Accessory Instruction Sheet

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Introduction

The KTTI-GPIB Communication and Digital I/O Accessory provides Keithley products that have a compatible accessory card slot with an IEEE-488 standard parallel interface.

The GPIB interface provides fast, consistent triggering with low trigger latency. It provides a consistent transfer rate and can send triggers to multiple instruments simultaneously.

The card provides six independently configurable digital input/output lines that can be used to control external digital circuitry, for example, a handler that is used to perform binning operations. The digital I/O port is a standard female DB-9 connector. You can also use these lines for triggering. The instrument can generate output trigger pulses and detect input trigger pulses.

Figure 1: KTTI-GPIB communications card

The item shipped may vary from model pictured.

General specifications

General ratings for the KTTI-GPIB are listed in the following table.

Category	Specification
Interface	**Maximum connected instruments:** 15 **Maximum data transfer rate:** 1.5 MB/s **Data transfer mode:** Eight bits parallel **Handshake:** Three-wire handshake; reception of each data byte is acknowledged
Compliance	Conforms to European Union EMC Directive Compliance with CE and NRTL listed to UL61010-1 and UL61010-2-30 Conforms with European Union Low Voltage Directive
Environmental conditions	**I/O connector:** IEEE-488 standard 24-pin **Operating temperature:** 0 °C (32 °F) to 55 °C (131 °F) **Storage temperature:** –20 °C (–4 °F) to 80 °C (176 °F) **Relative humidity:** 5% to 95%, noncondensing **Power consumption:** +5.0 V: 250 mA (typical), 300 mA (maximum) **Dimensions, (not including connectors):** 120 mm (4.72 inches) x 64.5 mm (2.54 inches)
Digital I/O	**Connector:** 9-pin female D. **5V Power Supply Pin:** Limited to 500 mA at > 4 V (solid-state fuse protected). **Lines:** Six input/output, user-defined, for digital I/O or triggering. **Input Signal Levels:** 0.7 V (maximum logic low), 3.7 V (minimum logic high). **Input Voltage Limits:** –0.25 V (absolute minimum), +5.25 V (absolute maximum). **Maximum Source Current:** +2.0 mA at >2.7 V (per pin). **Maximum Sink Current:** –50 mA at 0.7 V (per pin, solid-state fuse protected).
Environmental conditions	**Operating environment:** Temperature 23 ºC ± 5 ºC, 5% to 80% relative humidity, noncondensing **Storage environment:** –25 ºC to 65 ºC

Unpack and inspect

Make sure to handle the KTTI-GPIB carefully. Always grasp the card by the side edges. Do not touch board surfaces, components, or areas adjacent to electrical contacts. Contamination from foreign materials such as dirt, dust, and body oils can substantially degrade card performance.

To unpack and inspect your instrument:

1. Inspect the box for damage.
2. Open the box.
3. Remove the card and inspect for any obvious signs of physical damage.
4. Report any damage to the shipping agent immediately.

Installation

⚠ WARNING

Slot covers must be installed on unused slots to prevent personal contact with high-voltage circuits. Failure to recognize and observe standard safety precautions could result in personal injury or death due to electric shock.

To install the communications card:

1. Turn the instrument off and disconnect the power line cord and any other cables connected to the rear panel.
2. Position the instrument so that you are facing the rear panel.
3. Remove the slot cover plate from the slot on the back of the instrument. Retain the plate and screws for future use.
4. Align the card with the connector toward the inside edge of the slot and slide the card into the chassis. For the last ¼ inch, press in firmly to mate the card to the connector.
5. On each side of the card, there is a spring-loaded mounting screw. Tighten these two screws, either by hand or with a Phillips-head screwdriver, to secure the card in the case. Do not overtighten.
6. Reconnect the power line cable and any other cables to the rear panel.
7. Turn on the instrument.

Making connections

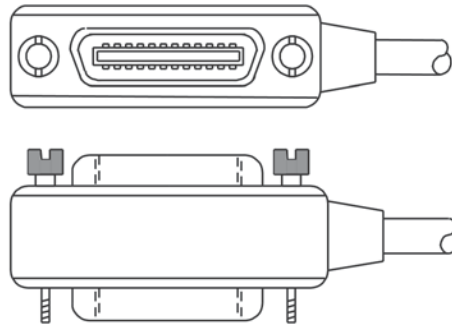Connect the GPIB cable to the card using a standard GPIB connector.

Figure 2: KTTI-GPIB connector view

Connect GPIB cables to your instrument

To connect a KTTI-GPIB to the GPIB interface, use a cable equipped with standard GPIB connectors, as shown below.

Figure 3: GPIB connector

To allow many parallel connections to one instrument, stack the connectors. Each connector has two screws on it to ensure that connections remain secure. The figure below shows a typical connection diagram for a test system with multiple instruments.
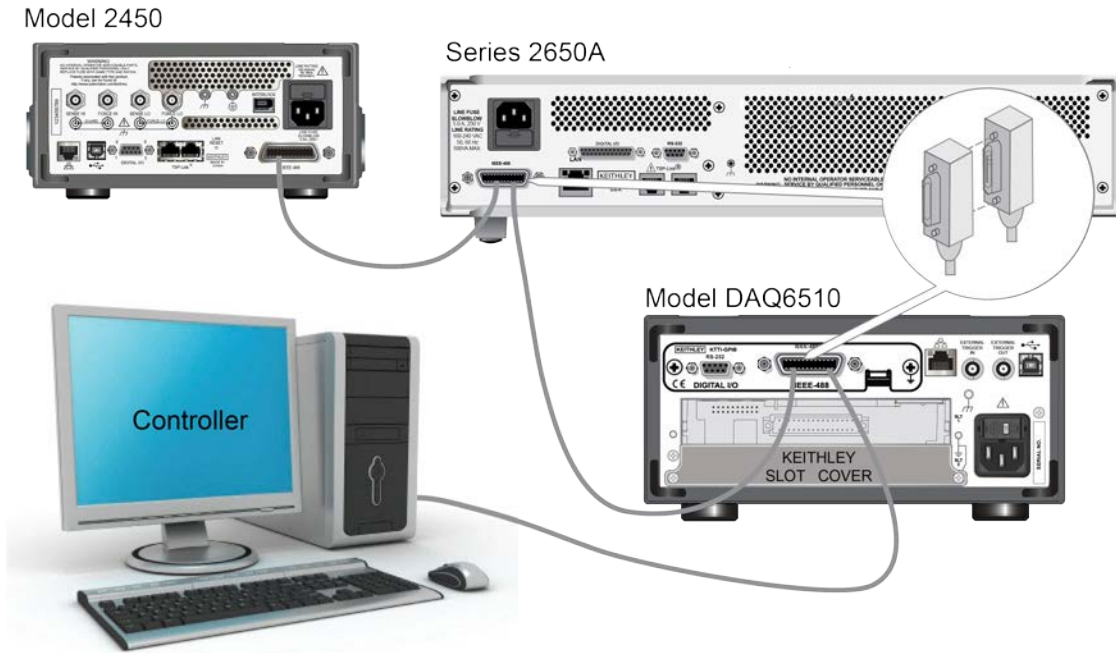
CAUTION

To avoid possible mechanical damage, stack no more than three connectors on any one instrument. To minimize interference caused by electromagnetic radiation, use only shielded GPIB cables. Contact Keithley Instruments for shielded cables.

Connect GPIB cables to your instrument

Figure 4: Typical GPIB connection scheme

Operation

This section provides information needed to use the KTTI-GPIB.

When the communications card is installed, the instrument recognizes the card when the power is turned on.

Refer to the instrument's reference manual for information about controlling the instrument from a remote interface.

Configuration

Set the GPIB address. The default GPIB address is 16. You can set the address from one to 30 if it is unique in the system. This address cannot conflict with an address that is assigned to another instrument or to the GPIB controller.

NOTE

GPIB controllers are usually set to 0 or 21. To be safe, do not configure any instrument to have an address of 21.

The instrument saves the address in nonvolatile memory. It does not change when you send a reset command or when you turn the power off and on again.

To set the GPIB address from the front panel:

1. Press the **MENU** key.
2. Select **Communication**.
3. Select the **GPIB** tab.
4. Set the **GPIB address.**
5. Select **OK**.

NOTE

You can also set the GPIB address using remote commands. Set the GPIB address with the SCPI command `:SYSTem:GPIB:ADDRess` or the TSP command `gpib.address`.

Set the GPIB address using remote commands

This section provides the information needed to set the GPIB address using remote commands (SCPI or TSP).

:SYSTem:GPIB:ADDRess

This command contains the GPIB address.

Type	Affected by	Where saved	Default value
Command and query	Not applicable	Nonvolatile memory	16

Usage

```
:SYSTem:GPIB:ADDRess <n>
:SYSTem:GPIB:ADDRess?
```

<n>	The GPIB address of the instrument (1 to 30)

Details

The address can be set to any address value from 1 to 30. However, the address must be unique in the system. It cannot conflict with an address that is assigned to another instrument or to the GPIB controller.

A new GPIB address takes effect when the command to change it is processed. If there are response messages in the output queue when this command is processed, they must be read at the new address.

If command messages are being queued (sent before this command has executed), the new settings may take effect in the middle of a subsequent command message, so care should be exercised when setting this attribute from the GPIB interface.

You should allow sufficient time for the command to be processed before attempting to communicate with the instrument again.

`*RST` does not affect the GPIB address.

Example

`:SYSTem:GPIB:ADDRess 26` `:SYSTem:GPIB:ADDRess?`	Sets the GPIB address and reads the address. Output: `2.600000e+01`

Also see

GPIB setup (on page 8)

gpib.address

This attribute contains the GPIB address.

Type	TSP-Link accessible	Affected by	Where saved	Default value
Attribute (RW)	No	Not applicable	Nonvolatile memory	16

Usage

```
address = gpib.address
gpib.address = address
```

address	The GPIB address of the instrument (1 to 30)

Details

The address can be set to any address value from 1 to 30. However, the address must be unique in the system. It cannot conflict with an address that is assigned to another instrument or to the GPIB controller.

A new GPIB address takes effect when the command to change it is processed. If there are response messages in the output queue when this command is processed, they must be read at the new address.

If command messages are being queued (sent before this command has executed), the new settings may take effect in the middle of a subsequent command message, so care should be exercised when setting this attribute from the GPIB interface.

You should allow sufficient time for the command to be processed before attempting to communicate with the instrument again.

The `reset()` function does not affect the GPIB address.

Example

`gpib.address = 26`
`address = gpib.address`
`print(address)`
	Sets the GPIB address and reads the address.
	Output:
	`26`

Also see

GPIB setup

This topic contains information about GPIB standards, bus connections, and primary address selection.

The KTTI-GPIB GPIB interface is IEEE Std 488.1 compliant and supports IEEE Std 488.2 common commands and status model topology.

You can have up to 15 devices connected to a GPIB interface, including the controller. The maximum cable length is the lesser of either:

- The number of devices multiplied by 2 m (6.5 ft)
- 20 m (65.6 ft)

You may see erratic bus operation if you ignore these limits.

NOTE

GPIB communications require the KTTI-GPIB communications accessory card to be installed in the instrument.

Digital I/O

The KTTI-GPIB digital I/O port provides six independently configurable digital input/output lines.

You can use these lines for digital control by writing a bit pattern to the digital I/O lines. Digital control is used for applications such as providing binning codes to a component handler. Digital control uses the state of the line to determine the action to take.

You can also use these lines for triggering by using the transition of the line state to initiate an action. The instrument can generate output trigger pulses and detect input trigger pulses. Triggering is used for applications such as synchronizing the operations of a measurement instrument with the operations of other instruments.
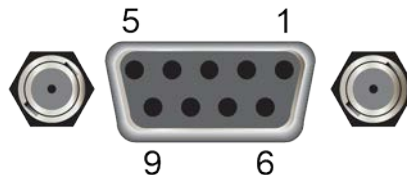
You cannot configure or directly control the digital I/O lines from the front panel. To configure and control any of the six digital input/output lines, you need to send commands to the KTTI-GPIB over a remote interface. You can use either the SCPI or TSP command set.

See Remote communications interfaces in the instrument reference manual for information about setting up a remote interface and choosing a command set.

Digital I/O connector and pinouts

The digital I/O port uses a standard female DB-9 connector, located on the rear panel of the KTTI-GPIB. You can connect to the KTTI-GPIB digital I/O using a standard male DB-9 connector. The port provides a connection point to each of the six digital I/O lines and other connections, as shown in the following table.

Figure 5: Digital I/O communication port

KTTI-GPIB digital I/O port pinouts

Pin	Description
1	I/O line #1
2	I/O line #2
3	I/O line #3
4	I/O line #4
5	V_{ext} line (relay flyback diode protection; maximum 33 V)
6	I/O line #5
7	+5 V line. Use this pin to drive external logic circuitry. Maximum current output is 500 mA. This line is protected by a self-resetting fuse (one-hour recovery time).
8	I/O line #6
9	Ground

Digital I/O port configuration

The following figure shows the basic configuration of the digital I/O port.

To set a line high (nominally +5 V), write a `1` to it; to set a line low (nominally 0 V), write a `0` to it. To allow an external device to control the state of the line, the line must be set to input mode or open-drain mode. An attached device must be able to sink at least 50 μA from each I/O line.

Figure 6: Digital I/O port configuration
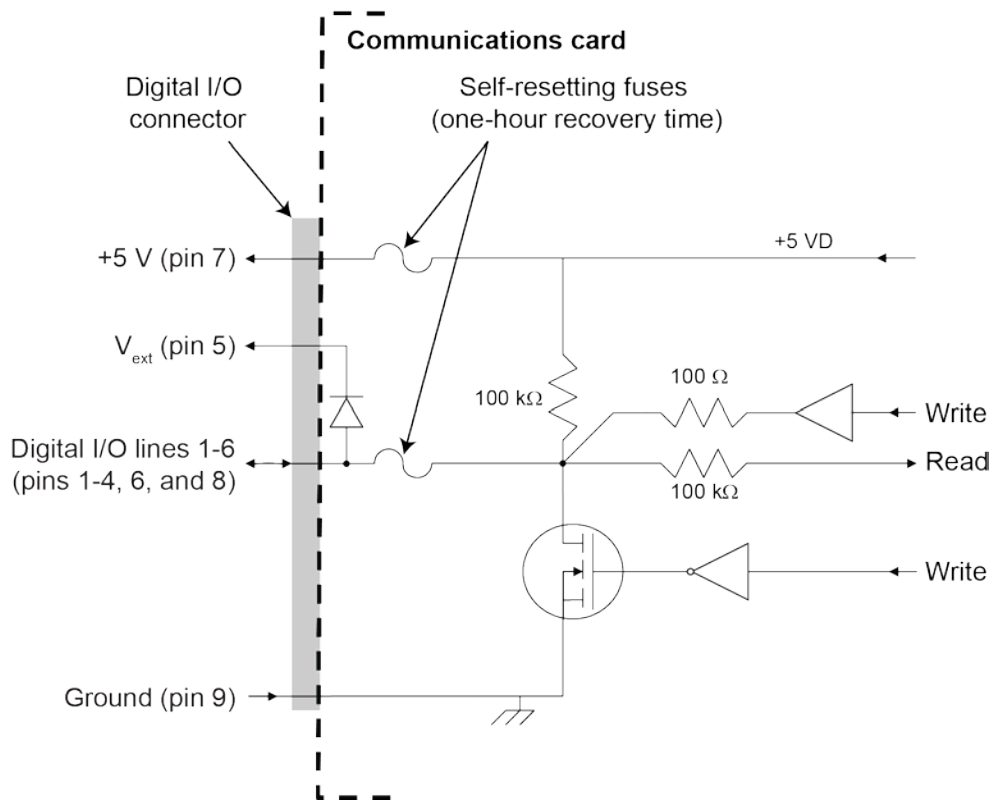
NOTE

For additional details about the digital output, see the KTTI-GPIB specifications, available at the Keithley Instruments support website.

Vext line

The digital I/O port provides a line (V_{ext}) with a flyback diode clamp that you can use when controlling inductive circuitry such as relay coils or low-power solenoids. You can use the built-in 5 V supply or an external voltage supply for these types of applications. The externally supplied voltage can be up to +33 V.

CAUTION

Do not apply more than 50 mA (maximum current) or exceed +33 V (maximum voltage) on the digital I/O lines. Applying current or voltage exceeding these limits may damage the instrument.

Refer to the following figure for a simplified schematic of a sample control circuit for a relay. You can externally power a different device by replacing the relay coil with the other device. The relay is actuated by configuring the corresponding digital output line. Most of these types of applications use an active-low (set the bit to 0) to turn the relay on (ON = 0 V). In the low state (0 V), the output transistor sinks current through the external device. In the high state, the output transistor is off (transistor switch is open). This interrupts current flow through the external device.

Figure 7: Digital I/O port (example external circuit)
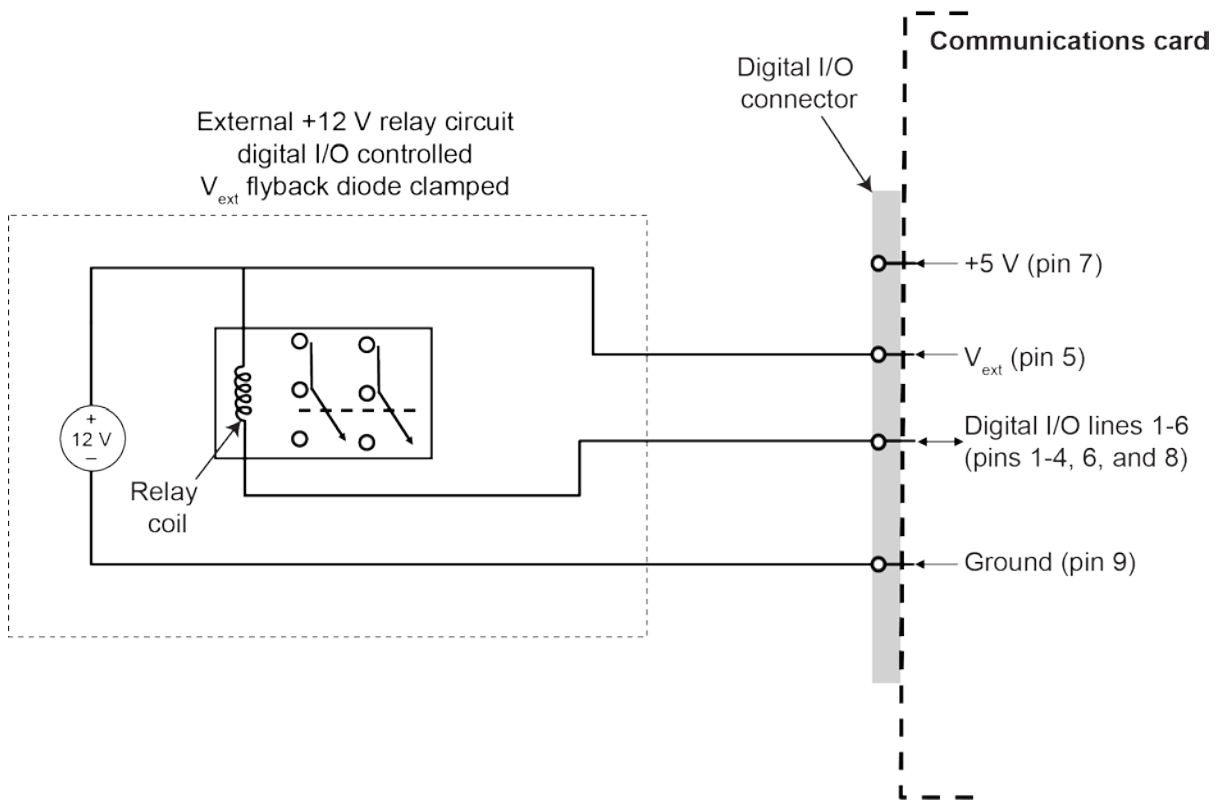
+5 V line

The digital I/O port provides a +5 V output. You can use this line to drive external circuitry. The maximum current output for this line is 500 mA. A self-resetting fuse with a one-hour recovery time protects this line.

If you are using this supply to drive a relay, it should be connected to the V_{ext} line so that the relay is protected by the flyback diode clamp.

Digital I/O lines

You can place each digital I/O line into one of the following modes:

- Digital open-drain, output, or input
- Trigger open-drain, output, or input
- Trigger synchronous master or acceptor

NOTE

When you configure the digital I/O lines for triggering applications, configure the output lines before the input lines. This prevents possible false input trigger detection in certain situations.

Digital control modes

If you are setting a line for digital control, you can set the line to be open-drain, output, or input, as described in the following topics.

Open-drain

When you place a line in open-drain mode, the line is configured to be an open-drain signal with a 100 kΩ pull-up resistor. This makes the line compatible with other instruments that use open-drain digital I/O lines, such as other Keithley Instruments products that only support open-drain for its digital I/O. In this mode, the line can serve as an input, an output, or both. You can read from the line or write to it. When a digital I/O line is used as an input in open-drain mode, you must write a 1 to the line to enable it to detect logic levels that are generated from external sources.

Output

When you place a line in output mode, you can set the line as logic high (+5 V) or as logic low (0 V). The default level is logic low (0 V). When the instrument is in output mode, the line is actively driven high or low. Unlike the input or open-drain modes, it will not respond to externally generated logic levels.

When you read the line, it shows the present output status and an event message is generated.

Input

The input mode is similar to the open-drain mode, except that a line in this mode is intended to be used strictly as an input. When you place a line in input mode, the instrument automatically writes a 1 to the line to enable it to detect externally generated logic levels.

You can read an input line, but you cannot write to it. You also cannot change the logic level while the line is in input mode. If you attempt to change the logic level of a line that is in input mode, an event message is generated.

Trigger control modes

You can use the trigger control modes to synchronize instrument operation with the operation of other instruments. These modes either detect or generate transitions in the state of the line, from high to low (falling edge) or from low to high (rising edge). The input edge detection setting of the instrument determines which type of transition is detected as an input trigger. Output triggers are typically generated in the form of a pulse. The type of transition that occurs on the leading edge of the pulse is determined by an output logic setting. The duration of the pulse is determined by a pulse width setting.

You can use the trigger control modes with interactive triggering or with the trigger model. For more information about the trigger modes and triggering, refer to the triggering section of the instrument reference manual.

Open-drain

When you set the instrument to trigger mode and place a line in open-drain mode, the line is configured to be an open-drain signal with a 100 kΩ pull-up resistor. This makes the line compatible with other instruments that use open-drain trigger signals, such as other Keithley Instruments products that only support open-drain for its digital I/O. In this mode, you can use the line to detect input triggers or generate output triggers, or both. To use this mode successfully, you must carefully configure the input edge and output logic settings because both of these affect the initial state of the trigger line. It is recommended that you reset the line before selecting and configuring this mode.

To use the line only as a trigger input:

1. Reset the line.
2. Set the input trigger edge detection type to falling, rising, or either.

The command that sets the detection type automatically sets the line high. This enables the line to respond to and detect externally generated triggers.

Do not set the output trigger logic type to positive after setting the edge detection type. This sets the line low, which will prevent the line from operating correctly as a trigger input.

To use the line only as a trigger output:

1. Reset the line.
2. Set the output trigger logic type to negative (falling edge) or positive (rising edge).

When you set the logic type to negative, the instrument automatically sets the line high. Setting the logic type to positive automatically sets the line low.

Do not set the input trigger edge detection type after setting the positive logic type. This will set the line high, which will prevent the line from operating correctly as a trigger output.

To use the line as both a trigger input and a trigger output (falling edge triggers only):

1. Reset the line.
2. Set the output trigger logic type to negative (falling edge).
3. Set the input trigger edge detection type to falling, rising, or either.

You can use these settings for triggering applications that use Keithley Instrument products featuring Trigger Link.

Output

When you place a line in output mode, it is automatically set high or low depending on the output logic setting. Use the negative logic setting when you want to generate a falling edge trigger. Use the positive logic setting when you want to generate a rising edge trigger. You cannot detect incoming triggers on a line configured as a trigger output.

Input

When you place a line in input mode, it is automatically set high to allow it to respond to and detect externally generated triggers. Depending on the input edge detection setting, the line can detect falling-edge triggers, rising-edge triggers, or both.

The line cannot generate an output trigger if it is set to the trigger input mode.

Synchronous triggering

The synchronous triggering modes allow you to:

- Implement bidirectional triggering on a single trigger line
- Start operations on one or more external instruments using a single trigger line
- Wait for all instruments to complete all triggered actions

To coordinate non-Keithley instrumentation with synchronous triggering, the non-Keithley instrument must have a trigger mode that is similar to the synchronous acceptor or synchronous master trigger mode.

To use synchronous triggering, configure the triggering master to synchronous master trigger mode or the non-Keithley equivalent. Configure all other instruments in the test system to the synchronous acceptor trigger mode or equivalent.

Synchronous master

Use the synchronous master trigger mode with the synchronous acceptor mode or its non-Keithley equivalent.

Configure only one instrument as a synchronous master. Configure all other instruments that are connected to the synchronization line as synchronous acceptors.

When a digital I/O line is set to the synchronous master mode, it generates falling edge output triggers and detects rising edge input triggers on the same trigger line.

Instruments that are configured as synchronous acceptors detect the falling-edge trigger and begin their triggered actions. At the same time, they latch the line low and hold it in that state until their triggered actions complete. Each instrument configured as an acceptor releases the line upon completion of its triggered actions.

When all instruments have released the line, the line changes state and generates a rising edge trigger. This trigger is detected by the synchronous master, which then performs its next triggered action.

Input characteristics:

- All rising edges are input triggers.
- When all external drives release the physical line, the rising edge is detected as an input trigger.
- A rising edge is not detected until all external drives release the line and the line floats high.
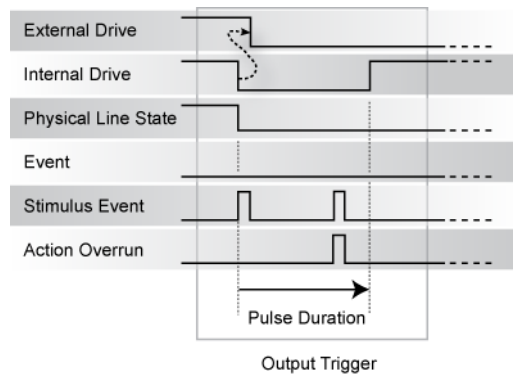
Figure 8: Synchronous master input trigger
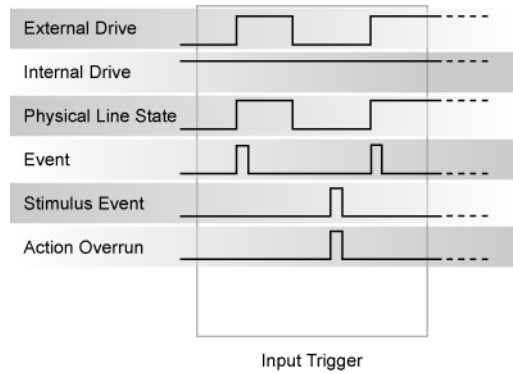
Input Trigger

Output characteristics:

- In addition to trigger events from other trigger objects, the TSP command `trigger.digout[N].assert()` generates a low pulse that is similar to the falling-edge trigger mode.
- An action overrun occurs if the physical line state is low when a stimulus event occurs.

Figure 9: Synchronous master output trigger

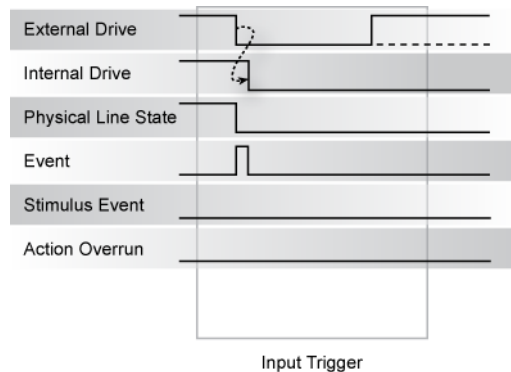Output Trigger

Synchronous acceptor

Use the synchronous acceptor trigger mode with the synchronous master mode or its non-Keithley equivalent.

Only one instrument should be configured as a synchronous master. All other instruments connected to the synchronization line must be configured as synchronous acceptor or equivalent.

A line that is set to the synchronous acceptor mode detects falling edge input triggers and generates rising edge output triggers on the same trigger line. When a line that is configured as synchronous acceptor detects the falling edge trigger, it latches the line low and holds it in that state until all triggered actions for that instrument are complete. When the triggered actions are complete, the synchronous acceptor line releases the line. When all connected instruments have released the line, the line changes state and generates a rising edge trigger.

Input characteristics:

▪ The falling edge is detected as the external drive pulses the line low, and the internal drive latches the line low.

Figure 10: Synchronous acceptor input trigger

Output characteristics:

▪ In addition to trigger events from other trigger objects, the TSP command `trigger.digout[N].assert()` triggers events as well.
▪ The physical line state does not change until all drives (internal and external) release the line.
▪ Action overruns occur if the internal drive is not latched low and a source event is received.

Figure 11: Synchronous acceptor output trigger
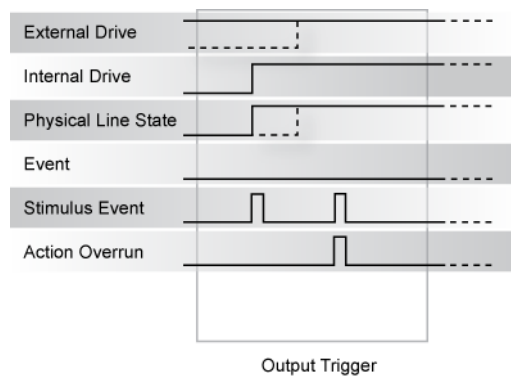
Remote digital I/O commands

Commands for both SCPI and TSP are summarized in the following table. You can use the digital I/O port to perform the following actions:

- Perform basic steady-state digital I/O operations, such as reading and writing to individual I/O lines or reading and writing to the entire port
- Trigger the instrument when external trigger pulses are applied to the digital I/O port
- Provide trigger pulses to external devices

For detailed descriptions and sample applications, see the instrument reference manual.

SCPI command TSP command	Description
`:DIGital:LINE<n>:MODE` `digio.line[N].mode`	This command sets the mode of the digital I/O line to be a digital line, trigger line, or synchronous line and sets the line to be input, output, or open-drain.
A line reset is not available in SCPI; however, the line is reset when a global reset (`*RST`) is sent `digio.line[N].reset()`	This command resets digital I/O line values to their factory defaults.
`:DIGital:LINE<n>:STATe` `digio.line[N].state`	This command sets a digital I/O line high or low when the line is set for digital control and returns the state on the digital I/O lines.
`:DIGital:READ?` `digio.readport()`	This command reads the digital I/O port. All six lines must be configured as digital control lines. If not, this command generates an error.
`:DIGital:WRITe <n>` `digio.writeport()`	This command writes to all digital I/O lines. All six lines must be configured as digital control lines. If not, this command generates an error.
`:TRIGger:DIGital<n>:IN:CLEar` `trigger.digin[N].clear()`	This command clears the trigger event on a digital input line.
`:TRIGger:DIGital<n>:IN:EDGE` `trigger.digin[N].edge`	This command sets the edge used by the trigger event detector on the given trigger line.
`:TRIGger:DIGital<n>:IN:OVERrun?` `trigger.digin[N].overrun`	This command returns the event detector overrun status.
Not available in SCPI `trigger.digin[N].wait()`	This command waits for a trigger.
Not available in SCPI	This command asserts a trigger pulse on one of the

SCPI command TSP command	Description
`trigger.digout[N].assert()`	digital I/O lines.
`:TRIGger:DIGital<n>:OUT:LOGic` `trigger.digout[N].logic`	This command sets the output logic of the trigger event generator to positive or negative for the specified line.
`:TRIGger:DIGital<n>:OUT:PULSewidth` `trigger.digout[N].pulsewidth`	This command describes the length of time that the trigger line is asserted for output triggers.
Not available in SCPI `trigger.digout[N].release()`	This command releases an indefinite length or latched trigger.
`:TRIGger:DIGital<n>:OUT:STIMulus` `trigger.digout[N].stimulus`	This command selects the event that causes a trigger to be asserted on the digital output line.

NOTE

To use the trigger model as a stimulus to a digital I/O line, you can use the trigger model Notify block. For information on the Notify block, see the reference manual for your instrument.

Digital I/O bit weighting

Bit weighting for the digital I/O lines is shown in the following table. Line 1 is the least significant bit.

Line #	Bit	Pin	Decimal	Hexadecimal	Binary
1	B1	1	1	0x01	000001
2	B2	2	2	0x02	000010
3	B3	3	4	0x04	000100
4	B4	4	8	0x08	001000
5	B5	6	16	0x10	010000
6	B6	8	32	0x20	100000

Digital I/O programming examples

These examples provide typical methods you can use to work with the digital I/O port.

Outputting a bit pattern

The programming examples below illustrate how to output the bit pattern 110101 at the digital I/O port. Line 1 (bit 1) is the least significant bit.

Using SCPI commands to configure all six lines as digital outputs:

```
:DIGital:LINE1:MODE DIGital, OUT
:DIGital:LINE2:MODE DIGital, OUT
:DIGital:LINE3:MODE DIGital, OUT
:DIGital:LINE4:MODE DIGital, OUT
:DIGital:LINE5:MODE DIGital, OUT
:DIGital:LINE6:MODE DIGital, OUT
```

Using SCPI commands to set the state of each line individually:

```
:DIGital:LINE6:STATe 1
:DIGital:LINE5:STATe 1
:DIGital:LINE4:STATe 0
:DIGital:LINE3:STATe 1
:DIGital:LINE2:STATe 0
:DIGital:LINE1:STATe 1
```

Using SCPI commands to set all six lines at once by writing the decimal equivalent of the bit pattern to the port:

```
:DIGital:WRITe 53
```

Using TSP commands to configure all six lines as digital outputs:

```
-- Send for loop as a single chunk or include in a script.
for i = 1, 6 do
   digio.line[i].mode = digio.MODE_DIGITAL_OUT
end
```

Using TSP commands to set the state of each line individually:

```
digio.line[1].state = digio.STATE_HIGH
digio.line[2].state = digio.STATE_LOW
digio.line[3].state = digio.STATE_HIGH
-- You can use 0 instead of digio.STATE_LOW.
digio.line[4].state = 0
-- You can use 1 instead of digio.STATE_HIGH.
digio.line[5].state = 1
digio.line[6].state = 1
```

Using TSP commands to set all six lines at once by writing the decimal equivalent of the bit pattern to the port:

```
-- You can write binary, decimal or hexadecimal values, as shown below.
-- Use binary value.
digio.writeport(0b110101)
-- Use decimal value.
digio.writeport(53)
-- Use hexadecimal value.
digio.writeport(0x35)
```

Reading a bit pattern

The programming examples below illustrate how to read part or all of a bit pattern that has been applied to the digital I/O port by an external instrument. The binary pattern is 111111 (63 decimal). Line 1 (bit 1) is the least significant bit.

Using SCPI commands:

Configure all six lines as digital inputs:

```
DIGital:LINE1:MODE DIGital, IN
DIGital:LINE2:MODE DIGital, IN
DIGital:LINE3:MODE DIGital, IN
DIGital:LINE4:MODE DIGital, IN
DIGital:LINE5:MODE DIGital, IN
DIGital:LINE6:MODE DIGital, IN
```

Read the state of Line 2:

```
DIGital:LINE2:STATe?
```

Value returned is 1.

Read the state of Line 3:

```
DIGital:LINE3:STATe?
```

Value returned is 1.

Read the value applied to the entire port:

```
DIGital:READ?
```

Value returned is 63, which is the decimal equivalent of the binary bit pattern.

Using TSP commands:

```
-- Configure all six digital I/O lines as digital inputs.
-- You can also use a for loop.
digio.line[1].mode = digio.MODE_DIGITAL_IN
digio.line[2].mode = digio.MODE_DIGITAL_IN
digio.line[3].mode = digio.MODE_DIGITAL_IN
digio.line[4].mode = digio.MODE_DIGITAL_IN
digio.line[5].mode = digio.MODE_DIGITAL_IN
digio.line[6].mode = digio.MODE_DIGITAL_IN
-- Read and then print the state of Line 2 (bit 2).
b2 = digio.line[2].state
print(b2)
```

The value returned is digio.STATE_HIGH.

```
-- Print the state of Line 3 (bit 3).
print(digio.line[3].state)
```

The value returned is digio.STATE_HIGH.

```
-- Read and then print the value applied to the entire port.
port = digio.readport()
print(port)
```

The value returned is 63, which is the decimal equivalent of the binary bit pattern.

Effect of GPIB line events on KTTI-GPIB

The GPIB has control lines that allow predefined information, called events, to be transferred quickly. The following information lists some of the GPIB line events and how the KTTI-GPIB reacts to them.

DCL

This event clears the GPIB interface. When the KTTI-GPIB detects a device clear (DCL) event, it does the following:

- Clears the input buffer, output queue, and command queue
- Cancels deferred commands
- Clears any command that prevents the processing of any other device command

A DCL event does not affect instrument settings and stored data.

GET

The group execute trigger (GET) command is a GPIB trigger that triggers the instrument to take readings from a remote interface.

GTL

When the instrument detects the go to local (GTL) event, it exits remote operation and enters local operation. When the instrument is operating locally, you can control the instrument from the front panel.

IFC

When the instrument detects an interface clear (IFC) event, the instrument enters the talker and the listener idle state. When the instrument is in this state, the GPIB ↑↓ indicators on the front panel are not displayed.

An IFC event does not interrupt the transfer of command messages to and from the instrument. However, messages are suspended. If the transfer of a response message from the instrument is suspended by an IFC event, the transfer resumes when the instrument is addressed to talk. If transfer of a command message to the instrument is suspended by an IFC event, the rest of the message can be sent when the instrument is addressed to listen.

LLO

When the instrument detects a local-lockout (LLO) event, most of the front-panel controls are disabled. This event disables all front-panel controls and POWER switches.

To enable the front panel, use the go-to-local (GTL) event.

REN

When the instrument detects the remote enable (REN) event, it is set up for remote operation. The instrument is not placed in remote mode when it detects the REN event; the instrument must be addressed to listen after the REN event before it goes into remote mode.

You should place the instrument into remote mode before you attempt to program it using a remote interface.

SDC

The selective device clear (SDC) event is similar to the device clear (DCL) event. However, the SDC event clears the interface for an individual instrument instead of clearing the interface of all instruments.

When the KTTI-GPIB detects an SDC event, it will do the following for the selected instrument:

- Clears the input buffer, output queue, and command queue
- Cancels deferred commands
- Clears any command that prevents the processing of any other device command

An SDC event does not affect instrument settings and stored data.

SPE, SPD

When the instrument detects the serial polling enable (SPE) and serial polling disable (SPD) events, it sends the status byte of the instrument. This contains the serial poll byte of the instrument.

The serial poll byte contains information about internal functions. See Status model in the instrument reference manual for detail. Generally, the serial polling sequence is used by the controller to determine which of several instruments has requested service with the SRQ line.

Upgrading the firmware

You will periodically update the instrument firmware. During the upgrade process, the instrument verifies that the version you are loading is newer than what is on the instrument. If the version is older or at the same revision level, no changes are made.

If you have a KTTI-GPIB communications accessory card installed in the instrument, the firmware on the card is upgraded.

You can load the file from the front-panel USB port or you can use Test Script Builder (TSB) using a file saved to the computer on which TSB is running.

The firmware file must be in the root subdirectory of the flash drive and must be the only firmware file in that location.

If you want to return to a previous version or reload the present version of the firmware, select **Downgrade to Older**. This forces the instrument to load the firmware regardless of the version.

The upgrade process normally takes about five minutes.

Upgrade files are available on tek.com/keithley.

Accessories

Model 7006: Single-shielded GPIB cable terminated with one feedthrough-style and one straight IEEE-488 connector. The mating thumb screws are metric.

- 7006-1 1 m (3.3 ft)
- 7006-2 2 m (6.6 ft)

Model 7007: Double-shielded premium GPIB cable. Each end is terminated with a feedthrough-style metal housing for longest life and best performance. The mating thumb screws are metric.

- 7007-05 0.5 m (1.6 ft)
- 7007-1 1 m (3.3 ft)
- 7007-2 2 m (6.6 ft)
- 7007-3 3 m (10 ft)
- 7007-4 4 m (13.1 ft)

Other options:

- KPCI-488LPA GPIB Controller Interface Card
- DB-9 Gender Changer
- KUSB-488B USB to GPIB Converter

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 nonhazardous voltages, there are situations where hazardous conditions may be present.

This product is intended for use by 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 user documentation for complete product specifications.

If the product is used in a manner not specified, the protection provided by the product warranty 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 user documentation. 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, perform safe installations, and repair products. Only properly trained service personnel may perform installation and service procedures.

Keithley products are designed for use with electrical signals that are measurement, control, and data I/O connections, with low transient overvoltages, and must not be directly connected to mains voltage or to voltage sources with high transient overvoltages. Measurement Category II (as referenced in IEC 60664) connections require protection for high transient overvoltages often associated with local AC mains connections. Certain Keithley measuring instruments may be connected to mains. These instruments will be marked as category II or higher.

Unless explicitly allowed in the specifications, operating manual, and instrument labels, do not connect any instrument to mains.

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 30 V RMS, 42.4 V peak, or 60 VDC 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 V, no conductive part of the circuit may be exposed.

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.

For safety, instruments and accessories must be used in accordance with the operating instructions. If the instruments or accessories are used in a manner not specified in the operating instructions, the protection provided by the equipment may be impaired.

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

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

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

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

The **CAUTION** heading with the ⚠ symbol in the user documentation explains hazards that could result in moderate or minor injury or damage the instrument. Always read the associated information very carefully before performing the indicated procedure. Damage to the instrument 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. Standard fuses with applicable national safety approvals may be used if the rating and type are the same. The detachable mains power cord provided with the instrument may only be replaced with a similarly rated power cord. 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 to maintain accuracy and functionality of the product). If you are unsure about the applicability of a replacement component, call a Keithley office for information.

Unless otherwise noted in product-specific literature, Keithley instruments are designed to operate indoors only, in the following environment: Altitude at or below 2,000 m (6,562 ft); temperature 0 °C to 50 °C (32 °F to 122 °F); and pollution degree 1 or 2.

To clean an instrument, use a cloth dampened with deionized water 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., a 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.

Safety precaution revision as of June 2017.