is the most significant bit (MSB) and bit 0 is the least significant bit (LSB). This makes the pin 1 screw terminal of Channel 21 (TE2) the LSB and the pin 10 screw terminal of Channel 22 (TE1) the MSB.

To find the decimal equivalent of the binary pattern, first determine the pattern mapped to the screw terminals on the desired digital output (refer to the example contained in Figure 12). Setting a bit to a logic ‘1’ effectively sets the screw terminal to +5V while setting it to a logic ‘0’ sets the screw terminal to 0V. Then, for each screw terminal (or bit position), multiply the binary value (either a 1 or a 0) by the decimal weight (see Figure 12). The sum of the products is the decimal equivalent value of the binary pattern. This decimal value can be sent over the bus as in the example.

The digital output allows the use of an external power supply up to 42V. Refer to Figure 13.

**Inductive loads**

Model 7706 operation is specified for resistive loads. Reactive (inductive) loads require voltage clamping. Before using inductive loads, take adequate circuit protection measures (refer to the appropriate appendices of the Model 2700 User’s Manual).
**Figure 12**

Sample sending a digital output word (16-bit)

- **Digital output CH22**
  - Bit Positions: B15, B14, B13, B12, B11, B10, B9, B8
  - Binary Values: 0/1, 0/1, 0/1, 0/1
  - Weights: (2³)(2⁴)(2⁵)(2⁶)(2⁷)(2⁸)
  - Equivalent decimal weight: 32768, 16384, 8192, 4096

- **Digital output CH21**
  - Screw terminal label
  - Bit Position
  - Binary Value
  - Weights
  - Equivalent decimal weight

<table>
<thead>
<tr>
<th>Binary Value</th>
<th>Decimal Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>32768</td>
<td>16384</td>
</tr>
<tr>
<td>8192</td>
<td>4096</td>
</tr>
<tr>
<td>2048</td>
<td>1024</td>
</tr>
<tr>
<td>512</td>
<td>256</td>
</tr>
</tbody>
</table>

Therefore, the command to send is:

```
OUTP:DIG:WORD 49288, (@121)
```

- Channel 21 of the Model 7706 in slot 1 (this command can only be sent to Channel 21)
- NRf value of 49288 (specifies which terminals are 1 / 0)
Figure 13
Typical digital output with external power supply

Output +5V
Digital Output Terminal
User supplied circuitry
42V (Maximum)

Model 7706 Module
Digital ground (non-isolated, referenced to chassis)

Figure 14
Typical digital output (no external power supply)

Output +5V
Digital Output Terminal
User supplied circuitry
Logic Circuit
≥2.4V @ 1mA

Model 7706 Module
Digital ground (non-isolated, referenced to chassis)
Analog outputs (channels 23–24)

CAUTION

Analog output current limit: 5mA (maximum).

The Model 7706 contains two DAC (Digital to Analog Converters). Use these analog outputs for tasks such as applying a voltage bias to DUTs or analog control. The two analog outputs of the Model 7706 are capable of providing voltages in the range of ±12V. The analog outputs can be set from the front panel or over the bus. Figure 15 shows a simplified schematic of the analog outputs.

Figure 15

Analog output

In the following examples, the Model 7706 module is in slot one of the Model 2700.

Sample 1: Set analog output 1 (channel 23) to 10.0V

To set analog output 1 using the front panel: under the SHIFT->CARD menu, key in the decimal value (for this example, 10.0) for the menu item “AOUT1: +XX.XX”, and press enter. To set Channel 23 (analog output 1) over the bus, send the following command:

OUTP:VOLT 10.0,(@123)

NOTES

Refer to “Front panel operation” for more information on menus and key location.

Voltage may be set in 1mV steps (values are rounded to the nearest millivolt).
Sample 2: Set analog output 2 (channel 24) to -5.5V

To set analog output 2 using the front panel: under the SHIFT->CARD menu, key in the decimal value (for this example, -5.5) for the menu item “AOUT2: +XX.XX”, and press enter. To set Channel 24 (analog output 2) over the bus, send the following command:

`OUTP:VOLT -5.5, (@124)`

Note that each output is referenced to the chassis. Each output can not “float” from each other. To operate with the analog output in specification as a calibrated voltage source, the minimum resistance load is 2.2kΩ (refer to Figure 16).

Figure 16

Sample analog connection schematic
**Loading effects**

Loading of the voltage source becomes a consideration for low resistance loads. As the source resistance increases, the error caused by loading increases. **Figure 17** shows the method used to determine the percent error due to loading where:

\[
V_s \text{ is the programmed analog output of the Model 7706}
\]

\[
R_{\text{Lead}} \text{ is the total lead resistance of the wiring and connections}
\]

\[
R_{\text{Load}} \text{ is the resistance of the user’s circuit}
\]

\[
V_M \text{ is the measured voltage}
\]

The voltage actually measured by the meter is attenuated by the voltage divider action of \( R_S \) and \( R_L \), and it can be calculated as follows:

\[
V_M = \frac{V_S \cdot R_{\text{Load}}}{R_{\text{Load}} + R_{\text{Lead}}}
\]

This relationship can be modified to directly compute for percent error:

\[
\text{Percent Error} = \frac{R_{\text{Load}}}{R_{\text{Load}} + R_{\text{Lead}}} \times 100
\]

Using the above equation, to keep loading error within 0.1%, the resistance of the Model 7706 system must be at least \( \frac{1}{999} \) the value of load resistance.

**Figure 17**

**Loading effects**

![Diagram](http://example.com/diagram.png)

**DAC output errors**

The DAC output is most accurate when the Model 7706 is operated in stable temperature conditions that are as close as possible to the environmental conditions used for calibration. Offset voltage drift over temperature is 1mV/°C. Also, the offset voltage value may change when changing from slot 1 to slot 2.
**Totalizer**

Use the Totalizer to count more than 4 billion on/off events (contact closures, revolutions, power cycles, etc.). The Totalizer can be accessed from the front panel or over the bus. *Figure 18* shows a simplified schematic of the Totalizer connected to a function generator.

**NOTE**

The Totalizer can count exactly up to 4,294,967,295 events ($2^{32}-1$). The count resets (sets its value to 0) when it reaches $2^{32}$.  

*Figure 18*  
**Totalizer**
**Threshold detection**

The Totalizer can count events at a rate of up to 100kHz. The count can be initiated manually or by configuring a scan. When counting, the Totalizer can:

- Reset to zero every time it is read.
- Count on the rising or falling edge of the input signal.
- Count AC or TTL signals.
- Be governed by a gate signal.

Either through a menu (Figure 23) or over the bus (Table 5), the Totalizer can be configured to read (“READ”), or read and reset (“RRES”). It can also be configured to which edge of the signal is read (rising or falling).

The type of threshold detected by the Totalizer is set by the position of jumper J2 (see Figure 3). Factory default setting for this jumper is closed (TTL). The TTL wave as well as the AC type wave form are shown in Figure 19.

*Figure 19*

*AC and TTL waveforms*

TTL (J2 closed) 2.5V Threshold

AC (J2 opened) 0V Threshold

**NOTES**

The Totalizer counts when both terminals are either enabled or open.

Threshold levels cannot be programmed or set.
Gating provides specific control over when the Totalizer readings are taken. A gate always is interpreted if no gating signal is present. To control counting through the G+ screw terminal, send a TTL high signal to enable counting and a TTL low signal to disable counting. To control counting through the G- screw terminal, send a TTL low signal to enable counting and a TTL high signal to disable counting. The Totalizer can be controlled from the G+ screw terminal, the G- screw terminal, or both (both G+ and G- screw terminals have to be enabled to count). Samples of Totalizer input with gating are contained in Figure 20.

**Figure 20**

Sample totalizer input with gating

Viewing Totalizer count

View the Totalizer count by using the CLOSE key and entering the Totalizer channel number (front panel). This opens all relays, switches the Model 2700 function to Totalizer (“TOTALIZE”), and remembers the previous function. In this mode, the TOTalize:TYPE setting is ignored (effectively ‘READ’).

The front panel of Model 2700 is shown in Figure 21. When viewing the Totalizer count, the Model 2700 keys function as contained in the list keyed to Figure 21.
1 **Special keys and power switch:**

Normal operation.

2 **Function and operation keys:**

**Top Row**
- Unshifted
  - DCV, ACV, DCl, ACI, Ω2, Ω4, FREQ, TEMP
  - Blocked.
- Shifted
  - RATIO, CH-AVG, CONT, OCOMP, PERIOD
  - Blocked.

**Middle Row**
- Unshifted
  - TRIG
  - Moves between Totalizer channels (if more than one Model 7706 installed).
  - STORE, RECALL, FILTER, REL
  - Blocked.
- Shifted
  - LIMITS
  - Sets the High Limit count for the Totalizer.
  - ON/OFF
  - Enables/disables limits.
  - MONITOR
  - Sets unit to monitor Totalizer channel and turns monitor on. If monitor is already on, it will be turned off.
  - CARD
  - Enters the card specific menu.
  - DELAY, HOLD
  - Normal Operation.
  - TYPE, CH-OFF
  - Blocked.

**Bottom Row**
- Unshifted
  - OPEN, CLOSE
  - Normal operation.
  - EXIT
  - Clears the Totalizer count to zero.
  - STEP, SCAN, DIGITS, RATE, ENTER
  - Blocked.
- Shifted
  - SAVE, SETUP, CONFIG, TEST, GPIB, RS-232
  - Normal operation.
  - HALT, LSYNC
  - Blocked.

3 **Range keys:**

- ▲ and ▼
- Normal operation.
- AUTO
- Blocked.

4 **INPUTs switch:**

Normal operation—the position of this switch does not affect Totalizer operation.

**Adding Totalizer to scan list (via front panel)**

Toggle the state of the Totalizer channel in the scan list using the SHIFT->CH-OFF key. The TYPE and EDGE controls are set globally through the SHIFT->CARD menu key.

**NOTE**

Changing Totalizer settings (“READ” or “RRES”) must be done outside of the scanlist configuration.

**Adding to scan list via GPIB**

The ROUT:SCAN command is used to add Totalizer to the scan list. When a card that supports Totalizer is in the unit, the Totalizer channel can only be used as a Totalizer. Whenever it is added to the list it will read the current count value. The TYPE and EDGE controls are set globally through the SENSe:TOTalize:EDGE and SENSe:TOTalize:TYPE commands.
Limit subsystem and analog trigger

The limit subsystem and analog scan triggering works the same for the TOTalize function as for any other Model 2700 function with the exception that only the UPPer limit is evaluated. The LOWer limit setting is ignored by the TOTalize function. The TOTalizer MUST be monitoring in order to initiate a scan based on a Totalizer limit. When a scan is initiated by a TOTalizer count, and the Totalizer type is set to ‘READ’, the limit that initiated the scan is removed from the ROUTe:SCAN:TSOurce list so that the Model 2700 only runs through the scan list once. Otherwise, it would keep scanning since the TOTalizer count would remain above the upper limit until reset.

Totalizer channel monitor scan example

For this example, Channel 25 of the Model 7706 is used to monitor the Totalizer with the Model 7706 inserted into slot 1 of the Model 2700. This is an example of a four channel scan with Channels 101–103 measuring DC voltage while, as previously mentioned, Channel 125 monitors the Totalizer. As programmed, when the Totalizer reaches 100,000 counts, the scan is initiated.

Operation

A simplified model of scan operation is contained in Figure 22. The procedure for front panel operation and equivalent programming commands for this simplified model is contained in Table 1. For this example, there are two modes of operation: monitor and scan (see Figure 22). While in monitor mode, continuous Totalizer measurements are performed. The instrument remains in the monitor mode until it reaches the high limit (in this example, the high limit is set to 100,000 counts). When this limit is reached, the instrument changes over to scan mode (see Figure 22). The instrument is configured to scan four channels: three DCV readings and the Totalizer channel (the buffer stores all four readings). After the fourth channel is measured, operation turns again to the monitor mode to again measure Totalizer.

NOTE

When scan is initiated by a TOTalizer count with the type set to READ, the limit that initiated the scan is removed from the ROUTe:SCAN:TSOurce list. This makes the unit run the scan list once. Otherwise, scanning would continue until reset as long as the TOTalizer count remains above the upper limit. If the type is set to RRES when a scan is initiated and after the Totalizer channel is scanned, it is reset to zero (0). If the Totalizer again counts past the high limit set, the unit will run the scan list again, reset the count to zero, and so on.
Figure 22

Monitor scan example

**Monitor Mode:**
Close Monitor Channel (125)

- **Measure TOTALIZER**

- **No**
  - **100,000 Counts?**
  - **Yes** → **Scan**

**Scan Mode:**
Close First Channel

- **Measure**

- **No**
  - **4 Measurements?**
  - **Yes** → Return to Monitor Mode
  - **No** → Open Last Chan Close Next Chan

**Return to Monitor Mode**
Table 1

Monitor scan example (front panel and remote steps)

<table>
<thead>
<tr>
<th>Step</th>
<th>Front panel operation</th>
<th>Remote programming</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Restore defaults:</td>
<td>*RST</td>
</tr>
<tr>
<td></td>
<td>- Restore defaults (SHIFT SETUP &gt; RESTORE: FACT).</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>For front panel operation, proceed to step 3.</td>
<td>TRAC:CLE</td>
</tr>
<tr>
<td></td>
<td>- For remote programming, clear buffer and disable buffer auto clear:</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Configure advanced scan (SHIFT CONFIG &gt; ADVANCED):</td>
<td></td>
</tr>
<tr>
<td></td>
<td>a  Channel 101, 102, and 103:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Select DCV function.</td>
<td>FUNC 'VOLT', (@101:103)</td>
</tr>
<tr>
<td></td>
<td>- Select 10V range.</td>
<td>VOLT:RANG 10, (@101:103)</td>
</tr>
<tr>
<td></td>
<td>- Set filter count to 20 (SHIFT TYPE &gt; 020 RDGS).</td>
<td>VOLT:AVER:COUN 20, (@101:103)</td>
</tr>
<tr>
<td></td>
<td>- Enable filter (FILTER).</td>
<td>VOLT:AVER:STAT ON, (@101:103)</td>
</tr>
<tr>
<td></td>
<td>b  Channel 104:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Disable (off) Channels 104-120 (SHIFT CH-OFF).</td>
<td>ROUT:SCAN (@101:103, 125)</td>
</tr>
<tr>
<td></td>
<td>c  Channel 125:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Enable Totalizer channel (SHIFT-CH OFF).</td>
<td>CALC3:LIM1:UPP 1e5, (@125)</td>
</tr>
<tr>
<td></td>
<td>- Set and enable high limit 1:</td>
<td>CALC3:LIM1:STAT ON, (@125)</td>
</tr>
<tr>
<td></td>
<td>- Set limit to 100000 (SHIFT LIMITS &gt; HI1:+100.0000K).</td>
<td>ROUT:SCAN:TSO HLIM1</td>
</tr>
<tr>
<td></td>
<td>- Set and enable high limit 2:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Set limit to 1000000000 (SHIFT LIMITS &gt; HI2:+1000000K).</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Enable (on) limit (SHIFT OFF/ON &gt; LIMITS: ON).</td>
<td></td>
</tr>
<tr>
<td></td>
<td>d  Disable immediate scan (IMM SCAN: N), and enable high limit 1 (HLIM1 SCAN:Y).</td>
<td></td>
</tr>
<tr>
<td></td>
<td>e  Disable timer (TIMER? OFF).</td>
<td></td>
</tr>
<tr>
<td></td>
<td>f  Set reading count to 4.</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>For front panel operation, proceed to step 5.</td>
<td>ROUT:MON:POIN 4</td>
</tr>
<tr>
<td></td>
<td>For remote programming, set the number of points in the monitor scan.</td>
<td>ROUT:MON (@125)</td>
</tr>
<tr>
<td>5</td>
<td>Select and enable monitor channel (SHIFT MONITOR &gt; 125).</td>
<td>ROUT:MON:STAT ON</td>
</tr>
</tbody>
</table>

Specifications

Full Model 7706 specifications are included at the end of this guide.

Connection log

Make a copy of Table 2 and affix it to the cover of the Model 7706. Use this to record connection information and channel descriptions as needed.
Table 2

*Connection log Model 7706*

<table>
<thead>
<tr>
<th>Channel</th>
<th>Color</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>INPUT</td>
<td>H</td>
<td></td>
</tr>
<tr>
<td></td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>SENSE</td>
<td>H</td>
<td></td>
</tr>
<tr>
<td></td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>CH1</td>
<td>H</td>
<td></td>
</tr>
<tr>
<td></td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>CH2</td>
<td>H</td>
<td></td>
</tr>
<tr>
<td></td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>CH3</td>
<td>H</td>
<td></td>
</tr>
<tr>
<td></td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>CH4</td>
<td>H</td>
<td></td>
</tr>
<tr>
<td></td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>CH5</td>
<td>H</td>
<td></td>
</tr>
<tr>
<td></td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>CH6</td>
<td>H</td>
<td></td>
</tr>
<tr>
<td></td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>CH7</td>
<td>H</td>
<td></td>
</tr>
<tr>
<td></td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>CH8</td>
<td>H</td>
<td></td>
</tr>
<tr>
<td></td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>CH9</td>
<td>H</td>
<td></td>
</tr>
<tr>
<td></td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>CH10</td>
<td>H</td>
<td></td>
</tr>
<tr>
<td></td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>CH11</td>
<td>H</td>
<td></td>
</tr>
<tr>
<td></td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>CH12</td>
<td>H</td>
<td></td>
</tr>
<tr>
<td></td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>CH13</td>
<td>H</td>
<td></td>
</tr>
<tr>
<td></td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>CH14</td>
<td>H</td>
<td></td>
</tr>
<tr>
<td></td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>CH15</td>
<td>H</td>
<td></td>
</tr>
<tr>
<td></td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>CH16</td>
<td>H</td>
<td></td>
</tr>
<tr>
<td></td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>CH17</td>
<td>H</td>
<td></td>
</tr>
<tr>
<td></td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>CH18</td>
<td>H</td>
<td></td>
</tr>
<tr>
<td></td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>CH19</td>
<td>H</td>
<td></td>
</tr>
<tr>
<td></td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>CH20</td>
<td>H</td>
<td></td>
</tr>
<tr>
<td></td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>CH21</td>
<td>B0</td>
<td>B1  B2  B3  B4  B5  B6  B7  GND</td>
</tr>
<tr>
<td>CH22</td>
<td>B0</td>
<td>B1  B2  B3  B4  B5  B6  B7  GND</td>
</tr>
<tr>
<td>CH23</td>
<td>H</td>
<td></td>
</tr>
<tr>
<td>CH24</td>
<td>H</td>
<td></td>
</tr>
<tr>
<td>CH25</td>
<td>IN+</td>
<td>IN-  G+  G-</td>
</tr>
</tbody>
</table>
**Front panel operation**

**Card specific menu**

To open the card specific menu, press SHIFT->CARD (CARD is over the RIGHT arrow key). This menu contains all card-specific functions from the front panel. For example, the analog outputs of a 7706 card would be configured from here. A sample of accessing the card specific functions is contained in Figure 23.

*Figure 23*

**Menu tree — Accessing card specific functions**

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Key</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SHIFT-CARD</td>
<td>SLOT1: 7706</td>
</tr>
<tr>
<td>2</td>
<td>ENTER</td>
<td>AOUT1:+00.000V</td>
</tr>
<tr>
<td>3</td>
<td>▼</td>
<td>AOUT2:+00.000V</td>
</tr>
<tr>
<td>4</td>
<td>▼</td>
<td>DIGOUT1: 255</td>
</tr>
<tr>
<td>5</td>
<td>▼</td>
<td>DIGOUT2: 255</td>
</tr>
<tr>
<td>6</td>
<td>▼</td>
<td>TOT TYPE:(READ</td>
</tr>
<tr>
<td>7</td>
<td>▼</td>
<td>TOT EDGE:(RISE</td>
</tr>
<tr>
<td>8</td>
<td>▼</td>
<td>SWREV: A01</td>
</tr>
</tbody>
</table>

**Readings mode**

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Key</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>▼</td>
<td>SLOT2: 7702</td>
</tr>
<tr>
<td>10</td>
<td>ENTER</td>
<td>Resumes normal readings since the Model 7702 does not have card-specific features that need to be addressed in this menu.</td>
</tr>
</tbody>
</table>
Bus commands

When issuing commands over the bus, keep the following channel usage in mind:

Table 3
Channel description

<table>
<thead>
<tr>
<th>Channels</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-20</td>
<td>Voltage, resistance, temperature, frequency, period, etc., measurements</td>
</tr>
<tr>
<td>21-22</td>
<td>Eight-bit digital outputs</td>
</tr>
<tr>
<td>23-24</td>
<td>Sixteen-bit analog outputs</td>
</tr>
<tr>
<td>25</td>
<td>Totalizer</td>
</tr>
<tr>
<td>26</td>
<td>2/4 pole selection relay. Closing Channel 26 makes a 4-pole measurement</td>
</tr>
<tr>
<td>27</td>
<td>Sense terminals to backplane isolation</td>
</tr>
<tr>
<td>28</td>
<td>Input terminals to backplane isolation</td>
</tr>
</tbody>
</table>

Sending channel numbers

Express channel numbers as a three-digit number where the first digit is the slot number. For example, Channel 1 on slot 1 would be Channel 101, and Channel 5 on slot 2 would be 205. The hundreds digit is the slot number, and the remaining digits denote the channel number on the card (see “Channel list parameter” located at the bottom of Table 4).
OUTPut Subsystem

Commands to perform output operations are listed in Table 4. Details on these commands follow the table.

NOTE

The output subsystem is specific to the Model 7706 module. It is only available if a Model 7706 is installed.

Table 4
Output subsystem commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
<th>Default</th>
</tr>
</thead>
<tbody>
<tr>
<td>:OUTPut</td>
<td>Set the output of a 7706 channel.</td>
<td></td>
</tr>
<tr>
<td>:VOLTage &lt;NRf&gt;, &lt;clist&gt;</td>
<td>Forces the analog output of the given analog channel[s] to the desired values in volts from -12 to +12.</td>
<td>0.0</td>
</tr>
<tr>
<td>:VOLTage? &lt;clist&gt;</td>
<td>Query the present voltage for the analog output channel[s].</td>
<td></td>
</tr>
<tr>
<td>:DIGital</td>
<td>Path to the digital commands.</td>
<td></td>
</tr>
<tr>
<td>:BYTE &lt;nrf&gt;,&lt;clist&gt;</td>
<td>Force the digital output of the given channel[s] to the desired value (0 &lt; x ≤ 255) in decimal format.</td>
<td>255</td>
</tr>
<tr>
<td>:BYTE? &lt;clist&gt;</td>
<td>Query the present bit pattern (0 &lt; x ≤ 255) for the digital output channels.</td>
<td></td>
</tr>
<tr>
<td>:WORD &lt;nrf&gt;,&lt;clist&gt;</td>
<td>Force the digital output of the given channel[s] to the desired value (0 &lt; x ≤ 65535) in decimal format.</td>
<td>65535</td>
</tr>
<tr>
<td>:WORD? &lt;clist&gt;</td>
<td>Query the present bit pattern (0 &lt; x ≤ 65535) for the digital output channels (returned in decimal format).</td>
<td></td>
</tr>
</tbody>
</table>

Channel list parameter:
<clist> = (@SCH)
where: S = Mainframe slot number (1 or 2); CH = Switching module channel number (must be 2 digits);

Examples:
(@101) = Slot 1, Channel 1
(@101, 203) = Slot 1, Channel 1 and Slot 2, Channel 3
(@101:110) = Slot 1, Channels 1 through 10

:OUTPut

As mentioned in Table 3, Channels 21 and 22 are eight-bit digital output channels, and Channels 23 and 24 are analog output channels with a range of -12V to +12V. For individual digital channels, the range of values allowed is 0-255, and the outputs are set to the closest integer to the sent value. Analog outputs will accept values of -12 to +12. Attempting to use this command with an input channel generates error -221 settings conflict.

:VOLTage <nrf>,<clist>  
:VOLTage? <clist>

Force voltage  
Query voltage

Use to force (or query) the analog output of the given channel[s] to the desired value. Values are rounded to the nearest mV. (-12VDC ≤ x ≤ +12VDC).
**DIGital**

:DIGital

:BYTE <nrf>,<clist> — Use to force the digital output of the given channel[s] to the desired value (0 < × < 255) in decimal format. Use this command to write to Channel 21 or 22 individually. Bit 0 of each port is the LSB.

:BYTE? <clist> — Query the present bit pattern (0 < × < 255) for the digital output channels (returned in decimal format). Use this command to query Channel 21 or 22 individually.

:WORD <nrf>,<clist> — Must write to the lower port (channel 21). Channel 21 bit 0 will be the LSB and Channel 22 bit 7 will be the MSB.

:WORD? <clist> — Query the present bit pattern (0 < × < 65535) for the digital output channels (returned in decimal format). This command must be sent to Channel 21.

**SENSe[1] Subsystem**

Commands to perform Model 7706 specific operations are listed in Table 5.

**Table 5**

*SENSe subsystem commands*

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
<th>Default</th>
</tr>
</thead>
<tbody>
<tr>
<td>:TOTalize</td>
<td>Path to configure 7706 Totalizer.</td>
<td></td>
</tr>
<tr>
<td>:TYPE &lt; READ</td>
<td>RRESET &gt;,&lt;clist&gt;</td>
<td>RRESET (read and reset) causes the Totalizer count to be reset to zero every time it is read.</td>
</tr>
<tr>
<td>:TYPE? &lt;clist&gt;</td>
<td>Query Totalizer count readback type.</td>
<td></td>
</tr>
<tr>
<td>:EDGE &lt; RISING</td>
<td>FALLing &gt;,&lt;clist&gt;</td>
<td>Set which edge of the input signal to count.</td>
</tr>
<tr>
<td>:EDGE? &lt;clist&gt;</td>
<td>Query trigger edge for the Totalizer.</td>
<td>RIS</td>
</tr>
<tr>
<td>:DATA? &lt;clist&gt;</td>
<td>Query the current Totalizer count. This command will reset the count to 0 if TOT:TYPE is set to RRESET.</td>
<td></td>
</tr>
</tbody>
</table>

Channel list parameter:

<clist> = (@SCH)

where: S = Mainframe slot number (1 or 2); CH = Switching module channel number (must be 2 digits);

Examples:

(@101) = Slot 1, Channel 1
(@101, 203) = Slot 1, Channel 1 and Slot 2, Channel 3
(@101:110) = Slot 1, Channels 1 through 10
Unsupported SCPI commands

NOTE

The display will indicate which cards are installed immediately after showing the firmware revision at power-up.

The ROUT:SCAN:NVOLatile command is not supported for Model 7706 module operation. Attempts to set ROUT:SCAN:NVOL ON with a 7706 card present in either slot will generate error -221 settings conflict.

Verification

Use the procedures contained in this section to verify the analog outputs or the Totalizer.

Analog outputs

WARNING

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

NOTE

After correctly wiring the Model 7706, installing it in the Model 2700, and turning the power on (step 5 in the following procedure), the unit is required to warm up for two hours before proceeding.

Use the following steps to verify the Model 7706 analog output channels.

1. Connect CH23 H and L outputs to CH1 H and L input terminals (respectively).
2. Connect CH24 H and L outputs to CH2 H and L input terminals (respectively).
3. Close and lock the Model 7706 cover.
4. Install the Model 7706 in slot 1 of the Model 2700.
5. Turn on the Model 2700.
6. Allow unit to warm up for two hours before proceeding.
7. Set the front panel INPUTS switch to the REAR position.
8. Set the Model 2700 to the 10V range:
   a. Select the DC volts function by pressing the DCV key.
   b. Select the 10V range.
9. Close channel 1:
   a. Press the CLOSE key.
   b. Key in 101.
10. Set analog output 1 to +10V:
    a. Open the SHIFT-CARD menu (press SHIFT-CARD).
    b. Key in analog output for AOUT1:+10.000V.
11. Verify analog output reading is within stated limits (see Table 6).
12. Set analog output 1 to -10V:
    a. Open the SHIFT-CARD menu (press SHIFT-CARD).
    b. Key in analog output for AOUT1:-10.000V.
13. Verify analog output reading is within stated limits.
14. Close channel 2:
   a. Press the CLOSE key.
   b. Key in 102.
15. Set analog output 2 to +10V:
   a. Open the SHIFT-CARD menu (press SHIFT-CARD).
   b. Key in analog output for AOUT2:+10.000V.
16. Verify analog output reading is within stated limits.
17. Set analog output 2 to -10V:
   a. Open the SHIFT-CARD menu (press SHIFT-CARD).
   b. Key in analog output for AOUT2:-10.000V.
18. Verify analog output reading is within stated limits.
19. Open channel 2 (press the OPEN key).

Figure 24
Verification—analog connections

Table 6
Analog output limits

<table>
<thead>
<tr>
<th>Source DC Voltage</th>
<th>Reading limits (1 year, 18° to 28°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>+10V</td>
<td>+9.966 to +10.034V 0.15% of reading + 19mV</td>
</tr>
<tr>
<td>-10V</td>
<td>-10.034 to -9.966V</td>
</tr>
</tbody>
</table>
Use the following steps to verify the Model 7706 Totalizer function.

1. Connect the function generator to the Model 7706 Totalizer IN+ and IN- terminals (see Figure 25).
2. Make sure to leave gate inputs (G+ and G-) open (gate always).
3. Set the threshold jumper to the TTL position (J2 closed).
4. Close and lock the Model 7706 cover.

   NOTE
   Make sure the Model 2700 is OFF before installing the Model 7706.

5. Install the Model 7706 in slot 1 of the Model 2700.
6. Turn on the Model 2700.
7. Set the function generator to:
   - Burst mode
   - Burst cycle count of 50,000
   - Manual trigger source
   - Output: 100kHz
   - 0–5V square wave (50% duty cycle)
8. Close CH25:
   a. Press the CLOSE key.
   b. Key in 125.
9. Check Totalizer count — if count is not zero press EXIT key to clear count.
10. Verify that each time the function generator is triggered to output a burst, the Totalizer count increases by 50,000.
11. Open CH25:
12. Press the OPEN key.
Figure 25
Verification—Totalizer connections

Threshold jumper (J2) closed (1-2 TTL)
**Calibration**

The following procedures calibrate the temperature sensors on the Model 7706 plug-in module as well as the analog outputs.

**Recommended test equipment**

In order to calibrate the Model 7706, you will need equipment summarized in Table 7.

**Extender board connections**

The Model 7706 being calibrated should be connected to the 7798-250B Calibration/Extender Board, and the extender board must be installed in scanner Slot #1. Note that the module being calibrated will be external to the Model 2700 to avoid card heating during calibration.

*Table 7*

**Recommended calibration equipment**

<table>
<thead>
<tr>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digital thermometer:18° to 28°C, ±0.1°C</td>
</tr>
<tr>
<td>Keithley 7798-250B Calibration Extender Board</td>
</tr>
</tbody>
</table>

**Front panel Model 7706 temperature calibration**

**NOTE**

Before calibrating the temperature on the Model 7706, 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 2700 to warm up for at least two hours.

1. Connect the Model 7706 to the 7798-250B Calibration Extender Board.
2. With the power off, install the Model 7706/7798 combination in Slot 1, and select the rear inputs with the INPUTS switch.
3. Press in and hold the Model 2700 OPEN key while turning on the power.
4. Allow five minutes for thermal equilibrium.
5. Accurately measure and record the cold temperature of the Model 7706 card surface at the center of the card.
6. 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: 002700).
7. Using the up or down range key, select CARD at the CAL:RUN prompt, then press ENTER.
8. Using the up or down range key, select TEMP, then press ENTER.
9. Set the display value to the cold junction calibration temperature (°C) measured in step 4, then press ENTER to complete Model 7706 temperature calibration.
**Remote Model 7706 temperature calibration**

1. Connect the Model 7706 to the 7798-250B Calibration/Extender Board.
2. With the power off, install the Model 7706/7798 combination in Slot 1, and select the rear inputs with the INPUTS switch.
3. Press in and hold the Model 2700 OPEN key while turning on the power.
4. Allow five minutes for thermal equilibrium.
5. Accurately measure and record the cold temperature of the Model 7706 card surface at the center of the card.
6. Turn on the Model 2700 power.
7. Unlock calibration by sending:
   ```
   :DIAG:KEIT:CAL:UNLOCK
   ```
8. Enable calibration by sending the :CODE command. For example, the default command is:
   ```
   :CAL:PROT:CODE 'KI002700'
   ```
9. Initiate calibration by sending the following command:
   ```
   :CAL:PROT:CARD1:INIT
   ```
10. Calibrate temperature on the Model 7706 with the following command:
    ```
    :CAL:PROT:CARD1:STEP0 <temp>
    ```
    Here `<temp>` is the cold calibration temperature measured in step 4.
11. Send the following commands to save calibration, and lock out calibration:
    ```
    :CAL:PROT:CARD1:SAVE
    :CAL:PROT:CARD1:LOCK
    ```

**Front panel Model 7706 analog output (DAC) calibration**

1. Connect the Model 7706 CH23 and 24 to CH1 and 2 (use the same connection setup as in Figure 24):
   - Connect CH23 H and L terminals to CH1 H and L terminals (H to H; L to L).
   - Connect CH24 H and L terminals to CH2 H and L terminals (H to H; L to L).
2. With the power off, install the Model 7706 in Slot 1, and select the rear inputs with the INPUTS switch.
3. Press in and hold the Model 2700 OPEN key while turning on the power.
4. Allow unit to warm up for two hours before proceeding.
5. Press the SHIFT key and then the TEST key.
6. Select TEST:CALIB using the up or down range keys.
7. Press the ENTER key, select RUN, and enter the appropriate calibration code (default: 002700).
8. Using the up or down range key, select CARD at the CAL:RUN prompt, then press ENTER.
9. Using the up or down range key, select DAC at the next CARD prompt, then press ENTER to complete Model 7706 DAC calibration.
Remote Model 7706 analog output (DAC) calibration

1. Connect the Model 7706 CH23 and 24 to CH1 and 2 (use the same connection setup as in Figure 24):
   • Connect CH23 H and L terminals to CH1 H and L terminals (H to H; L to L).
   • Connect CH24 H and L terminals to CH2 H and L terminals (H to H; L to L).
2. With the power off, install the Model 7706 in Slot 1, and select the rear inputs with the INPUTS switch.
3. Turn on the Model 2700 power.
4. Allow unit to warm up for two hours before proceeding.
5. Unlock calibration by sending:
   :DIAG:KEIT:CAL:UNLOCK
6. Enable calibration by sending the :CODE command. For example, the default command is:
   :CAL:PROT:CODE 'KI002700'
7. Initiate calibration by sending the following command:
   :CAL:PROT:CARD1:INIT
8. Calibrate the Model 7706 analog output with the following command:
   :CAL:PROT:CARD1:DAC:STEP0
9. Send the following commands to save calibration, and lock out calibration:
   :CAL:PROT:CARD1:SAVE
   :CAL:PROT:CARD1:LOCK

Calibration commands

Table 8 summarizes calibration commands for the Model 7706 plug-in module. Note that CARD1 commands calibrate the card in Slot 1, while CARD2 commands request calibration count and date information from a card in Slot 2.

**NOTE**

The 7706 must be installed in Slot 1 through a Model 7798 extender card to perform temperature calibration.
**Table 8**  
**Model 7706 calibration commands**

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>:CALibration</td>
<td>Calibration root command.</td>
</tr>
<tr>
<td>:PROTected</td>
<td>All commands in this subsystem are protected by the calibration lock (except queries and :CODE).</td>
</tr>
<tr>
<td>:CODE '&lt;up to 8 char. string&gt;'</td>
<td>Send calibration code. (Default KI002700)</td>
</tr>
<tr>
<td>:CARD1</td>
<td>Path to card in slot 1.</td>
</tr>
<tr>
<td>:INITiate</td>
<td>Initiate card calibration.</td>
</tr>
<tr>
<td>:COUNt?</td>
<td>Request number of times card had been calibrated.</td>
</tr>
<tr>
<td>:RCOunt</td>
<td>Reset card calibration count to 0.</td>
</tr>
<tr>
<td>:DATE?</td>
<td>Request card calibration date.</td>
</tr>
<tr>
<td>:SAVE</td>
<td>Save cal constants to card EEPROM.</td>
</tr>
<tr>
<td>:LOCK</td>
<td>Lock out calibration.</td>
</tr>
<tr>
<td>:LOCK?</td>
<td>Request cal lock state. (0 = locked, 1 = unlocked)</td>
</tr>
<tr>
<td>:STEP0 &lt;NRf&gt;</td>
<td>Temperature sensor cold calibration (&lt;NRf&gt; = temperature, °C).</td>
</tr>
<tr>
<td>:DAC</td>
<td>Path to analog output calibration.</td>
</tr>
<tr>
<td>:STEP0 &lt;NRf&gt;</td>
<td>Analog output DAC calibration.</td>
</tr>
<tr>
<td>:CARD2</td>
<td>Path to card in slot 2.</td>
</tr>
<tr>
<td>:COUNt?</td>
<td>Request number of times card has been calibrated.</td>
</tr>
<tr>
<td>:DATE?</td>
<td>Request card calibration date.</td>
</tr>
<tr>
<td>:DIAGnostic</td>
<td>Diagnostic root.</td>
</tr>
<tr>
<td>:KEITHley</td>
<td>Keithley path.</td>
</tr>
<tr>
<td>:CALibration</td>
<td>Calibration path.</td>
</tr>
<tr>
<td>:UNLOCK</td>
<td>Unlock command.</td>
</tr>
</tbody>
</table>
::CODE

(:CALibration:PROTected:CODE)

NOTES

The :CODE command should be sent only once before performing calibration. Do not send :CODE before each calibration step.

The code parameter must be enclosed in single quotes.

**Purpose**
To program the calibration code or password so that you can perform the Model 7706 calibration procedures.

**Format**
:CAL:PROT:CODE 'CHAR_STRING'

**Parameter**
Up to an 8-character string including letters and numbers.

**Description**
The :CODE command enables the Model 7700 calibration procedures when performing these procedures over the bus. This command must be sent to the unit before sending any other Model 7706 calibration command. The default calibration code is KI002700.

**Example**
:CAL:PROT:CODE 'KI002700'  Send default code of KI002700.

::COUNt?

(:CALibration:PROTected:CARD1:COUNt?)
(:CALibration:PROTected:CARD2:COUNt?)

**Purpose**
To determine how many times a Model 7706 has been calibrated.

**Format**
:CAL:PROT:CARD1:COUN?
:CAL:PROT:CARD2:COUN?

**Response**

<n> Calibration count.

**Description**
The :CARD1:COUN? and :CARD2:COUN? commands allow you to determine how many times a Model 7706 in Slot 1 and Slot 2, respectively, has been calibrated.

**NOTE**

Use the :COUNt? command to help you monitor for unauthorized calibration procedures.

**Example**
Calibration commands

:DATE?

(:CALibration:PROTected:CARD1:DATE?)
(:CALibration:PROTected:CARD2:DATE?)

Purpose
To request the Model 7706 calibration date.

Format
:CAL:PROT:CAR1:DATE?
:CAL:PROT:CAR2:DATE?

Response
<year>, <month>, <day>

Description
The :CARD1:DATE? and :CARD2:DATE? queries allow you to read back the calibration date from a Model 7706 in Slot 1 and Slot 2 respectively.

NOTE
The card calibration date is automatically set to the Model 2700 real time clock date when the card is calibrated.

Example

:INIT

(:CALibration:PROTected:CARD1:INITiate)

Purpose
To initiate Model 7706 calibration procedures.

Format
:CAL:PROT:CAR1:INIT

Parameter
None

Description
The :INIT command enables Model 7706 calibration when performing these procedures over the bus. This command must be sent to the unit after sending the :CODE command, but before performing Model 7706 calibration.

Example
:CAL:PROT:CAR1:INIT Initiate 7706 calibration.

:LOCK

(:CALibration:PROTected:CARD1:LOCK)

Purpose
To lock out Model 7706 calibration.

Format
:CAL:PROT:CAR1:LOCK

Parameter
None

Description
The :LOCK command allows you to lock out Model 7706 calibration after completing the procedure. Thus, :LOCK performs the opposite of enabling calibration with the :CODE command.

Example
:CAL:PROT:CAR1:LOCK Lock out card 1 calibration.
:**LOCK?**

(:CALibration:PROTected:CARd1:LOCK?)

**Purpose** To read Model 7706 calibration lock status.

**Format** :CAL:PROT:CAR1:LOCK?

**Response**

0 Calibration locked.
1 Calibration unlocked.

**Description** The :LOCK? query requests status from the Model 2700 on Model 7706 calibration locked/unlocked state. Calibration must be enabled sending the :CODE command before calibration can be performed.

**Example**


:**SAVE**

(:CALibration:PROTected:CARd1:SAVE)

**Purpose** To save calibration constants in card EEROM after the calibration procedure.

**Format** :CAL:PROT:CAR1:SAVE

**Parameter** None

**Description** The :SAVE command stores calculated calibration constants derived during Model 7706 calibration in card EEROM. (EEROM is non-volatile memory.) Calibration constants will be retained indefinitely once saved. Generally, :SAVE is sent after all other calibration steps (except for :LOCK).

**NOTE**

Card calibration will be only temporary unless the :SAVE command is sent to permanently store calibration constants.

**Example**

:CAL:PROT:CAR1:SAVE Save card calibration constants.
**:STEP0**

(:CALibration:PROTected:CARD1:STEP0)

**Purpose**  
To perform Model 7706 temperature calibration.

**Format**  
:CAL:PROT:CARD1:STEP0 <TEMP>

**Parameter**  
<temp> = Cold calibration temperature (°C)

**Description**  
:STEP0 performs temperature sensor calibration of the Model 7706. The card must be allowed to cool down to ambient temperature before calibration, and the cold temperature of the card must be measured and sent as the <temp> parameter during calibration.

**NOTE**

Before calibrating the temperature for the Model 7706, 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.

**Example**  
:CAL:PROT:CARD1:STEP0 23  
Perform 7706 temperature calibration with card at a temperature of 23°C (measured with an external probe).

---

**:DAC**

**:STEP0**

(:CALibration:PROTected:CARD1:DAC:STEP0)

**Purpose**  
To perform Model 7706 analog output (DAC) calibration.

**Format**  
:CAL:PROT:CARD1:DAC:STEP0

**Parameter**  
none

**Description**  
:STEP0 performs analog output calibration of the Model 7706. The card must be allowed to warm up inside the powered-up unit for two hours before calibration. In this step, CH23 (analog output 1) must be connected to CH1, and CH24 (analog output 2) must be connected to CH2.

**Example**  
:CAL:PROT:CARD1:DAC:STEP0  
Perform 7706 DAC calibration.
(CALibration:PROTected:CARd1:STEP0)

**Purpose**  
To perform Model 7706 temperature calibration.

**Format**  
:CAL:PROT:CARd1:STEP0 <TEMP>

**Parameter**  
<temp> = Cold calibration temperature (°C)

**Description**  
:STEP0 performs temperature sensor calibration of the Model 7706. The card must be allowed to cool down to ambient temperature before calibration, and the cold temperature of the card must be measured and sent as the <temp> parameter during calibration.

**NOTE**  
Before calibrating the temperature on the Model 7706, 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.

**Example**  
:CAL:PROT:CARd1:STEP0 23  Perform 7706 calibration.

### Remote error reporting

Methods to detect and determine the nature of calibration errors are discussed below.

#### Error summary

*Table* 9 summarizes Model 2700 calibration errors.
Table 9

<table>
<thead>
<tr>
<th>Calibration error summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Error number and description</td>
</tr>
<tr>
<td>+400, “10 vdc zero error”</td>
</tr>
<tr>
<td>+401, “100 vdc zero error”</td>
</tr>
<tr>
<td>+402, “10 vdc full scale error”</td>
</tr>
<tr>
<td>+403, “-10 vdc full scale error”</td>
</tr>
<tr>
<td>+404, “100 vdc full scale error”</td>
</tr>
<tr>
<td>+405, “-100 vdc full scale error”</td>
</tr>
<tr>
<td>+406, “1k 2-w zero error”</td>
</tr>
<tr>
<td>+407, “10k 2-w zero error”</td>
</tr>
<tr>
<td>+408, “100k 2-w zero error”</td>
</tr>
<tr>
<td>+409, “10M 2-w zero error”</td>
</tr>
<tr>
<td>+410, “10M 2-w full scale error”</td>
</tr>
<tr>
<td>+411, “10M 2-w open error”</td>
</tr>
<tr>
<td>+412, “1k 4-w zero error”</td>
</tr>
<tr>
<td>+413, “10k 4-w zero error”</td>
</tr>
<tr>
<td>+414, “100k 4-w zero error”</td>
</tr>
<tr>
<td>+415, “10M 4-w sense lo zero error”</td>
</tr>
<tr>
<td>+416, “1k 4-w full scale error”</td>
</tr>
<tr>
<td>+417, “10k 4-w full scale error”</td>
</tr>
<tr>
<td>+418, “100k 4-w full scale error”</td>
</tr>
<tr>
<td>+419, “1M 4-w full scale error”</td>
</tr>
<tr>
<td>+420, “10M 4-w full scale error”</td>
</tr>
<tr>
<td>+421, “10m adc zero error”</td>
</tr>
<tr>
<td>+422, “100m adc zero error”</td>
</tr>
<tr>
<td>+423, “10m adc full scale error”</td>
</tr>
<tr>
<td>+424, “100m adc full scale error”</td>
</tr>
<tr>
<td>+425, “1 adc full scale error”</td>
</tr>
<tr>
<td>+438, “Date of calibration not set”</td>
</tr>
<tr>
<td>+439, “Next date of calibration not set”</td>
</tr>
<tr>
<td>+450, “100m vac dac error”</td>
</tr>
<tr>
<td>+451, “1 vac dac error”</td>
</tr>
<tr>
<td>+452, “10 vac dac error”</td>
</tr>
<tr>
<td>+453, “100 vac dac error”</td>
</tr>
<tr>
<td>+454, “100m vac zero error”</td>
</tr>
</tbody>
</table>

*Model 7706 card specific.

Error queue

As with other Model 2700 errors, any calibration error will be reported in the bus error queue. You can read this queue by using the :SYST:ERR? query. The Model 2700 will respond with the appropriate error message, as summarized in Table 9.

Status byte EAV (Error Available) bit

Whenever an error is available in the error queue, the EAV (Error Available) bit (bit 2) of the status byte will be set. Use the *STB? query or serial polling to obtain the status byte, then test bit 2 to see if it is set. If the EAV bit is set, an error has occurred, and you can use the :SYST:ERR? query to read the error and at the same time clear the EAV bit in the status byte.
Generating an SRQ on error

To program the instrument to generate an IEEE-488 bus SRQ when an error occurs, send the following command: *SRE 4. This command will enable SRQ when the EAV bit is set. You can then read the status byte and error queue as outlined above to check for errors, and to determine the exact nature of the error.

Detecting calibration step completion

When sending remote calibration commands, you must wait until the instrument completes the current operation before sending a command. You can use either *OPC? or *OPC to help determine when each calibration step is completed.

Using the *OPC? query

With the *OPC? (operation complete) query, the instrument will place an ASCII 1 in the output queue when it has completed each step. To determine when the OPC response is ready, do the following:

1. Repeatedly test the MAV (Message Available) bit (bit 4) in the status byte and wait until it is set. (You can request the status byte by using the *STB? query or by serial polling.)
2. When MAV is set, a message is available in the output queue, and you can read the output queue and test for an ASCII 1.
3. After reading the output queue, repeatedly test MAV again until it clears. At this point, the calibration step is completed.

Using the *OPC command

The *OPC (operation complete) command can also be used to detect the completion of each calibration step. To use *OPC to detect the end of each calibration step, you must do the following:

1. Enable operation complete by sending *ESE 1. This command sets the OPC (operation complete bit) in the standard event enable register, allowing operation complete status from the standard event status register to set the ESB (event summary bit) in the status byte when operation complete is detected.
2. Send the *OPC command immediately following each calibration command. For example:
   
   :CAL:PROT:DC:STEP1;*OPC
   
   Note that you must include the semicolon (;) to separate the two commands, and that the *OPC command must appear on the same line as the calibration command.
3. After sending a calibration command, repeatedly test the ESB (Event Summary) bit (bit 5) in the status byte until it is set. (Use either the *STB? query or serial polling to request the status byte.)
4. Once operation complete has been detected, clear OPC status using one of two methods: (1) Use the *ESR? query, then read the response to clear the standard event status register, or (2) send the *CLS command to clear the status registers. Note that sending *CLS will also clear the error queue and operation complete status.

Generating an SRQ on calibration complete

An IEEE-488 bus SRQ (service request) can be used to detect operation complete instead of repeatedly polling the Model 2700. To use this method, send both *ESE 1 and *SRE 32 to the instrument, then include the *OPC command at the end of each calibration command line, as covered above. Refer to your controller’s documentation for information on detecting and servicing SRQs.
Replaceable parts

Introduction
This section contains replacement parts information and component layout drawings for the Model 7706.

Parts lists
Both electrical and mechanical parts for the Model 2700 are listed in several tables on the following pages.

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 7706 module)
- 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
A component layout for the Model 7706 circuit board is provided on the pages following the Model 7706 parts list (Table 10).

Table 10
Model 7706 parts list

<table>
<thead>
<tr>
<th>Circuit Designation</th>
<th>Description</th>
<th>Keithley Part No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1,C2,C3,C4,C6</td>
<td>CAP, 1000PF, 10%, 50V, MONO CERAMIC</td>
<td>C-452-1000P</td>
</tr>
<tr>
<td>C13</td>
<td>CAP, 47P, 5%, 100V, CERAMIC</td>
<td>C-465-47P</td>
</tr>
<tr>
<td>C14</td>
<td>CAP, 47P, 5%, 100V, CERAMIC</td>
<td>C-465-47P</td>
</tr>
<tr>
<td>C16</td>
<td>CAP, 22U, 20%, 25V, TANTALUM</td>
<td>C-451-22</td>
</tr>
<tr>
<td>C17,C22,C23</td>
<td>CAP, 0.47U, 20%, 25V</td>
<td>C-520-.47</td>
</tr>
<tr>
<td>C18,C19,C20,C21,C28,C29</td>
<td>CAP, 100P, 10%, 100V, CERAMIC</td>
<td>C-451-100P</td>
</tr>
<tr>
<td>C39,C40</td>
<td>CAP, 47UF, 20%, 20%, TANTALUM</td>
<td>C-575-47</td>
</tr>
<tr>
<td>C41</td>
<td>CAP, 10UF, 20%, 25V, TANTALUM</td>
<td>C-440-10</td>
</tr>
<tr>
<td>C42,C43,C44,C45</td>
<td>CAP, 1000P, 10%, 100V, CERAMIC</td>
<td>C-451-1000P</td>
</tr>
<tr>
<td>C47</td>
<td>CAP, 1000pF, 20%, 50V, CERAMIC</td>
<td>C-418-1000P</td>
</tr>
<tr>
<td>C48</td>
<td>CAP, 0.01uF, 20%, 50V, CERAMIC</td>
<td>C-418-.01</td>
</tr>
<tr>
<td>C7-C9,C10-12,C24-C27,C30-C35,38,46,49-53</td>
<td>DIODE, DUAL SWITCHING, BAV99L</td>
<td>RF-82</td>
</tr>
<tr>
<td>CR2-6,25,28,42,44,46,48,43,45,47,49,50</td>
<td>DIODE, DUAL HSM-2822T31</td>
<td>RF-95</td>
</tr>
<tr>
<td>CR26,CR27</td>
<td>CAP, 0.1UF, 20%, 50V, CERAMIC</td>
<td>C-418-.1</td>
</tr>
</tbody>
</table>
### Table 10 (Continued)

#### Model 7706 parts list

<table>
<thead>
<tr>
<th>Circuit Designation</th>
<th>Description</th>
<th>Keithley Part No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CR29,CR30,CR40,CR41</td>
<td>DUAL HIGH SPEED DIODE</td>
<td>RF-147</td>
</tr>
<tr>
<td>CR31,32,34,36,38,1,33,35,37,39</td>
<td>DIODE, DUAL SWITCHING, BAV99L</td>
<td>RF-82</td>
</tr>
<tr>
<td>CR51-CR54</td>
<td>DIODE, DUAL COMMON ANODE</td>
<td>RF-98</td>
</tr>
<tr>
<td>CR7-CR22</td>
<td>BAW56LT2</td>
<td></td>
</tr>
<tr>
<td>J1, J2, K1-K20,K23</td>
<td>CONN, RT ANGLE DUAL ROW RECEPT</td>
<td>CS-1065-1</td>
</tr>
<tr>
<td>K21,K22, L1,L2,L3,L4</td>
<td>SINGLE COIL LATCHING</td>
<td>CS-339</td>
</tr>
<tr>
<td>Q1,Q2,Q3,Q4,Q53,Q54,Q56,Q58</td>
<td>NON LATCHING RELAY</td>
<td>RL-244</td>
</tr>
<tr>
<td>Q25,27,29,31,33,35,37,41,43,45,47,49</td>
<td>FERRITE CHIP, 600 OHM, BLM32A07</td>
<td>CH-62</td>
</tr>
<tr>
<td>Q26,28,30,32,34,36,38,40,42,44,46,48,50</td>
<td>TRANS, NPN SILICON</td>
<td>TG-389</td>
</tr>
<tr>
<td>Q5,Q6</td>
<td>TRANS, PNP SILICON</td>
<td>TG-388</td>
</tr>
<tr>
<td>Q51</td>
<td>TRANS, PNP SILICON</td>
<td>TG-388</td>
</tr>
<tr>
<td>Q52</td>
<td>TRANS, NPN SILICON</td>
<td>TG-389</td>
</tr>
<tr>
<td>Q55,Q57, Q9-Q24</td>
<td>TRANS, N-MEGAFET, RFD14N05LSM</td>
<td>TG-267</td>
</tr>
<tr>
<td>R122,R126,R30</td>
<td>RES, ARRAY, 4×10K, 5%, 0.125W</td>
<td>TF-276-10K</td>
</tr>
<tr>
<td>R13,R14,R17,R18</td>
<td>RES, 499K, 1%, 125MW, METAL FILM</td>
<td>R-391-499K</td>
</tr>
<tr>
<td>R19,R21</td>
<td>RES, 332, 10%, 125MW, METAL FILM</td>
<td>R-391-332</td>
</tr>
<tr>
<td>R1-R12,R15,R16</td>
<td>RES, 1K, 1%, 125MW, METAL FILM</td>
<td>R-391-13K</td>
</tr>
<tr>
<td>R20,R22</td>
<td>RES, 2K, 1%, 125mW, METAL FILM</td>
<td>R-391-2K</td>
</tr>
<tr>
<td>R23,R24,R25</td>
<td>RES, 28.7K, 1%, 0.125W, METAL FILM</td>
<td>R-391-28.7K</td>
</tr>
<tr>
<td>R26</td>
<td>RES, 4.75K, 1%, 125mW, METAL FILM</td>
<td>R-391-4.75K</td>
</tr>
<tr>
<td>R27</td>
<td>RES, 49.9K, 1%, 125mW, METAL FILM</td>
<td>R-391-49.9K</td>
</tr>
<tr>
<td>R28,32-34,39,59-63,73,74,76,77</td>
<td>RES, 4.99K, 1%, 125mW, METAL FILM</td>
<td>R-391-4.99K</td>
</tr>
<tr>
<td>R29,R86,R87</td>
<td>RES, 220, 5%, 125MW, METAL FILM</td>
<td>R-375-220</td>
</tr>
<tr>
<td>R31,R38,R40</td>
<td>RES, ARRAY, 4×4.3K, 5%, 0.125W</td>
<td>TF-276-4.3K</td>
</tr>
<tr>
<td>R36,R37,R41-R46,R75,R85,R35</td>
<td>RES, 475, 1%, 100MW, THICK FILM</td>
<td>R-418-475</td>
</tr>
<tr>
<td>R51,R52,R55,R56</td>
<td>RES, 1K, 5%, 125MW, METAL FILM</td>
<td>R-375-1K</td>
</tr>
<tr>
<td>R53,54,57,58,94-97,100-102</td>
<td>RES, ARRAY, 4×10K, 5%, 0.125W</td>
<td>TF-276-100K</td>
</tr>
<tr>
<td>R64,R65,R66,R67</td>
<td>RES, 12.4, 10%, 100MW, THICK FILM</td>
<td>TF-276-10K</td>
</tr>
<tr>
<td>R68,R69</td>
<td>RES, 40.2K, 1%, 100MW, THICK FILM</td>
<td>R-418-40.2K</td>
</tr>
<tr>
<td>R70,R71</td>
<td>RES, 54.9, 1%, 100MW, THICK FILM</td>
<td>R-418-54.9</td>
</tr>
<tr>
<td>R78,R79,R80,R81</td>
<td>RES, ARRAY, 4×1K, 5%, 0.125W</td>
<td>TF-276-1K</td>
</tr>
<tr>
<td>R82,R83</td>
<td>RES, 10K, 5%, 125mW, METAL FILM</td>
<td>R-375-10K</td>
</tr>
<tr>
<td>R84</td>
<td>RES, 100K, 5%, 125mW, METAL FILM</td>
<td>R-375-100K</td>
</tr>
<tr>
<td>RV1,RV2,RV3,RV4</td>
<td>BIDIRECTIONAL TRANSIENT VOLT SUPPRESSOR</td>
<td>VR-8</td>
</tr>
<tr>
<td>SO33</td>
<td>SOCKET</td>
<td>SO-143-44</td>
</tr>
<tr>
<td>TE1,TE2, TE3,TE4,TE5,TE6,TE7</td>
<td>CONN, FEMALE 12-PIN</td>
<td>TE-118-12</td>
</tr>
<tr>
<td>TP1,TP2</td>
<td>CONN, TEST POINT</td>
<td>TE-118-10</td>
</tr>
<tr>
<td>U1</td>
<td>IC, VOLT. COMPARATOR, LM311M</td>
<td>IC-776</td>
</tr>
<tr>
<td>U12</td>
<td>IC, 8-CHAN ANA MULTIPLEXER, DG408DY</td>
<td>IC-844</td>
</tr>
<tr>
<td>U13,U23</td>
<td>IC, DUAL OPTO</td>
<td>IC-1358</td>
</tr>
<tr>
<td>U14,U15,U16,U17</td>
<td>IC, CENTIGRADE TEMP SENSOR LM35DM</td>
<td>IC-906</td>
</tr>
<tr>
<td>U18</td>
<td>IC, UNREGULATED DC/DC CONVERTER</td>
<td>IC-1355</td>
</tr>
<tr>
<td>U19,U20</td>
<td>IC, 16-BIT MONOLITHIC PCM AUDIO DAC</td>
<td>IC-1136</td>
</tr>
<tr>
<td>U2</td>
<td>IC, QUAD 2-INPUT NAND, 74HC00M</td>
<td>IC-781</td>
</tr>
<tr>
<td>U21,U22</td>
<td>IC, OPA1777S</td>
<td>IC-960</td>
</tr>
<tr>
<td>U24,U34</td>
<td>IC, TINYLOGIC CMOS INVERTER</td>
<td>IC-1282</td>
</tr>
</tbody>
</table>
Table 10 (Continued)

**Model 7706 parts list**

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<tr>
<th>Circuit Designation</th>
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</tr>
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<tbody>
<tr>
<td>U24,U34,U11,U26,U29,U7,U8,U9</td>
<td>IC, OCTAL D FLIP FLOP</td>
<td>IC-1353</td>
</tr>
<tr>
<td>U25</td>
<td>IC, -5V VOLTAGE REGULATOR</td>
<td>IC-1171</td>
</tr>
<tr>
<td>U3</td>
<td>IC, 8 STAGE SHIFT/STORE, MC14094BD</td>
<td>IC-772</td>
</tr>
<tr>
<td>U30,U31</td>
<td>IC, OCTAL BUFFER</td>
<td>IC-1252</td>
</tr>
<tr>
<td>U32</td>
<td>IC, 2.5V, CASCADABLE SERIAL EEPROM</td>
<td>LSI-212</td>
</tr>
<tr>
<td>U33</td>
<td>IC, 8-BIT MICROCONTROLLER</td>
<td>LSI-242</td>
</tr>
<tr>
<td>U4,U5</td>
<td>IC, SCHMITT-TRIGGER NAND GATE</td>
<td>IC-950</td>
</tr>
<tr>
<td>U6,U10</td>
<td>IC, 3-TO-8 LINE DECODE, 74ACT138</td>
<td>IC-654</td>
</tr>
<tr>
<td>VR1,VR2</td>
<td>DIODE ZENER 12V, MMSZ12T1</td>
<td>DZ-112</td>
</tr>
<tr>
<td>Y1</td>
<td>CRYSTAL CERAMIC RESONATOR, 8M</td>
<td>CR-59-2</td>
</tr>
<tr>
<td>MECHANICAL PARTS</td>
<td>TOP COVER HEAT STAKE ASSEMBLY</td>
<td>7700-302A</td>
</tr>
<tr>
<td></td>
<td>BOTTOM CARD COVER</td>
<td>7702-301C</td>
</tr>
<tr>
<td></td>
<td>COMPRESSION SPRING</td>
<td>SP-7-3</td>
</tr>
</tbody>
</table>
Figure 26
Component layout (Side-04)
Figure 27
Component layout (Side-01)

SECONDARY SIDE COMPONENTS {SIDE-01}
7706 All-in-One I/O Module

GENERAL

20 CHANNELS: 20 channels of 2-pole relay input. All channels configurable to 4-pole.

RELAY TYPE: Latching electromechanical.

ACTUATION TIME: <3ms.

CAPABILITIES

CHANNELS 1–20: Multiplex one of 20 2-pole or one of 10 4-pole signals into DMM.

CHANNELS 21–25 are referenced to chassis ground.


CHANNELS 23–24: Analog Voltage Output (2).

CHANNELS 25: Totalize Input.

INPUTS (Channels 1–20)

MAXIMUM SIGNAL LEVEL (Channels 1–20): 300V DC or rms, 1A switched, 60W, 125VA maximum.

SAFETY CATEGORY: CAT I.

CONTACT LIFE (typ.): >10^5 operations at max. signal level: >10^8 operations cold switching.

CONTACT POTENTIAL: <±2µV typical per contact pair, 3µV max.

OFFSET CURRENT: <100pA.

CONNECTOR TYPE: Screw terminal, #22 AWG wire size.

ISOLATION BETWEEN ANY TERMINAL AND EARTH: >10^9 Ω, <200pF.

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

DIGITAL OUTPUT (Channels 21 and 22)

Vout(L): <0.8V @ Iout = 400mA.

Vout(H): >2.4V @ Iout = 1mA.

Vout(H)MAX: <42V with external open drain pull-up.

WRITE SPEED: 50/s.

ANALOG VOLTAGE OUTPUT (Channels 23 and 24)

DAC 1, 2: ±12V, non-isolated.

RESOLUTION: 1mV.

Ion: 5mA max.

SETTLING TIME: 1ms to 0.01% of output.

ACCURACY ±% of output + mV: Measured with ±10mΩ input resistance DMM.

1 year ±5°C: 0.15% + 19mV;

24 hour ±1°C: 0.04% + 19mV.

TEMPERATURE COEFFICIENT: ±(0.015% + 1mV)/°C.

WRITE SPEED: 50/s.

All specifications subject to change without notice.