

**KEITHLEY**

# Model 7707

## User's Guide

PA-770 Rev. B / 8-03

The Model 7707 can be used with Keithley Models 2700, 2701, and 2750. All references to the Model 27xx apply to the Models 2700, 2701, and 2750.

A GREATER MEASURE OF CONFIDENCE

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

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

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

The types of product users are:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

The  symbol indicates a connection terminal to the equipment frame.

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

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

Instrumentation and accessories shall not be connected to humans.

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

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

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

The information in this packing list is organized as follows:

- Card configuration — schematic on page 2.
- Connections and wiring overview on page 4.
  - D-shell connectors on page 4.
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  - Typical analog input connections on page 14.
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  - Setting digital outputs on page 22.
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  - Input bit patterns on page 28.
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- Specifications — 7707 Multiplexer-Digital I/O Module on page 52.
- Measurement considerations (digital outputs) on page 53.

**NOTE** *The 7707 module can be used with Keithley Models 2700, 2701, and 2750. All references to the Model 27xx apply to the Models 2700, 2701, and 2750.*

# Introduction

The Model 7707 is a 10-channel differential multiplexer card with the following features:

- 10 channels of analog input with 300V, 1A capacity; 60W, 125VA maximum.
- 32 digital input/output channels.
- 2-wire or 4-wire  $\Omega$  measurement (automatically pairs switches for four wire measurements —  $n + 5$ ).
- Temperature applications (RTD, thermistor).
- 50-pin male D-Shell connector (DB-50) for digital I/O channels 11 through 14.
- 25-pin female D-Shell connector (DB-25) for analog input channels 1 through 10.

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

## Card configuration — schematic

Figure 1 shows a simplified schematic diagram of the Model 7707 module. As shown, the Model 7707 has channels that are grouped into two banks of five channels (10 channels total). Backplane isolation is provided for each bank. The first bank contains channels 1 through 5 while the second bank contains channels 6 through 10. Each channel of the 10-channel multiplexer card is wired with separate inputs for HI/LO providing fully isolated inputs.

**NOTE** Although the Model 7707 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 ( $\Omega$ 4-wire) connections

Channel 15 (2W/4W configuration), Channel 16 (sense isolation), and Channel 17 (input isolation) are automatically configured for normal system channel operation. When a 4-wire function is selected, the channels are paired as follows:

- CH1 and CH6
- CH2 and CH7
- CH3 and CH8
- CH4 and CH9
- CH5 and CH10

## Dual independent multiplexers

Multiple channel operation (ROUT :MULT :CLOS command) allows individual control of switching module channels. Multiple channel operation allows the switching module to be configured as two independent multiplexers. The Model 7707 is normally used as a single  $1 \times 10$  multiplexer, but it can also be configured as two  $1 \times 5$  multiplexers.

In Figure 1, the open position of channel 15 is shown. When channel 15 is closed, Multiplexer 1 (channels 1 through 5) is isolated from Multiplexer 2 (channels 6 through 10).

For the dual multiplexer configuration, only channels 1 through 5 can be internally connected to the DMM of the Model 27xx. Closing channel 17 allows channels 1 through 5 to be measured by the DMM.

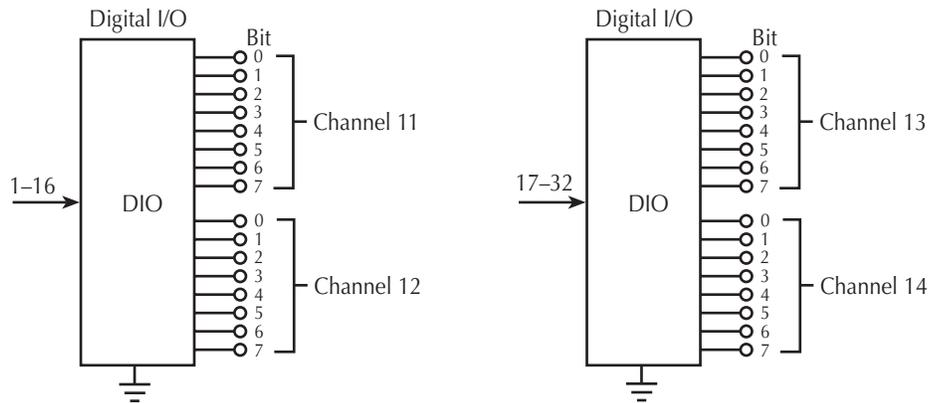
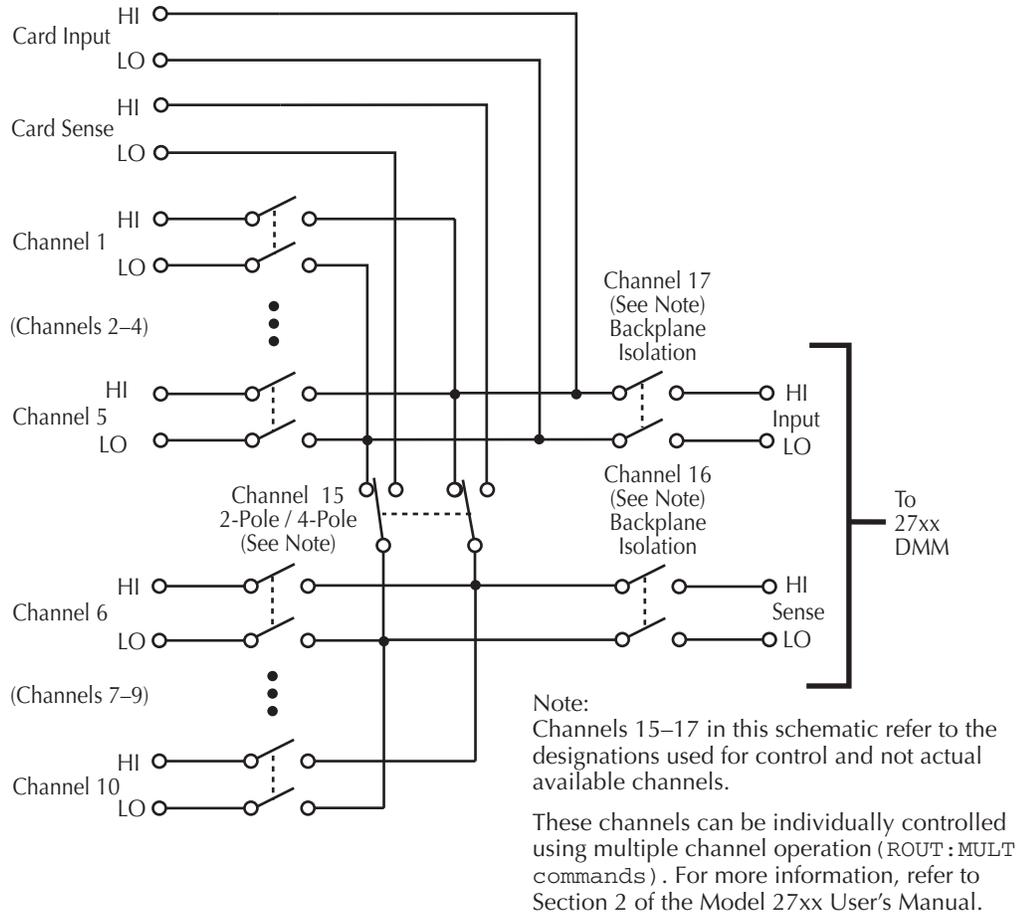
When using the dual multiplexer configuration, channels 6 through 10 must be isolated from the sense terminals of the DMM by keeping channel 16 open.

**WARNING** Multiple channel operation should only be performed by experienced test engineers who recognize the dangers associated with multiple channel closures.

## Digital I/O

As shown in Figure 1, channels 11, 12, 13, and 14 are digital I/O channels. Each digital I/O port can be configured as eight bits of digital input or eight bits of digital output.

Figure 1  
Simplified schematic for Model 7707



# Connections and wiring overview

**WARNING** All connection and wiring information is intended for qualified service personnel. Do not make switching module connections unless qualified to do so.

To prevent electric shock that could result in serious injury or death, adhere to the following safety precautions:

- Before removing or installing the switching module in the mainframe, make sure the mainframe is turned off and disconnected from line power.
- Before making or breaking connections to the switching module, make sure power is removed from all external circuitry.
- Do not connect signals that may exceed the maximum specifications of the Model 7707. Specifications are provided at the end of this section.

## D-shell connectors

Figure 2 shows the pin numbers for the Model 7707 rear panel connectors. The 50-pin D-shell is used to access digital input/output channels, and the 25-pin D-shell is used to access analog input channels. Terminal identification for the D-shell connector pins is provided in Table 1.

Figure 2

### Rear view—Model 7707 pinouts

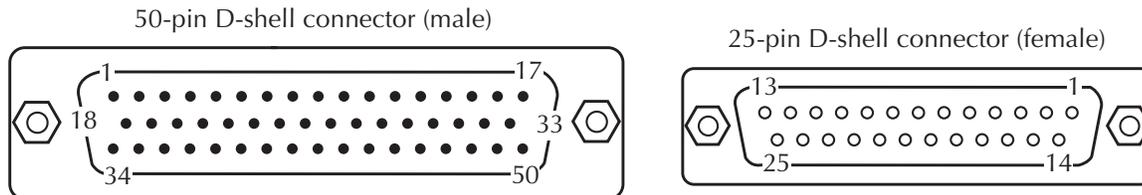


Table 1  
**D-shell pin identification**

50-pin D-shell (DB-50)									
Pin	7707 Terminal	Pin	7707 Terminal	Pin	7707 Terminal	Pin	7707 Terminal	Pin	7707 Terminal
1	Gnd	11	Ch 13 Bit 3	21	Gnd	31	Ch 14 Bit 1	41	Protection K2
2	Ch 11 Bit 2	12	Ch 16 Bit 6	22	Ch 12 Bit 0	32	Ch 14 Bit 4	42	Gnd
3	Ch 11 Bit 5	13	Gnd	23	Ch 12 Bit 3	33	Ch 14 Bit 7	43	Ch 13 Bit 1
4	Protection K1	14	Gnd	24	Ch 12 Bit 6	34	Ch 11 Bit 0	44	Ch 13 Bit 4
5	Gnd	15	Ch 14 Bit 2	25	Gnd	35	Ch 11 Bit 3	45	Ch 13 Bit 7
6	Ch 12 Bit 1	16	Ch 14 Bit 5	26	Gnd	36	Ch 11 Bit 6	46	Gnd
7	Ch 12 Bit 4	17	Protection K4	27	Ch 13 Bit 2	37	Gnd	47	Ch 14 Bit 0
8	Ch 12 Bit 7	18	Ch 11 Bit 1	28	Ch 13 Bit 5	38	Gnd	48	Ch 14 Bit 3
9	Gnd	19	Ch 11 Bit 4	29	Protection K3	39	Ch 12 Bit 2	49	Ch 14 Bit 6
10	Ch 13 Bit 0	20	Ch 11 Bit 7	30	Gnd	40	Ch 12 Bit 5	50	Gnd

25-pin D-shell (DB-25)									
Pin	7707 Terminal	Pin	7707 Terminal	Pin	7707 Terminal	Pin	7707 Terminal	Pin	7707 Terminal
1	Ch 1 Hi	6	Ch 6 Hi	11	Sense Hi	16	Ch 3 Lo	21	Ch 8 Lo
2	Ch 2 Hi	7	Ch 7 Hi	12	Input Hi	17	Ch 4 Lo	22	Ch 9 Lo
3	Ch 3 Hi	8	Ch 8 Hi	13	—	18	Ch 5 Lo	23	Ch 10 Lo
4	Ch 4 Hi	9	Ch 9 Hi	14	Ch 1 Lo	19	Ch 6 Lo	24	Sense Lo
5	Ch 5 Hi	10	Ch 10 Hi	15	Ch 2 Lo	20	Ch 7 Lo	25	Input Lo

## Wiring

**NOTE** *The Model 7707 is shipped with plastic connector covers installed on the D-shell connectors. Each cover is secured to the connector by two screws. After removing a connector cover, retain it and the screws for future use. Any unused D-shell connector must have the connector cover installed.*

The Model 7707 is supplied with one 50-pin female IDC ribbon cable connector, and one 25-pin male IDC ribbon cable connector. These ribbon cable connectors mate to the D-shell connectors of the switching module.

**WARNING** When using IDC ribbon cable connections on the DB-25 (analog inputs), DO NOT exceed 42V on any analog input in the test system (including the front panel inputs of the Model 27xx). For higher voltage applications (up to 300V), use wire rated for the application and add supplementary insulation to the wire harness (Figure 6).

The DB-50 connector is used for digital I/O connections. DO NOT exceed 40V on any digital terminal in the test system.

There are two connector kits that have connectors that can be used with the Model 7707:

- **Model 7790 ribbon cable adapter kit** — Contains one female DB-50, one male DB-50 and one male DB-25 IDC ribbon cable connectors. The female DB-50 and the male DB-25 mate to the D-shell connectors on the Model 7707.
- **Model 7789 50/25-pin solder cup connector kit** — Contains one male DB-50 and one male DB-25 solder cup connectors. The male DB-25 mates to the 25-pin D-shell on the Model 7707.

### IDC ribbon cable connections

**WARNING** When using IDC ribbon cable for analog inputs (DB-25), DO NOT exceed 42V on any analog input (including front panel terminals). When using IDC ribbon cable for the digital I/O (DB-50), DO NOT exceed 40V on any digital terminal.

Connect an appropriate length of 50-conductor IDC ribbon cable to a 50-pin female D-shell IDC connector, and connect an appropriate length of 25-conductor IDC ribbon cable to a 25-pin male D-shell IDC connector. Table 2 and Figure 3 provide terminal identification for the 50-pin ribbon cable connections. Table 3 and Figure 4 provide terminal identification for the 25-pin ribbon cable connections.

The connectors of the prepared ribbon cable assemblies mate to the 50- and 25-pin D-shell connectors of the Model 7707 (Figure 5). Make sure an unused D-shell connector has the connector cover installed.

Table 2

**Terminal identification for 50-conductor IDC ribbon cable and 7707 DB-50 connector**

Ribbon cable*		7707 Terminal	DB-50 Pin #	Ribbon cable*		7707 Terminal	DB-50 Pin #
Conductor	Color			Conductor	Color		
1	Brown	Gnd	1	26	Blue	Gnd	42
2	Red	Ch 11 Bit 0	34	27	Violet	Gnd	26
3	Orange	Ch 11 Bit 1	18	28	Grey	Ch 13 Bit 0	10
4	Yellow	Ch 11 Bit 2	2	29	White	Ch 13 Bit 1	43
5	Green	Ch 11 Bit 3	35	30	Black	Ch 13 Bit 2	27
6	Blue	Ch 11 Bit 4	19	31	Brown	Ch 13 Bit 3	11
7	Violet	Ch 11 Bit 5	3	32	Red	Ch 13 Bit 4	44
8	Grey	Ch 11 Bit 6	36	33	Orange	Ch 13 Bit 5	28
9	White	Ch 11 Bit 7	20	34	Yellow	Ch 13 Bit 6	12
10	Black	Protection K1	4	35	Green	Ch 13 Bit 7	45
11	Brown	Gnd	37	36	Blue	Protection K3	29
12	Red	Gnd	21	37	Violet	Gnd	13
13	Orange	Gnd	5	38	Grey	Gnd	46
14	Yellow	Gnd	38	39	White	Gnd	30
15	Green	Ch 12 Bit 0	22	40	Black	Gnd	14
16	Blue	Ch 12 Bit 1	6	41	Brown	Ch 14 Bit 0	47
17	Violet	Ch 12 Bit 2	39	42	Red	Ch 14 Bit 1	31
18	Grey	Ch 12 Bit 3	23	43	Orange	Ch 14 Bit 2	15
19	White	Ch 12 Bit 4	7	44	Yellow	Ch 14 Bit 3	48
20	Black	Ch 12 Bit 5	40	45	Green	Ch 14 Bit 4	32
21	Brown	Ch 12 Bit 6	24	46	Blue	Ch 14 Bit 5	16
22	Red	Ch 12 Bit 7	8	47	Violet	Ch 14 Bit 6	49
23	Orange	Protection K2	41	48	Grey	Ch 14 Bit 7	33
24	Yellow	Gnd	25	49	White	Protection K4	17
25	Green	Gnd	9	50	Black	Gnd	50

\* 50-conductor IDC ribbon cable is available from Keithley.

Figure 3  
**50-conductor ribbon cable terminal identification**

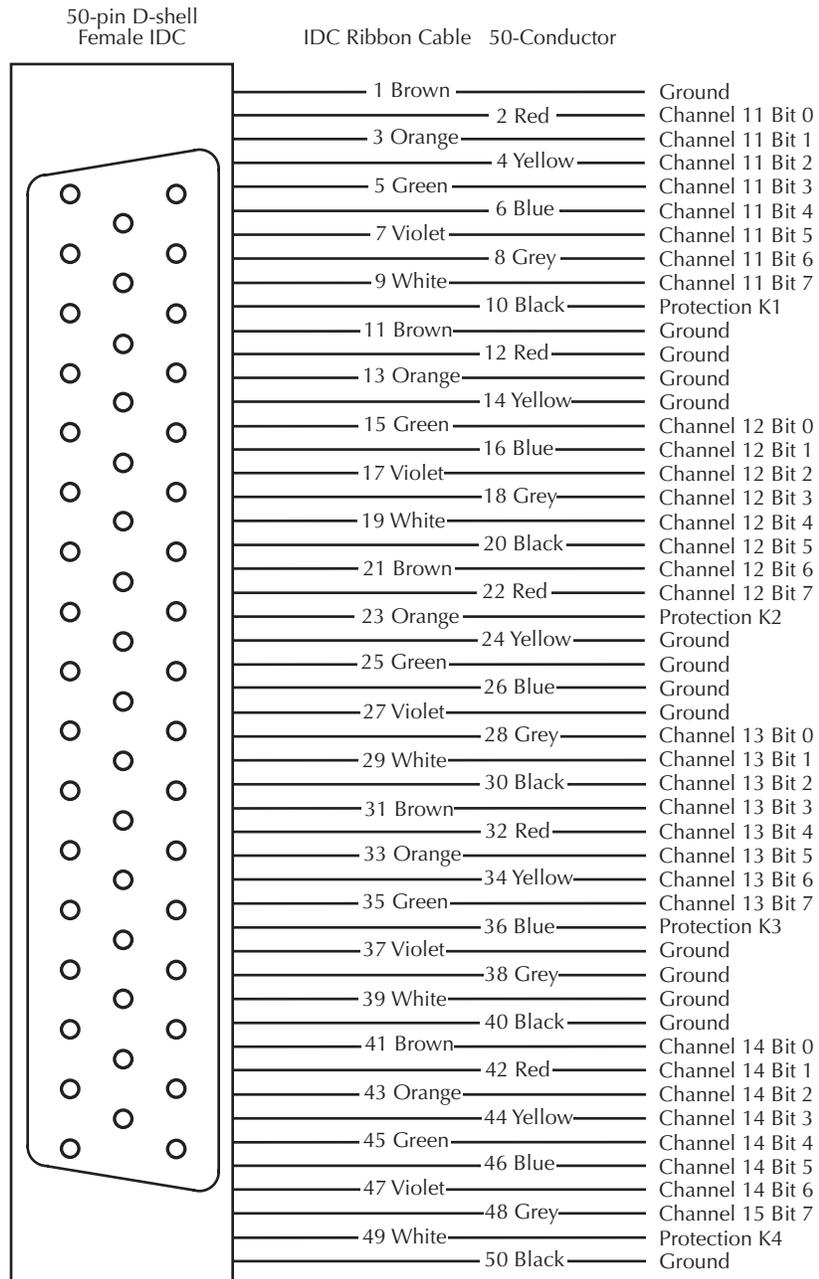


Table 3

**Terminal identification for 25-conductor IDC ribbon cable and 7707 DB-25 connector**

Ribbon cable*		7707 Terminal	DB-25 Pin #	Ribbon cable*		7707 Terminal	DB-25 Pin #
Conductor	Color			Conductor	Color		
1	Brown	Ch 1 Hi	1	14	Yellow	Ch 7 Lo	20
2	Red	Ch 1 Lo	14	15	Green	Ch 8 Hi	8
3	Orange	Ch 2 Hi	2	16	Blue	Ch 8 Lo	21
4	Yellow	Ch 2 Lo	15	17	Violet	Ch 9 Hi	9
5	Green	Ch 3 Hi	3	18	Grey	Ch 9 Lo	22
6	Blue	Ch 3 Lo	16	19	White	Ch 10 Hi	10
7	Violet	Ch 4 Hi	4	20	Black	Ch 10 Lo	23
8	Grey	Ch 4 Lo	17	21	Brown	Sense Hi	11
9	White	Ch 5 Hi	5	22	Red	Sense Lo	24
10	Black	Ch 5 Lo	18	23	Orange	Input Hi	12
11	Brown	Ch 6 Hi	6	24	Yellow	Input Lo	25
12	Red	Ch 6 Lo	19	25	Green	—	—
13	Orange	Ch 7 Hi	7				

\* 25-conductor IDC ribbon cable is available from Keithley.

Figure 4

**25-conductor ribbon cable terminal identification**

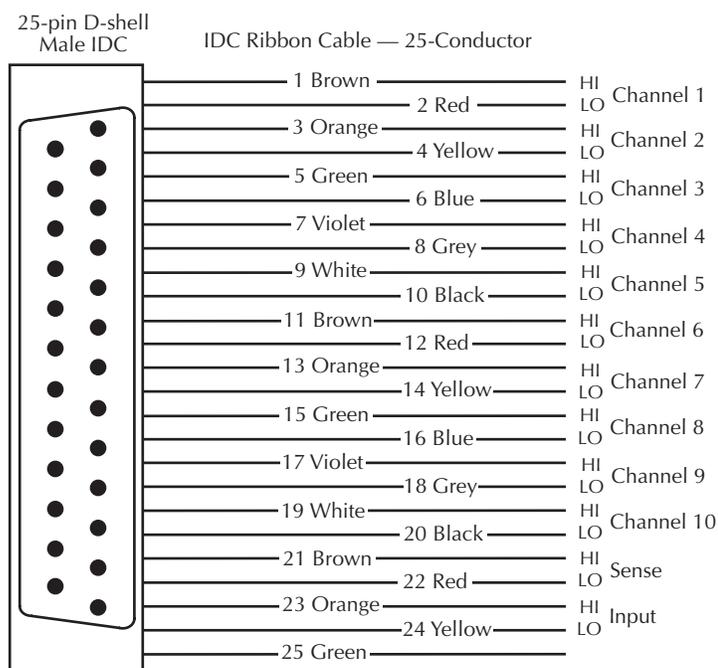
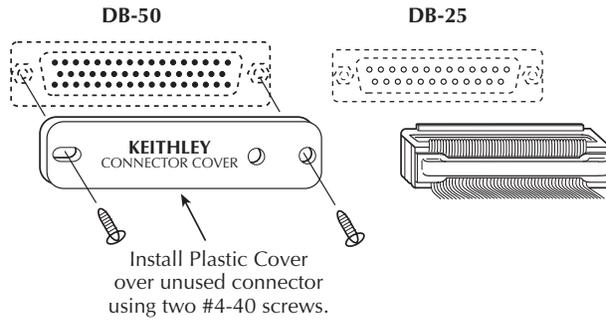


Figure 5  
**Connecting ribbon cable assembly**



**WARNING:** When using ribbon cable, on the DB-25, DO NOT exceed 42 volts on any analog input in the test system (including the front panel inputs of the Model 2700/2750).

The DB-50 connector is used for digital I/O connections. DO NOT exceed 40V on any digital terminal in the test system.

### Solder cup cable connections

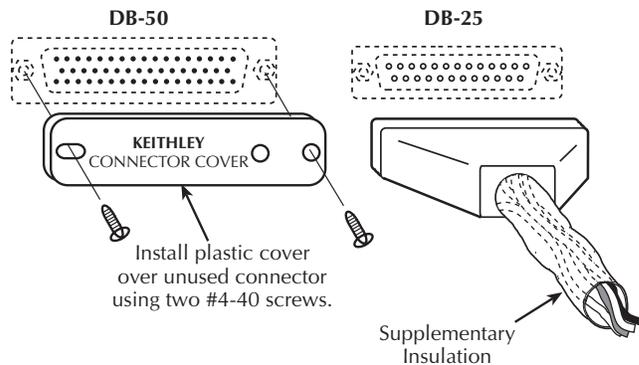
Make all connections to D-shell male solder cup connectors using the correct wire size up to 20 AWG. Terminal identification for the 50-pin D-shell connector is provided in Table 1 and Table 2. Terminal identification for the 25-pin D-shell connector is provided in Table 1 and Table 3. Make sure to add supplementary insulation around the harness for voltages above 42V peak (Figure 6).

**WARNING** For analog inputs (DB-25), all solder cup wiring must be rated for the maximum voltage in the system. For example, if 300V is applied to the front terminals of the DMM, all wiring for analog inputs must be rated for 300V.

For the digital I/O (DB-50), wiring must be rated for the maximum voltage applied to a digital terminal (up to 40V).

A connector cover must be installed on an unused 50-pin D-shell connector. If the connector is left open, an electrical shock hazard may be present.

Figure 6  
**Connecting solder cup cable assembly**



**WARNING:** When using a solder cup cable on the DB-25, use supplementary insulation around the harness for voltages above 42V peak.

The DB-50 connector is used for digital I/O connections. DO NOT exceed 40V on any digital terminal in the test system.

## Connection log

Make a copy of [Table 4](#) and affix it to the cover of the Model 7707. Use this to record connection information and channel descriptions as needed.

*Table 4*  
**Connection log Model 7707**

Channel		Color	Description
INPUT	H		
	L		
SENSE	H		
	L		
CH1	H		
	L		
CH2	H		
	L		
CH3	H		
	L		
CH4	H		
	L		
CH5	H		
	L		
CH6	H		
	L		
CH7	H		
	L		
CH8	H		
	L		
CH9	H		
	L		
CH10	H		
	L		

Table 4 (cont)  
**Connection log Model 7707**

I/O Line	Ch 11			Ch 12			Ch 13			Ch 14		
	In	Out	Color									
Bit 0	(B0)	0 1		(B8)	0 1		(B16)	0 1		(B24)	0 1	
Bit 1	(B1)	0 1		(B9)	0 1		(B17)	0 1		(B25)	0 1	
Bit 2	(B2)	0 1		(B10)	0 1		(B18)	0 1		(B26)	0 1	
Bit 3	(B3)	0 1		(B11)	0 1		(B19)	0 1		(B27)	0 1	
Bit 4	(B4)	0 1		(B12)	0 1		(B20)	0 1		(B28)	0 1	
Bit 5	(B5)	0 1		(B13)	0 1		(B21)	0 1		(B29)	0 1	
Bit 6	(B6)	0 1		(B14)	0 1		(B22)	0 1		(B30)	0 1	
Bit 7	(B7)	0 1		(B15)	0 1		(B23)	0 1		(B31)	0 1	
	K1			K2			K3			K4		

0 = low, 1 = high

## Analog inputs

The following Model 7707 channels are used to measure analog input:

- Channels 1 through 10 are system measurement channels.
- Channel 15 is the 2-pole/4-pole selection relay.
- Channels 16 and 17 are the backplane isolation relays for sense and input respectively.

## Operation

Operation to measure analog input is the same as operation for the Model 7700. The only exceptions are that the Model 7707 does not have any amps channels, and it does not have a cold junction for thermocouple temperature measurements.

Operation information for the Model 7700 switching module is provided in the Model 27xx User's Manual. Section 2 covers basic open/close operation, while the "Scanning" section covers scanning.

## Amps measurements

The 7707 module does not support amps measurements. System channel operation cannot be used to close channels while an amps function (DCI or ICI) is selected.

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

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

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

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

**Making amps measurements** – In order to perform amps measurements, you must use the front panel inputs of the 27xx mainframe. You can still use the 7707 module for other aspects of the test, but you must use multiple channel operation to close channels. Example:

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

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

## Dual independent multiplexers

Multiple channel operation can be used to configure the Model 7707 as two independent 1 × 5 multiplexers by closing channel 15 (Figure 1). This isolates channels 1 through 5 from channels 6 through 10.

**WARNING** Multiple channel operation should only be performed by experienced test engineers who recognize the dangers associated with multiple channel closures.

## Typical analog input connections

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

- $\Omega$ 2-Wire resistance and thermistor connections, [Figure 7](#).
- $\Omega$ 4-Wire resistance and RTD connections, [Figure 8](#).
- Voltage connections (AC or DC), [Figure 9](#).

Figure 7

### 2-wire resistance and thermistor connections

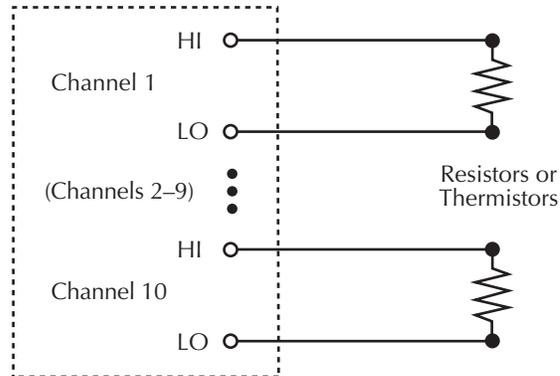


Figure 8

### 4-wire resistance and RTD connections

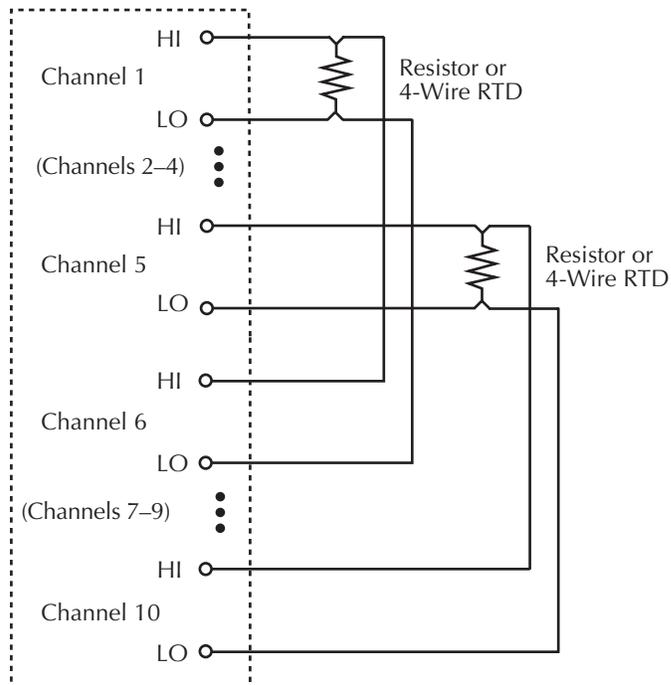
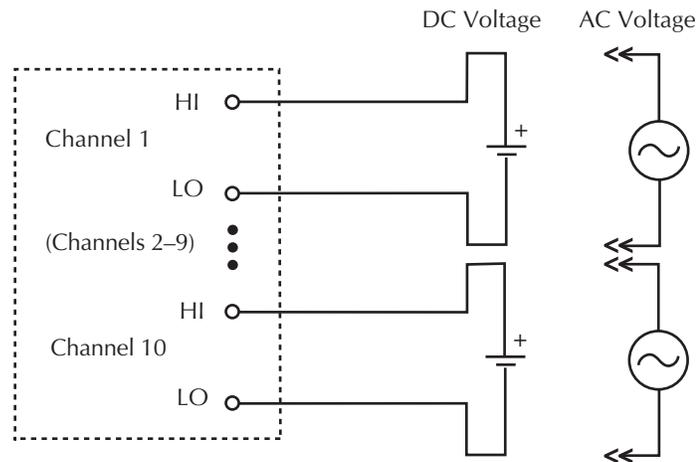


Figure 9  
Voltage connections (AC or DC)

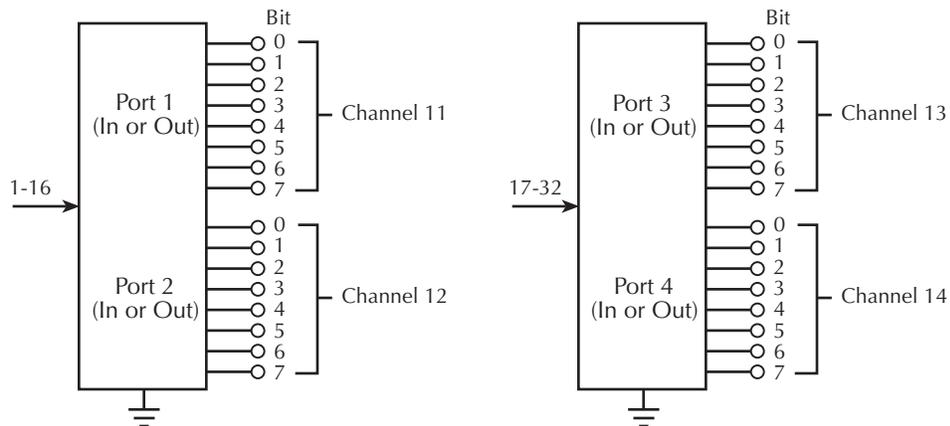


## Digital I/O

The Model 7707 has four digital input/output channels (11, 12, 13, and 14). Each I/O channel can be set as either a digital input port or a digital output port. As shown in Figure 10, each port has 8 lines (bits 0 through 7).

When an I/O channel is used as an input port, the state (high or low) of each input line (bit) can be read. When an I/O channel is used as an output port, each line (bit) can be set high or low to control external circuitry.

Figure 10  
Block diagram of digital I/O channels



## Digital outputs

Digital outputs are used to control logic devices, indicators, fixtures, switches, solenoids, loads, relays, etc. With one I/O channel set as an output port, eight output lines (bits) are available. With two channels set as output ports, 16 output lines (bits) are available. With three channels set as output ports, 24 output lines (bits) are available. And finally, with all four channels set as output ports, 32 output lines (bits) are available.

An output line can be set high to  $\approx 4.3\text{V}$  or low to  $0\text{V}$  (digital ground). Output lines are set as follows:

- Logic '0' sets output line low to  $0\text{V}$  (digital ground).
- Logic '1' sets output line high to  $\approx 4.3\text{V}$ .

**NOTE** A digital I/O channel must first be configured as an output port before its output lines can be set high or low. See *Setting digital outputs on page 22*, for details.

## Sink or source

A digital output line (bit) can be used as a sink for an external source (up to  $40\text{V}$ ), or as a  $\approx 4.3\text{V}$  source for a low-current device.

## Sink mode

As a sink, current provided by an external source flows into the module when the output line is set low (logic '0'). Using an output line as a sink provides control for high voltage (up to  $40\text{V}$ ) and/or high current (up to  $100\text{mA}$ ) devices, such as relays, solenoids, and other loads.

**CAUTION** Do not apply more than  $+40\text{V}$  to the K1, K2, K3, and K4 pins of the module. For the output lines, do not exceed the maximum sink current. The maximum sink current for an output line is  $100\text{mA}$ . Exceeding these limits may cause damage to the instrument that is not covered by the warranty.

Figure 11  
Typical digital output—sink mode (with K1 protection)

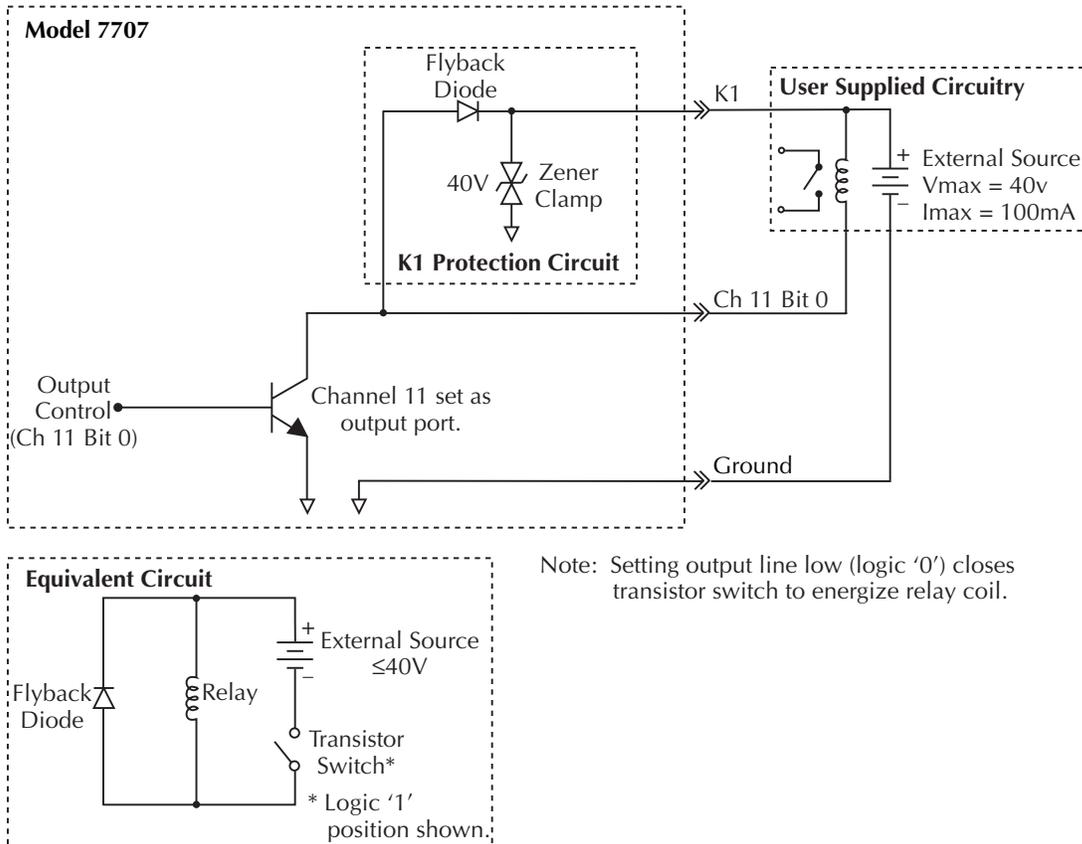
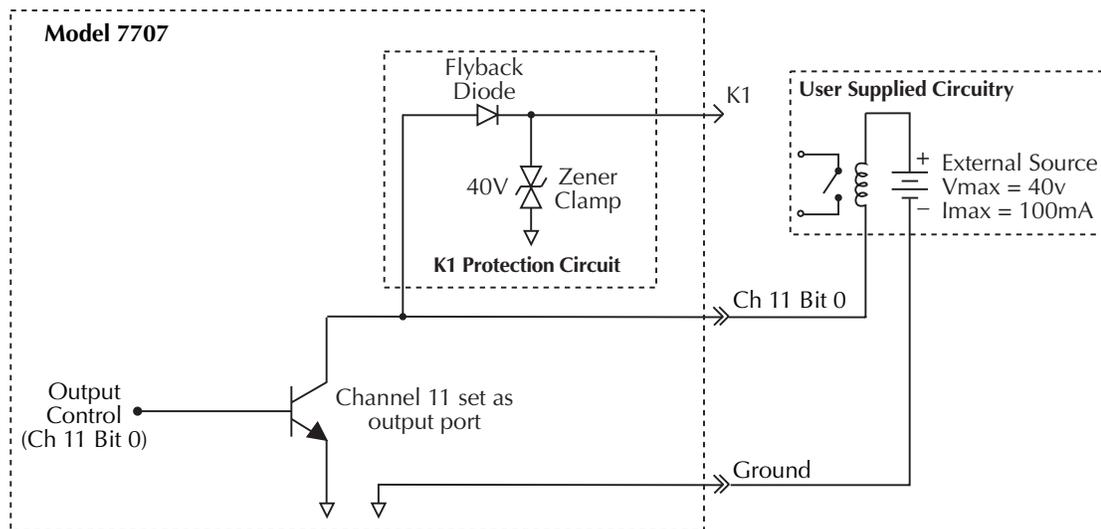
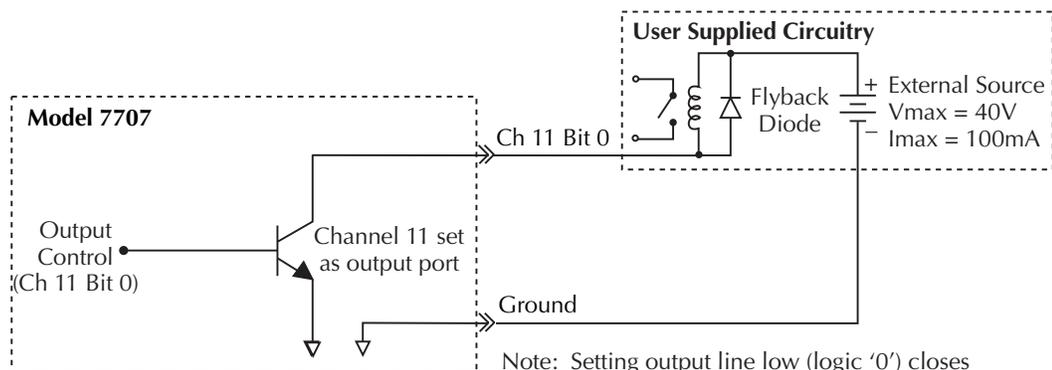


Figure 12  
**Typical digital output—sink mode (without K1 protection)**



Note: Setting output line low (logic '0') closes transistor switch to energize relay coil.

Figure 13  
**Typical digital output—sink mode (external flyback diode protection used)**



Note: Setting output line low (logic '0') closes transistor switch to energize relay coil.

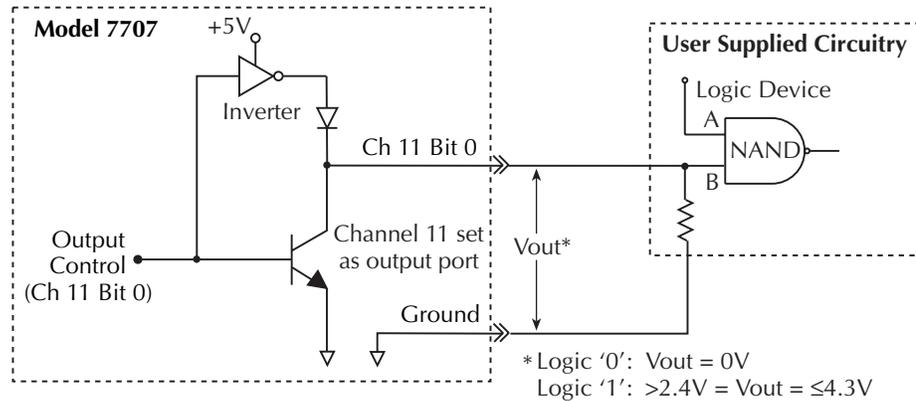
## Source mode

When used as a source, current provided by the internal 5V supply flows out of the module to a load when the output line is set high (logic '1'). Using an output line as a source provides control for low voltage, low current (up to 1mA) loads, such as logic devices and indicator lamps. Figure 14 shows how to use an output line to apply high and low logic levels to a NAND gate.

**CAUTION** Each output line can source up to 1mA. Exceeding 1mA may cause damage to the Model 7707 that is not covered by the warranty.

Figure 14

### Typical digital output—source mode



Note: Setting output line high (logic '1') opens transistor switch to apply logic high ('1') to NAND gate.  
Setting output line low (logic '0') closes transistor switch to apply logic low (digital ground) to NAND gate.

## Digital I/O protection

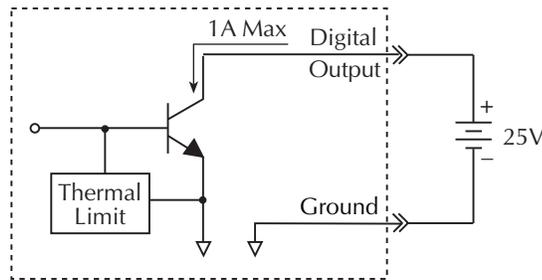
### Short circuit protection

Each digital output line has internal short circuit protection up to 25V. Over-current protection is tripped at approximately 1A. A simplified circuit showing thermal protection for a digital output is shown in Figure 15.

In Figure 15, a short circuit condition exists when the transistor switch for the digital output is closed (logic '0'). When the current reaches 1A, the driver for the digital output automatically reduces the current to a level that will not damage the digital I/O. If the short circuit condition is maintained, thermal limit circuitry senses the rise in device temperature and further decreases the current.

**CAUTION** Short circuit protection is effective up to 25V. To avoid damage to the Model 27xx, DO NOT apply >25V directly to a digital I/O line.

Figure 15  
**Short circuit protection for digital outputs**



**CAUTION** To avoid damage to digital circuitry, DO NOT apply >25 directly to a digital I/O line.

### K1, K2, K3, and K4 protection circuits

Each digital I/O channel has a circuit to protect it from high voltage. Figure 11 shows the key components of the protection circuit for channel 11. It includes a zener clamp to limit voltage to 40V, and a fly-back diode to provide a current discharge path for an inductive load (i.e., relay coil). Without a current discharge path, fly-back voltage that occurs when the inductive load is switched could damage the digital I/O.

Figure 11 shows how to connect an external circuit to the K1 protection circuit for channel 11. This circuit is shown connected to output line Bit 0, but it is also connected to the other output lines (Bits 1 through 7) in a similar fashion to protect those lines. As shown in the Equivalent Circuit, the flyback diode is placed across the relay coil to provide a discharge path for fly-back voltage. There are similar protection circuits for the other three digital I/O channels; K2 protects channel 12, K3 protects channel 13, and K4 protects channel 14.

### External protection circuits

For localized protection, an external flyback diode can be connected directly across the relay coil to provide a current discharge path for flyback voltage. Figure 13 shows how to connect the diode across the coil.

Even when using K1, K2, K3, or K4 protection, additional devices, such as fuses and current limiting resistors, may be required to adequately protect the switching module from damage caused by reactive loads.

### Output bit patterns

A binary bit pattern is a series of '0's' and '1's' that identifies the state of each output line (bit) in the pattern. Setting a bit to a logic '1' effectively sets the output line high to approximately +4.3V while setting it to a logic '0' sets the output line low to 0V.

Operations to set output bit patterns are divided into two categories; basic operation and advanced operation:

**Basic operation** — Basic operation handles each output channel as a single 8-bit output pattern. An 8-bit pattern is known as a byte. Output bytes can be set from either the front panel or set using remote programming.

*NOTE For most applications, it is only necessary to set one 8-bit output pattern (byte). When working with bytes, you do not need to concern yourself with advanced operation.*

**Advanced operation** — Advanced operation provides additional flexibility by allowing two digital output ports to be treated as a single 16-bit output pattern (word), or all four output ports to be treated as a 32-bit output pattern (double-word). Words and a double-word can only be set using remote programming.

## Basic operation — setting bytes (8-bits)

### 8-bit output patterns (bytes)

Each I/O channel is set as an output port in an 8-bit binary output pattern (byte). Bit 7 (B7) of each port is the most significant bit (MSB) and Bit 0 (B0) is the least significant bit (LSB).

An 8-bit output pattern for each port is set by entering a value that is the equivalent of the desired binary bit pattern. From the front panel, the entered value can be in the decimal, hexadecimal, or octal format. The decimal (ASCII) format is the factory and \*RST default.

Figure 16 lists the decimal weights for the bits of an 8-bit output pattern. To determine the decimal value for an output pattern, simply add up the decimal weights for the bits to be set to '1'. As shown in Figure 16, the decimal equivalent for output binary pattern '10100101' is the sum of the decimal weights for B7, B5, B2, and B0.

Figure 16

### Decimal weighting for 8-bit output pattern (byte)

Channel 11, 12, 13, or 14

Digital I/O line:	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Bit position:	B7	B6	B5	B4	B3	B2	B1	B0
Binary bit pattern*:	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
Decimal weight:	128 (2 <sup>7</sup> )	64 (2 <sup>6</sup> )	32 (2 <sup>5</sup> )	16 (2 <sup>4</sup> )	8 (2 <sup>3</sup> )	4 (2 <sup>2</sup> )	2 (2 <sup>1</sup> )	1 (2 <sup>0</sup> )

\* 0 = line set low, 1 = line set high.

Example – Determine decimal value for binary output pattern '10100101' (bits B7, B5, B2 and B0 to be set high to logic '1'):

Bit position:	B7	B6	B5	B4	B3	B2	B1	B0
Binary bit pattern:	1	0	1	0	0	1	0	1
Decimal weight of bits set high:	128	—	32	—	—	4	—	1

$$\begin{aligned}
 \text{Decimal value for bit pattern:} &= B7 + B5 + B2 + B0 \\
 &= 128 + 32 + 4 + 1 \\
 &= 165
 \end{aligned}$$

For remote programming, the following command is used to set the 8-bit output pattern for each output port:

```
OUTP:BYTE <NRF|NDN>,<clist>
```

Valid channels for the byte <clist> parameter include channels 11, 12, 13, and 14.

Like front panel operation, the decimal equivalent of the binary pattern can be used to set the port. The pattern can also be set using the binary, octal, or hexadecimal equivalent. For details, see “Setting digital outputs — “Remote programming,” page 24.

## Advanced operation — setting words (16-bits) or double-words (32-bits)

### 16-bit output patterns (words)

For remote programming, there is a single command to set two output ports to form a 16-bit output pattern (word):

```
OUTP:WORD <NRf|NDN>,<clist>
```

Valid channels for the word <clist> parameter include channels 11 and 13.

This command is used to write to channel 11 or channel 13. Channel 11 is combined with channel 12 to form a 16-bit output pattern, and channel 13 is combined with channel 14 to form a second 16-bit output pattern.

When channel 11 is set as a word, Bit 0 (B0) of channel 11 will be the LSB, and Bit 7 (B15) of channel 12 will be the MSB. When channel 13 is set as a word, Bit 0 (B0) of channel 13 will be the LSB, and Bit 7 (B15) of channel 14 will be the MSB.

The decimal equivalent of the 16-bit output pattern can be used to set the ports. [Figure 17](#) lists the decimal weights of the 16 bits. The bit pattern can also be set using the binary, octal, or hexadecimal equivalent. For details, see “[Setting digital outputs — “Remote programming,” page 24.](#)”

Figure 17

### Decimal weighting for 16-bit output pattern (word)

#### Channel 11 or 13 (B0 - B7)

Digital I/O line:	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Bit position:	B7	B6	B5	B4	B3	B2	B1	B0
Binary bit pattern:	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
Decimal weight:	128 (2 <sup>7</sup> )	64 (2 <sup>6</sup> )	32 (2 <sup>5</sup> )	16 (2 <sup>4</sup> )	8 (2 <sup>3</sup> )	4 (2 <sup>2</sup> )	2 (2 <sup>1</sup> )	1 (2 <sup>0</sup> )

#### Channel 12 or 14 (B8 - B15)

Digital I/O line:	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Bit position:	B15	B14	B13	B12	B11	B10	B9	B8
Binary bit pattern:	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
Decimal weight:	32768 (2 <sup>15</sup> )	16384 (2 <sup>14</sup> )	8192 (2 <sup>13</sup> )	4096 (2 <sup>12</sup> )	2048 (2 <sup>11</sup> )	1024 (2 <sup>10</sup> )	512 (2 <sup>9</sup> )	256 (2 <sup>8</sup> )

### 32-bit output pattern (double-word)

For remote operation, there is a single command to set the four output ports to form a 32-bit output pattern (double word):

```
OUTP:DWOR <NRf|NDN>,<clist>
```

The only valid channel for the double-word <clist> parameter is channel 11.

This command is used to write to channel 11. Channel 11 is combined with channels 12, 13, and 14 to form the 32-bit output pattern. When channel 11 is set as a double-word, Bit 0 of channel 11 (B0) will be the LSB, and Bit 7 of channel 14 (B31) will be the MSB.

The decimal equivalent of the 32-bit output pattern can be used to set the ports. [Figure 18](#) lists the decimal weights of the 32 bits. The bit pattern can also be set using the binary, octal, or hexadecimal equivalent. For details, see “[Setting digital outputs — “Remote programming,” page 24.](#)”

## Setting digital outputs

Before setting a digital output pattern, an I/O channel must first be set as an output port. This can be done from the front panel or remote programming.

From the front panel, the pattern for each 8-bit port must be set individually. For remote programming, commands are provided to set 8-bit patterns (bytes), 16-bit patterns (words) and a 32-bit pattern (double-word).

From the front panel, each 8-bit port is set using a decimal, hexadecimal, or octal value that is the equivalent of the binary output bit pattern. For remote programming, an output bit pattern can be set using decimal, binary, hexadecimal, or octal values.

Figure 18

### Decimal weighting for 32-bit output pattern (double-word)

#### Channel 11 (B0 - B7)

Digital I/O line:	<b>Bit 7</b>	<b>Bit 6</b>	<b>Bit 5</b>	<b>Bit 4</b>	<b>Bit 3</b>	<b>Bit 2</b>	<b>Bit 1</b>	<b>Bit 0</b>
Bit position:	B7	B6	B5	B4	B3	B2	B1	B0
Binary bit pattern:	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
Decimal weight:	128 ( $2^7$ )	64 ( $2^6$ )	32 ( $2^5$ )	16 ( $2^4$ )	8 ( $2^3$ )	4 ( $2^2$ )	2 ( $2^1$ )	1 ( $2^0$ )

#### Channel 12 (B8 - B15)

Digital I/O line:	<b>Bit 7</b>	<b>Bit 6</b>	<b>Bit 5</b>	<b>Bit 4</b>	<b>Bit 3</b>	<b>Bit 2</b>	<b>Bit 1</b>	<b>Bit 0</b>
Bit position:	B15	B14	B13	B12	B11	B10	B9	B8
Binary bit pattern:	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
Decimal weight:	32768 ( $2^{15}$ )	16384 ( $2^{14}$ )	8192 ( $2^{13}$ )	4096 ( $2^{12}$ )	2048 ( $2^{11}$ )	1024 ( $2^{10}$ )	512 ( $2^9$ )	256 ( $2^8$ )

#### Channel 13 (B16 - B23)

Digital I/O line:	<b>Bit 7</b>	<b>Bit 6</b>	<b>Bit 5</b>	<b>Bit 4</b>	<b>Bit 3</b>	<b>Bit 2</b>	<b>Bit 1</b>	<b>Bit 0</b>
Bit position:	B23	B22	B21	B20	B19	B18	B17	B16
Binary bit pattern:	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
Decimal weight*:	$2^{23}$	$2^{22}$	$2^{21}$	$2^{20}$	$2^{19}$	$2^{18}$	$2^{17}$	$2^{16}$

#### Channel 14 (B24 - B31)

Digital I/O line:	<b>Bit 7</b>	<b>Bit 6</b>	<b>Bit 5</b>	<b>Bit 4</b>	<b>Bit 3</b>	<b>Bit 2</b>	<b>Bit 1</b>	<b>Bit 0</b>
Bit position:	B31	B30	B29	B28	B27	B26	B25	B24
Binary bit pattern:	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
Decimal weight*:	$2^{31}$	$2^{30}$	$2^{29}$	$2^{28}$	$2^{27}$	$2^{26}$	$2^{25}$	$2^{24}$

* $2^{16} = 65536$	$2^{20} = 1048576$	$2^{24} = 16777216$	$2^{28} = 268435456$
$2^{17} = 131072$	$2^{21} = 2097152$	$2^{25} = 33554432$	$2^{29} = 536870912$
$2^{18} = 262144$	$2^{22} = 4194304$	$2^{26} = 67108864$	$2^{30} = 1073741824$
$2^{19} = 524288$	$2^{23} = 8388608$	$2^{27} = 134217728$	$2^{31} = 2147483648$

## Front panel basic operation

*NOTE* 8-bit output bit patterns are set and viewed from the CARD menu. The following summarizes how to use this menu to set digital outputs. For detailed information, see [CARD menu on page 42](#).

CARD: CONFIG – The CONFIG option of the CARD menu is used to set 8-bit output patterns. The menu is accessed by pressing SHIFT and then CARD. After selecting the CONFIG option, and the slot that has the Model 7707, you will be prompted to select the format for digital data; ASC (decimal), HEX (hexadecimal), BIN (binary) or OCT (octal). After selecting the format, you can then set one or more of the digital I/O channels as an output port.

*NOTE* There is not enough room on the front panel to display binary readings. Therefore, if you select the binary format, the hexadecimal format will instead be used for front panel operation.

There is a menu item for every digital I/O channel. For example, assume a Model 7707 is installed in slot 1. From these menu items, a channel can be set as an output (OUT) port:

CHAN 111 OUT  
CHAN 112 OUT  
CHAN 113 OUT  
CHAN 114 OUT

After a digital I/O channel is set as an output (OUT) port, you will then be prompted to enter a decimal, hexadecimal, or octal value to set the 8-bit output pattern:

Decimal format:

DIGOUT1: Set digital output port 1 (channel 11) from 000 to 255 (in decimal).  
DIGOUT2: Set digital output port 2 (channel 12) from 000 to 255 (in decimal).  
DIGOUT3: Set digital output port 3 (channel 13) from 000 to 255 (in decimal).  
DIGOUT4: Set digital output port 4 (channel 14) from 000 to 255 (in decimal).

CARD: VIEW — The VIEW option of the CARD menu is used to view the decimal, hexadecimal, or octal equivalent of the set output patterns for the output ports. The menu is accessed by pressing SHIFT and then CARD. After selecting the VIEW item and the slot that has the Model 7707, the output pattern values for channels 11, 12, 13, and 14 will scroll across the display. Example for hexadecimal format:

111:OUT 0xFF = hexadecimal FF set for output port

The binary equivalent of hexadecimal FF is the '11111111.' For this binary bit pattern, all 8 bits are set high to logic '1.'

## Remote programming

Commands are available to set byte, word, and double-word output patterns. These commands are listed in [Table 5](#). Details on these commands follow the table.

**NOTE** Attempting to set or query an output pattern for an input port will generate error -221 (settings conflict). Make sure to set the appropriate I/O channels as output ports using the `OUTPut:DIGital:STATe` command.

Both digital output and digital input commands are summarized together in [Table 7](#) (see [Digital I/O command summary on page 45](#)). A photo copy of that table serves as a handy reference to program the digital I/O.

Table 5  
**Commands to set digital outputs**

Command	Description	Default
<p>Set port(s) as input or output:            OUTPut:DIGital              :STATe &lt;b&gt;, &lt;clist&gt;                :STATe? &lt;clist&gt;</p>	<p>Path to set channels of digital I/O port:            Set listed channels as output or input ports; 1 (on) sets channels as output ports, 0 (off) sets channels as input ports.            Query port type of listed channels (1 = output port, 0 = input port).</p>	Note 1
<p>Setting bytes (basic operation):            OUTPut:DIGital              :BYTE &lt;NDN or NRf&gt;, &lt;clist&gt;                :BYTE? &lt;clist&gt;</p>	<p>Path to set digital output bytes:            Set a byte output pattern<sup>2</sup> (valid channels are 11, 12, 13, and 14):              &lt;NDN&gt; = #Bxx...x Binary format; each x = 1 or 0                  = #Hx Hexadecimal format; x = 0 to FF                  = #Qx Octal format; x = 0 to 377              &lt;NRf&gt; = 0 to 255 Decimal format            Query the byte bit pattern for the specified output channels.</p>	Note 3
<p>Setting words or double-words (advanced operation):            OUTPut:DIGital              :WORD &lt;NDN or NRf&gt;, &lt;clist&gt;                :WORD? &lt;clist&gt;                :DWORD &lt;NDN or NRf&gt;, &lt;clist&gt;                :DWORD? &lt;clist&gt;</p>	<p>Path to set digital output words and double-word:            Set a word output pattern<sup>2</sup> (valid channels are 11 and 13):              &lt;NDN&gt; = #Bxx...x Binary format; each x = 1 or 0                  = #Hx Hexadecimal format; x = 0 to FFFF                  = #Qx Octal format; x = 0 to 177777              &lt;NRf&gt; = 0 to 65535 Decimal format            Query digital word output pattern for channels 11 and/or 13.            Set a double-word output pattern<sup>2</sup> (valid channel is 11):              &lt;NDN&gt; = #Bxx...x Binary format; each x = 1 or 0                  = #Hx Hexadecimal format; x = 0 to FFFFFFFF                  = #Qx Octal format; x = 0 to 3777777777              &lt;NRf&gt; = 0 to 4294967295 Decimal format            Query digital double-word output pattern for channel 11.</p>	Note 4  Note 5

Table 5 (cont.)

**Commands to set digital outputs**

Command	Description	Default																		
<p><i>Selecting format for reading outputs:</i></p> <p>:OUTPut:DiGital</p> <p>:FORMat &lt;name&gt;, [&lt;NRf&gt;]</p> <p>:FORMat?</p>	<p>Path to select reading format:</p> <p>Select data format for reading digital outputs<sup>6</sup>:</p> <table> <tr> <td>&lt;name&gt;</td> <td>= ASCii</td> <td>Decimal format</td> </tr> <tr> <td></td> <td>BINary</td> <td>Binary format</td> </tr> <tr> <td></td> <td>HEXadecimal</td> <td>Hexadecimal format</td> </tr> <tr> <td></td> <td>OCTal</td> <td>Octal format</td> </tr> <tr> <td>&lt;NRf&gt;</td> <td>= 0</td> <td>Return value without leading zeros</td> </tr> <tr> <td></td> <td>1 to 32</td> <td>Specify number of digits to return</td> </tr> </table> <p>Query digital output data format.</p>	<name>	= ASCii	Decimal format		BINary	Binary format		HEXadecimal	Hexadecimal format		OCTal	Octal format	<NRf>	= 0	Return value without leading zeros		1 to 32	Specify number of digits to return	Note 7
<name>	= ASCii	Decimal format																		
	BINary	Binary format																		
	HEXadecimal	Hexadecimal format																		
	OCTal	Octal format																		
<NRf>	= 0	Return value without leading zeros																		
	1 to 32	Specify number of digits to return																		
<p>Channel list parameter:</p> <p>&lt;clist&gt; = (@SCH)</p> <p>where: S = Mainframe slot number (1, 2, 3, 4 or 5);</p> <p>CH = Module channel number (must be 2 digits)</p> <p>Examples:</p> <p>(@111) = Slot 1, Channel 11</p> <p>(@511, 513) = Slot 5, Channels 11 and 13</p>																				

Notes:

- \*RST and SYSTem:PRESet sets channels 11, 12, 13, and 14 as input ports (0).
- The non-decimal numeric parameter (<NDN>) is used to specify the output pattern using a non-decimal value.
- The default byte bit pattern depends on the selected data format; ASC=255, BIN=11111111, HEX=FF, OCT=377.
- The default word bit pattern depends on the selected data format; ASC=65535, BIN=16 "1's", HEX=FFFF, OCT=177777.
- The default double-word pattern depends on the selected data format; ASC=4294967295, BIN=32 "1's", HEX=FFFFFFFF, OCT=3777777777.
- The [SENSe[1]]:DiGital:FORMat command can instead be used to select data format (Table 6).
- \*RST and SYSTem:PRESet have no effect on the data format for reading digital outputs.

**OUTPut:DiGital**

Using remote programming, the Model 7707 can be set to output up to four 8-bit digital patterns (bytes), two 16-bit digital patterns (words), or one 32-bit pattern. The output bit pattern can be set using the decimal, binary, hexadecimal or octal format.

*NOTE Examples for the following commands assume a Model 7707 installed in slot 1 of the mainframe.*

**:STATe <b>, <clist>** Set I/O channel(s) as output or input

**:STATe? <clist>** Query port type

Use to set (or query) the specified I/O channels as either output ports or input ports. Parameter value "1" (or "on") sets the channels as output ports. Parameter value "0" (or "off") sets the channels as input ports.

The :STATe? <clist> command queries the port type for the specified I/O channels. A "1" or a "0" will be returned for each channel in the list:

- 1 = Output port
- 0 = Input port

For example, the following command queries port type for I/O channels 11, 12, 13, and 14:

OUTP:DiG:STAT? (@111:114)

The response message "0, 0, 1, 1" indicates that channels 11 and 12 are input ports, and channels 13 and 14 are output ports.

**:BYTE <NDN or NRf>, <clist>** Set digital output byte patterns  
**:BYTE? <clist>** Query output byte patterns

Use to set (or query) an 8-bit digital output byte pattern for the specified I/O channel(s). Channels 11, 12, 13, and 14 can be set as 8-bit output patterns.

*NOTE Only channels 11, 12, 13, and 14 are valid with the :BYTE command. Using any other channel number(s) with the command generates error -221 (settings conflict).*

The value to set the 8-bit output pattern can be sent in the decimal, binary, hexadecimal, or octal format.

Example: Set output bit pattern “100101” for channel 13 (Bits B5, B2 and B0 set high):

```
OUTP:DIG:STAT 1, (112)          ' Set channel 12 as output port.  
OUTP:DIG:BYTE #B100101, (@121) ' Set pattern; binary format.
```

In order to use one of the other formats, convert the binary value to its hexadecimal, octal, or decimal equivalent and send the command as follows:

```
OUTP:DIG:BYTE #H25, (@121)      ' Set pattern; hexadecimal format.  
OUTP:DIG:BYTE #Q45, (@121)      ' Set pattern; octal format.  
OUTP:DIG:BYTE 37, (@121)        ' Set pattern; decimal format.
```

**:BYTE?** command — For non-decimal formats, one of the following headers will accompany the returned value to identify which format is selected:

#B = Header for binary values

#H = Header for hexadecimal values

#Q = Header for octal values

The **:FORMat** command is used to select the format for returned values.

**:WORD <NDN or NRf>, <clist>** Set digital output word patterns  
**:WORD? <clist>** Query output word patterns

Use to set (or query) a 16-bit digital output word pattern. Channels 11 and 12 are combined to form one 16-bit pattern, and channels 13 and 14 are combined to form a second 16-bit pattern.

*NOTE Only channels 11 and 13 are valid with the :WORD command. Using any other channel number(s) with the command generates error -221 (settings conflict).*

When you write a word output pattern to channel 11, the bits for both channels 11 and 12 will set. As shown in [Figure 17](#), channel 11 is used for bits B0 through B7, and channel 12 is used for bits B8 through B15. In a similar manner, when you write a word output pattern to channel 13, the bits of channels 13 and 14 will set.

*NOTE When setting a word bit pattern, both channels (11 and 12, or 13 and 14) must be configured as output ports. Otherwise, error -221 (settings conflict) will occur when the :WORD command is sent.*

The value to set the 16-bit output pattern can be sent in the decimal, binary, hexadecimal, or octal format.

Example: Write 16-bit output bit pattern “00000001 00000111” to channel 11 (Bits B8, B2, B1 and B0 set high):

```
OUTP:DIG:STAT 1, (111, 112)      ' Set I/O channels 11 and 12 as outputs ports.  
OUTP:DIG:WORD #B100000111, (@111) ' Set pattern; binary format.
```

Notice that leading zeroes for the binary word need not be included in the command.

In order to use one of the other formats, convert the binary value to its hexadecimal, octal, or decimal equivalent and send the command as follows:

```
OUTP:DIG:WORD #H107, (@111)      ' Set pattern; hexadecimal format.
OUTP:DIG:WORD #Q407, (@111)      ' Set pattern; octal format.
OUTP:DIG:WORD 263, (@111)        ' Set pattern; decimal format.
```

:WORD? command — For non-decimal formats, one of the following headers will accompany the returned value to identify which format is selected:

#B = Header for binary values  
#H = Header for hexadecimal values  
#Q = Header for octal values

The :FORMAt command is used to select the format for returned values.

**:DWORD <NDN or NRF>, <clist>** Set digital output double-word pattern  
**:DWORD? <clist>** Query output double-word pattern

Use to set (or query) a 16-bit digital output word pattern. Channels 11, 12, 13, and 14 are combined to form one 32-bit pattern.

*NOTE Only channel 11 is valid with the :DWORD command. Using any other channel number with the command generates error -221 (settings conflict).*

When you write an output pattern to channel 11, the bits for channels 11, 12, 13, and 14 will set. As shown in [Figure 18](#), channel 11 is used for bits B0 through B7, channel 12 is used for bits B8 through B15, channel 13 is used for bits B16 through B23, and channel 14 is used for bits B24 through B31.

*NOTE When setting a double-word bit pattern, all I/O channels (11, 12, 13, and 14) must be configured as output ports. Otherwise, error -221 (settings conflict) will occur when the :DWORD command is sent.*

The value to set the 32-bit output pattern can be sent in the decimal, binary, hexadecimal, or octal format.

Example: Write 32-bit output bit pattern “00000001 00000000 00000001 00000111” to channel 11 (Bits B24, B8, B2, B1, and B0 set high):

```
OUTP:DIG:STAT 1, (111:114)      ' Set I/O channels 11, 12, 13, and 14 as output ports.
OUTP:DIG:DWOR #B1000000000000000100000111, (@111)  ' Set pattern; binary format.
```

Notice that leading zeroes for the binary double-word need not be included in the command.

In order to use one of the other formats, convert the binary value to its hexadecimal, octal, or decimal equivalent and send the command as follows:

```
OUTP:DIG:DWOR #H1000107, (@111)  ' Set pattern; hexadecimal format.
OUTP:DIG:DWOR #Q100000407, (@111) ' Set pattern; octal format.
OUTP:DIG:DWOR 16777479, (@111)   ' Set pattern; decimal format.
```

:DWORD? command — For non-decimal formats, one of the following headers will accompany the returned value to identify which format is selected:

#B = Header for binary values  
#H = Header for hexadecimal values  
#Q = Header for octal values

The :FORMAt command is used to select format for the returned values.

**:FORMat <name>, [<NRf>]** Select data format for reading output patterns  
**:FORMat?** Query data format

Select (or query) the data format for reading digital output patterns. The :BYTE?, :WORD? and :DWORD? commands are used to read digital output patterns.

The response message for :BYTE?, :WORD? and :DWORD? will be a value that corresponds to the set output pattern. The binary format (BINary) allows you to directly identify which bits are set. For example, for a returned binary value of #B100101, bits B5 (MSB), B2, and B0 (LSB) are set. When using one of the other data formats, you will have to convert the returned value to its binary equivalent to determine which bits are set.

The optional <NRf> parameter is used to specify the length of the byte/word/dword returned by the :BYTE?, :WORD? and :DWORD? commands. Parameter value “0” will return the complete byte/word/dword but not include any leading zeroes. Parameter values 1 to 32 sets the length (number of digits) of the byte/word/dword. If the length is too small for the value, then the least significant digits of the byte/word/dword will be truncated.

When the :FORMat? command is sent, the response message will indicate the selected data format and the length for the returned pattern (i.e., BIN, 0).

*NOTE The OUTP:DIG:FORM command is coupled to the SENS:DIG[:DATA]:FORM command. That is, they both perform the same function. Either one of these commands can be used to set the format for returned digital I/O bit patterns.*

## Digital inputs

Digital TTL inputs can be read by the Model 27xx. With one I/O channel set as an input port, eight input lines (bits) are available. With two channels set as input ports, 16 input lines (bits) are available. With three channels set as input ports, 24 input lines (bits) are available. And finally, with all four channels set as input ports, 32 input lines (bits) are available.

TTL inputs are read as follows:

- TTL high (>2V to 5V) is read as logic ‘1.’
- TTL low (<0.8V) is read as logic ‘0.’

*NOTE A digital I/O channel must first be configured as an input port before its input lines can be read. See “Reading digital inputs,” page 30, for details.*

## Input bit patterns

Operations to read input bit patterns are divided into two categories; basic operation and advanced operation:

**Basic operation** — Basic operation handles each input channel as a single 8-bit input pattern. An 8-bit pattern is known as a byte. Input bytes can be read from either the front panel or read using remote programming.

*NOTE For most applications, it is only necessary to read one 8-bit input pattern (byte). When working with bytes, you do not need to concern yourself with advanced operation.*

**Advanced operation** — Advanced operation provides additional flexibility by allowing two digital input ports to be treated as a single 16-bit input pattern (word), or all four input ports to be treated as a 32-bit input pattern (double-word). Words and a double-word can only be read using remote programming.

## Basic operation — reading bytes (8-bits)

### 8-bit input patterns (bytes)

Each I/O channel that is set as an input port is an 8-bit binary input pattern (byte). As shown in [Figure 16](#), Bit 7 (B7) of each port is the most significant bit (MSB) and Bit 0 (B0) is the least significant bit (LSB).

From the front panel, the 8-bit output pattern for each port is read as a decimal, hexadecimal, or octal value. To determine the bit pattern, the value has to be converted to its binary equivalent. For example, the binary equivalent of hexadecimal 'F1' is '11110001.' For that bit pattern, Bits 0, 4, 5, 6, and 7 are set to TTL high (logic '1'). Bits 1, 2, and 3 are set to TTL low (logic '0').

For remote programming, the following command is used to read an 8-bit input pattern for each input port:

```
SENS:DIG[:DATA]:BYTE? <clist>
```

Valid channels for the byte <clist> parameter include channels 11, 12, 13, and 14.

The bit pattern can be returned as a decimal, binary, hexadecimal, or octal value. [Figure 16](#) provides decimal weighting for each bit. The binary equivalent of the returned bit pattern value directly identifies the state of each line (bit). For example, assume the following binary equivalent of a returned value for an 8-bit pattern:

```
11110000
```

The above bit pattern indicates that bits B0 through B3 are TTL low (logic '0') and bits B4 through B7 are TTL high (logic '1').

The :FORMat command sets the returned reading format for the bit pattern. For details on commands to read bit patterns, see [“Reading digital inputs — Remote programming,” page 32](#).

## Advanced operation — reading words (16-bits) or double-words (32-bits)

### 16-bit input patterns (words)

For remote programming, there is a single command to read 16-bit patterns (words) formed by two input ports. Sixteen bits of data (two bytes) is called a word. The following command reads a word bit pattern:

```
SENS:DIG[:DATA]:WORD? <clist>
```

Valid channels for the word <clist> parameter include channels 11 and 13.

This command is used to read channel 11 or channel 13. Channel 11 is combined with channel 12 to form a 16-bit pattern, and channel 13 is combined with channel 14 to form a second 16-bit pattern.

When channel 11 is read as a word, Bit 0 (B0) of channel 11 will be the LSB, and Bit 7 (B15) of channel 12 will be the MSB. When channel 13 is read as a word, Bit 0 (B0) of channel 13 will be the LSB, and Bit 7 (B15) of channel 14 will be the MSB.

The bit pattern can be returned as a decimal, binary, hexadecimal, or octal value. [Figure 17](#) provides decimal weighting for each bit. The binary equivalent of the returned bit pattern value directly identifies the state of each line (bit). For example, assume the following binary equivalent of a returned 16-bit pattern:

```
00001111 11110000
```

The above bit pattern indicates that bits B4 through B11 are TTL high (logic '1'). The other bits are TTL low (logic '0').

The :FORMat command sets the returned reading format for the bit pattern. For details on commands to read bit patterns, see [“Reading digital inputs — Remote programming,” page 32](#).

### 32-bit input pattern (double-word)

For remote programming, there is a single command to read a 32-bit pattern (double-word) formed by four input ports. Thirty-two bits of data (two words) is called a double-word. The following command reads a double-word bit pattern:

```
SENS:DIG[:DATA]:WORD? <clist>
```

The only valid channels for the double-word <clist> parameter is 13.

This command is used to read channel 11. Channel 11 is combined with channels 12, 13, and 14 to form a 32-bit pattern. When channel 11 is read as a double-word, Bit 0 (B0) of channel 11 will be the LSB, and Bit 7 (B31) of channel 14 will be the MSB.

The bit pattern can be returned as a decimal, binary, hexadecimal, or octal value. [Figure 18](#) provides decimal weighting for each bit. The binary equivalent of the returned bit pattern value directly identifies the state of each line (bit). For example, assume the following binary equivalent of a returned 32-bit pattern:

```
00001111 11111111 11111111 11110000
```

The above bit pattern indicates that lines (bits) B4 through B27 are TTL high (logic '1'). The other bits are TTL low (logic '0').

The :FORMat command sets the returned reading format for the bit pattern. For details on commands to read bit patterns, see [“Reading digital inputs — Remote programming,”](#) page 32.

## Reading digital inputs

Before reading a digital input pattern, an I/O channel must first be set as an input port. This can be done from the front panel or remote programming.

From the front panel, each 8-bit port is read individually. For remote programming, commands are provided to read 8-bit patterns (bytes), 16-bit patterns (words), and a 32-bit pattern (double-word).

### Front panel basic operation

From the front panel, the decimal, hexadecimal, or octal equivalent of the 8-bit pattern can be read for each input port. The digital data format and port type (input or output) are set from the CONFIG option of the CARD menu. For details on using the CARD menu, see [“CARD menu”](#).

There are two ways to read digital input ports from the front panel. You can use the CLOSE key to select a channel to read or scroll through channels using the VIEW option of the CARD menu.

### Setting digital data format

The CONFIG option of the CARD menu is used to set the digital data format. The menu is accessed by pressing SHIFT and then CARD. After selecting the CONFIG option and the slot that has the Model 7707, select one of the formats.

FORMAT: ASC	Decimal format
FORMAT: HEX	Hexadecimal format
FORMAT: OCT	Octal format
FORMAT: BIN	Binary format. Note that there is not enough room on the display for a binary reading. Therefore, the hexadecimal format will instead be used to display digital input readings.

## Setting I/O channels as input ports

While still in the CONFIG option of the CARD menu, you can then set one or more digital I/O channels as input ports:

CHAN 111 IN	Channel 111 set as input port.
CHAN 112 IN	Channel 112 set as input port.
CHAN 113 IN	Channel 113 set as input port.
CHAN 114 IN	Channel 114 set as input port.

## Reading digital input using CLOSE key

1. Press CLOSE and select the SINGLE option.
2. Use the edit keys to display the digital input channel to be read (i.e., CLOSE CH: 114) and press ENTER.
3. The digital input reading will be displayed using the selected data format. Example:

36 D:114 Bit pattern 00100100 (decimal 36) on input channel 114.

*NOTE* If you select a channel that is an output port, the message “SET TO INPUT” will be displayed. Either select a digital channel that is an input port or EXIT from the close menu and set the channel as an input port.

4. Use the left and right arrow keys to read the other digital input channels.
5. To return to the normal display state, press OPEN and select the ALL option (OPEN: ALL).

## Reading digital inputs using the CARD menu

The VIEW option of the CARD menu can be used to read digital inputs. The menu is accessed by pressing SHIFT and then CARD. After selecting the VIEW option and the slot that has the Model 7707, card channel data will scroll across the display.

Scrolled data will include closed analog input channels and digital I/O readings. A digital input channel is identified by the “IN” message. Example:

114:IN 036 Bit pattern 00100100 (decimal 36) on input channel 114.

To exit from the CARD menu, press EXIT.

## Scanning digital channels

Digital input channels can be included in the scan list of an advanced scan. When a digital channel is scanned, the input channel pattern will be read and displayed.

## Front panel operation

Perform the following steps to add a digital input channel to the scan list:

*NOTE* The format for digital readings can be checked and/or changed from the FORMAT item of the CARD: CONFIG menu:

*Press SHIFT > press CARD > select CONFIG > select 7077 slot > set FORMAT*

*See “CARD menu” for details on using the menu to set the digital data format.*

1. Press SHIFT and then CONFIG.
2. Select “INT: ADVANCED” and press ENTER.
3. Use the left and right edit keys to display the desired digital channel (111, 112, 113, or 114).

4. Press SHIFT and then CH OFF to enable the channel. If, for example, you enable channel 112, the following will be displayed:

SETUP D:112

*NOTE* If the channel was configured as an output channel (SETUP message dimmed), it will automatically switch to an input when it is enabled.

5. Repeat steps 3 and 4 if you wish add another digital input channel to the scan list.
6. With the desired digital input channels added to the scan list, press ENTER and finish configuring the scan.

**Scanning** — The scan is started by pressing STEP or SCAN. When a digital channel is scanned, the input pattern will be read and displayed. The selected digital data format determines the type of reading that is displayed (decimal, hexadecimal, or octal). Example for hexadecimal format:

0xFF D:112 Hexadecimal FF read at input channel 112. The bit pattern for this value is 11111111.

**Buffer** — This same digital data is also stored in the buffer as each channel is scanned (press RECALL to access data stored in the buffer). Note that if you change the digital data format, the format for digital readings already stored in the buffer will also change.

## Remote programming

Use the ROUTe:SCAN <clist> command to add digital channels to a scan list. For details, see [Table 6](#) and the command descriptions that follow the table.

*NOTE* For details on all other aspects of scanning, see Section 7 of the Model 27xx User's Manual.

## Digital limit testing

An input channel can be configured to compare the input to a specified 8-bit digital pattern. There are two modes for the comparison; pattern or mask. When the input is compared to an exact pattern, the limit test will fail for anything but an exact pattern match. For example, assume the set pattern is 00001111. The digital limit test will only pass if the 8-bit input pattern is 00001111. The limit test will fail for any other input pattern.

When compared to a mask, only 1's in the mask are used for the comparison. Any 0's in the mask are treated as "don't care" bits. Assume the mask is set to 00001111. When the limit test is performed, the limit test will pass only if the four least significant bits of the input pattern are 1's. Examples:

Assume mask = 00001111:

If input = 00001110, the limit test will fail.

If input = 10101111, the limit test will pass.

If input = 11111111, the limit test will pass.

*NOTE* Like limit testing for analog inputs, there are two sets of limits available for each digital input channel; Limit 1 and Limit 2. However, for front panel operation, Limit 1 has precedence over Limit 2. For details on limit testing for analog inputs, see Section 8 in the Model 27xx User's Manual.

## Front panel operation

Perform the following steps to configure a digital input channel of the Model 7707 to perform limit testing. This procedure assumes a Model 7707 is installed in slot 1 of the mainframe. Also, keep in mind that an I/O channel must first be configured as an input port.

**NOTE** *The format for digital readings can be checked and/or changed from the **FORMAT** item of the **CARD: CONFIG** menu:*

*Press **SHIFT** > press **CARD** > select **CONFIG** > select 7077 slot > set **FORMAT***

*See “**CARD menu**” for details on using the menu to set the digital data format.*

1. Press **CLOSE** and select the **SINGLE** option.
2. Use the edit keys to display the desired input channel and press **ENTER**. Example:  
0 D:111 Bit pattern 00000000 (decimal 0) on input channel 111.
3. Configure limits for digital input channels — Press **SHIFT** and then **LIMITS** to enter the limits menu. Use the left, right, up, and down edit keys and **ENTER** to configure limits.

To configure digital limit 1, select the mode (pattern or mask) and then set the digital pattern by specifying the equivalent decimal (0 to 255), hexadecimal (0 to FF), or octal (0 to 377) value. Digital limit 2 is configured in a similar manner.

The following menu messages show digital limit 1 set to bit pattern 00001111 (decimal 15) for the pattern mode:

```
DL1 MOD: PATT
DL1 PAT: 015
```

If still in the limits menu structure, use the **ENTER** key to return to the close key menu.

4. Enable limits – Press **SHIFT** and then **ON/OFF** to display the state of limits (off or on). Use the up or down edit key to display “**LIMITS: ON**” and press **ENTER**. The **HIGH** and **LOW** annunciators will turn on to indicate that limits is enabled for the channel.
5. The digital input reading and the result of the limits test will be displayed for the selected channel. If both limit 1 and 2 passes, the letter ‘**I**’ will be displayed. If the test fails, the number ‘**1**’ or ‘**2**’ will be displayed. If limit 1 fails, ‘**1**’ will be displayed (even if limit 2 also fails). If limit 1 passes, but limit 2 fails, ‘**2**’ will be displayed. The **HIGH** or **LOW** annunciator will also turn on for a failure. **LOW** indicates that the input reading is less than the set pattern. **HIGH** indicates that the input reading is greater than the set pattern.

Example of a limit test that has passed (decimal format):

**15 :I:112** — Limit test 1 and 2 for channel 112 passed. Bit pattern 11111111 (decimal 15) read at input.

Examples of limit tests that have failed (decimal format):

**0 :1:112** (**LOW** annunciator on) — Limit 1 for channel 112 failed (limit 2 may or may not have failed). Bit pattern 00000000 (decimal 0) read at input. **LOW** indicates that the input reading is less than the set pattern.

**36 :1:112** (**HIGH** annunciator on) — Limit 1 for channel 112 failed (Limit 2 may or may not have failed). Bit pattern 00100100 (decimal 36) read at input. **HIGH** indicates that the input reading is greater than the set pattern.

**0 :2:112** (**LOW** annunciator on) — Limit 2 for channel 112 failed (Limit 1 passed). Bit pattern 00000000 (decimal 0) read at input. **LOW** indicates that the input reading is less than the set pattern.

6. Use the left and right arrow keys to display input readings and limit test results for the other input channels. Keep in mind that the configured limits are global for all input channels. That is, the settings in steps 3 and 4 of this procedure apply to all input channels.
7. To return to the normal display state, press **OPEN** and select the **ALL** option (**OPEN: ALL**).

**Buffer** — This same digital data is also stored in the buffer as each channel is scanned (press RECALL to access data stored in the buffer). Note that if you change the digital data format, the format for digital readings already stored in the buffer will also change.

## Remote programming

The following commands are used to set digital limits. For details, see [Table 6](#) and the command descriptions that follow the table.

CALC3:LIM[1]:DIG:MODE <name>	Limit 1 mode; PATtern or MASK.
CALC3:LIM[1]:DIG:PATT <NDN or NRf>	Limit 1 bit-pattern for comparison.
CALC3:LIM[1]:STAT <b>	Enable or disable limit 1 test.
CALC3:LIM2:DIG:MODE <name>	Limit 2 mode; PATtern or MASK.
CALC3:LIM2:DIG:PATT <NDN or NRf>	Limit 2 bit-pattern for comparison.
CALC3:LIM[2]:STAT <b>	Enable or disable limit 2 test.

## Digital limit testing while scanning

Input channels for an advanced scan can also be configured to perform digital limit tests.

1. Press SHIFT and then CONFIG.
2. Select “INT: ADVANCED” and press ENTER.
3. Use the left and right edit keys to display the desired digital channel (111, 112, 113, or 114).
4. Press SHIFT and then CH OFF to enable the channel. If, for example, you enable channel 112, the following will be displayed:

```
SETUP D:112
```

*NOTE* If the channel was configured as an output channel (SETUP message dimmed), it will automatically switch to an input when is enabled.

5. Configure limits for scan channel — Press SHIFT and then LIMITS to enter the limits menu. Use the left, right, up, and down edit keys and ENTER to configure limits.

To configure digital limit 1, select the mode (pattern or mask) and then set the digital pattern by specifying the equivalent decimal value (000 to 255). Digital limit 2 is configured in a similar manner.

The following menu messages show digital limit 1 set to bit pattern 00001111 (decimal 15) for the pattern mode:

```
DL1 MOD: PATT  
DL1 PAT: 015
```

If still in the limits menu structure, use the ENTER key to return to the scan channel edit mode.

6. Enable limits for scan channel — Press SHIFT and then ON/OFF to display the state of limits (off or on). Use the up or down edit key to display “LIMITS: ON” and press ENTER. The HIGH and LOW annunciators will turn on to indicate that limits is enabled for the channel.
7. To configure another digital channel, repeat steps 3 through 6.
8. When finished setting up scan channels, press ENTER and finish configuring the scan.

**Scanning** — The scan is started by pressing STEP or SCAN. When a digital channel is scanned, the input pattern will be read and displayed. The the result of the limit test is also displayed. The letter 'I' indicates that the test has passed.

If the test fails, the number '1' or '2' will be displayed. If Limit 1 fails, '1' will be displayed (even if Limit 2 also fails). If Limit 1 passes, but Limit 2 fails, '2' will be displayed. The HIGH or LOW annunciator will also turn on for a failure. LOW indicates that the input reading is less than the set pattern. HIGH indicates that the input reading is greater than the set pattern.

Example of a limit test that has passed (decimal format):

**15 :I:112** — Limit test for channel 112 passed. Bit pattern 11111111 (decimal 15) read at input.

Examples of limit tests that have failed (decimal format):

**0 :1:112** (LOW annunciator on) — Limit 1 for channel 112 failed (Limit 2 may or may not have failed). Bit pattern 00000000 (decimal 0) read at input. LOW indicates that the input reading is less than the set pattern.

**36 :1:112** (HIGH annunciator on) — Limit 1 for channel 112 failed (Limit 2 may or may not have failed). Bit pattern 00100100 (decimal 36) read at input. HIGH indicates that the input reading is greater than the set pattern.

**0 :2:112** (LOW annunciator on) — Limit 2 for channel 112 failed (Limit 1 passed). Bit pattern 00000000 (decimal 0) read at input. LOW indicates that the input reading is less than the set pattern.

**Buffer** — This same digital data is also stored in the buffer as each channel is scanned (press RECALL to access data stored in the buffer). Note that if you change the digital data format, the format for digital readings already stored in the buffer will also change.

## Remote programming

Use the ROUTe:SCAN <clist> command to add digital channels to a scan list. The <clist> parameter is then used with digital limit commands to set limits for scan channels. For details, see [Table 6](#) and the command descriptions that follow the table.

CALC3:LIM[1]:DIG:MODE <name>, <clist>	Limit 1 mode; PATtern or MASK.
CALC3:LIM[1]:DIG:PATT <NDN or NRf>, <clist>	Limit 1 bit-pattern for comparison.
CALC3:LIM[1]:STAT <b>, <clist>	Enable or disable limit 1 test.
CALC3:LIM2:DIG:MODE <name>, <clist>	Limit 2 mode; PATtern or MASK.
CALC3:LIM2:DIG:PATT <NDN or NRf>, <clist>	Limit 2 bit-pattern for comparison.
CALC3:LIM[2]:STAT <b>, <clist>	Enable or disable limit 2 test.

*NOTE For details on all other aspects of scanning, see Section 7 of the Model 27xx User's Manual.*

## Monitor scan (digital input trigger)

A digital input channel can be assigned as a monitor channel. When the monitor channel detects a pattern or mask match, the scan will be triggered to start. The procedure to run a digital monitor scan is basically the same as running an analog monitor scan. However, the monitor channel can only be selected and enabled using remote programming.

When configuring the scan, make sure to include a digital input channel that will be used as the monitor channel. Also make sure to configure the monitor scanner for digital limit testing, as required. After configuring the scan, select and enable the monitor channel. When the pattern or mask match occurs, the scan will start.

The following commands are used for a monitor scan.

ROUTe:MONitor <clist>	Specify one channel as monitor channel.
ROUTe:MONitor:POINts <NRf>	Specify number of channels to scan.
ROUTe:MONitor:STATe <b>	Enable/disable monitor channel.
ROUTe:MONitor:DATA?	Returns the most recent monitor reading.

*NOTE For details on monitor scan and the commands, refer to Section 7 of the Model 27xx User's Manual.*

The following command sequence monitors digital input channel 111. When input pattern 1111111 appears on the input port, the scan will start. Keep in mind that the scan will continue to repeat as long as a pattern match exists on channel 111.

SYST: PRES	‘ Return to default settings.
TRAC: CLE	‘ Clear buffer.
ROUT: SCAN (@101:104, 111)	‘ Set scan list.
CALC3: LIM1: DIG: MODE PATT, (@111)	‘ Select pattern mode.
CALC3: LIM1: DIG: PATT #HFF, (@111)	‘ Set pattern (1111111).
ROUT: MON: POIN 5	‘ Specify number of channels in scan.
ROUT: MON (@111)	‘ Specify channel 111 as monitor channel.
ROUT: MON: STAT ON	‘ Enable monitor channel.
CALC3: LIM1: STAT ON, (@111)	‘ Enable limit 1.
ROUT: SCAN: TSO HLIM1	‘ Set trigger source for scan.

**NOTE** The :TSO HLIM1 command sets the monitor scan to start when high limit 1 is reached. For a digital monitor scan, the low limit trigger source parameter (LLIM1) can instead be used. Both settings will trigger the scan when a pattern match occurs.

Table 6  
Commands for digital inputs

Command	Description	Default
<p><i>Set port(s) as input or output:</i></p> <p>OUTput: DIGital :STATe &lt;b&gt;, &lt;clist&gt;</p> <p>:STATe? &lt;clist&gt;</p>	<p>Path to set channels of digital I/O port: Set listed channels as input or output; 0 (off) sets channels as input ports. 1 (on) sets channels as output ports. Query port type for listed channels; 0 = input, 1 = output.</p>	Note 1
<p><i>Read input port bit patterns:</i></p> <p>SENSe: DIGital[:DATA] :FORMat &lt;name&gt;, [&lt;Nrf&gt;]</p> <p>:FORMat? :BYTE? &lt;clist&gt; :WORD? &lt;clist&gt; :DWORD? &lt;clist&gt;</p>	<p>Path to read digital input patterns: Select data format for reading digital inputs<sup>2</sup>: &lt;name&gt; = ASCii      Decimal format                   BINary      Binary format                   HEXadecimal      Hexadecimal format                   OCTal      Octal format &lt;Nrf&gt; = 0      Return value without leading zeros                   1 to 32      Specify number of digits to return</p> <p>Query data format for reading digital inputs. Read byte input patterns (valid channels are 11, 12, 13, and 14). Read word input patterns (valid channels are 11 and 13). Read double-word input pattern (valid channel is 11).</p>	Note 3
<p><i>Add digital channel(s) to scan list:</i></p> <p>ROUTE: SCAN &lt;clist&gt; ROUT: SCAN?</p>	<p>Specify channel list (analog and/or digital input channels). Query scan list.</p>	

Table 6 (cont.)

**Commands for digital inputs**

Command	Description	Default
<i>Set digital limits:</i>		
CALCulate3:LIMit[1]:DIGital :MODE <name> [, <clist>]  :MODE? [<clist>] :PATtern <NDN or NRf> [, <clist>]  :PATtern? [<clist>] CALCulate3:LIMit[1] :STATe <b> [, <clist>] :STATe? [, <clist>] CALCulate3:LIMit2:DIGital :MODE <name> [, <clist>]  :MODE? [<clist>] :PATtern <NDN or NRf> [, <clist>]  :PATtern? [<clist>] CALCulate3:LIMit2 :STATe <b> [, <clist>] :STATe? [, <clist>]	Path to set the digital limit attributes for limit 1: Select limit mode for exact pattern match (PATtern) or mask (MASK). Query limit mode. Set 8-bit pattern for comparison: <NDN> = #Bxx...x Binary format; each x = 1 or 0. = #Hx Hexadecimal format; x = 0 to FF. = #Qx Octal format; x = 0 to 377. <NRf> = 0 to 255 Decimal format. Query pattern for comparison. Path to control limit 1 test: Enable or disable limit 1. Query state of limit 1 test. Path to set the digital limit attributes for limit 2: Select limit mode for exact pattern match (PATtern) or mask (MASK). Query limit mode. Set 8-bit pattern for comparison: <NDN> = #Bxx...x Binary format; each x = 1 or 0. = #Hx Hexadecimal format; x = 0 to FF. = #Qx Octal format; x = 0 to 377. <NRf> = 0 to 255 Decimal format. Query pattern for comparison. Path to control limit 2 test: Enable or disable limit 2. Query state of limit 2 test.	PATT  0  OFF  PATT  0  OFF
<i>Read results of limits:</i>		
CALCulate3:LIMit[1] :FAIL? :CLEar:AUTO <b> :CLEar:AUTO? :CLEar CALCulate3:LIMit2 :FAIL? :CLEar:AUTO <b> :CLEar:AUTO? :CLEar	Path to read the results of digital Limit 1: Query test result; 0 = pass, 1 = fail. Enable (ON) or disable (OFF) auto clear. Query state of auto clear. Clear fail indication. Path to read the results of digital Limit 2: Query test result; 0 = pass, 1 = fail. Enable (ON) or disable (OFF) auto clear. Query state of auto clear. Clear fail indication.	ON  ON

Notes:

1. \*RST and SYSTem:PRESet sets I/O channels 11, 12, 13, and 14 as input ports (0).
2. The OUTPut:DIGital:FORMat command can instead be used to select data format (Table 5).
3. \*RST and SYSTem:PRESet have no effect on the data format for reading digital inputs.

**NOTE** Examples for the following commands assume a Model 7707 installed in slot 1 of the mainframe.

## OUTPut:DIGital

The following OUTPut command is used to set I/O channels as input ports or output ports:

**:STATe <b>, <clist>** Set I/O channel(s) as input or output  
**:STATe? <clist>** Query port type

Use to set (or query) the specified I/O channels as either output ports or input ports. Parameter value “0” (or off) sets the channels as input ports. Parameter value “1” (or on) sets the channels as output ports.

The :STATe? <clist> command queries the port type for the specified I/O channels. A “0” or a “1” will be returned for each channel in the list:

0 = Input port  
1 = Output port

For example, the following command queries port type for I/O channels 11, 12, 13, and 14:

```
OUTP:DIG:STAT? (@111:114)
```

The response message “0, 0, 1, 1” indicates that channels 11 and 12 are input ports, and channels 13 and 14 are output ports.

## SENSe:DIGital[:DATA]

Using remote programming, the Model 7707 can read four 8-bit digital patterns (bytes), two 16-bit digital patterns (words), or one 32-bit pattern. The input bit pattern can read using the decimal, binary, hexadecimal, or octal format.

**:FORMat <name>, [<NRf>]** Select data format for reading input patterns  
**:FORMat?** Query data format

Select (or query) the data format for reading digital input patterns. The :BYTE?, :WORD? and :DWORD? commands are used to read digital input patterns.

The response message for :BYTE?, :WORD? and :DWORD? will be a value that corresponds to the input pattern. The binary format (BINary) allows you to directly identify which bits are set. For example, for a returned binary value of #B100101, bits B5 (MSB), B2, and B0 (LSB) are set. When using one of the other data formats, you will have to convert the returned value to its binary equivalent to determine which bits are set.

The optional <NRf> parameter is used to specify the length of the byte/word/dword returned by the :BYTE?, :WORD? and :DWORD? commands. Parameter value “0” will return the complete byte/word/dword but not include any leading zeroes. Parameter values 1 to 32 sets the length (number of digits) of the byte/word/dword. If the length is too small for the value, then the least significant digits of the byte/word/dword will be truncated.

When the :FORMat? command is sent, the response message will indicate the selected data format and the length for the returned pattern (i.e., BIN, 0).

*NOTE The SENS:DIG[:DATA]:FORM command is coupled to the OUTP:DIG:FORM command. That is, they both perform the same function. Either one of these commands can be used to set the format for returning digital I/O bit patterns.*

**:BYTE? <clist>** Read input byte patterns

Use to read an 8-bit input pattern (byte) present on the specified input channel(s). Input channels 11, 12, 13, and 14 can be read as 8-bit input ports. When reading a byte, Bit B0 will be the LSB, and Bit B7 will be the MSB, as shown in [Figure 16](#).

*NOTE Only channels 11, 12, 13, and 14 are valid with the :BYTE command. Using any other channel number(s) with the command generates error -221 (settings conflict).*

An input pattern can be returned in the decimal, binary, hexadecimal, or octal format. For non-decimal formats, one of the following headers will accompany the returned value to identify which format is selected:

#B = Header for binary values

#H = Header for hexadecimal values

#Q = Header for octal values

Use the :FORMat command to select the format for reading input patterns.

Example: Assume bit pattern “00011001” is present on channel 13. The following commands will read the byte input pattern using the binary format:

```
OUTP:DIG:STAT 0, (113)           ' Set channel 13 as input port.
SENS:DIG:FORM BIN, 0             ' Select binary format (no leading zeroes).
SENS:DIG:BYTE? @113             ' Read byte bit pattern.
```

The returned response message will be “#B11001” to indicate that Bits B0, B3, and B4 of channel 113 are set to TTL high (logic ‘1’). The rest of the byte bits are set low (logic ‘0’).

### **:WORD? <clist>** Read input word pattern(s)

Use to read a 16-bit input pattern (word) present on the specified input channel(s). Input channels 11 and 13 can be read as 16-bit input ports. Channel 11 is combined with channel 12 to form one 16-bit pattern, and channel 13 is combined with channel 14 to form a second 16-bit pattern.

*NOTE Only channels 11 and 13 are valid with the :WORD command. Using any other channel number(s) with the command generates error -221 (settings conflict).*

*When reading a word bit pattern, both channels (11 and 12, or 13 and 14) must be configured as input ports. Otherwise, error -221 (settings conflict) will occur when the :WORD command is sent.*

When channel 11 is read as a word, Bit 0 (B0) of channel 11 will be the LSB, and Bit 7 (B15) of channel 12 will be the MSB. When channel 13 is set as a word, Bit 0 (B0) of channel 13 will be the LSB, and Bit 7 (B15) of channel 14 will be the MSB. Bit positions for a word are shown in [Figure 17](#).

An input pattern can be returned in the decimal, binary, hexadecimal, or octal format. For non-decimal formats, one of the following headers will accompany the returned value to identify which format is selected:

#B = Header for binary values

#H = Header for hexadecimal values

#Q = Header for octal values

Use the :FORMat command to select the format for reading input patterns.

Example: Assume bit pattern “00001001 00010101” is present on channels 11 and 12. The following commands will read the word input pattern using the binary format:

```
OUTP:DIG:STAT 0, (111, 112)      ' Set channels 11 and 12 as input ports.
SENS:DIG:FORM BIN, 0             ' Select binary format (no leading zeroes).
SENS:DIG:WORD? @111             ' Read word bit pattern.
```

The returned response message will be “#B100100010101” to indicate that Bits B0, B2, B4, B8, and B11 for channels 11 and 12 are set to TTL high (logic ‘1’). The rest of the byte bits are set low (logic ‘0’).

## **:DWORD? <clist>** Read input double-word pattern

Use to read a 32-bit input pattern (double-word) present on the four input ports. Input channel 11 is read to return the 32-bit pattern. Channel 11 is combined with channels 12, 13, and 14 to form one 32-bit pattern.

*NOTE Only channel 11 is valid with the :DWORD command. Using any other channel with the command generates error -221 (settings conflict).*

*When reading a double-word bit pattern, all I/O channels (11, 12, 13, and 14) must be configured as input ports. Otherwise, error -221 (settings conflict) will occur when the :DWORD command is sent.*

When channel 11 is read as a double-word, Bit 0 (B0) of channel 11 will be the LSB, and Bit 7 (B31) of channel 14 will be the MSB. Bit positions for a double-word are shown in [Figure 18](#).

An input pattern can be returned in the decimal, binary, hexadecimal, or octal format. For non-decimal formats, one of the following headers will accompany the returned value to identify which format is selected:

#B = Header for binary values

#H = Header for hexadecimal values

#Q = Header for octal values

Use the :FORMat command to select the format for reading input patterns.

Example: Assume bit pattern “00000001 00110010 00001001 00010101” is present on channels 11, 12, 13, and 14. The following commands will read the double-word input pattern using the binary format:

```
OUTP:DIG:STAT 0, (111:114)      ' Set channels 11, 12, 13, and 14 as input ports.
SENS:DIG:FORM BIN, 0           ' Select binary format (no leading zeroes).
SENS:DIG:WORD? @111           ' Read word bit pattern.
```

The returned response message will be “#B1001100100000100 00010101” to indicate that Bits B0, B2, B4, B8, B11, B17, B20, B21, and B24 are set to TTL high (logic ‘1’). The rest of the byte bits are set low (logic ‘0’).

## **ROUTE:SCAN <clist>** Specify scan list **ROUTE:SCAN?** Query scan list

Use the ROUTE:SCAN <clist> command to add digital channels to a scan list. However, the digital channel must first be configured as an input channel. If you send this command to add a channel that is presently configured as an output channel, error -221 (settings conflict) will occur.

The following command sequence shows how to set channel 112 as an input channel and then add it to a scan list that already contain channels 101 through 110:

```
OUTPut:DIGital:STATe 0, (@111)   ' Set channel 111 as an input channel.
ROUTE:SCAN (@101:110,111)       ' Add channel 111 to scan list.
```

A digital input channel cannot be included in a range of scan channels when configuring a list. Digital input channels must be listed individually. The following examples show the right and wrong ways to add a digital input channel to a scan list.

```
ROUTE:SCAN (@101:110,111)       ' Correct way to add channel 111 to scan list.
ROUTE:SCAN (@101:111)           ' INVALID – Error -222 (Parameter data out of range).
```

*NOTE For details on scanning, see Section 7 of the Model 27xx User’s Manual.*

**CALCulate3:LIMit[1]:DIGital**  
**CALCulate3:LIMit2:DIGital**

**:MODE <name> [, <clist>]**  
**:MODE? [, <clist>]**

**Path to set digital limit 1 attributes**  
**Path to set digital limit 2 attributes**  
**Select digital limit mode**  
**Query digital limit mode**

For non-scan channels, the :MODE command is global to all digital input channels. That is, the selected mode (PATTERN or MASK) applies to all digital input channels.

When configuring a scan, use the <clist> parameter. Each digital input channel can have its own unique digital limits configuration. For example, digital input channel 111 can be set for the pattern mode, while input channel 112 can be set for the mask mode.

With the MODE? command, you can read the selected global mode or the mode of individual input scan channels using the <clist> parameter.

Errors: -221 settings conflict – Tried to set the mode for a digital output scan channel.  
-224 Illegal parameter value – Tried to set the mode for an analog input scan channel.

Examples:

CALC3 : LIM1 : DIG : MODE MASK, (@111)	‘ Set limit 1 mask mode for scan channel.
CALC3 : LIM1 : DIG : MODE PATT	‘ Set limit 1 global pattern mode.
CALC3 : LIM1 : DIG : MODE?, (@111)	‘ Query limit 1 mode for scan channel.
CALC3 : LIM1 : DIG : MODE?	‘ Query limit 1 global mode.

**:PATTERN <NDN or NRf> [, <clist>]**  
**:PATTERN? [, <clist>]**

**Set digital limit pattern**  
**Query digital limit pattern**

For non-scan channels, the :PATTERN command is global to all digital input channels. That is, the set bit pattern applies to all digital input channels.

When configuring a scan, use the <clist> parameter. Each digital input channel can have its own unique digital limits configuration. For example, a pattern can be set for digital input channel 111, while a different pattern can be set for input channel 112.

With the PATTERN? command, you can read the set global pattern or the pattern of individual input scan channels using the <clist> parameter. The format for the returned value(s) are determined by the selected digital data format (see :FORMAT command).

Errors: -221 settings conflict – Tried to set a pattern for a digital output scan channel.  
-224 Illegal parameter value – Tried to set a pattern for an analog input scan channel.

Examples:

CALC3 : LIM1 : DIG : PATT #B100101, (@111)	‘ Set pattern for scan channel; binary format.
CALC3 : LIM1 : DIG : PATT 37	‘ Set global pattern; decimal format.
CALC3 : LIM1 : DIG : PATT #H25, (@111)	‘ Set pattern for scan channel; hexadecimal format.
CALC3 : LIM1 : DIG : PATT #H25	‘ Set global pattern; hexadecimal format.
CALC3 : LIM1 : DIG : PATT?	‘ Query global pattern.
CALC3 : LIM1 : DIG : PATT? (@111)	‘ Query pattern for scan channel.

<b>CALCulate3:LIMit[1]:STATe &lt;b&gt; [, &lt;clist&gt;]</b>	<b>Enable or disable limit 1</b>
<b>CALCulate3:LIMit[1]:STATe? [, &lt;clist&gt;]</b>	<b>Query state of limit 1</b>
<b>CALCulate3:LIMit2:STATe &lt;b&gt; [, &lt;clist&gt;]</b>	<b>Enable or disable limit 2</b>
<b>CALCulate3:LIMit2:STATe? [, &lt;clist&gt;]</b>	<b>Query state of limit 2</b>

For non-scan channels, STATe is a global command to enable or disable all digital input channels. When configuring a scan, use the <clist> parameter. Each digital input channel can have its own unique limits state. For example, digital limit 1 can be enabled for digital input channel 111, while digital limit 1 can be disabled for input channel 112.

With the STATe? command, you can read the global limit state or the limit state of individual input scan channels using the <clist> parameter.

Error: -221 settings conflict – Tried to set a limit state for a digital output scan channel.

Examples:

CALC3:LIM1:STATe ON, (@111)	‘ Enable limit 1 for scan channel.
CALC3:LIM1:STATe OFF	‘ Disable global limit 1 state.
CALC3:LIM1:STATe? (@111)	‘ Query limit 1 state for scan channel.
CALC3:LIM1:STATe?	‘ Query global limit 1 state.

<b>CALCulate3:LIMit[1]:FAIL?</b>	<b>Query result of limit 1 test</b>
<b>CALCulate3:LIMit2:FAIL?</b>	<b>Query result of limit 2 test</b>

These commands are used to query the results of Limit 1 and Limit 2:

0 = Pass  
1 = Fail

<b>CALCulate3:LIMit1:CLEar</b>	<b>Clear fail indication for limit 1</b>
<b>CALCulate3:LIMit1:CLEar:AUTO &lt;b&gt;</b>	<b>Enable or disable auto clear for limit 1</b>
<b>CALCulate3:LIMit1:CLEar:AUTO?</b>	<b>Query state of auto clear for limit 1</b>
<b>CALCulate3:LIMit2:CLEar</b>	<b>Clear fail indication for limit 2</b>
<b>CALCulate3:LIMit2:CLEar:AUTO &lt;b&gt;</b>	<b>Enable or disable auto clear for limit 2</b>
<b>CALCulate3:LIMit2:CLEar:AUTO?</b>	<b>Query state of auto clear for limit 2</b>

The CLEar and CLEar:AUTO commands are used to clear the fail (“1”) indications for Limit 1 and Limit 2. If auto clear is enabled for a limit, the fail indication clears when instrument operation enters the idle state. With auto clear disabled, the fail indication will remain until it is cleared by the :CLEar command.

The CLEar:AUTO? command simply returns the state (on or off) of auto clear.

## CARD menu

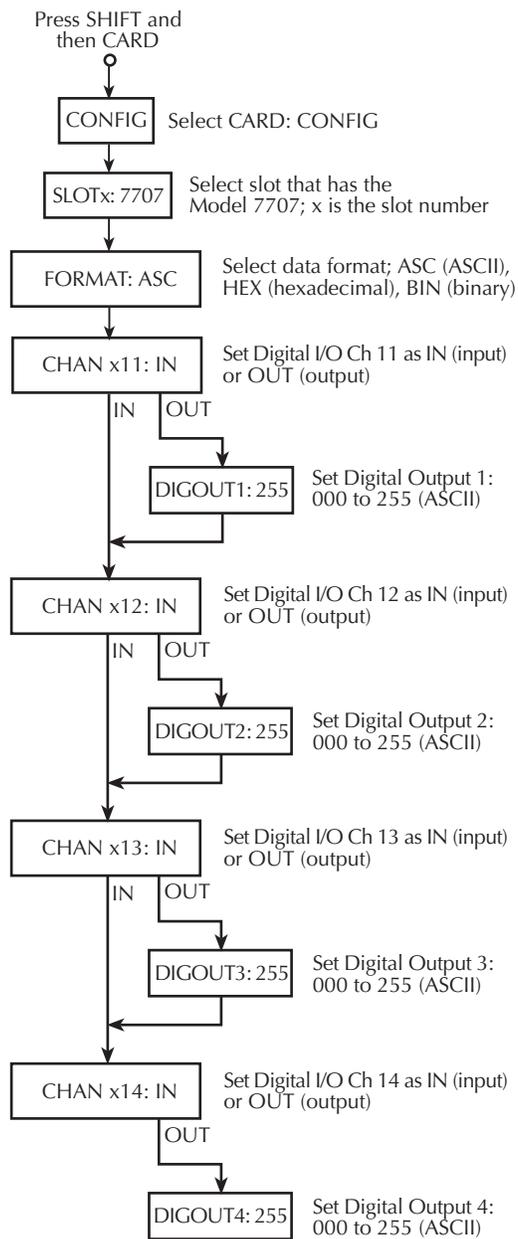
The CARD menu is used for the following operations:

- CONFIG — This menu item is used to select the format for displaying digital I/O data (decimal, hexadecimal, or octal) and set digital I/O channels as input or output ports. For output ports, this menu item is used to set the output bit pattern.
- VIEW — View the analog input channels that are presently closed. Also, view the bit patterns for input and output channels.

Figure 19 shows the two navigation paths for the CARD menu. The menu shows the default settings: ASCII (decimal) digital data format selected, input ports selected, digital outputs set to 255 (bit pattern 11111111).

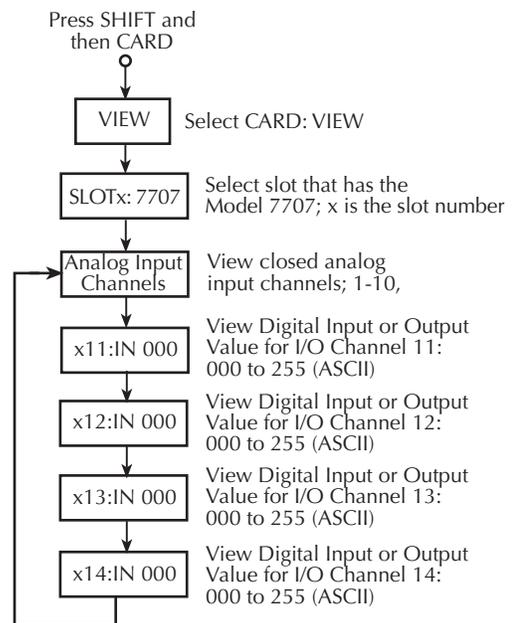
As shown, the CARD menu is accessed by pressing SHIFT and then CARD. In general, the manual range keys (▲ and ▼), cursor keys (◀ and ▶), and the ENTER key are used to navigate through the menu structure.

Figure 19  
**CARD menu paths for Model 7707**



**A) Configure module**

**NOTE:** Factory and \*RST default settings are shown in these flowcharts.



**B) View channels**

## CONFIG menu item

Figure 19A shows the menu path to configure the digital I/O channels. After the appropriate slot is selected, work your way through the menu to select the format for digital I/O data and set each channel as an input or output port. After setting a channel as an output port, you will be prompted to enter a value that corresponds to the desired bit pattern.

The digital data format can set as ASCII (decimal), HEXadecimal, BINary, or OCTal. However, there is not enough room on the front panel to display binary readings. Therefore, if you select the binary format, the hexadecimal format will instead be used for front panel operation.

Example — The following CONFIG settings set Digital Output 1 for bit pattern 01001100. Also shown are the valid settings range for each format type.

<u>Selected format</u>	<u>CONFIG menu</u>	<u>Setting range</u>
ASCII (decimal)	DIGOUT1: 076	000 to 255
Hexadecimal	DIGOUT1:0x04C	000 to 0FF
Octal	DIGOUT1:0o114	000 to 377

## VIEW menu item

Figure 19B shows the menu path to view Model 7707 channels. After the appropriate slot is selected, close analog input channels (1 through 10, 15, 16, and 17) and the digital input/output bit pattern values for channels 11, 12, 13 and 14 will scroll across the display. The actual values for bit patterns will depend on the selected digital data format. The ASCII (decimal) data format is the factory and \*RST default.

The scrolling channel string is truncated by four dots (....) to indicate the end. The string of channels will scroll continuously until it is stopped by pressing a front panel key.

Example — Assume a Model 7707 installed in slot, the hexadecimal digital data format has been selected and the following channel string is scrolling for the VIEW item of the menu:

102, 117, 111:IN 0xAA, 112:IN 0xC1, 113:OUT 0xB2, 114:OUT 0xF0 ....

The above channel string indicates the following:

- Analog input channels 102 and 117 are closed. Channel 117 connects the input at channel 102 to the DMM.
- Channels 111 and 112 are set as input ports. Hexadecimal value AA for channel 111 indicates bit pattern 10101010 on the input port. Hexadecimal value C1 for channel 112 indicates bit pattern 11000001 on the input port.
- Channels 113 and 114 are set as input ports. Hexadecimal value B2 for channel 113 indicates bit pattern 10110010 is set for the output port. Hexadecimal value F0 for channel 114 indicates bit pattern 11110000 is set for the output port.

**NOTE** The scrolling speed of the channel string is adjustable or can be paused. The ◀ key slows down scrolling speed and the ▶ key speeds it up. The ENTER key pauses scrolling. Press ENTER a second time to resume scrolling.

To exit from VIEW, press the EXIT key. Pressing an instrument setting key will also exit VIEW, but it will also perform the operation associated with the key. For example, pressing Ω2 will exit VIEW, and select the Ω2 function.

# Digital I/O command summary

The commands to control the digital I/O are summarized in [Table 7](#). A photocopy of this table serves as a handy reference to program the digital I/O.

**NOTE** For more information on digital input and output commands, see [Table 5](#) (outputs) and [Table 6](#) (inputs). Details follow those tables.

Table 7  
Summary of digital I/O commands

Command	Description
<p><i>Configure I/O ports as input or output:</i></p> <p>OUTPut:DiGital :STATe &lt;b&gt;, &lt;clist&gt; :STATe? &lt;clist&gt;</p>	<p>Path to set digital I/O channels: Set channels as output or input ports; 1 (on) = output, 0 (off) = input. Query port type of listed channels (1 = output port, 0 = input port).</p>
<p><i>Set digital output patterns:</i></p> <p>OUTPut:DiGital :BYTE &lt;NDN or NRf&gt;, &lt;clist&gt; :BYTE? &lt;clist&gt; :WORD &lt;NDN or NRf&gt;, &lt;clist&gt; :WORD? &lt;clist&gt; :DWORD &lt;NDN or NRf&gt;, &lt;clist&gt; :DWORD? &lt;clist&gt; :FORMat &lt;name&gt;, [&lt;NRf&gt;]  :FORMat?</p>	<p>Path to set digital output patterns: Set a byte output pattern (valid channels are 11, 12, 13, and 14): Query the byte bit pattern for the specified output channels. Set a word output pattern (valid channels are 11 and 13): Query digital word output pattern for channels 11 and/or 13. Set a double-word output pattern (valid channel is 11): Query digital double-word output pattern for channel 11. Select data format for reading digital outputs*:     &lt;name&gt; = ASCii, BINary, HEXadecimal or OCTal     &lt;NRf&gt; = 0 (no leading zeros), or 1 to 32 (# of digits to return) Query digital output data format.</p>
<p><i>Read digital input patterns:</i></p> <p>SENSe:DiGital[:DATA] :BYTE? &lt;clist&gt; :WORD? &lt;clist&gt; :DWORD? &lt;clist&gt; :FORMat &lt;name&gt;, [&lt;NRf&gt;]  :FORMat?</p>	<p>Path to read digital input patterns: Read byte input patterns (valid channels are 11, 12, 13, and 14). Read word input patterns (valid channels are 11 and 13). Read double-word input pattern (valid channel is 11). Select data format for reading digital outputs*:     &lt;name&gt; = ASCii, BINary, HEXadecimal, or OCTal     &lt;NRf&gt; = 0 (no leading zeros), or 1 to 32 (# of digits to return) Query digital output data format.</p>
<p><i>Add digital channel(s) to scan list:</i></p> <p>ROUTE:SCAN &lt;clist&gt; ROUT:SCAN?</p>	<p>Specify channel list (analog and/or digital input channels). Query scan list.</p>

Table 7 (cont.)

**Summary of digital I/O commands**

Command	Description
<p><i>Set digital limits:</i></p> <p>CALCulate3:LIMit[1]:DIGital  :MODE &lt;name&gt; [, &lt;clist&gt;]  :MODE? [&lt;clist&gt;]  :PATtern &lt;NDN or NRf&gt; [, &lt;clist&gt;]</p> <p>:PATtern? [&lt;clist&gt;]</p> <p>CALCulate3:LIMit[1]  :STATe &lt;b&gt; [, &lt;clist&gt;]  :STATe? [, &lt;clist&gt;]</p> <p>CALCulate3:LIMit2:DIGital  :MODE &lt;name&gt; [, &lt;clist&gt;]  :MODE? [&lt;clist&gt;]  :PATtern &lt;NDN or NRf&gt; [, &lt;clist&gt;]</p> <p>:PATtern? [&lt;clist&gt;]</p> <p>CALCulate3:LIMit2  :STATe &lt;b&gt; [, &lt;clist&gt;]  :STATe? [, &lt;clist&gt;]</p>	<p>Path to set the digital limit attributes for limit 1:  Select limit mode for exact pattern match (PATtern) or MASK.  Query limit mode.  Set 8-bit pattern for comparison:  &lt;NDN&gt; = #Bxx...x Binary format; each x = 1 or 0.  = #Hx Hexadecimal format; x = 0 to FF.  = #Qx Octal format; x = 0 to 377.  &lt;NRf&gt; = 0 to 255 Decimal format.  Query pattern for comparison.</p> <p>Path to control limit 1 test:  Enable or disable limit 1.  Query state of limit 1 test.</p> <p>Path to set the digital limit attributes for limit 2:  Select limit mode for exact pattern match (PATtern) or MASK.  Query limit mode.  Set 8-bit pattern for comparison:  &lt;NDN&gt; = #Bxx...x Binary format; each x = 1 or 0.  = #Hx Hexadecimal format; x = 0 to FF.  = #Qx Octal format; x = 0 to 377.  &lt;NRf&gt; = 0 to 255 Decimal format.  Query pattern for comparison.</p> <p>Path to control limit 2 test:  Enable or disable limit 2.  Query state of limit 2 test.</p>
<p><i>Read results of limits:</i></p> <p>CALCulate3:LIMit[1]  :FAIL?  :CLEar:AUTO &lt;b&gt;  :CLEar:AUTO?  :CLEar</p> <p>CALCulate3:LIMit2  :FAIL?  :CLEar:AUTO &lt;b&gt;  :CLEar:AUTO?  :CLEar</p>	<p>Path to read the results of digital Limit 1:  Query test result; 0 = pass, 1 = fail.  Enable (ON) or disable (OFF) auto clear.  Query state of auto clear.  Clear fail indication.</p> <p>Path to read the results of digital Limit 2:  Query test result; 0 = pass, 1 = fail.  Enable (ON) or disable (OFF) auto clear.  Query state of auto clear.  Clear fail indication.</p>

\* The OUTP:DIG:FORM command is coupled to the SENS:DIG[:DATA]:FORM command. That is, they both perform the same function. Either one of these commands can be used to set the format for returned digital I/O bit patterns.

# Service

Service for the Model 7707 includes a procedure to verify performance of analog input channels, and provides replaceable parts information.

**WARNING** All service information is intended only for qualified service personnel. Do not attempt to service the Model 7707 unless you are qualified to do so.

## Performance verification

Use the performance verification procedure for the Model 7700.

## Replaceable parts

This section contains replacement parts information and component layout drawings for the Model 7707.

### Parts lists

Both electrical and mechanical parts for the Model 7707 are listed in [Table 8](#).

### 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 7707 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.

Table 8  
Model 7707 parts list

Circuit designation	Description	Keithley part no.
C1	CAP, 1000pF, 20%, 50V, CERAMIC (1206)	C-418-1000P
C101, C102, C103, C104	CAP, 47PF, 10%, 100V, CERAMIC (1206)	C-451-47P
C106	CAP, .01uF, 20%, 50V, CERAMIC (1206)	C-418-.01
C107-C115	CAP, 470U, 20%, 25V, ALUM ELEC	C-622-470
C2, C7, C9, C11, C13, C15, C17, C19, C21, C25, C27	CAP, .1UF, 20%, 50V CERAMIC (1206)	C-418-.1
C200-C231, C301-C304	CAP, 22PF, 10%, 100V, CERAMIC (1206)	C-451-22P
C24, C26, C28, C30, C34, C36, C38, C40	CAP, 1000P, 10%, 100V, CERAMIC (1206)	C-451-1000P
C29, C31-C33, C35, C37, C39, C41-C51	CAP, .1UF, 20%, 50V CERAMIC (1206)	C-418-.1
C3, C550, C551	CAP, 4.7U, 10%, 35V TANTALUM	C-476-4.7
C4, C5	CAP, .1UF, 20%, 50V CERAMIC (1206)	C-418-.1
C500	CAP, 100P, 10%, 100V CERAMIC	C-451-100P
C6, C8, C10, C12, C14, C16, C18, C20	CAP, 1000PF, 10%, 50V, MONO CERAMIC (0805)	C-452-1000P
C600, C601	CAP, 100P, 10%, 100V CERAMIC	C-451-100P
CR1, CR6-CR15, CR26-CR29	DIODE, DUAL SWITCHING, BAV99L (SOT-23)	RF-82
CR16, CR17	DIODE MBR5130LT3	RF-115
CR2, CR3	DUAL HIGH SPEED DIODE	RF-147
CR30-CR61	DIODE, SWITCHING, 250MA, BAV103 (SOD-80)	RF-89
FOR 7709-312A	4-40X1/4 PHILLIPS PAN HD	4-40X1/4PPH
HS100	HEAT SINK	HS-58
J1	CONN, RT ANGLE DUAL ROW RECEPT	CS-1065-1
J2	CONN, FEMALE, 25 PIN	CS-484
K11, K12	NON LATCHING RELAY	RL-242
K1-K10, K13	SINGLE COIL LATCH RELAY	RL-225
L1, L2, L3, L4, L5, L6, L100	FERRITE CHIP 600 OHM BLM32A07 (1206)	CH-62
L7-L42	CHOKE, 22UH	CH-66-22
P2	CONN, RT ANGLE, D-SUB, 50 PINS	CS-1107-1
Q1, Q2	P CHANNEL TMOSFET	TG-392
Q20	TRANS, NPN PWR, TIP31 (TO-220AB)	TG-253
Q3, Q5, Q7, Q9, Q11, Q23, Q25, Q33, Q35	TRANS, PNP SILICON	TG-388
Q4, Q6, Q8, Q10, Q12, Q24, Q26, Q31, Q32, Q34, Q36	TRANS, NPN SILICON	TG-389
R1	RES, 100K, 5%, 125mW, METAL FILM (1206)	R-375-100K
R111-R118, R54-R61, R73-R80, R92-R99	RES, 10K, 1%, 1/4W METAL FILM (1206)	R-391-10K
R129, R133-R164, R5, R7, R9, R11, R36, R38, R45, R47, R72	RES, 10K, 1%, 100MW, THICK FILM (0805)	R-418-10K
R19	RES, 12.1, 1%, 1/4W METAL FILM (1206)	R-391-12.1
R2, R16, R18, R21, R40, R49, R208	RES, 1K, 5%, 125MW METAL FILM (1206)	R-375-1K
R201, R202, R210	RES ARRAY 4X4.3K, 5%, .125W	TF-276-4.3K
R203, R204, R216-R223	RES, ARRAY 4X1K 5%, .125W	TF-276-1K
R205	THICK FILM SMT	TF-276-220
R209	RES ARRAY 4X10K, 5%, .125W	TF-276-10K
R211, R212, R215, R250-R256	RES, 2.21K, 1%, 1/4W METAL FILM (1206)	R-391-2.21K
R22-R25, R30-R35	RES, 4.22K, 1%, 1/4W METAL FILM (1206)	R-391-4.22K
R26	RES, 15k, 1%, 100MW, THICK FILM (0805)	R-418-15K
R27	RES, 24.9K, 1%, 100MW, THICK FILM (0805)	R-418-24.9K
R3	RES, 1K, 1%, 100MW, THICK FILM (0805)	R-418-1K
R43, R44, R52, R53	RES, 10K, 5%, 125MW, METAL FILM (1206)	R-375-10K

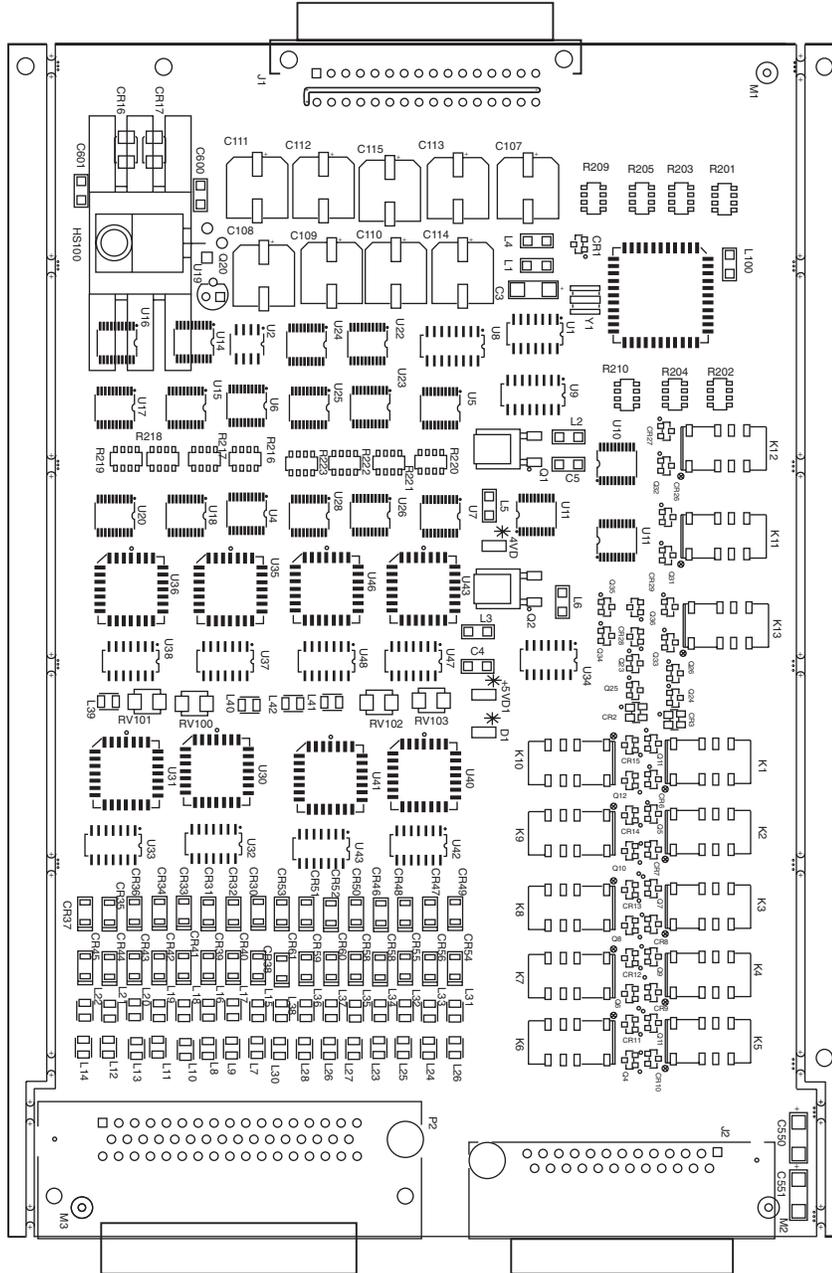
Table 8 (cont.)  
**Model 7707 parts list**

Circuit designation	Description	Keithley part no.
R46, R48, R50, R51, R206, R207	RES, 220, 5%, 125MW, METAL FILM (1206)	R-375-220
R6, R8, R10, R12-R15, R17, R37, R39, R41, R42	RES, 220, 5%, 125MW, METAL FILM (1206)	R-375-220
R62-R69, R81-R88, R100-R107, R119-R126	RES, 10K, 1%, 1/4W METAL FILM (1206)	R-391-10K
R70	RES, 6.19K, 1%, 100MW, THICK FILM (0805)	R-418-6.19K
R71	RES, 4.53K, 1%, 100MW, THICK FILM (0805)	R-418-4.53K
R91, R110	RES, 10K, 1%, 100MW, THICK FILM (0805)	R-418-10K
RV100, RV101, RV102, RV103	TRANSIENT VOLTAGE SUPPRESSOR	VR-25
U1	IC, SCHMITT-TRIGGER NAND GATE (SOIC)	IC-950
U18, U20, U26, U28	IC, OCTAL BUFFER DRIVER, 3-ST INVERT	IC-1454
U19	IC, AJD SHUNT REGULATOR, TL431CLP	IC-677
U2	IC, 2.5V CASCADABLE SERIAL EEPROM	LSI-212
U3	PROGRAM	7707-800A01
U30, U31, U35, U36, U40, U41, U45, U46	IC, PROTECTED QUAD POWER DRIVERS	IC-1212
U32, U33, U37, U38, U42, U43, U47, U48	IC, QUAD COMPARATOR, LM339D (SOIC)	IC-774
U34	IC, POS NAND GATES/INVERT, 74HCT14 (SOIC)	IC-656
U4-U7, U10-U12, U14-U17, U22-U25	IC, OCTAL D FLIP-FLOP, POS 3-ST	IC-1448
U8, U9	IC, 3-TO-8 LINE DECODE, 74ACT138 (SOIC)	IC-654
Y1	CRYSTAL CERAMIC RESONATOR, 8M	CR-59-2
	I/O MODUL 0 R	ANALOG/
	FINAL INSPECTION	7707-FIN-51
	50 5-SHELL FEMALE IDC	7707-306A
	25 D-SHELL MALE	7709-307A
	CHIPLOC BAG STATIC SHIELDING	PO-13-1
	SCANNER BOARD STAKING	7707-SCAN-31
	4-40 PEM NUT	FA-131
	MECHANICAL ASSEMBLY	7707-SCAN-MECH-3
	#4-40 X 1/4 LG. PHIL. FLAT HD. SCREW	4-40X1/4PFH
	4-40X3/16 PHIL. PAN HD SEMS	4-40X3/16PPHSEM
	BOTTOM CARD COVER	7703-301B
	TOP CARD COVER	7703-302C
	SCANNER PC BOARD ASSEMBLY	7707-100B
	SCANNER BOARD SURFACE MOUNT BOTTOM	7707-SCAN-1B
	SCANNER BOARD THRU HOLE	7707-SCAN-1H
	MASS TERM BRACKET	7709-303-3A
	SCREWLOCK, FEMALE	CS-725
	SCANNER BOARD SURFACE MOUNT TOP	7707-SCAN-1T
	HOLE SIZE	7707-102B
	IC, 8 BIT MICROCONTROLLER	LSI-242
	LABEL	MC-926A
	DUAL CONN COVER	7709-312A
	SERIAL NUMBER LABEL	MC-285
	4-40X7/16 STANDOFF	ST-166-18
	FGS SHIPPING KIT	7707-SHI-41
	2700 SUPPORT SOFTWARE	2700-850B03
	PACKING LIST	PA-770A
	PACKING LIST	PA-774A

# Component layout

Component layouts for the Model 7707 circuit boards are provided in Figure 20 and Figure 21.

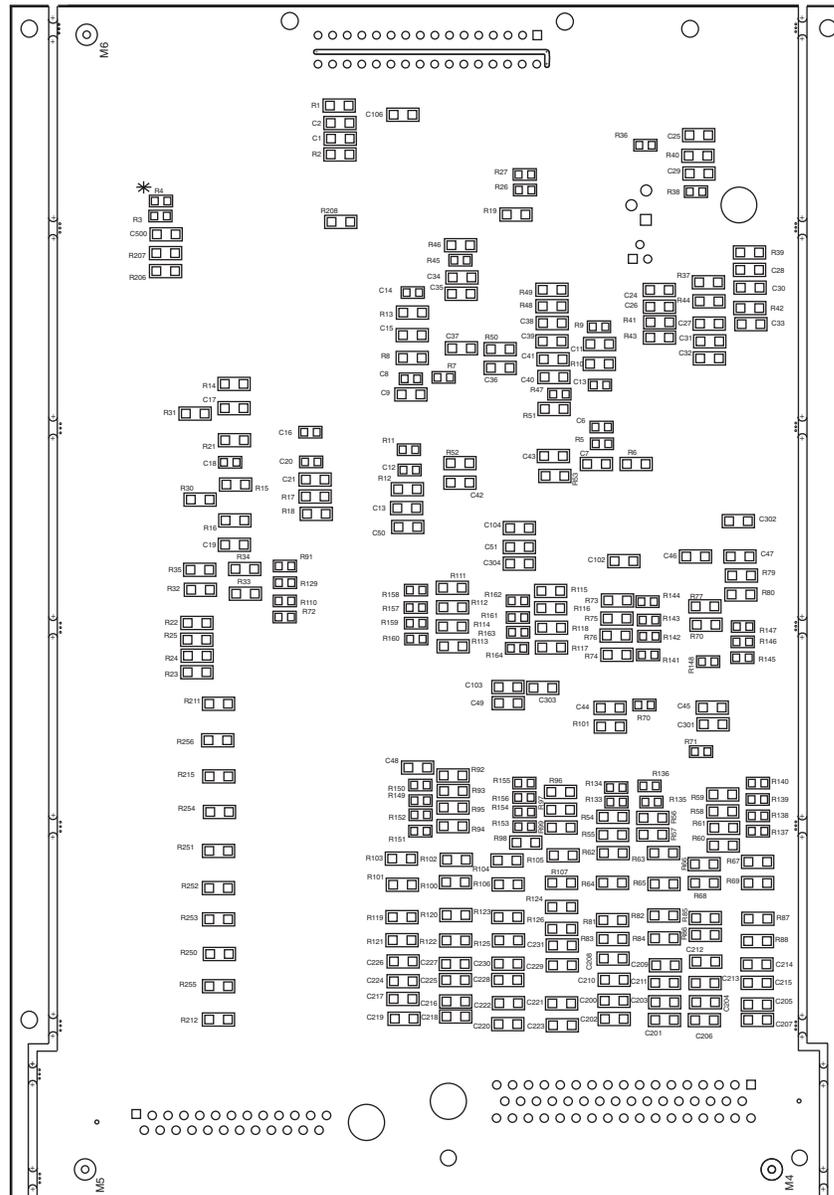
Figure 20  
Model 7707 component layout



Primary Side Components (Side - 06)

Note: For component information, see 7707 Product Structure.

Figure 21  
**Model 7707 component layout—secondary side**



Secondary Side Components (Side - 01)  
 Note: For component information, see 7707 Product Structure.

# Specifications — 7707 Multiplexer-Digital I/O Module

## GENERAL

**10 CHANNELS:** 10 channels of 2-pole relay input.  
All channels configurable to 4-pole.

**RELAY TYPE:** Latching electromechanical.

**ACTUATION TIME:** <3ms.

**FIRMWARE:** Specified for Model 2700 rev. B03 and Model 2750 rev. A01.

**CAPACITY:** Model 2700: (1) 7707 and (1) 770X\*  
Model 2750: (4) 7707 and (1) 770X\*

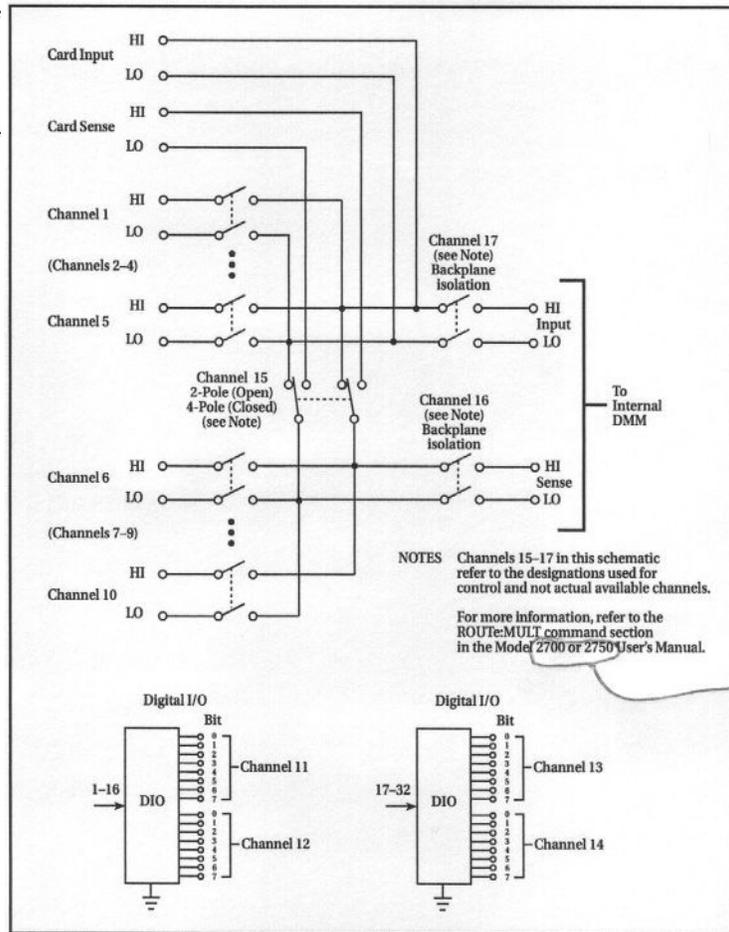
\*Refer to Model 7707 Manual for measurement considerations when used with Model 7706.

## CAPABILITIES

**CHANNELS 1-10:** Multiplex one of 10 2-pole or one of 5 4-pole signals into DMM.

**CHANNELS 11-14:** 32 Digital Inputs/Outputs referenced to chassis ground.

**THERMAL PROTECTION:** Channels 11-14 are thermally protected to 1A up to 25V.



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## Measurement considerations (digital outputs)

The Model 7707 digital outputs provide thermal short circuit protection. That is, when a channel is programmed as an output, internal circuitry will be protected from an inadvertent connection up to 1A at 25V.

The protection on the Model 7707 consumes power at approximately 80mA per channel or 320mA per Model 7707 with all four channels (11-14; 32-bits) programmed as outputs. Generated heat is dissipated within the Model 7707 module and Model 27xx mainframes.

As a result of the power (current) consumption and heat dissipation, adhere to the following guidelines.

### Capacity

**Model 2700 Multimeter/Data Acquisition System** — The Model 2700 can provide power, up to a total of 350mA, for both module slots. This is sufficient power to properly operate a Model 7707 with any Model 770X module, except the Model 7706 all-in-one module. The Model 7706 consumes power at approximately 180mA. Power consumption of the Model 7706 is independent of digital channels Output State. Therefore, when the Model 7707 is used with the Model 7706, only two Model 7707 Digital I/O channels can be programmed as outputs (16 bits). Failure to adhere to these limitations will cause erratic operations, such as resetting the Model 2700 internal microprocessors.

**Model 2701 Ethernet Multimeter/Data Acquisition System** — The Model 2701 is basically the same as the Model 2700, except it is an ethernet-based system. It does not have a GPIB interface. The limitations stated for the Model 2700 also apply to the Model 2701.

**Model 2750 Multimeter Switch System** — The Model 2750 can provide power, up to a total of 1.3A, for the five module slots. This is sufficient power for up to four Model 7707s and one other switching module. The capacity limits, when using four Model 7707s, are as follows:

- Four Model 7707s and one Model 770X (except Model 7706) – There is sufficient power to properly operate up to 4 Model 7707s (128 bits) with any Model 770X module, except the Model 7706.
- Four Model 7707s and one Model 7706 – Four Model 7707s can be used with a Model 7706 but not all digital channels of the Model 7707 can be used since power for Model 7706 must be factored in. The Model 7706 has two output channels (16 bits). That leaves 112 bits available for use by the Model 7707s. For example, 14 digital channels (112 bits) on four Model 7707s can be programmed as outputs.

*NOTE* When a digital channel on the Model 7707 is programmed as an input or off, no power is consumed and capacity limitations do not apply.

### Additional measurement uncertainty

On the Model 7707, additional heat is dissipated when the digital channels are programmed as outputs. This heat can cause additional uncertainty in thermocouple temperature measurements in the Model 27xx mainframe and 7708 Thermocouple Module when more than two digital channels are programmed as outputs.

The amount of uncertainty is dependent on slot number location of the Model 7707, the amount of time the channel is programmed as an output, and the other Model 770X module being used. The following table lists additional uncertainty to the published specification for the Model 27xx (front terminals), and the Model 7708. Other modules, such as the Model 7700 that measures thermocouple temperature, are also affected by this heat, but are still within published specification.

**NOTE** The listed uncertainty is with Channel 11-14 programmed as outputs. The uncertainty is linear. That is, for each channel programmed as input or off, there will be approximately 25% reduction in the listed uncertainty.

Table 9  
**Additional uncertainty for Model 7708**

Thermocouple	Range	2700/2701 front terminals	2750 front terminals	7708
J	-200 to 0°C 0 to +768°C	0.7 0.1	0.4	
K	-200 to 0°C 0 to +1372°C	0.5 0.2		1.6
N	-200 to 0°C 0 to +1300°C	0.8 0.2	0.3	3.0 0.5
T	-200 to 0°C 0 to +400°C	0.5 0.1	0.1	1.5
E	-200 to 0°C 0 to +1000°C	0.2		0.6
R	0 to +400°C +400 to +1768°C	1.2 0.4	0.3 2.2	5.9
S	0 to +400°C +400 to +1768°C	1.3 0.4	0.5 2.6	5.7
B	+350 to +1100°C +1100 to +1820°C	1.8 0.5	1.1	9.4 2.4

Notes:

1. The above listed uncertainties are guaranteed by design for types J, K, N, T, E, R, S and B.
2. When the 7707 and 7708 are used together, 7707 must be installed in the lowest numbered slot.  
For example: Model 2700/2701: 7707 in slot 1  
7708 in slot 2  
Model 2750: 7707 in slot 2  
7708 in slot 3



Specifications are subject to change without notice.

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