

FLUKE®

Calibration

5560A/5550A/5540A

Calibrator

Remote Programmers Manual

August 2022 Rev. 1, 9/23

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Introduction

This document defines the remote interface commands for the 5560A/5550A/5540A Calibrator (the Product or Instrument). A computer can connect through any of the remote interface ports to change settings, read measurement data, and control the operation of the Product. Command syntax and names follow the IEEE-488.2 standards.

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Remote Operations

This section describes methods to operate the Calibrator by remote control.

⚠⚠ Warning

The Calibrator can produce voltages up to 1020 V rms. Program the Calibrator with caution to prevent the production of hazardous voltages without sufficient warning to the operator.

Write programs carefully and test them extensively to ensure safe operation of the Calibrator. Fluke Calibration recommends that you include routines to catch errors in your programs. These routines help to identify programming errors that can cause the Calibrator to behave other than intended. Set the Service Request Enable (SRQ) register to program the Calibrator to cause an SRQ when it detects an error. The skeleton program below includes error-catching code:

```
10    PRINT @4, "*CLS"           ! Clear status
20    PRINT @4, "*SRE 8"        ! Set SRE Error Available
30    ON SRQ GOTO 1000         ! Enable SRQ Function
100                                     ! Place body of program here

900   STOP                     ! End of program

1000  REM Start of SRQ Handler   ! Start routine
1010  PRINT @4, "FAULT?"        ! Request fault code
1020  INPUT @4, A%              ! Input fault code
1030  PRINT @4, "EXPLAIN? ";A%  ! Request fault text
1040  INPUT @4, A$              ! Input fault text
1050  PRINT "Fault ";A$" detected" ! Print message
1060  PRINT @4, "STBY"         ! Place 5560A in standby
1070  STOP
```

Operate the Product by direct local control from the front panel or by remote control from an instrument controller, computer, or terminal. Remote control can be interactive, with each step controlled by the user from a terminal, or can be set up to run automatically, taking commands from a computer within an automated system. This section explains how to connect, configure, and operate the Product in remote mode.

The remote interfaces use *device-dependent commands* to duplicate the functions of the front-panel controls. The Calibrator has four remote interfaces: IEEE-488, RS-232 Serial, 10/100/1000-baseT Ethernet, and USBTMC. All of the remote interfaces may be used simultaneously.

Note

Dual output and Inductance and 52120-related commands are not available in the 5540A.

Set up the IEEE-488 Port for Remote Control

The Calibrator is fully programmable for use on the IEEE Standard 488.1 (GPIB) interface bus. The IEEE-488 interface is also designed in compliance with supplemental standard IEEE-488.2, which describes additional IEEE-488 features. Devices connected to the IEEE-488 bus are designated as talkers, listeners, talker/listeners, or controllers. Under remote control of an instrument, the Calibrator operates as a talker/listener.

A PC equipped with an IEEE-488 interface, controls the Calibrator. Compatible software for IEEE-488 operation may be purchased from Fluke, this includes MET/CAL.

When you use the IEEE-488 remote control interface, there are two restrictions:

- **Number of Devices** A maximum of 15 devices can be connected in a single IEEE-488 bus system. For example, one instrument controller, one Calibrator, and thirteen devices under test (DUTs).
- **Cable Length** The total length of IEEE-488 cables used in one IEEE-488 system is 2 meters times the number of devices in the system, or 20 meters, whichever is less. For example, if 8 devices are connected, the maximum cable length is $2 \times 8 = 16$ meters. If 15 devices are connected, the maximum cable length is 20 meters.

IEEE-488 Interface Configuration

The Calibrator IEEE-488 interface supports the IEEE-488 interface function subsets listed in Table 1.

Table 1. Supported IEEE-488 Interface Function Subsets

Interface Function	Description
SH1	Complete source handshake capability
AH1	Complete acceptor handshake capability
T6	Basic talker; serial poll; no talk-only function; unaddress if MLA
TE0	No extended talker capabilities
L4	Basic listener operation; no listen-only function; unaddress if MTA
LE0	No extended listener capabilities
SR1	Full service request capability with ability to bit-mask SRQ
RL1	Full remoter/local capability this includes local lockout
PP0	No parallel poll capability
DC1	Device clear capability
DT1	Device trigger capability
C0	No bus control capability

IEEE-488 Bus Communication Overview

Communication between the controller and the Calibrator takes place with commands established by IEEE-488.1 standards and commands specifically related to the Calibrator. The commands in Tables 20 through 27 are all the remote commands, both common and device-dependent.

Definitions of the different types of messages used on the IEEE-488 bus follow:

- Device-dependent commands are messages used to transfer information directly between the Calibrator and the IEEE-488 controller. Some commands cause an action to take place in the Calibrator. Others, called queries in the IEEE-488.2 standards, ask for information, and always generate a response message from the Calibrator. While message format is governed by IEEE-488.2 standards, message content can be unique to the Calibrator. For example, device-dependent commands are used to set the output function and amplitude, and to switch from standby to operate.
- Common commands defined by IEEE-488.2 standards are used for functions common to most bus devices. Examples include the command to reset a device (*RST) and the query for device identification (*IDN?). Common commands and queries can be identified easily because they all begin with an asterisk (*).
- Interface messages defined by IEEE-488.1 standards have their own control lines, and others are sent over the data lines by first asserting the control line ATN (Attention). It is important to note that interface messages unlike device-dependent and common commands, are not sent literally (for example, when a device-dependent query is sent to the Calibrator, the controller automatically sends the interface message MTA (My Talk Address)).

USBTMC Interface

Set Up the USBTMC Port for Remote Control

To use the USBTMC port for remote control, first install the necessary VISA (Virtual Instrument Software Architecture) drivers on the host computer. Download the drivers from National Instruments (<http://www.ni.com>).

NI-VISA contains a USB Test and Measurement Class (USBTMC) driver that supports the necessary protocol to communicate with USBTMC class instruments. Once installed, the driver allows the host computer to automatically recognize and communicate with USBTMC devices.

The USBTMC driver only recognizes USBTMC and USBTMC-488 devices. The driver does not recognize other USB devices such as mass-storage devices, cameras, and mobile phones.

In this section, USBTMC refers to devices that support the USBTMC or USBTMC-USB488 protocol. When you use USBTMC, a separate USB cable is necessary for each instrument that is connected to the host computer.

1. Connect the Type A end of the cable to the host computer.
2. Connect the Type B end of the cable to the Calibrator USB/Control Device port.
3. Turn on the Calibrator. When the host computer detects the Calibrator, it automatically installs the necessary USBTMC drivers (this is a one-time operation).
4. Make sure that the Calibrator is detected: right-click on the Windows Start icon and select **Device Manager**. Under that is **USB Test and Measurement Devices** and under that, is **USB Test and Measurement Device (IVI)**.
5. Close the Device Manager on the PC.

USBTMC Communication Overview

USBTMC features these endpoints for communication:

- Use **Control Endpoint** to send standard, class, and vendor-specific requests to the Calibrator.
- Use **Bulk Out Endpoint** to send USBTMC command messages to the Calibrator.
- The Calibrator uses **Bulk In Endpoint** to send USBTMC response messages to the controller.

USBTMC-488 adds an additional endpoint called the Interrupt IN Endpoint. The Calibrator uses the interrupt IN endpoint to send notifications (such as SRQ messages) to the controller. The interrupt IN endpoint is also used for serial poll requests of the Calibrator. See the Universal Serial Bus Test and Measurement Class and Universal Serial Bus Test and Measurement Class, subclass USB488 specification for more detailed information.

The USBTMC488 interface implements a full Remote/Local state machine for USBTMC communication. See the IEEE-488.1 standard section 4.8.2.

Use USBTMC to Communicate with the Product

For the Calibrator to communicate with the USB device, Fluke Calibration recommends that you use NI-VISA drivers.

NI-VISA requires a resource string in this format to connect to the correct USB instrument:

```
USB0::0x0F7E::0x800A::[serial number]::INSTR
```

Where:

- 0x0F7E: The Fluke vendor ID
- 0x800A: The Calibrator model number (5560A, 5550A, or 5540A)
- [serial number]: The serial number of the Calibrator. The serial number is also on the rear panel or by use of the *IDN? command on one of the other remote interfaces. You can also find the serial number with the **Setup > About** menu.
- INSTR: Use the USBTMC protocol.

Note

To ensure the most efficient use of the Service Request (SRQ) mechanism provided by USBTMC-USB488, first check that the RQS bit in the Status Byte is clear. To do this, perform a serial poll of the Calibrator before you send any commands that could generate SRQ events. This only needs to be done once in your program/procedure.

Check communications can be established:

*Write *IDN?*

Read the response

Clear registers and read the status byte:

*Write: *CLS;*RST*

*Write *ESE 0*

*Write *SRE 191*

Read the status byte (Serial POLL)

Before you proceed, set the event and status registers as required.

RS-232 Serial Interface

Use the RS-232 Port for Remote Control

This procedure is intended for those who use the Calibrator serial interface for remote control from a terminal or computer with a serial interface. This section describes how to set up the RS-232 interface for remote control with protocol similar to IEEE-488. This section provides all details on data transmission. The RS-232 interface is designed in accordance with EIA (Electronic Industries Association) standard RS-232.

RS-232 Interface Specifications

The RS-232 interface is configured as DTE (Data Terminal Equipment). A null-modem cable with two female 9-pin subminiature D connectors must be used to connect the Calibrator to other DTE such as a typical computer serial interface. Fluke Calibration recommends a Fluke RS43 cable.

The choices available and the defaults for all programmable interface parameters for the Calibrator are shown in Table 2.

Table 2. RS-232 Interface Parameter Choices

Parameter	Choices	Default Setting
Data Bits	7 or 8	8
Stop Bits	1 or 2	1
Flow Control	Ctrl S/Ctrl Q, (XON/XOFF), RTS, or none	Ctrl S/ Ctrl Q
Parity Checking	Odd, even, or none	None
Baud Rate	9600, 19200, 38400, 57600, or 115200	9600
EOL (End of Line)	CR, LF, or CR LF	CR LF

Set up the RS-232 Port for Remote Control

The Calibrator is fully programmable over an RS-232 link with a PC via the rear-panel RS-232 port. You can enter individual commands from a terminal, write your own programs with a Windows-based language such as Visual Basic, or run optional Windows-based Fluke software.

The RS-232 cable length for the port should not exceed 15 meters (50 feet). Longer cable lengths are permitted if the load capacitance measured at a connection point (including the signal terminator) does not exceed 2500 pF.

RS-232 Port Setup Procedure

Set up the RS-232 Port from the system menu.

To set RS-232 parameters:

1. Tap the **Setup** softkey.
2. Select **System Settings**.
3. Select **Remote Port Setup > RS-232**.

Exceptions for Serial and Ethernet Remote Control

When the RS-232/Ethernet port remotely controls the Calibrator, either interactively with a terminal or under computer control, operation is the same as with an IEEE-488 controller connected to the IEEE-488 port for control. These are exceptions:

- Control/C does the same function as DCL (Device Clear) or SDC (Selected Device Clear).
- The EOL (End of Line) input terminator is Carriage Return (Control/M) or Line Feed (Control/J). All output lines are terminated by the terminator programmed in a setup menu, or set with the remote command SP_SET. This setting applies to all lines, including those with the *PUD command (see the next bullet point).
- For the *PUD (Protected User Data) Command, that stores characters for later recall, the serial remote interface does not store the subsequent characters: Control/C, Line Feed (Control/J), Carriage Return (Control/M), Control/S (XOFF), Control/Q (XON). These characters are processed as described above. They cannot be a part of the *PUD command. The *PUD command terminates with Line Feed or Carriage Return, the same as all other serial remote commands.
- There is no SRQ capability when serial remote control is used. The status registers still behave as described in this section, but the Calibrator serial interface does not have a way to perform the SRQ function.
- There are three special commands available only for serial/Ethernet remote control (Remote, Local, Lockout).

Ethernet Interface

The subsequent sections describe how to use an Ethernet interface with the Calibrator.

Set up and Connect the Ethernet Interface

Refer to the specifications for the LAN network, and use this section to set up the Ethernet interface for the application.

To get to the **Ethernet Setup** menu, tap **Setup > System Settings > Ethernet**.

Note

Connect to the LAN network before you make any changes to the Ethernet configuration.

When addressing some LAN addresses, computers often interpret zeros in the IP address as OCTAL values. As an example, if the IP address is configured from the front panel as 129.196.017.023. Attempts to establish a connection to 129.196.017.023 can result in a connection request to 129.196.15.19 rather than 129.196.17.23. 017 is interpreted as Octal 17 which is Decimal 15, 023 is interpreted as Octal 23 which is Decimal 19.

Configure Network Security – Allowed Host IP Addresses

Use the **Network Security** entries to limit the IP addresses of devices allowed to connect to the 5560A Ethernet interface. Specify a maximum of three address ranges and enable or disable each range as needed.

Set the Starting IP Address

The **Starting IP Address** is the first IP address allowed to connect to the 5560A.

Set the Ending IP Address

The **Ending IP Address** is the last address in the range allowed and must be equal to or greater than the Starting IP Address. If the ending address and the starting address are equal then only a single address is allowed.

Set Range Enable / Disable

Use the **Set Range Enable / Disable** function to disable the range. If all three ranges are disabled, no Ethernet access is allowed.

Set the IP Address

An Internet (IP) address is necessary for all Internet and TCP/IP communications. If DHCP is enabled, the Calibrator uses the dynamic address supplied by the DHCP server. If the DHCP server fails to supply the address, the IP address is shown as 0.0.0.0.

Select the Dynamic Host Configuration Protocol (DHCP)

Dynamic Host Configuration Protocol (DHCP) is a client-server protocol that eliminates the manual set up of permanent/static IP addresses. The DHCP server provides configuration parameters (dynamic IP address, subnet mask, and default gateway IP addresses) that are necessary for a client to participate in an IP network.

DHCP is the easiest way to configure the Calibrator for remote communication through the LAN interface. DHCP is enabled by default when the Calibrator is shipped from the factory. When connected to a network, and the LAN port is enabled, the Calibrator attempts to retrieve the parameters from a DHCP server necessary for communications.

To disable or enable DHCP on the Calibrator, from the LAN menu, tap **DHCP**. If DHCP is already enabled, **ON** shows on the selection label.

To use DHCP addressing:

1. Connect a LAN cable from a hub to the LAN port on the back of the Calibrator.
2. Select the ON radio button for DHCP in the Ethernet menu.

Set a Static Internet Address

The Calibrator comes from the factory with 169.254.001.001 in the static IP address register.

Note

If the Calibrator is to be used on a corporate LAN and DHCP is not used, contact the network administrator for a static IP address to be used exclusively by the Calibrator. DHCP must be disabled to set a static IP address.

To change the Calibrator static IP address:

1. Select the **Static IP Address** box.
2. Use the numeric keypad to enter a new value.
3. Push **ENTER**.

Note

*The IP address is stored in non-volatile memory, and does not change when power is removed and reapplied to the Calibrator or when the Calibrator receives an *RST command.*

Configure the General Network Socket Port

In order to communicate with each other, a client computer and the Calibrator must use the same socket port number. The default port is 3490. Typically, the default port does not need to be changed. If the socket port must be changed, enter the Socket Port number supplied by the network administrator.

To change the Socket Port number:

1. Tap the **Setup** softkey.
2. Tap **System Settings > Ethernet**.
3. In the right column you will see **Port** with a box where you can enter a new value.

Note

The Network Socket Port Number is stored in non-volatile memory.

Configure the LAN Default Gateway

The default gateway IP address is the IP address of a gateway (router) attached to the same network as the device. When the Calibrator detects that a client computer is not on the same network (with the network number), the data is sent through the gateway to reach the host computer. The default for the Calibrator is 0 (no gateway, and subnetting is in use).

To set the LAN Default Gateway address:

1. Select the **Gateway** box from the Ethernet menu.
2. Use the numeric keypad to enter a new value.
3. Push **ENTER**.

Set the LAN Subnet Mask

If communication between the client computer and the Calibrator passes through a router or gateway, and DHCP is disabled, you must set the subnet mask and default gateway address on both the client computer and the Calibrator. Get the correct subnet mask and gateway address from the network administrator. The LAN Subnet Mask is a 32-bit number. This number is represented as four 3-digit segment numbers on the display. The default subnet mask set at the factory is 255.255.255.0.

To change the Calibrator subnet mask:

1. Select the **Netmask** box.
2. Use the numeric keypad to enter a new value.
3. Push **ENTER**.

Read the MAC Address

The MAC Address is set at the factory and cannot be changed. The MAC address can be read from the **Ethernet** setup menu. Another way to access the MAC address with a remote connection is to send the MACADDR? remote command.

Establish an Ethernet Connection

Telnet is the easiest method to establish an Ethernet connection with the Calibrator. Telnet is a client-server protocol, based on TCP. The Telnet Protocol provides a fairly general, bi-directional, eight-bit byte oriented communications method. Telnet is available on all UNIX servers and on most PCs. The Windows PUTTY application can also be used.

The LAN connection to the Calibrator must be established with the specified Network Socket Port. See [Configure the General Network Socket Port](#). When you power on the Calibrator, a LAN server initiates in the Calibrator that listens for client connections on the socket port at the specified IP address.

To establish a LAN connection to the Calibrator from a computer with either UNIX, LINUX, or MS-DOS command prompts:

1. At the command prompt on the client computer, enter:

```
telnet <IP Address> <Socket Port>
```

As an example, if the IP address is known to be 129.196.136.131 and the Socket Port is set to 3490.

2. At a command prompt from any client computer, enter:

```
telnet 129.196.136.131 3490
```

Once the internal LAN server connects with the client computer, the LAN server rejects any other connection attempts by other computers/clients and will *tunnel* a channel to the connected computer. This prevents multiple computers from trying to control the Calibrator.

Terminate an Ethernet Connection

To terminate the Ethernet connection, terminate the Telnet session on the client computer. Client Telnet session termination can vary from computer to computer. Typically, if you terminate the shell (or command window in DOS) this terminates the Telnet session. When the client terminates the Telnet session, the LAN server in the Calibrator goes back into listen mode and waits for a new client to make a LAN connection request.

Ethernet Remote Control

When the Ethernet port is used to remotely control the Calibrator, either interactively with a terminal or under computer control, operation is the same as with an RS-232 controller connected to the RS-232 port for control.

Change Between Remote and Local Operation

In addition to local mode (front-panel operation) and remote, the Calibrator can be placed in a local lockout condition at any time by command of the controller. Combined, the local, remote, and lockout conditions yield four possible operational states:

Local State

The Calibrator responds to local and remote commands. This is normal front panel operation. All remote commands are allowed to execute.

Local with Lockout State

Local with lockout is identical to local, except the Calibrator will go into the remote with lockout state instead of the remote state when it receives a remote command.

Remote State

In the remote state, the display continues to show the output setting or measurement as in local operation. To put the Calibrator in a remote state, use the RS-232/Ethernet REMOTE command, or IEEE-488 asserting the REN line or USBTMC sending a REN signal.

The display changes reflect **REMOTE CONTROL**.

The display shows information about the present output function. However, the Calibrator restricts front panel operation to use of the power switch and the **Go To Local** softkey. To return the Calibrator to the local state:

- Push the **Go to Local** softkey and use RS-232/Ethernet to send the LOCAL command.
- or
- Use IEEE-488/USB to send the GTL (Go To Local) message.

Remote with Lockout State

In the lockout state, the Calibrator front panel controls are inoperable. To enter the lockout state use the RS-232/Ethernet LOCKOUT command, or the IEEE-488 message LLO or the USB LOCAL_LOCKOUT message.

The display shows information about the present output function. However, front panel operation is restricted to use of the power switch. To return the Calibrator to the local with lockout state, send the RS-232/Ethernet LOCAL command, or the IEEE-488 GTL (Go To Local) message, or USBTMC GO_TO_LOCAL message. Only the remote interface that placed the instrument into the LOCKOUT state, can take the instrument out of the LOCKOUT state.

Table 3 summarizes the possible Remote/Local state transitions. (For more information on IEEE-488 (GPIB) messages, see [IEEE-488 Bus Communication Overview](#).)

Table 3. Operating State Transitions

From	To	Front Panel	GPIB Message	USBTMC Command	RS-232/ Ethernet Command
Local	Remote		MLA (REN True)	REN Control=true and (Initiate Clear or TRIGGER or DEV_DEP_MSG_OUT)	REMOTE
	Local with Lockout		LLO	REN Control=true and LOCAL_LOCKOUT	LOCKOUT
Remote	Local	Go to Local Softkey	GTL or REN False	GO_TO_LOCAL or REN Control=false or cable disconnect	LOCAL
	Remote with Lockout		LLO	LOCAL_LOCKOUT	LOCKOUT
Local with Lockout	Local		REN False	REN_Control=false	LOCAL
	Remote with Lockout		MLA (REN True)	Initiate Clear or TRIGGER or DEV_DEP_MSG_OUT	REMOTE
Remote with Lockout	Local		REN False	REN_Control=false	REMOTE
	Local with Lockout		GTL	GO_TO_LOCAL or cable disconnect.	

RS-232 Interface Overview

The RS-232 port is a EIA (Electronic Industries Association) standard RS-232. RS-232 is a serial binary data interchange that operates from 9600 baud to 115200 baud (selectable), and distances up to 50 feet. The Calibrator rear-panel RS-232 port is configured as DTE (Data Terminal Equipment).

See Figure 1. See [RS-232/IEEE-488 Cables and Connectors](#).

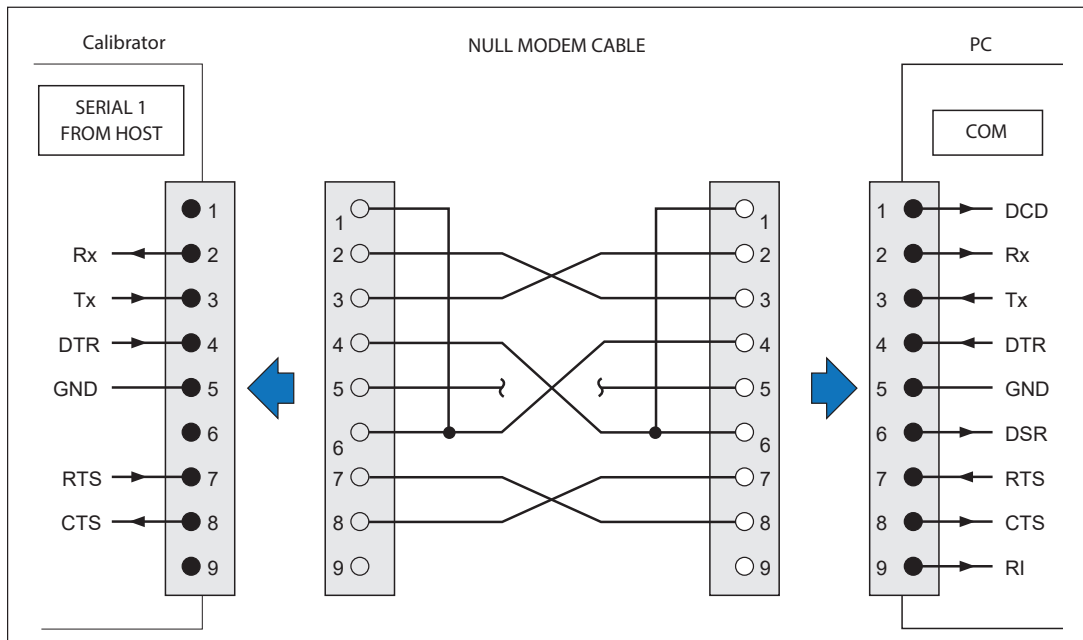
For detailed information, see the EIA standard RS-232.

A summary of RS-232 terms, interface lines and mnemonics are shown in Table 4.

Table 4. RS-232 Interface Wiring

Mnemonic	Description
CTS	Clear to Send
DB-9	Type DB connector, 9 pins (See Figure 1)
DB-25	Type DB connector, 25 pins
DCD	Data Carrier Detect
DCE	Data Communications Equipment
DSR	Data Set Ready
DTE	Data Terminal Equipment
DTR	Data Terminal Ready
GND	Ground
RI	Ring Indicator
RLSD	Received Line Signal Detector
RTS	Request to Send
RX	Receive Line
TX	Transmit Line

Figure 1. Serial Port Connections (DB-9/DB-9)



RS-232/IEEE-488 Cables and Connectors

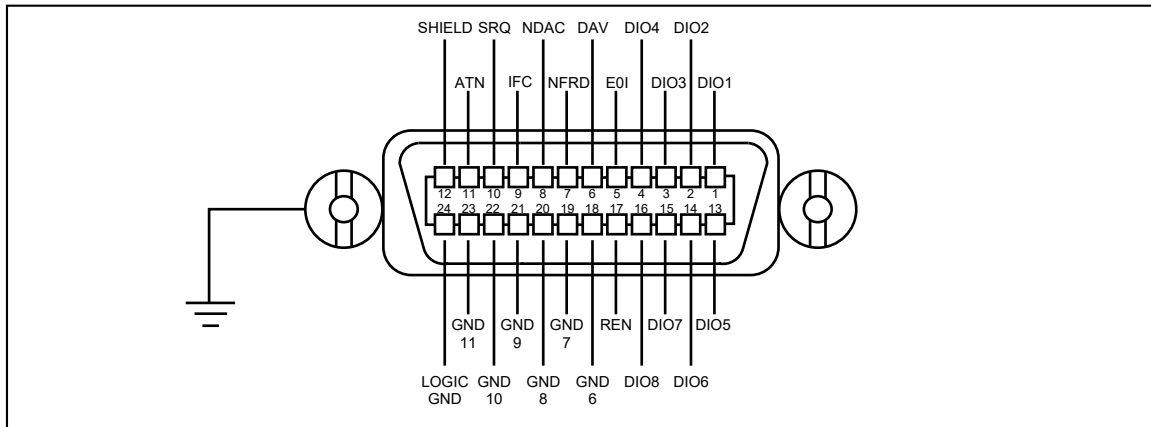
IEEE-488 Connector

The IEEE-488 connector on the rear panel mates with an IEEE-488 standard cable. The pin assignments of the rear-panel IEEE-488 connector are shown in Figure 2. IEEE 488 connection cables are available from Fluke as shown in Table 5. See the Operators Manual for order information.

Table 5. IEEE-488 Connection Cables

IEEE-488 Connection Cable	Fluke Calibration Part Number
0.5 m (1.64 feet)	PM2295/05
1 m (3.28 feet)	PM2295/10
2 m (6.56 feet)	PM2295/20

Figure 2. IEEE-488 Connector Pinout (connection side)



RS-232 Serial Connector

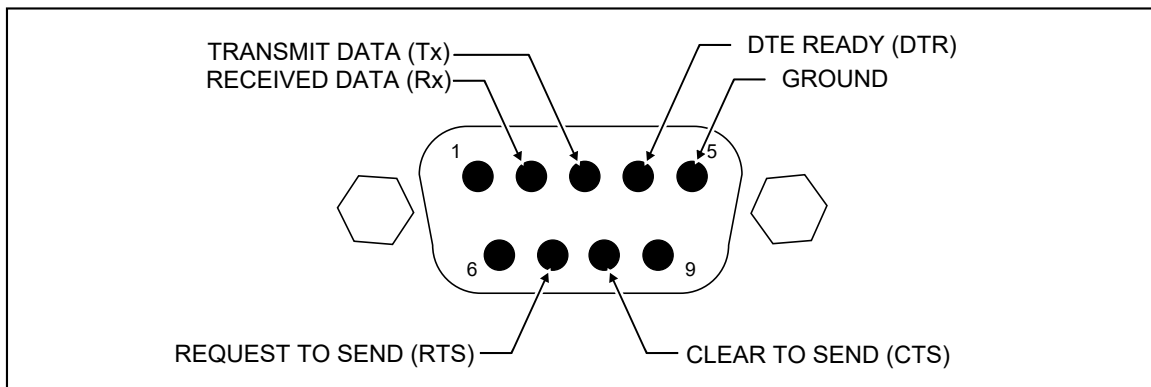
The 9 pin serial connector on the rear of the Calibrator interfaces to a computer or controller. The pin assignments of the rear-panel serial connector conforms to EIA/TIA-574 standard and is shown in Figure 3.

Serial connection cables available from Fluke Calibration are listed in Table 6.

Table 6. Serial Port Connection Cables

Connection Cable		Fluke Calibration Part Number
RS-232	PC COM port (DB-9)	PM8914/001

Figure 3. From RS-232 Port Connector Pinout



IEEE-488 Interface Overview

The IEEE-488 parallel interface sends commands as data and receives measurements and messages as data. The maximum data exchange rate is 1 Mbyte, with a maximum distance of 20 meters for the sum length of the cable connections. A single cable should not exceed 4 meters in length. Some commands are reserved for RS-232/Ethernet operation because these functions must be implemented as IEEE messages per the IEEE-488.1 Standards. For example, the command REMOTE could be sent as data over the IEEE-488 interface to place the Calibrator into remote, but the message is not sent as data because the IEEE Standards call for the remote function to be sent to the device as the uniline message REN. This is also true for several other commands and functions, as shown below, with their equivalent RS-232/Ethernet emulation. A summary of IEEE-488 messages is shown in Table 7.

Table 7. RS-232/Ethernet Emulation of IEEE-488 Messages

IEEE-488 Message	RS-232/Ethernet Equivalent
GTL	LOCAL command
GTR	REMOTE command
LLO	LOCKOUT command
SDC, DCL	^C (<Cntl> C) character [clear the device]
GET	^T (<Cntl> T) character [execute a group trigger]
SPE, SPD	^P (<Cntl> P) character [print the serial poll string]
UNL, UNT	(not emulated on RS-232/Ethernet)

The IEEE-488 interface is based on the IEEE Standards 488.1 (GPIB) and 488.2. For detailed information, refer to the standards IEEE-488.1 (GPIB) and IEEE-488.2.

IEEE-488.1 IEEE-488.1 (GPIB) is the hardware portion of the interface. The parallel signal lines are divided into eight lines for the data bus, three lines for the handshake, and five lines for bus management. The handshake lines take care of the timing for data exchange. The bus management lines control the operation of data exchange. The ATN line indicates the use of the DIO lines for addresses or messages (true), or for DIO data (false). The EOI line is used with the data lines to mark the end of a message, and with the ATN line for polling. The SRQ line is used by the devices to indicate to the controller that they require service. The IFC line is used by the controller to quickly get all the devices on the bus to stop talking and start listening. The REN line is used to implement the remote/local states.

IEEE-488.2 IEEE-488.2 is the software portion of the interface, that specifies data formats, common commands, message exchange protocol and the status register implementation.

Use the key below to decode the columns in Table 8. [RS-232/IEEE-488 Cables and Connectors](#) shows a typical IEEE-488 connector and pin assignments.

Type	M – Multiline	
	U - Uniline	
Class	AC - Addressed Command	DD - Device Dependent
	AD - Address (Talk or listen)	HS – Handshake
	UC - Universal Command	SE – Secondary
	ST - Status	
Other	B1, B2, for example - Information Bits	Logic Zero = 0 = False
	Blanks - Doesn't Care condition	Logic One = 1 = True

Table 8. IEEE-488 Remote Message Coding

M N E M	MESSAGE NAME	T Y P E	C L A S S	DATA BUS								HAND- SHAKE			BUS MANAGEMENT						
				D I O 8	D I O 7	D I O 6	D I O 5	D I O 4	D I O 3	D I O 2	D I O 1	D A V	N R F D	N D A C	A T N	E O I	S R Q	I F C	R E N		
ACG	Addressed Command Group	M	AC		0	0	0										1				
ATN	Attention	U	UC														1				
DAB	Data Byte	M	DD	B8	B7	B6	B5	B4	B3	B2	B1						0				
DAC	Data Accepted	U	HS												0						
DAV	Data Valid	U	HS										1								
DCL	Device Clear	M	UC		0	0	1	0	1	0	0						1				
END	End	U	ST														0	1			
EOS	End Of String	M	DD	B8	B7	B6	B5	B4	B3	B2	B1						0				
GET	Group Execute Trigger	M	AC		0	0	0	1	0	0	0						1				
GTL	Go To Local	M	AC		0	0	0	0	0	0	1						1				
IDY	Identify	U	UC															1			
IFC	Interface Clear	U	UC																	1	
LAG	Listen Address Group	M	AD		0	1											1				1
LLO	Local Lock Out	M	UC		0	0	1	0	0	0	1						1				
MLA	My Listen Address	M	AD		0	1	B5	B4	B3	B2	B1						1				
MTA	My Talk Address	M	AD		1	0	B5	B4	B3	B2	B1						1				
MSA	My Secondary Address	M	SE		1	1	B5	B4	B3	B2	B1						1				
NUL	Null Byte	M	DD		0	0	0	0	0	0	0										
OSA	Other Secondary Address	M	SE	(OSA = SCG and MSA-NOT)																	
OTA	Other Talk Address	M	AD	(OTA = TAG and MTA-NOT)																	
PCG	Primary Command Group	M	----	(PCG = ACG or UCG or LAG or TAG)																	
PPC	Parallel Poll Configure	M	AC		0	0	0	0	1	0	1						1				
PPE	Parallel Poll Enable	M	SE		1	1	0	B4	B3	B2	B1						1				
PPD	Parallel Poll Disable	M	SE		1	1	1	B4	B3	B2	B1						1				
PPR1	Parallel Poll Response 1	U	ST								1						1	1			
PPR2	Parallel Poll Response 2	U	ST							1							1	1			
PPR3	Parallel Poll Response 3	U	ST						1								1	1			
PPR4	Parallel Poll Response 4	U	ST					1									1	1			
PPR5	Parallel Poll Response 5	U	ST				1										1	1			
PPR6	Parallel Poll Response 6	U	ST			1											1	1			
PPR7	Parallel Poll Response 7	U	ST		1												1	1			
PPR8	Parallel Poll Response 8	U	ST	1													1	1			
PPU	Parallel Poll Unconfigure	M	UC		0	0	1	0	1	0	1						1				
REN	Remote Enable	U	UC																		1
RFD	Ready For Data	U	HS											0							
RQS	Request For Service	U	ST		1												0				
SCG	Secondary Command Group	M	SE		1	1											1				
SDC	Selected Device Clear	M	AC		0	0	0	0	1	0	0						1				
SPD	Serial Poll Disable	M	UC		0	0	1	1	0	0	1						1				
SPE	Serial Poll Enable	M	UC		0	0	1	1	0	0	0						1				
SRQ	Service Request	U	ST																1		
STB	Status Byte	M	ST	B8		B6	B5	B4	B3	B2	B1						0				
TCT	Take Control	M	AC		0	0	0	1	0	0	1						1				
TAG	Talk Address Group	M	AD		1	0											1				
UCG	Universal Command Group	M	UC		0	0	1										1				
UNL	Unlisten	M	AD		0	1	1	1	1	1	1						1				
UNT	Untalk	M	AD		1	0	1	1	1	1	1						1				

USBTMC Interface Overview

The USBTMC interface uses the bulk-out endpoint to send GPIB ATN=FALSE program messages to the Calibrator. The bulk-out endpoint is also used to send trigger command messages to the Calibrator.

The bulk-in endpoint receives GPIB ATN=FALSE response messages from the Calibrator.

The Calibrator uses the interrupt-in endpoint to request service (it sends an SRQ message to the controller) and to communicate the status byte register value. The SRQ condition communicated automatically whenever the RQS bit is set in the Status Byte Register.

The control endpoint is used to send initiate clear (DCL,SDC) messages, REN enable messages (REN), GO_TO_LOCAL (GTL), LOCAL_LOCKOUT (LLO) and READ_STATUS_BYTE (SPL).

How to Use Commands

Communications between the controller and the Calibrator consists of commands, queries, and interface messages. Although the commands are based on the 488.2 standard, they can be used on either the IEEE-488, USBTMC, Ethernet or RS-232 interface, except for a few specialized RS-232/Ethernet commands described in [Commands for RS-232/Ethernet Only](#). (For more information on command structures, see the IEEE 488.2 standard.)

Refer to [Remote Commands](#) when you require additional information about command references used this section.

All commands and units may be entered in UPPER or lower case.

There are four specific remote control configurations that use commands, queries and interface messages: IEEE-488/GPIB, USBTMC, RS-232/Ethernet Terminal function, and RS-232/Ethernet Computer Mode.

IEEE-488/GPIB Mode Use the IEEE-488/GPIB mode when the Calibrator is operated by computer program. In this mode, requested information is returned by query, and interface messages are queued and returned by command.

USBTMC Mode Use the USBTMC mode when the Calibrator is operated by computer program. In this mode, requested information is returned by query, and interface messages are queued and returned by command.

RS-232/Ethernet Terminal Mode The RS-232 and/or Ethernet terminal mode is an interactive mode where an operator inputs commands, with immediate returns for requested information (queries) and interface messages.

RS-232/Ethernet Computer Mode Use the RS-232 and/or Ethernet computer mode when the Calibrator is operated by computer program. In this mode, requested information is returned by query, and interface messages are queued and returned by command.

Types of Commands

The Calibrator can group commands into one or more categories, depending on how they function. Each category is described below.

Device-Dependent Commands

Device-dependent commands are unique to the Calibrator. An example of a device-dependent command is,

```
OUT 100 V, 1 A, 60 HZ
```

this instructs the Calibrator to source 100 watts of ac power.

Common Commands

Common commands are defined by the IEEE 488.2 standard and are common to most bus devices. Common commands always begin with an * (asterisk) character. Common commands are available whether you use the IEEE-488, USBTMC, RS-232 or Ethernet interface for remote control. An example of a common command is,

```
*IDN?
```

this instructs the Calibrator to return the instrument identification string.

Query Commands

Query commands request information, which is returned as the command executes (RS-232/Ethernet), or placed in a buffer until requested (GPIB/USBTMC). An example of a query, which always end with a question mark, is,

```
RANGE?
```

this instructs the Calibrator primary and secondary (if in dual output function) range values.

Interface Messages (IEEE-488)

Interface messages manage traffic on the IEEE-488 interface bus. Device addressing and clearing, data handshaking, and commands to place status bytes on the bus are all directed by interface messages. Some of the interface messages occur as state transitions of dedicated control lines. The rest of the interface messages are sent over the data lines with the ATN signal true. (All device-dependent and common commands are sent over the data lines with the ATN signal false.)

Note that interface messages, unlike device-dependent and common commands, are not sent literally (in a direct way). For example, when you send a device-dependent query to the Calibrator, the controller automatically sends the interface message MTA (My Talk Address).

IEEE-488 standards define interface messages. Table 9 lists the interface messages that the Calibrator accepts. Table 10 lists the interface messages that the Calibrator sends. The interface messages that the Calibrator sends are also listed. The mnemonics listed in the tables are not sent as literal statements as commands are. In this way they are different from device-dependent and common commands.

Interface messages are handled automatically in most cases. For example, handshake messages DAV, DAC, and RFD automatically occur under the direction of an instrument's interface itself as each byte is sent over the bus.

Table 9. IEEE-488 Interface Messages (Received)

Mnemonic	Name	Function
ATN	Attention	A control line that, when asserted, notifies all instruments on the bus that the next data bytes are an interface message. When ATN is low, the next data bytes are interpreted as device-dependent or common commands addressed to a specific instrument.
DAC	Data Accepted	Set the handshake signal line NDAC low.
DAV	Data Valid	Asserts the handshake signal line DAV.
DCL	Device Clear	Clears the input/output buffers.
END	End	A message that occurs when the Controller asserts the EOI signal line before it sends a byte.
GET	Group Execute Trigger	Trigger a TC measurement and put the reading in the output buffer.
GTL	Go To Local	Transfer control of the Calibrator from one of the remote states to one of the local states. (See Table 3)
LLO	Local Lockout	Transfers remote/local control of the Calibrator. (See Table 3)
IFC	Interface Clear	A control line that sets the interface to a quiescent state.
MLA	My Listen Address	Addresses a specific device on the bus as a listener. The controller sends MLA automatically whenever it directs a device-dependent or common command to a specific instrument.
MTA	My Talk Address	Addresses a specific device on the bus as a talker. The controller sends MTA automatically whenever it directs a device-dependent or common query to a specific instrument.
REN	Remote Enable	Transfer remote/local control of the Calibrator. (See Table 3)
RFD	Ready For Data	Set the handshake signal line NRFD low.
SDC	Selected Device Clear	Does the same as DCL, but only if the Calibrator is currently addressed as a listener.
SPD	Serial Poll Disable	Cancels the effect of a Serial Poll Enable.
SPE	Serial Poll Enable	After the Calibrator receives this message, it sends the Status Byte the next it is addressed as a listener, no matter what the command is.
UNL	Unlisten	Unaddresses a specific device on the bus as a listener. The controller sends UNL automatically after the device has successfully received a device-dependent or common command.

Table 9. IEEE-488 Interface Messages (Received)

Mnemonic	Name	Function
UNT	Untalk	Unaddresses a specific device on the bus as a listener. The controller sends UNL automatically after the device has successfully received a device-dependent or common query.

Table 10. IEEE-488 Interface Messages (Sent)

Mnemonic	Name	Function
END	End	A message that occurs when the Calibrator asserts the EOI control line. The Calibrator asserts EOI while it transmits the ASCII character LF for its termination sequence or terminator.
DAC	Data Accepted	Set the handshake signal line NDAC low.
DAV	Data Valid	Asserts the handshake signal line DAV.
RFD	Ready for Data	Set the handshake line NRFD low.
SRQ	Service Request	A control line that any device on the bus can assert to indicate that it requires attention. See Check Product Status for details.
STB	Status Byte	The status byte is what the Calibrator sends when it responds to a serial poll (interface message SPE).

Compound Commands

A compound command is two or more commands in a single command line. For example, these two commands could be entered individually,

```
OUT 1 V, 60 HZ
OPER
```

where the Calibrator sources 1 V ac at 60 Hz, and then goes into operate, or they could be combined into a compound command, that uses a semi-colon as a separator.

```
OUT 1 V, 60 HZ ; OPER
```

Use care when a compound command includes any of the coupled commands. (See [Coupled Commands](#))

Coupled Commands

A coupled command refers to two or more commands that appear in a compound command (see [Compound Commands](#)) that perform actions that could interfere with each other and cause a fault. Commands in a compound command are separated by the use of the ; character. Compound commands that use only coupled commands are not order-dependent.

In [Remote Commands](#), the command shows a checkbox for coupled commands.

The coupled commands are:

DBMZ	TMWAVE
DC_OFFSET	TRIG
HARMONIC	VIDEOFMT
OUT	VIDEOMARK
OUT_IMP	WAVE
RANGE	

An example of the coupled command interference is the command

```
*RST; OUT 100V, 1kHz; WAVE SINE
```

Followed by the commands

```
WAVE TRI
OUT 10V, 1kHz
```

The `WAVE TRI` causes an error. At 100 V, only sine waves are allowed. Both `WAVE` and `OUT` are coupled commands. So, the compound command

```
WAVE TRI; OUT 10V, 1kHz
```

executes successfully. The `WAVE` and `OUT` are programmed together and at 10 V, triangle waves are allowed.

Overlapped Commands

Commands that begin execution, but require slightly more time to complete, are called overlapped commands because they can be overlapped by the next command before they have completed execution.

In [Remote Commands](#), the command shows a checkbox for overlapped commands.

The overlapped commands, excluding scope commands, are:

BOOST	LOWS	RTD_TYPE
DBMZ	MULT	STBY
DC_OFFSET	OLDREF	SYNCOUT
DPF	OPER	TC_OFFSET
DUTY	OUT	TC_OTCD
EXTGUARD	PHASE	TC_REF
EXTSENSE	POST_52120	TC_TYPE
HARMONIC	RANGELCK	TSENS_TYPE
INCR	REFPHASE	WAVE
LCOMP_52120	*RST	ZCOMP

You can use the command `*WAI` to wait until the overlapped command has completed execution before you execute the next command. For example,

```
OUT 1 V, 1 A, 60 HZ ; *WAI
```

You can also use the status commands `*OPC` and `*OPC?` to detect completion of overlapped commands, see [Check Product Status](#).

Sequential Commands

Commands that execute immediately are called sequential commands.

In [Remote Commands](#), the command shows a checkbox for sequential commands.

The majority of the commands are sequential.

Commands that Require You to Unsecure the Calibrator

These commands do not work unless the Calibrator has been unsecured with the `cal_secure` command:

```
CLOCK      (when you set date but not time)
*PUD
RPT_STR
CAL_PASSCODE
VER_DATE
VER_TEMP
```

If you attempt to use any of these commands with the Calibrator in a secure state, the Calibrator logs an error into the error queue. (Or it returns the error message if in the RS-232/Ethernet Terminal Mode.)

Commands for RS-232/Ethernet Only

The RS-232/Ethernet checkbox indicates RS-232 and/or Ethernet interface commands.

The IEEE-488, USBTMC, Ethernet and RS-232 interfaces all send commands to the Calibrator as data, except for those IEEE-488 functions that must be implemented as a message as specified in the IEEE-488 standards. For example, the RS-232 and Ethernet interfaces use the command `REMOTE` to place the Calibrator in the remote mode. Although the IEEE-488 interface could also send a command `REMOTE` as data, it does not because this is one of the functions that must be implemented per IEEE-488.1 Standard. The relationship between these IEEE-488 messages and the equivalent RS-232/Ethernet emulation is shown in Table 11.

Table 11. Commands for RS-232/Ethernet Only

IEEE-488 Message	RS-232/Ethernet Equivalent
GTL	LOCAL command
GTR	REMOTE command
LLO	LOCKOUT command
SRQ	SRQSTR command
SDC, DCL	^C (<Cntl> C) character [clear the device]
GET	^T (<Cntl> T) character [execute a group trigger]
SPE, SPD	^P (<Cntl> P) character [print the serial poll string]

In addition to the commands and special characters that emulate the IEEE-488 functions shown above, there are several more commands that are related to operation and control of the actual RS-232 or Ethernet port and are therefore completely unrelated to IEEE-488/USBTMC operations. These include these commands.

```

SP_SET      SRQSTR?
SP_SET?    SPLSTR?

```

Commands for IEEE-488 Only

The IEEE-488 checkbox indicates commands that are used for the IEEE-488 interface. This is all of the commands, except for those used for RS-232/Ethernet operations, see [Commands for RS-232/Ethernet Only](#). All commands are transferred over the IEEE-488 as data, except for the commands LOCAL, REMOTE, and LOCKOUT. These are implemented per IEEE-488.1 Standard as messages, see Table 12.

Table 12. Commands for IEEE-488 Only

IEEE-488 Message	Command Representation
GTL	LOCAL command
GTR	REMOTE command
LLO	LOCKOUT command
SRQ	SRQSTR command
SDC, DCL	Clear the device
GET	Execute a group trigger
SPE, SPD	Print the serial poll string

Command Syntax

The syntax rules below apply to all the remote commands. Information about syntax of response messages is also given.

Parameter Syntax Rules

Table 13 lists the units accepted in command parameters and used in responses. All commands and units may be entered in UPPER or lower case.

Table 13. Units Accepted in Parameters and Used in Responses

Units	Meaning
HZ	Frequency in units of hertz
KHZ	Frequency in units of kilohertz
MHZ	Frequency in units of megahertz
UV	Volts in units of microvolts
MV	Volts in units of millivolts
V	Volts in units of volts
KV	Volts in units of kilovolts
UA	Current in units of microamperes
MA	Current in units of milliamps
A	Current in units of amps
PCT	Percent
PPM	Parts-per-million
DBM	Volts in units of decibels referenced to 1 milliwatt into 600 Ω load
OHM	Resistance in units of ohms
KOHM	Resistance in units of kilohms
MOHM	Resistance in units of megohms
NF	Capacitance in units of nanofarads
PF	Capacitance in units of picofarads
UF	Capacitance in units of microfarads
MF	Capacitance in units of millifarads
F	Capacitance in units of farads
CEL	Temperature in degrees Celsius
FAR	Temperature in degrees Fahrenheit
NS	Period in units of nanoseconds
US	Period in units of microseconds
MS	Period in units of milliseconds
S	Period in units of seconds

General Rules The general rules for parameter usage is as follows:

- When a command has more than one parameter, the parameters must be separated by commas. For example: `OUT 1V, 2A`.
- Numeric parameters may have up to 15 significant digits and their exponents can be in the range $\pm 1.0E\pm 20$.
- Including too many or too few parameters causes a command error.
- Missing parameters cause an error, for example, the adjacent commas in `OUT 1V, , 2A`.
- Expressions, for example `4+2*13`, are not allowed as parameters.
- Binary Block Data can be in one of two forms: Indefinite Length and Definite Length format (both IEEE-488.2 standards).

Indefinite Length The Indefinite Length format accepts data bytes after the #0 until the ASCII Line Feed character is received with an EOI signal (for RS-232 or Ethernet, just a line feed or carriage return will terminate the block).

Definite Length The Definite Length format specifies the number of data bytes. The data bytes are preceded by #n and an n-digit number. The n-digit number identifies how many data bytes follow. For examples, see the *PUD command descriptions in [Remote Commands](#).

Extra Space or Tab Characters

In the command descriptions in the Remote Commands section, parameters are shown separated by spaces. One space after a command is required (unless no parameters are required). All other spaces are optional. Spaces are inserted for clarity in the manual and may be left in or omitted. You can insert extra spaces or tabs between parameters. Extra spaces within a parameter are generally not allowed, except for between a number and its associated prefix or unit. See [Remote Commands](#) for examples of commands whose parameters or responses are not self-explanatory.

Terminators

Table 14 summarizes the terminator characters for the IEEE-488, USBTMC, Ethernet and RS-232 remote interfaces.

Table 14. Terminator Characters

Terminator Function	ASCII Characters		Control Command Terminator	Language Command Terminator
	Number	Program		
Carriage Return (CR)	13	Chr(13)	<Cntrl> M	\n
Line Feed (LF)	10	Chr(10)	<Cntrl> J	\r
Backspace (BS)	8	Chr(8)	<Cntrl> H	\b
Examples:				
RS-232 Terminal Mode	OUT 1 V, 60 Hz		<Enter>	
RS-232 Computer Mode	Comm1.Output = "OUT 1 V, 60 Hz" + Chr(10)			
IEEE-488 Mode	OUT 1 V, 60 Hz			
(command only)	DUT_SEND "REMS\n"			

IEEE-488 Interface The Calibrator sends the ASCII character Line Feed with the EOI control line held high as the terminator for response messages. The Calibrator recognizes these as terminators when encountered in incoming data:

- ASCII LF character
- Any ASCII character sent with the EOI control line asserted

RS-232 and Ethernet Interface The Calibrator returns an EOL (End of Line) character with each response to the PC. This is selectable as Carriage Return (CR), Line Feed (LF) or both CRLF, see [RS-232 Port Setup Procedure](#). Commands sent to the Calibrator must end in either a CR or LF, or both.

Incoming Character Processing

The Calibrator processes all incoming data as follows (except Binary Block Data as described in [Parameter Syntax Rules](#)):

- The most significant data bit (DIO8) is ignored.
- All data is taken as 7-bit ASCII.
- Lower-case or upper-case characters are accepted.
- ASCII characters whose decimal equivalent is <32 (Space) are discarded, except for characters 10 (LF) and 13 (CR) and in the *PUD command argument. Binary Block Data allows all characters in its argument and terminates in a special way.

Response Message Syntax

In the command descriptions in [Remote Commands](#), responses from the Calibrator are described wherever appropriate. In order to know what type of data to read in, refer to the first part of the entry under *Response* in the tables. The response is identified as one of the data types in Table 15.

Table 15. Response Data Types

Data Type	Description
Integer	Integers for some controllers or computers are decimal numbers in the range -32768 to 32768. Responses in this range are labeled Integer. Example: *ESE 123; *ESE? returns: 123
Floating	Numbers that may have up to 15 significant figures plus an exponent that may range from $\pm E20$. Example: DC_OFFSET? returns: 1.4293E+00
String	Any ASCII characters including quotation mark delimiters. Example: RPT_STR Fluke 5560A;RPT_STR? returns: Fluke 5560A
Character Response Data (CRD)	This type of response is always a keyword. Example: OUT 10V, 100HZ; FUNC? returns: ACV
Indefinite ASCII (IAD)	Any ASCII characters followed by EOM. Queries with this type of response MUST be the last Query in a program message. Example: *OPT? returns: SC600 CAL reports and lists which contains Line Feeds are typically of this type.
Binary Block Data	A special data type defined by the IEEE-488.2 standard. This type is used in *PUD? query. It is defined as follows: #(non-zero digit) (digits) (user data) The non-zero digit specifies the number of characters that will follow in the <digits> field. Characters allowed in the digits field are 0 through 9 (ASCII 48 through 57 decimal). The value of the number in the <digits> field in decimal defines the number of user data bytes that follow in the <user data> field. The maximum response is 64 characters. Example: *PUD "test1"; *PUD? returns: #205test1

Check Product Status

The programmer has access to status registers, enable registers, and queues in the Calibrator to indicate various conditions in the instrument as shown in Figure 4. Some registers and queues are defined by the IEEE-488.2 standard. The rest are specific to the Calibrator. In addition to the status registers, the Service Request (SRQ) control line, and a 16-element buffer called the Error Queue provide status information. Table 16 lists the status registers and gives the read/write commands and associated mask registers.

Table 16. Status Register Summary

Status Register	Read Command	Write Command
Status Byte Register (STB)	*STB?	--
Service Request Enable Register (SRE)	*SRE?	*SRE
Event Status Register (ESR)	*ESR?	--
Event Status Enable Register (ESE)	*ESE?	*ESE
Instrument Status Register (ISR)	ISR?	--
Instrument Status Change Register (ISCR)	ISCR?	--
ISCR 1 to 0 transition	ISCR0?	--
ISCR 0 to 1 transition	ISCR1?	--
Instrument Status Change Enable Register (ISCE)	ISCE?	ISCE
ISCE 1 to 0 transition	ISCE0?	ISCE0
ISCE 0 to 1 transition	ISCE1?	ISCE1

Each status register and queue has a summary bit in the Status Byte Register. Enable registers are used to mask various bits in the status registers and generate summary bits in the Status Byte Register. For IEEE-488/USBTMC interface operation, the Service Request Enable Register is used to assert the SRQ control line (or SRQ Interrupt in USBTMC) on detection of any status condition or conditions the programmer chooses. For RS-232/Ethernet interface operation, the SRQSTR string is sent over the interface when the RQS/MSS bit is set in the Status Byte Register. See the SRQSTR? command description in [Remote Commands](#) for more information.

Status Byte Register (STB)

The Calibrator sends the Status Byte Register (STB) when it responds to a serial poll. This byte is cleared (set to 0) when the power is turned on. The STB byte is defined as shown in Figure 4. If you use the RS-232 or Ethernet as the remote control interface, transmitting the ^P character (in the Terminal mode, hold down the <Cntl> key and push P) returns the SPLSTR Serial Poll String; the status byte and Event Status Register). Refer to the *STB? command, and for RS-232/Ethernet interface operation, the SPLSTR? command, in [Remote Commands](#).

Figure 4. Status Register Overview

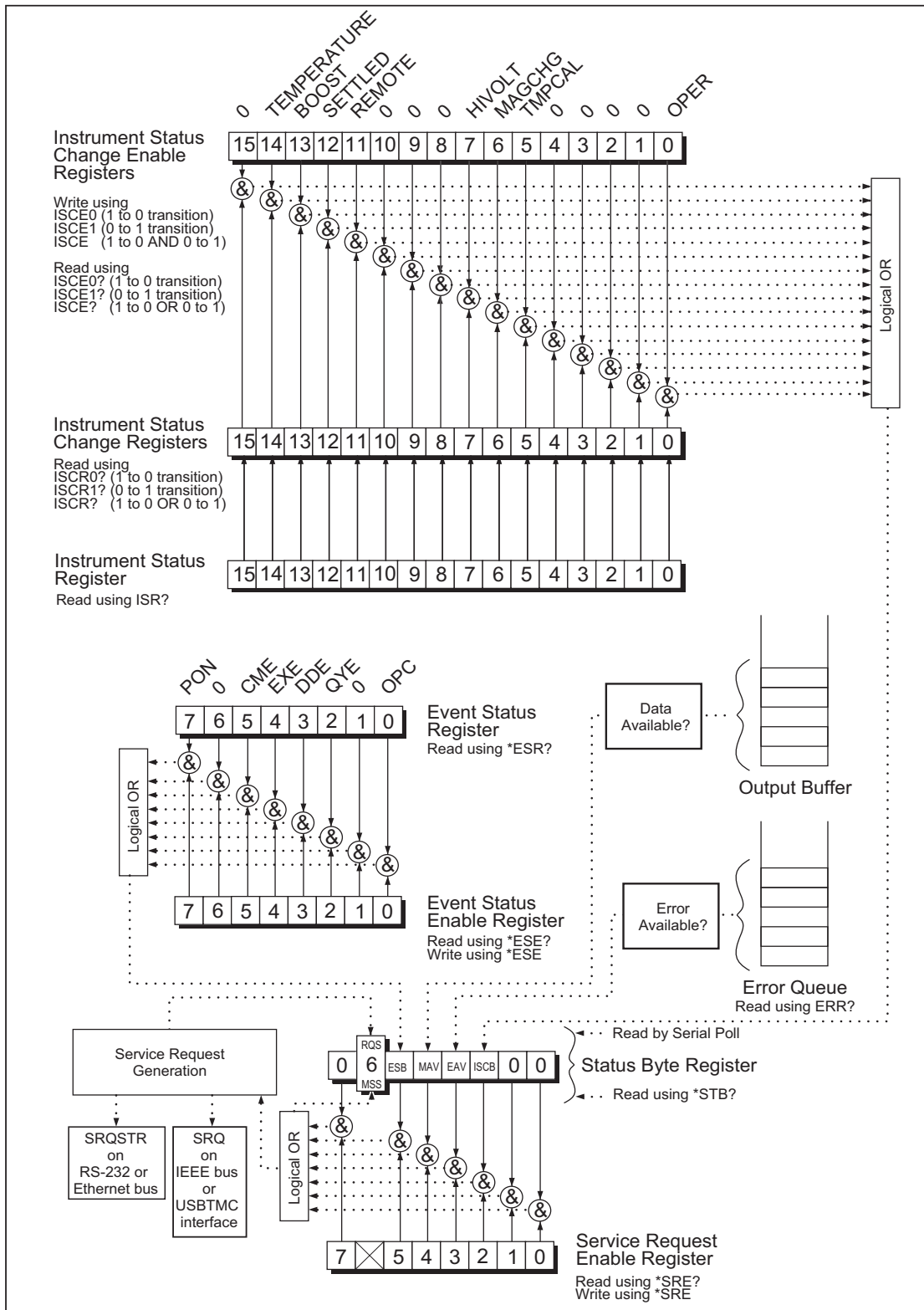


Table 17. Status Byte Register (STB) and Service Request Enable (SRE)

7	6	5	4	3	2	1	0
0	RQS	ESB	MAV	EAV	ISCB	0	0
	MSS						
RQS	Requesting service. The RQS bit is set to 1 whenever bits ESB, MAV, EAV, or ISCB change from 0 to 1 and are enabled (1) in the SRE. When RQS is 1, the Calibrator asserts the SRQ control line on the IEEE-488 interface or sends a SRQ request message when it uses USBTMC. You can do a serial poll and read this bit to see if the Calibrator is the source of an SRQ.						
MSS	Master summary status. Set to 1 whenever bits ESB, MAV, EAV, or ISCB are 1 and enabled (1) in the SRE. This bit can be read with the *STB? command in RS-232/Ethernet remote control in place of doing a serial poll.						
ESB	Set to 1 when one or more enabled ESR bits are 1.						
MAV	Message available. The MAV bit is set to 1 whenever data is available in the IEEE-488 interface output buffer of the Calibrator.						
EAV	Error available. An error has occurred and an error is available to be read from the error queue. Use the ERR? query.						
ISCB	One or more enable ISCR bits are 1.						

Service Request (SRQ) Line

IEEE-488 Service Request (SRQ) is an IEEE-488.1 (GPIB) bus control line that the Calibrator asserts to notify the controller that it requires some type of service. Many instruments can be on the bus, but they all share a single SRQ line. To determine which instrument set SRQ, the Controller normally does a serial poll of each instrument. The Calibrator asserts SRQ whenever the RQS bit in its Status Byte Register is 1. This bit informs the controller that the Calibrator was the source of the SRQ.

RS-232/Ethernet Remote operations that use the RS-232 or Ethernet interface emulate the IEEE-488 SRQ line by sending the SRQSTR string over the serial interface when the RQS/MSS bit is set in the Status Byte Register. See the SRQSTR? command description in [Remote Commands](#).

The Calibrator clears SRQ and RQS whenever the controller/host performs a serial poll, sends *CLS, or whenever the MSS bit is cleared. The MSS bit is cleared only when ESB, MAV, EAV, and ISCB are 0, or they are disabled by their associated enable bits in the SRE register being set to 0.

USBTMC The Calibrator uses the interrupt-in endpoint to request service (by sending a SRQ message to the controller) and to communicate the status byte register value. The SRQ condition communicates automatically whenever the RQS bit is set in the Status Byte Register.

Service Request Enable Register (SRE)

The Service Request Enable Register (SRE) enables or masks the bits of the Status Byte Register. The SRE is cleared at power up. See Table 17 for the bit functions.

Program the STB and SRE

If you reset (to 0) the bits in the SRE, you can mask (disable) associated bits in the Status Byte Register. Bits set to 1 enable the associated bit in the Status Byte Register. The sample BASIC program below enables the Error Available (EAV) bit.

```

10 ! THIS PROGRAM SETS EAV IN THE SRE
20 PRINT @4, "*SRE 8"           ! LOAD THE REGISTER
30 PRINT @4, "*SRE?"           ! ASK FOR THE SRE CONTENTS
40 INPUT @4, A%                 ! RETRIEVE THE REGISTER CONTENTS
50 PRINT "SRE = ";A%
60 RETURN

```

The BASIC program below generates an error and checks the Status Byte Register. Enable the EAV bit with the example above.

```

10 ! THIS PROGRAM GENERATES AN ERROR AND CHECKS IT
20 PRINT @4, "OUT 1300V"        ! 1300V IS OUT OF 5560A RANGE
30 A% = SPL(4)                  ! DO A SERIAL POLL
40 IF ((A% AND 72%)=0%) THEN PRINT "EAV and RQS should have been set"
50 PRINT @4, "*STB?"           ! RETRIEVE BYTE
60 INPUT @4, A%
70 IF ((A% AND 8%)=0%) THEN PRINT "EAV should have been set"

```

Event Status Register (ESR)

The Event Status Register is a two-byte register in which the higher eight bits are always 0, and the lower eight bits represent various conditions of the Calibrator. The ESR is cleared (set to 0) when the power is turned on, and every time it is read.

Many of the remote commands require parameters. Improper use of parameters causes command errors to occur. When a command error occurs, bit CME (5) in the Event Status Register (ESR) goes to 1, and the error is logged in the error queue.

Event Status Enable (ESE) Register

A mask register called the Event Status Enable register (ESE) allows the controller to enable or mask (disable) each bit in the ESR. When a bit in the ESE is 1, the corresponding bit in the ESR is enabled. When any enabled bit in the ESR is 1, the ESB bit in the Status Byte Register also goes to 1. The ESR bit stays 1 until the controller reads the ESR or does a device clear, a selected device clear, or sends the reset or *CLS command to the Calibrator. The ESE is cleared (set to 0) when the power is turned on.

Bit Assignments for the ESR and ESE

The bits in the Event Status Register (ESR) and Event Status Enable register (ESE) are assigned as shown in Table 18.

Table 18. Event Status Register (ESR) and Event Status Enable (ESE)

15	14	13	12	11	10	9	8
0	0	0	0	0	0	0	0

7	6	5	4	3	2	1	0
PON	0	CME	EXE	DDE	QYE	0	OPC

PON	Power on. This bit is set to 1 if line power has been turned off and on since the last time the ESR was read.
CME	Command error. The Calibrator encountered an incorrectly formed command. (The command ERR? fetches the earliest error code in the error queue, which contains error codes for the first 15 errors that have occurred.).
EXE	Execution error. An error occurred while the Calibrator tried to execute the last command. For example, when a parameter is out of range. (The command ERR? fetches the earliest error in the error queue, which contains error codes for the first 15 errors that have occurred.).
DDE	Device-dependent error. An error related to a device-dependent command has occurred.
QYE	Query error. The Calibrator was addressed to talk when no response data was available or appropriate, or when the controller failed to retrieve data on the output queue.
OPC	Operation complete. All commands previous to reception of a *OPC command have been executed, and the interface is ready to accept another message.

Program the ESR and ESE

To read the contents of the ESR, send the remote command, *ESR?. The ESR is cleared (set to 0) every time it is read. To read the contents of the ESE, send the remote command, *ESE?. The ESE is not cleared when it is read. When you read either register, the Calibrator sends a decimal number that when converted to binary represents bits 0 through 15. The sample BASIC program below retrieves the contents of both registers:

```

10  ! THIS PROGRAM READS THE ESR AND THE ESE REGISTERS
20  PRINT @4, "*"ESR?"           ! ASK FOR THE ESR CONTENTS
30  INPUT @4, A%                 ! RETRIEVE THE REGISTER CONTENTS
40  PRINT @4, "*"ESE?"           ! ASK FOR THE ESE CONTENTS
50  INPUT @4, B%                 ! RETRIEVE THE REGISTER CONTENTS
60  PRINT "ESR = ";A%            ! DISPLAY THE ESR REGISTER CONTENTS VALUE
70  PRINT "ESE = ";B%            ! DISPLAY THE ESE REGISTER CONTENTS VALUE
80  END

```

Convert the contents of variables A and B into binary, and you can read the status of the registers. For example if A is 32, its binary equivalent is: 00000000 00100000. Therefore, bit 5 (CME) in the ESR is set (1) and the rest of the bits are reset (0). This means that the Calibrator received an incorrectly formed command.

If you set the bits in the ESE, you can mask (disable) the associated bits in the ESR. For example, to prevent the occurrence of a command error from causing bit 5 (ESB) in the Status Byte Register to go to 1, you can reset (to 0) bit 5 in the ESE register. The sample program below accomplishes this. This program checks the status of the CME bit, then toggles it if it is 1.

```
10    ! THIS PROGRAM RESETS BIT 5 (CME) IN THE ESE
20    PRINT @4, "*ESE 33"                ! INITIAL ESE IS CME + OPC
30    GOSUB 100                          ! GET AND PRINT INITIAL ESE
40    IF (A% AND 32%) THEN A% = A% - 32% ! CLEAR CME (BIT 5)
50    PRINT @4, "*ESE ";A%              ! LOAD ESE WITH NEW VALUE
60    GOSUB 100                          ! GET AND PRINT NEW ESE
70    END
100   PRINT @4, "*ESE?"                 ! ASK FOR ESE CONTENTS
110   INPUT @4, A%                      ! RETRIEVE REGISTER CONTENTS
120   PRINT "ESE = ";A%
130   RETURN
```

Instrument Status Register (ISR)

The Instrument Status Register (ISR) gives the controller access to the state of the Calibrator, including some of the information presented to the operator on the display and the annunciators shown during local operation.

Instrument Status Change Registers

There are two registers dedicated to monitoring changes in the ISR. These are the ISCR0 (Instrument Status 1-0 Change Register) and the ISCR1 (Instrument Status 0-1 Change Register). Each status change register has an associated mask register. Each ISCR is cleared (set to 0) when the Calibrator is turned on, every time it is read, and at each *CLS (Clear Status) command.

Instrument Status Change Enable Registers

The Instrument Status Change Enable registers (ISCE0 and ISCE1) are mask registers for the ISCR0 and ISCR1 registers. If a bit in the ISCE is enabled (set to 1) and the corresponding bit in the ISCR makes the appropriate transition, the ISCB bit in the Status Byte is set to 1. If all bits in the ISCE are disabled (set to 0), the ISCB bit in the Status Byte never goes to 1. The contents of the ISCE registers are set to 0 at power-up.

Bit Assignments for the ISR, ISCR, and ISCE

The bits in the Instrument Status, Instrument Status Change, and Instrument Status Change Enable registers are assigned as shown in Table 19.

Table 19. Bit Assignments for the ISR, ISCEs, and ISCR

15	14	13	12	11	10	9	8
0	TEMPERATURE	BOOST	SETTLED	REMOTE	TRIPPED	0	0

7	6	5	4	3	2	1	0
HIVOLT	0	0	0	0	0	0	OPER

TEMPERATURE	Set to 1 when the ambient temperature differs by more than ± 5 degrees C from the temperature when Calibrator verification was completed.
BOOST	When 1, 52120 amplifier is active.
SETTLED	Set to 1 when the output has stabilized to within specification or the TC measurement has settled and is available.
REMOTE	Set to 1 when the Calibrator is under remote control.
TRIPPED	Set to 1 whenever operate reverts to standby due to an error. Value resets to 0 when the Product re-enters Operate or when RESET (or *RST).
HIVOLT	Set to 1 when the Calibrator is programmed to a voltage above 30 V.
OPER	Set to 1 when the Calibrator is in operate, 0 when it is in standby.

Program the ISR, ISCR, and ISCE

To read the contents of the ISR, send the remote command, `ISR?`. To read the contents of the ISCR0 or 1, send the remote command, `ISCR0?`, or `ISCR1?`. To read the contents of the ISCE0 or 1, send the remote command, `ISCE0?`, or `ISCE1?`. The Calibrator sends a decimal number that represents bits 0 through 15. Every time you read the ISCR0 or 1, its contents are zeroed. The sample program below reads all five registers:

```

10  ! THIS PROGRAM READS THE ISR, ISCR, AND ISCE REGISTERS
20  ! NOTE THAT THE ICSR? COMMANDS CLEAR THE ISCR CONTENTS
30  PRINT @4, "ISR?"           ! ASK ISR CONTENTS
40  INPUT @4, A%              ! RETRIEVE REGISTER CONTENTS FROM 5560A
50  PRINT @4, "ISCR0?"       ! ASK FOR AND CLEAR ISCR0 CONTENTS
60  INPUT @4, B%              ! RETRIEVE REGISTER CONTENTS FROM 5560A
70  PRINT @4, "ISCE0?"       ! ASK FOR ISCE0 CONTENTS
80  INPUT @4, C%              ! RETRIEVE REGISTER CONTENTS FROM 5560A
50  PRINT @4, "ISCR1?"       ! ASK FOR AND CLEAR ISCR1 CONTENTS
60  INPUT @4, D%              ! RETRIEVE REGISTER CONTENTS FROM 5560A
70  PRINT @4, "ISCE1?"       ! ASK FOR ISCE1 CONTENTS
80  INPUT @4, E%              ! RETRIEVE REGISTER CONTENTS FROM 5560A
90  PRINT "ISR = ";A%         ! DISPLAY ISR
100 PRINT "ISCR0 = ";B%       ! DISPLAY ISCR0
110 PRINT "ISCE0 = ";C%       ! DISPLAY ISCE0
100 PRINT "ISCR1 = ";D%       ! DISPLAY ISCR1
110 PRINT "ISCE1 = ";E%       ! DISPLAY ISCE1
120  END

```

Convert the returned variables into binary, and you can read the status of the instrument. For example if a register contains 128, its binary equivalent is: 00000000 10000000. Therefore, bit 7 (HIVOLT) is set (1) and the rest of the bits are reset (0).

If you set the bits in an ISCE register, you can mask (disable) the associated bits in the ISCR. For example, to cause an SRQ interrupt when the output has settled, bit 12 (SETTLED) in the ISCE1 register must be 1. (The ISCB bit must also be enabled in the SRE.) The sample program below loads a decimal 1024 into the ISCE, which sets bit 12 and resets the other bits:

```

10  ! THIS PROGRAM LOADS 00010000 00000000 BINARY INTO THE ISCE
20  PRINT @4, "ISCE 4096"     ! LOAD DECIMAL 4096 INTO ISCE
30  PRINT @4, "ISCE?"       ! READ BACK ISCE VALUE
40  INPUT @4, A%             ! "
50  PRINT "ISCE = ";A%       ! PRINT IT, IT SHOULD BE 4096
60  END

```

Output Queue

The output queue is loaded whenever a query is processed, and holds up to 800 characters. The controller reads it with a statement such as a BASIC INPUT statement, and removes what it reads from the queue. If the queue is empty, the Calibrator does not respond to the INPUT statement from the controller. The Message Available (MAV) bit in the Status Byte Register is 1 if there is something in the output queue and 0 if the output queue is empty.

Error Queue

When a command error, execution error, or device-dependent error occurs, its error code is placed in the error queue where it can be read by the `ERR?` command. A way to decode an error code is to send the command, `EXPLAIN?`, which returns a description of a error code. Reading the first error with the `ERR?` command removes that error from the queue. A response of 0 means the error queue is empty. The Error Available (EAV) bit in the Status Byte Register indicates whether the queue is empty. The error queue is cleared when you turn off the power, and when you use the `*CLS` (Clear Status) common command.

The error queue contains up to 16 entries. If many errors occur, only the first 15 errors are kept in the queue. A 16th entry in the queue is always an *error queue overflow* error, and all later errors are discarded until the queue is at least partially read. The first errors are kept, because if many errors occur before the user can acknowledge and read them, the earliest errors are the most likely to point to the problem. The later errors are usually repetitions or consequences of the original problem.

Remote Program Examples

The programming examples below illustrate ways to handle errors, to take measurements, take a number of successive readings, lock the range, and calibrate the Calibrator. These excerpts from programs are written in DOS BASIC.

Guidelines for Programming the Calibrator

Commands are processed one at a time as they are received. Some commands require a previous condition be set before the command will be accepted by the Calibrator. For example, the waveform must be `SQUARE` before the `DUTY` command will be accepted. Use the programming guidelines below to ensure that the output is programmed as necessary.

Program all external connections first. The Calibrator is placed in standby. Change the output to accommodate the new external connection. You can make the setting even if the present output does not use the setting (for example, setting the thermocouple type while sourcing voltage).

Next, program the output and output function next with the `OUT` command.

- All other output parameters such as impedance compensation, offset, and waveforms should be programmed next. The `DUTY` command must follow the `WAVE` command.
- Check the error status with the `ERR?` command.
- Finally, put the Calibrator into operate mode with the `OPER` command.

A controller program first initializes the interface and the Calibrator. Refer to this sample program:

```
10  INIT PORT 0 \ REMOTE @4          ! PUT THE 5560A INTO THE REMOTE STATE
20  PRINT @4, "*RST;OUT 10V;OPER" ! RESET THE 5560A, PROGRAM IT TO 10 VDC
```

To use SRQs, first use the *SRE, *ESE, and ISCE commands to enable the desired event, see [Check Product Status](#).

Retrieve instrument parameters with a query (a programming command that ends with a question mark):

```
200 PRINT @4, "FUNC?"           ! RETRIEVE OUTPUT FUNCTION
210 INPUT LINE @4, A$
220 PRINT "Function is: "; A$
230 PRINT @4, "ONTIME?"         ! RETRIEVE ON TIME
240 INPUT LINE @4, A$
250 PRINT "The instrument has been on for "; A$;" minutes"
```

This program generates this sample output:

```
Function is: DCV
The instrument has been on for 134 minutes
```

Check for programming errors as in these sample programs. Check the Error Available (EAV) bit in the serial poll register with a serial poll.

```
300 A = SPL(4)                 ! CHECK FOR ERRORS
310 IF (A AND 8) THEN PRINT "There was an error"
320 PRINT @4, "*CLS"           ! CLEAR ERRORS
```

Retrieve errors and explanations as follows. Since errors are accumulated in a queue, you must read the entire queue to retrieve and clear all the errors.

```
400 PRINT @4, "ERR?"           ! CHECK FOR ERRORS
410 INPUT @4, A, A$            ! READ IN THE ERROR
420 IF (A = 0) THEN GOTO 500   ! NO MORE ERRORS
430 PRINT "Error# :";A, A$     ! PRINT ERROR# AND EXPLANATION
440 GOTO 400
500 END
```

Writing an SRQ and Error Handler

It is good practice to include fault (error) handling routines in your applications. The sample program lines below show a method to halt program execution on occurrence of an SRQ (Service Request) on the bus, check to see if the Calibrator is the source of the SRQ, retrieve its fault messages, and act on the faults. Modify and extend this code as necessary for your application.

If you want to use SRQs, first use the *SRE, *ESE, and ISCE commands to enable the desired event. See [Check Product Status](#).

```
10  INIT PORT0                ! IFC the bus
20  CLEAR PORT0              ! DCL the bus
30  ! INITIALIZE THE 5560A SRQ HANDLER
40  PRINT @4, ``*SRE 8``      ! Enable STB.EAV (error available)
50  ON SRQ GOTO 1100         ! Install SRQ handler
60  ! Body of the application goes here
1100 ! Bus SRQ handler
1110 CLEAR PORT0            ! Make sure devices are not
                             confused
1120 IF (SPL(4) AND 64) THEN GOSUB 1200 ! If (STB.RQS) call SRQ
1130 ! TEST OTHER DEVICES RQS BITS IF DESIRED
1140 RESUME
1200 ! 5560A SRQ handler
1210 IF (SPL(4) AND 8) THEN GOSUB 1300 ! If (STB.EAV) call handler
1220 ! Test other STB bits if desired here
1299 RETURN
1300 ! 5560A STB.EAV (error) handler
1320 PRINT @4, ``ERR?``      ! Read and clear error
1330 INPUT @4, E%, E$        ! Read in error # and explanation
1340 PRINT ``Error# :``;E, E$ ! Print error # and explanation
1350 IF (E% <> 0) THEN GOTO 1320! Until no more errors
1360 STOP                    ! Other commands for your app
1370 END
```

Verify a Meter in the IEEE-488 Bus

This program selects 10 V dc output, verifies that the Calibrator is set to 10 V, then triggers a Fluke 45 to take a measurement. It shows calibrator output, Fluke 45 reading, and the meter error in ppm. The program assumes that the Calibrator bus address is 4 and the Fluke 45 bus address is 1.

```
10 REM  THIS PROGRAM VERIFIES THE ACCURACY OF A FLUKE 45 AT 10V DC
20 INIT PORT 0                ! INITIALIZE THE INTERFACE
30 CLEAR PORT 0              ! ``
40 PRINT @1, ``VDC;RATE 5;AUTO;TRIGGER 2`` ! SETS FLUKE 45 TO 10V DC
50 PRINT @4, ``OUT 10 V ; OPER;``        ! SET THE 5560A TO 10V DC
60 PRINT @4, ``*WAI; OUT?`` ! WAIT FOR SETTLE, REQUEST THE OUTPUT VALUE
70 INPUT @4, V,U$,F,V2,U2$      ! GET THE DATA FROM THE 5560A
80 PRINT @1, ``*TRG;VAL?``      ! TRIGGER 45 TO TAKE READING
90 INPUT @1, VM                ! GET THE DATA FROM THE 45
100 ER = ABS(V - VM) / V * 1E6  ! COMPUTE ERROR
110 PRINT ``5560 OUTPUT: ``;V;U$      ! PRINT THE RESULTS
120 PRINT ``45 MEASURED: ``;VM;``V``
130 PRINT ``ERROR:          ``;ER;``PPM``
140 END
```

***OPC?, *OPC, and *WAI**

The *OPC?, *OPC, and *WAI commands let you maintain control of the order of execution of commands that could otherwise be passed up by subsequent commands.

If you send an OUT command, you can check if the output has settled by sending the query *OPC?. As soon as the OUT command has completed (output settled), a 1 appears in the output buffer. Always follow an *OPC? command with a read command. The read command causes program execution to pause until the addressed instrument responds. This sample program shows how you can use *OPC?:

```

10 PRINT @4, "OUT 100V,1KHZ;OPER; *OPC?" ! 5560A ADDRESS IS 4
20 INPUT @4, A                               ! READ THE "1" FROM THE 5560A
30 !PROGRAM HALTS HERE UNTIL A "1" IS PUT INTO THE OUTPUT BUFFER
40 PRINT "OUTPUT SETTLED"

```

The *OPC command is similar in operation to the *OPC? query, except that it sets bit 0 (OPC for Operation Complete) in the Event Status Register to 1 rather than sending a 1 to the output buffer. One simple use for *OPC is to include it in the program in order for it to generate an SRQ (Service Request). Then an SRQ handler written into the program can detect the operation complete condition and respond appropriately. You can use *OPC similarly to *OPC?, except your program must read the ESR to detect the completion of all operations. This sample program shows how you can use *OPC:

```

10 REMOTE
20 PRINT @4, "OUT 100V,1KHZ;OPER;*OPC" ! 5560A ADDRESS IS 4
30 PRINT @4, "*ESR?" ! PUT THE ESR BYTE IN BUFFER
40 INPUT @4, A% ! READ THE ESR BYTE
50 IF (A% AND 1%) = 0% GOTO 30 ! TRY AGAIN IF NO OPC
60 PRINT "OUTPUT SETTLED"
70 END

```

The *WAI command causes the Calibrator to wait until any prior commands are completed before it continues to the next command, and takes no other action. The *WAI command is a convenient way to halt operation until the command or commands preceding it are completed. This sample program shows how you can use *WAI:

```

10 REMOTE
20 PRINT @4, "OUT 100V,1KHZ;OPER;*WAI" ! 5560A ADDRESS IS 4
30 PRINT @4, "OUT?" ! READ THE OUTPUT VALUE
40 INPUT @4, A$,B$,C$ ! A$ CONTAINS THE OUTPUT VALUE
50 PRINT "OUTPUT SETTLED"
60 PRINT "OUTPUT IS: ";A$;B$;" at ";C$
70 END

```

Take a Thermocouple Measurement

This program takes one temperature measurement at a time.

```
10 REM Set Bus Timeout to 20 seconds, Init IEEE Bus
20 TIMEOUT 20 * 1000
30 INIT PORT 0
40 CLEAR @4
100 REM Reset 5560A, TC measurement function
110 PRINT @4,"*RST; TC_TYPE J; TC_MEAS FAR"
200 PRINT "Hit Carriage Return to take a Reading"
210 INPUTLINE A$
220 REM Request the measurement value
230 PRINT @4, "VAL?"
240 REM Read measurement, unit
250 INPUT @4, M,U$
260 GOTO 200
```

Input Buffer Operation

As the Calibrator receives each data byte from the controller, it places the bytes in a portion of memory called the input buffer. The input buffer holds up to 350 data bytes and operates in a first in, first out fashion.

IEEE-488 The Calibrator treats the EOI IEEE-488 control line as a separate data byte and inserts it into the input buffer if it is encountered as part of a message terminator. Input buffer operation is transparent to the program running on the controller. If the controller sends commands faster than the Calibrator can process them, the input buffer fills to capacity. When the input buffer is full, the Calibrator holds off the IEEE-488 bus with the NRFD (Not Ready For Data) handshake line. When the Calibrator has processed a data byte from the full input buffer, it then completes the handshake, which allows the controller to send another data byte. The Calibrator clears the input buffer on power-up and on receiving the DCL (Device Clear) or SDC (Selected Device Clear) messages from the controller.

RS-232 Under RS-232-C serial port remote control using ^S (<Cntl> S) XOFF protocol, the Calibrator issues a ^S XOFF when the input buffer becomes 80 % full. The Calibrator issues a ^Q (<Cntl> Q) when it has read enough of the input buffer so that it is <40 % full. With RTS (Request to Send) protocol (selected as part of the [RS-232 Port Setup Procedure](#)), the serial interface asserts and unasserts RTS in response to same conditions as for XON/XOFF protocol.

Remote Commands

This section documents the IEEE-488/USBTMC/RS-232/Ethernet remote commands for the Calibrator. Remote commands duplicate activities that can be initiated from the front panel in local operation. After the summary table is a complete alphabetical listing of all commands complete with protocol details. Separate headings in the alphabetical listing provide the parameters and responses, plus an example for each command. For information on command use, see [Remote Operations](#).

Command Summary by Function

Tables 20 through 27 list and describes the command set for the Calibrator.

Table 20. Common Commands

Command	Description
*CLS	(Clear status.) Clears the ESR, ISCR0, ISCR1, the error queue, and the RQS bit in the status byte. This command terminates pending operation complete commands (*OPC or *OPC?).
*ESE	Loads a byte into the Event Status Enable register.
*ESE?	Returns the contents of the Event Status Enable register.
*ESR?	Returns the contents of the Event Status Register and clears the register.
*IDN?	Identification query. Returns instrument model number, serial number, and firmware revision levels for the main and inguard PGA.
*OPC	Enables setting of bit 0 (OPC for Operation Complete) in the Event Status Register to 1 when all pending device operations are complete.
*OPC?	Returns a 1 after all pending operations are complete. This commands causes program execution to pause until all operations are complete. (See also *WAI.)
*OPT?	Returns a list of the installed hardware and software options.
*PUD	Protected user data command. This command allows you to store a string of bytes in nonvolatile memory. This command works only when the calibrator is in the unsecure state.
*PUD?	Returns the contents of the *PUD (Protected User Data) memory.
*RST	Resets the state of the instrument to the power-up state. This command holds off execution of subsequent commands until it is complete. (Overlapped command.)
*SRE	Loads a byte into the Service Request Enable register (SRE).
*SRE?	Returns the byte from the Service Request Enable register.
*STB?	Returns the status byte. This is not the same action as doing a serial poll.
*TRG	Changes the operating function to thermocouple MEASURE, triggers a measurement, and returns the value of the measurement. This command is equivalent to sending TC_MEAS;*WAI;VAL?. When in the MEASZ or MEASC scope functions, this command triggers a new measurement and returns the measured resistance or capacitance.

Table 20. Common Commands (cont.)

Command	Description
*TST?	Initiates a series of self-tests, then returns a 0 for pass or a 1 for fail. If any faults are detected, they are logged into the fault queue where they can be read by the ERR? query.
*WAI	Prevents further remote command execution until all previous remote commands have been executed.

Table 21. Error Mode Commands

Command	Description
EDIT	Set the edit field. PRI is specified for the output value in single output functions and the primary output value in dual output functions.
EDIT?	Returns the edit field setting.
ERR_REF	Selects the error reference source.
ERR_REF?	Returns the presently selected error reference source.
ERR_UNIT	Chooses how DUT error is shown.
ERR_UNIT?	Returns presently selected value of ERR_UNIT.
INCR	Increments or decrements the output (as selected by the edit field) and enters error mode, the same as if you use the output adjustment knob in local operation.
MULT	Multiplies the reference magnitude (as selected by the edit field).
NEWREF	Set the reference value to be the present Calibrator output value, the same as if you tap New Reference in local operation.
OLDREF	Set the Calibrator output to the previously-programmed reference value, the same as if you push ENTER in local operation.
OUT_ERR?	Returns the DUT error computed after shifting the output with the INCR command.
REFOUT?	Returns the value of the reference, which is the output values of the Calibrator the last time a new reference was established with an OUT, NEWREF, or MULT.

Table 22. External Connection Commands

Command	Description
BOOST	Activates or deactivates the 52120A auxiliary amplifier.
BOOST?	Returns true if the 52120A auxiliary amplifier is activated.
CUR_POST?	Returns the active binding posts for current output.
EXTGUARD	Connects or disconnects the internal guard shield from the LO binding post.
EXTGUARD?	Returns whether the internal guard shields are connected or disconnected from earth (chassis) ground.
EXTSENSE?	Returns the status of the internal connection between SENSE and OUTPUT.
EXTSENSE	Opens and closes an internal connection between SENSE and OUTPUT.
LOWS?	Returns whether or not the low terminals are internally open or tied together.
LOWS	Selects whether or not the low terminals are internally open or tied together for dual outputs.
POST_52120	Set the output terminals for attached 52120As.
POST_52120?	Returns the setting of the output terminals for attached 52120As.
RTD_TYPE	Set the Resistance Temperature Detector (RTD) type.
RTD_TYPE?	Returns the Resistance Temperature Detector (RTD) type.
TC_REF	Set whether the internal temperature sensor or an external reference value is used for Thermocouple (TC) outputs and measurements.
TC_REF?	Returns the source and value of the temperature in use as a reference for thermocouple simulation and measurement.
TC_TYPE	Set the thermocouple (TC) temperature type.
TC_TYPE?	Returns the thermocouple (TC) type.
TSENS_TYPE	Set temperature sensor type when output is set to a temperature with OUT command.

Table 23. Oscilloscope Commands

Commands	Description
OL_TRIP?	Returns the detected state of scope overload protection.
OUT_IMP	Set the output impedance of the SCOPE BNC.
OUT_IMP?	Returns the output impedance of the SCOPE BNC.
RANGE	Set the Calibrator range when in PULSE or MEASR scope functions.
SCOPE	Set the Calibrator output to an oscilloscope function.
SCOPE?	Returns the present oscilloscope function.
TLIMIT	Set the time limit for Scope Option OVERLD function to stay in operate.
TLIMIT?	Returns the time limit for Scope Option OVERLD function to stay in operate.
TLIMIT_D	Sets the default for the time limit for Scope Option OVERLDAC and for the time limit for Scope Option OVERLDDC functions to stay in operate.
TLIMIT_D?	Returns the default time limit for Scope Option OVERLDAC and OVERLDDC functions to stay in operate.
TMWAVE	Selects the waveform for MARKER function.
TMWAVE?	Returns the timemark waveform setting for MARKER function.
TRIG	Set the frequency of the signal at the TRIG OUT BNC.
TRIG?	Returns the frequency of the signal at the TRIG OUT BNC.
*TRG	When in the MEASZ or MEASC scope functions, triggers a new measurement and returns the measured resistance or capacitance.
VAL?	Returns the last thermocouple, or, for the Scope Option, impedance measurement value.
VIDEOFMT	Selects the format for VIDEO function.
VIDEOFMT?	Returns the VIDEO function format.
VIDEOMARK	Set the VIDEO function line marker location.
VIDEOMARK?	Returns the VIDEO function line marker location.
ZERO_MEAS	Measure the zero offset for capacitance measurement with the Scope Option.
ZERO_MEAS?	Returns the zero offset for capacitance measurement with the Scope Option.

Table 24. Output Commands

Command	Description
CFREQ?	Returns the optimum frequency value for stimulus for capacitance functions.
DBMZ	Set the impedance used for dBm outputs (ac volts).
DBMZ?	Returns the impedance used for dBm outputs (ac volts).
DC_OFFSET	Applies a dc offset to an ac output voltage.
DC_OFFSET?	Returns the value of the dc offset voltage.
DPF	Set the displacement power factor (phase angle) between the OUTPUT and AUX terminals for ac power output only.
DPF?	Returns the displacement power factor (phase angle) between the OUTPUT and AUX terminals.
DUTY	Set the duty cycle of square wave outputs.
DUTY?	Returns the duty cycle of square wave outputs.
FUNC?	Returns the present output, measurement, or calibration function.
HARMONIC	Makes the frequency of one output be a harmonic (multiple) of the other output (called the fundamental).
HARMONIC?	Returns the present instrument harmonic and fundamental locations.
LCOMP_52120	Activates or deactivates inductive load compensation for 52120 ac current output.
LCOMP_52120?	Returns whether inductive load compensation for 52120 ac current output is active.
LFREQ?	Returns the optimum frequency value for stimulus for inductance functions.
OPER	Activates the Calibrator output if it is in standby.
OPER?	Returns the operate/standby setting.
OUT	Set the output of the Calibrator and establishes a new reference point for the error mode.
OUT?	Returns the output amplitudes and frequency of the Calibrator.
PHASE	Set the phase difference between the OUTPUT and AUX terminals for dual outputs. The OUTPUT terminal output is the phase reference.

Table 24. Output Commands (cont.)

Command	Description
PHASE?	Returns the phase difference between the OUTPUT and AUX terminals.
POWER?	Returns the equivalent power for dc and ac power output.
RANGE?	Returns the present output ranges.
RANGELCK	Locks in the present range, or selects auto ranging.
RANGELCK?	Returns whether or not the preset output range is locked.
REFPHASE	If two Calibrators are synchronized with 10 MHz IN/OUT, this sets the phase difference between the OUTPUT terminals on the secondary Calibrator and the OUTPUT terminals of the primary Calibrator.
REFPHASE?	If two Calibrators are synchronized with 10 MHz IN/OUT, this returns the phase difference between the OUTPUT terminals on the secondary Calibrator and the OUTPUT terminals of the primary Calibrator.
STBY	Puts the Calibrator in standby.
SYNCOUT	Sends a synchronization pulse out to a secondary Calibrator through the 10 MHz OUT BNC connector.
WAVE	Set the waveforms for ac outputs.
WAVE?	Returns the waveforms of the output.
ZCOMP	Activates (2-wire or 4-wire) or deactivates impedance compensation.
ZCOMP?	Returns whether or not impedance compensation is active and if active, which type.

RS-232/Ethernet Port Commands

Command	Description
LOCAL	Puts the Calibrator into the local state. This command duplicates the IEEE-488.1 GTL (Go To Local) message.
LOCKOUT	Puts the Calibrator into the lockout state. This command duplicates the IEEE-488.1 LLO (Local Lockout) message.
REMOTE	Puts the Calibrator into the remote state. This command duplicates the IEEE-488.1 REN (Remote Enable) message.
SPLSTR?	Returns the string programmed for serial remote mode Serial Poll responses.
SRQSTR?	Returns the string programmed for Serial Mode SRQ response.
^P (<cntl>p)	Control-P character prints the serial poll string. (See SPLSTR for string format.)
^C (<cntl>c)	Control-C character clears the device.
^T (<cntl>t)	Control-T character executes a group trigger.

Table 25. Setup and Utility Commands

Command	Description
AC_REP?	Returns the AC Representation for ac signals (RMS or PKPK).
ADDR	Set GPIB address.
ADDR?	Returns the GPIB address.
ADJ_DATE?	Returns the date when the Product was last adjusted.
ADJ_DAYS?	Returns the number of days since the last Product adjustment.
AMB_HUM?	Returns the internal ambient humidity.
AMB_TEMP?	Returns the internal ambient temperature.
CAL_INTV	Set the calibration/adjustment cycle to 90 days, 1 year, or 2 years.
CAL_INTV?	Returns the calibration/adjustment cycle setting.
CAL_PASSCODE	Changes the calibration passcode.
CAL_SECURE	Locks/unlocks calibration security.
CAL_SECURE?	Returns the lock state of calibration security.
CLOCK	Set the real-time clock.
CLOCK?	Queries the real-time clock.
COMM_MODE	Set computer/terminal mode for given port.
COMM_MODE?	Returns the computer/terminal mode for given port.
COMM_ENABLE	Set the communication active state status for the given port.
COMM_ENABLE?	Returns the communication active state status for the given port.
COMM_LOCK	Set the command lockout status for the given port.
COMM_LOCK?	Returns the command lockout status for the given port.
COILTURNS_D	Set the number of turns for a custom external current coil.
COILTURNS_D?	Returns the number of turns for a custom external current coil.
COILTYPE_D	Set the external current coil type.
COILTYPE_D?	Returns the external current coil type.
DATEFMT	Selects the clock/calendar date format.
DATEFMT?	Returns the date format setting.
DIAG	Run self-diagnostics routine.
DIAG_FAULT	Set the Calibrator response action to faults encountered when running self diagnostics.

Table 25. Setup and Utility Commands (cont.)

Command	Description
DIAG_FAULT?	Returns the Calibrator response action to faults encountered when running self diagnostics.
DISP_BRIGHTNESS	Set the backlight display brightness.
DISP_BRIGHTNESS?	Returns the setting of the backlight display brightness.
DBMZ_D	Set the power-up and reset default impedance used for dBm outputs (ac volts).
DBMZ_D?	Returns the power-up and reset default impedance used for dBm outputs (ac volts).
DHCP	Turns on/off DHCP.
DHCP?	Returns the state of the DHCP setting.
ENETPORT	Set Ethernet port.
ENETPORT?	Returns the Ethernet port setting.
EOLSTR	Set EOL for given port
EOLSTR?	Returns EOL for given port
FORMAT	Restores various parts of the system back to their factory default configuration.
GWADDR	Set gateway address.
GWADDR?	Returns the gateway address.
ID?	Returns the detailed instrument ID and software version information.
IPADDR	Set static IP address.
IPADDR?	Returns the IP address.
LED_BRIGHTNESS	Set the output block LED ring brightness.
LED_BRIGHTNESS?	Returns the setting of the output block LED ring brightness.
LIMIT	Set the maximum permissible output magnitudes, negative and positive.
LIMIT?	Returns the programmed output magnitude limits for voltage and current.
MACADDR?	Returns MAC address.
REFCLOCK_D	Set the power-up and reset default for the reference clock source (internal or through the 10 MHz IN BNC connector).
REFCLOCK_D?	Returns the power-up and reset default for the reference clock source (internal or through the 10 MHz IN BNC connector).
REFPHASE_D	If two Calibrators are synchronized with 10 MHz IN/OUT, this sets the power-up and reset default phase difference between the OUTPUT terminals on the secondary Calibrator and the OUTPUT terminals of the primary Calibrator.

Table 25. Setup and Utility Commands (cont.)

Command	Description
REFPHASE_D?	If two Calibrators are synchronized with 10 MHz IN/OUT, this returns the power-up and reset default phase difference between the OUTPUT terminals on the secondary Calibrator and the OUTPUT terminals of the primary Calibrator.
RPT_STR	Loads the user report string.
RPT_STR?	Returns the user report string.
RTD_TYPE_D	Set the default Resistance Temperature Detector (RTD) sensor type.
RTD_TYPE_D?	Returns the default Resistance Temperature Detector (RTD) sensor type.
SP_SET	Set the RS-232 serial port communication parameters and saves them in nonvolatile memory.
SP_SET?	Returns the RS-232 serial port communication parameters contained in nonvolatile memory.
SPEC_CONFIDENCE	Set the calibration specification confidence level (95% or 99%).
SPEC_CONFIDENCE?	Returns the calibration specification confidence level (95% or 99%).
SUBNETMASK	Set subnet mask.
SUBNETMASK?	Returns the subnet mask.
TC_TYPE_D	Set the power-up and reset default thermocouple type.
TC_TYPE_D?	Returns the power-up and reset default thermocouple type.
TEMP_STD	Set the temperature degree standard ipts-68 or its-90.
TEMP_STD?	Returns the temperature degree standard ipts-68, or its-90.
TEMP_STD_D	Set the default temperature degree standard ipts-68 or its-90.
TEMP_STD_D?	Returns the default temperature degree standard ipts-68 or its-90.
TEMP_UNIT_D	Set the default temperature units to either CEL or FAR.
TEMP_UNIT_D?	Returns the default temperature units.
TIMEFMT	Set the time format to either 12hr or 24hr format.
TIMEFMT?	Returns the time format.
UNCERT?	Returns specified uncertainties for the present output. If there are no specifications for an output, returns zero.

Table 26. Status Commands

Command	Description
ERR?	Returns the first error code with an explanation contained in the Calibrator error queue, then removes that error code from the queue.
EXPLAIN?	Explains an error code. This command returns a string that explains the error code furnished as the parameter.
FAULT?	Returns the first error code contained in the Calibrator error queue, then removes that error from the queue.
ISCE	Loads two bytes into both the Instrument Status 1 to 0 Change Enable register and the Instrument Status 0 to 1 Change Enable register.
ISCE?	Returns the OR of the contents of the Instrument Status 1 to 0 Change Enable register and the Instrument Status 0 to 1 Change Enable register.
ISCE0	Loads two bytes into the Instrument Status 1 to 0 Change Enable register.
ISCE0?	Returns the contents of the Instrument Status 1 to 0 Change Enable register.
ISCE1	Loads two bytes into the Instrument Status 0 to 1 Change Enable register.
ISCE1?	Returns the contents of the Instrument Status 0 to 1 Change Enable register.
ISCR?	Returns the OR of the contents of the Instrument Status 1 to 0 Change Register and the Instrument Status 0 to 1 Change Register and clears both registers.
ISCR0?	Returns and clears the contents of the Instrument Status 1 to 0 Change Register.
ISCR1?	Returns and clears the contents of the Instrument Status 0 to 1 Change Register.
ISR?	Returns the contents of the Instrument Status Register.
ONTIME?	Returns the time since the Calibrator was powered on last.

Table 27. Thermocouple (TC) Measurement Command

Command	Description
TC_MEAS	Changes the operating mode to thermocouple measurement.
TC_OFFSET	Set a temperature offset for the thermocouple measurement function.
TC_OFFSET?	Returns the temperature offset when in the thermocouple measurement function.
TC_OTCD?	Returns whether or not the open thermocouple detection circuit is set.
TC_OTCD	Activates or deactivates the open thermocouple detection circuit in thermocouple measurement function.
VAL?	Returns the last thermocouple or, for the Scope Option, impedance measurement value.
VVAL?	Returns the last value of the thermocouple measurement in volts.

Commands

An alphabetical list of all Calibrator commands and queries, including common commands and device-dependent commands is below. Each command title includes a graphic that indicates remote interface applicability, IEEE-488 and RS-232, and command group: Sequential, Overlapped, and Coupled.

IEEE-488 (GPIB), RS-232, USBTMC and Ethernet Applicability

IEEE-488 RS-232 USBTMC Ethernet

Each command and query has a check box that indicates applicability to IEEE-488 (general purpose interface bus, or GPIB), RS-232, and USBTMC and Ethernet remote operations. For sorting purposes, this list ignores the * character that precedes the common commands.

Sequential Commands Sequential Commands executed immediately as they are encountered in the data stream are called sequential commands. For more information, see [Sequential Commands](#).

Overlapped Commands Overlapped Commands that require additional time to execute are called overlapped commands because they can overlap the next command before completing execution. To be sure an overlapped command is not interrupted during execution, use the *OPC, *OPC?, and *WAI commands to detect command completion. For more information, see [Overlapped Commands](#).

Coupled Commands Coupled Commands These are called coupled commands (examples: WAVE and OUT) because they *couple* in a compound command sequence. Care must be taken to be sure the action of one command does not disable the action of a second command and thereby cause a fault. For more information, see [Coupled Commands](#).

Lockout Commands Lockout Commands These commands can be locked out (prevented from execution). When you use the Calibrator with multiple controllers, you can prevent the execution of lockout commands over a designated remote interface.

Note

For the subsequent commands, 5560A is used. If you have a 5550A or a 5540A, substitute your model number.

AC_REP?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Returns the AC Representation for primary and secondary outputs. AC functions will return either RMS or PKPK. Non-AC functions will return NONE. Use the command in conjunction with the WAVE command. When you use the WAVE command to change the waveform shape, the AC Representation changes from RMS (sine wave) to PKPK (square, triangle and truncated waves) and vice versa.

Additionally, the units of the OUT? command change depending on the current AC_REP? setting. If the setting is NONE or RMS, the OUT? response for voltage or current will be V or A, respectively. If the AC_REP? is PKPK, the OUT? for ac voltage or ac current will be VPP or APP, respectively.

Parameters: NONE

Example: AC_REP? returns RMS, NONE when it outputs 10 V ac sine wave. See these examples:

```
72> *rst
73> out 1v,0hz
74> out?
1.0000000E+00,V,0E+00,0,0E+00
75> ac_rep?
NONE,NONE
76> out 100hz
77> out?
1.000000E+00,V,0E+00,0,1.0000E+02
78> ac_rep?
RMS,NONE
79> wave square
80> ac_rep?
PKPK,NONE
81> out 5v
82> out?
5.00000E+00,VPP,0E+00,0,1.0000E+02
83> wave sine
84> ac_rep?
RMS,NONE
85> out 0hz
86> ac_rep?
NONE,NONE
87> func?
DCV
```

Refer to the Operators Manual for more information regarding AC Representation, waveforms, and RMS-PKPK calculations.

ADDR

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Sets the GPIB interface bus address.

Parameters: Bus address

Examples: ADDR 4 Sets the GPIB interface bus address to 4

ADDR?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Returns the GPIB interface bus address.

Parameters: None

Response: Integer

Example: ADDR? Returns 4 if the gpib interface bus address is set to 4.

ADJ_DATE?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Parameters:

MAIN adjustment

ZERO adjustment

OHMSZERO adjustment

SCOPE adjustment

Example: ADJ_DATE? MAIN returns 2023-02-14, 15:05:45 (the date MAIN adjustment was performed).

ADJ_DAYS?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Returns the number of days since adjustment was performed.

Parameters:

MAIN adjustment

ZERO adjustment

OHMSZERO adjustment

SCOPE adjustment

Example: ADJ_DAYS? ZERO returns 192 (the number of days since ZERO adjustment was performed).

AMB_HUM?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Returns the internal ambient humidity.

Parameters: None

Response: <value> of the internal ambient humidity measurement.

Example: AMB_HUM? returns 3.200E+01, PCT

AMB_TEMP?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Returns the internal ambient temperature.

Parameters: 1. (optional) CEL, FAR

Example: AMB_TEMP? 2.700E+01, CEL

AMB_TEMP? FAR 8.060E, FAR

BOOST

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Activates and deactivates the 52120A amplifier for DCI/ACI outputs.

Parameters: ON Activates the 52120A amplifier for DCI/ACI outputs.

OFF Deactivates the 52120A amplifier

Example: BOOST ON

Activates the 52120A amplifier if the last OUT command selected a current output.

BOOST?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Returns true if the 52120A auxiliary amplifier is activated.

Parameters: None

Response: (CRD)

Example: BOOST?

Returns ON if the 52120A amplifier is activated.

CAL_INTV

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Sets the verification interval to 90 days, 1 year or 2 years.

Parameters: I90D (90 day verification interval)

I1Y (1 year verification interval)

I2Y (2 year verification interval)

Example: CAL_INTV I1Y

Sets the verification interval to 1 year.

CAL_INTV?

Returns the verification interval setting. (90 days, 1 year, or 2 year)

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Parameters: None

I1Y (1 year verification interval)

I2Y (2 year verification interval)

Example: CAL_INTV I1Y

The verification interval has been set to 2 years (I2Y)

CAL_PASSCODE

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Sets security passcode. The Calibrator secure state must be set to off or an execution fault results.

Parameters: 1. current security passcode (string with up to 8 decimal digits).

2. new security passcode (string with up to 8 decimal digits).

Example: CAL_PASSCODE 5560,12345

Sets the security passcode to 12345.

CAL_SECURE

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Lock/unlocks the calibration security with passcode. The passcode is entered as a string of decimal digits (for example 12345). To secure the Calibrator, no passcode is necessary. If an incorrect passcode is entered, the Calibrator automatically resecures itself if it was unsecured.

The Product ships with the passcode set to the serial number of the Product.

Parameters:

1. ON/OFF
2. <passcode>

Example: CAL_SECURE OFF, 12345

Unsecures the Calibrator.

Example: CAL_SECURE ON

Secures the Calibrator.

CAL_SECURE?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Returns the current security state of the Calibrator.

Parameters: None

Example: CAL_SECURE?

Returns ON if the Calibrator is secured.

CFREQ?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Capacitance Frequency query) Returns the optimal frequency for stimulus when measuring or calibrating capacitance output.

Response: <value> of the optimal frequency

Example: CFREQ? returns 1.0E+2

Returns 100 Hz as the optimal frequency for the selected capacitance output (1.0 μ F for this example). The return is 0 if not sourcing capacitance.

CLOCK

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Real-Time Clock command) Sets the real time clock, time only, or date and time. To set the date, the Calibrator must be unsecured.

Parameters: 1.(optional) year in the format YYYY
2.(optional) month in the format MM
3.(optional) day in the format DD
4.hour in the format HH
5.minute in the format MM
6.second in the format SS

Examples: `CLOCK 2020,6,1,9,52,10` sets clock to June 1, 2020, 9:52:10 AM

`CLOCK 13,10,10` sets clock time only to 1:10:10 PM

CLOCK?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Real_Time Clock query) Returns the date and time of the real time clock with the current date format (see DATEFMT command).

Response: (character) 1.date in the format defined by the DATEFMT setting.
(character) 2.time in the format HH:MM:SS

Example: `CLOCK?` returns `2020-12-04,13:03:50.`

The clock is set to December 4, 2020, 13:03:50.

*CLS

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Clear Status command) Clears the ESR, ISCR0, ISCR1, the error queue, and the RQS bit in the status byte. This command terminates pending operation complete commands (*OPC or *OPC?).

Parameters: (None)

Example: `*CLS`

Clear the ESR, ISCR0, ISCR1, the error queue, and the RQS bit in the status byte.

COILTURNS_D

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Sets the default custom external current coil turns used at power on and reset, which is saved in the Calibrator non-volatile memory. (The Calibrator does not respond to remote commands for about 2 seconds while it saves configuration data in the non-volatile memory.)

COILTYPE_D must be set to CUSTOM for COILTURNS_D value to be applied.

Parameters: 1. <value> number of turns in custom external coil.

Example: COILTURNS_D 20

Sets the custom coil turns to 20.

COILTURNS_D?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Returns the default custom external current coil turns used at power on and reset.

Parameters: None

Example: COILTURNS_D? returns 30

The default custom external coil turns is set to 30.

COILTYPE_D

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Sets the default external current coil type at power on and reset, which is saved in the Calibrator non-volatile memory. (The Calibrator does not respond to remote commands for about 2 seconds while it saves configuration data in the non-volatile memory.)

Parameters: 1. NONE

C5500A50T

C9100_10T

C9100_50T

C55XXA50T

C55XXA1T

C55XXA2T

C55XXA10T

C52120A25T

C52120A50T

CUSTOM

Example: COILTYPE_D C55XXA10T

Sets the default external current coil type to the 55XXA 10 turn coil.

COILTYPE_D?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Returns the default external current coil type used at power on and reset.

Parameters: None

Example: COILTYPE_D? returns C5500A50T

The default external current coil type is set to the 5500 50 turn coil.

COMM_ENABLE

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Enables or disables a remote interface port.

Parameters: 1. SERIAL, TELNET, GPIB, TMC

2. 1. (Boolean) ON or 1 for on, OFF or 0 for off.

Example: COMM_ENABLE SERIAL, OFF

Disables the RS-232 Interface.

COMM_ENABLE TELNET, ON

Enables the telnet interface port.

COMM_ENABLE?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Returns the active status of the interface port.

Parameters: 1. SERIAL, TELNET, GPIB, TMC

Response: ON if the interface is active, OFF if the interface is disabled.

Example: COMM_ENABLE? SERIAL

Returns ON if the RS-232 interface is enabled/active, OFF if the RS-232 interface is disabled.

COMM_LOCK

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Locks out certain remote commands from executing on a specified remote port.

Parameters: 1. SERIAL, TELNET, GPIB, TMC

2. 1. (Boolean) ON or 1 for on, OFF or 0 for off

Example: COMM_LOCK SERIAL, OFF Disables the lockout feature on the RS-232 Interface.

COMM_LOCK TELNET, ON Enables the command lockout feature on the Telnet interface port.

COMM_LOCK?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Returns the lockout status of the interface port.

Parameters: 1. SERIAL, TELNET, GPIB, TMC

Response: ON if the interface is locked out from executing *lockout* commands, OFF if the interface can execute lockout commands.

Example: COMM_LOCK? SERIAL

Returns ON if the RS-232 interface prevented from executing locked out commands, OFF if all commands can be executed on the RS-232 interface.

COMM_MODE

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Sets the response type for a specified remote port.

Parameters: 1. SERIAL, TELNET

2. COMP, TERM

Example: COMM_MODE SERIAL, COMP sets the response type for serial communication to COMPUTER. COMM_MODE TELNET, TERM sets the response type for telnet communication to TERMINAL.

COMM_MODE?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Returns the response type for a specified remote port.

Parameters: 1. SERIAL, TELNET

Response: COMP Computer Mode

TERM Terminal Mode

Example: COMM_MODE? SERIAL

Returns TERM if the serial response type has been set to TERMINAL mode.

CUR_POST?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Current Post query) Returns the active front-panel binding post terminals used for current output: AUX or 30A.

Responses: AUX (AUX terminals are selected)

A30 (30A terminals are selected)

Example: CUR_POST? returns AUX

Returns AUX when the AUX terminals are selected for output current.

DATEFMT

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Sets the date format that is entered and returned (and shown on the front panel). This setting is kept in non-volatile memory. This command does not affect the CLOCK command.

Parameters: MDY (for MM-DD-YYYY in remote and MM/DD/YYYY on the display)

DMY (for DD-MM-YYYY in remote and DD/MM/YYYY on the display)

YMD (for YYYY-MM-DD in remote and YYYY/MM/DD on the display)

DATEFMT?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Returns the present date format setting.

Parameters: None

Responses: (CRD)

MDY (for MM-DD-YYYY in remote and MM/DD/YYYY on the display)

DMY (for DD-MM-YYYY in remote and DD/MM/YYYY on the display)

YMD (for YYYY-MM-DD in remote and YYYY/MM/DD on the display)

DBMZ

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(dBm Impedance command) Sets the impedance used for dBm outputs (ac volts).

Parameters: Z50 (50 ohms)

Z75 (75 ohms)

Z90 (90 ohms)

Z100 (100 ohms)

Z135 (135 ohms)

Z150 (150 ohms)

Z300 (300 ohms)

Z600 (600 ohms)

Z900 (900 ohms)

Z1000 (1000 ohms = dBv)

Z1200 (1200 ohms)

Example: DBMZ Z600

DBMZ?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(dBm Impedance query) Returns the impedance used for dBm outputs (ac volts).

Response: (character) Impedance keyword

Example: DBMZ? returns Z600

DBMZ_D

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(dBm Impedance Default command) Sets the power-up and reset default impedance used for dBm outputs (ac volts).

Parameters: Z50 (50 ohms)
Z75 (75 ohms)
Z90 (90 ohms)
Z100 (100 ohms)
Z135 (135 ohms)
Z150 (150 ohms)
Z300 (300 ohms)
Z600 (600 ohms)
Z900 (900 ohms)
Z1000 (1000 ohms = dBv)
Z1200 (1200 ohms)

Example: DBMZ_D Z600

This setting only applies when single output ac voltages are being sourced. The dBm impedance is set to the default at power on, reset, and when going into single output AC mode.

DBMZ_D?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(dBm Impedance Default query) Returns the power-up and reset default impedance used for dBm outputs (ac volts).

Response: (character) Impedance keyword

Example: DBMZ_D? returns Z600

DC_OFFSET

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(DC Voltage Offset command) Applies a dc offset to an ac output voltage (maximum six digits). This command applies only to single ac voltage outputs. If the selected offset is too large for the active ac voltage range, an error message is returned.

Parameters: <value> signed offset amplitude

Example: DC_OFFSET +123.45 MV

Load a dc offset of +123.45 mV to the ac output signal.

DC_OFFSET?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(DC Voltage Offset query) Returns the value of the dc offset voltage.

Response: <value> signed offset amplitude

Example: DC_OFFSET? returns +1.44E-03

Returns 1.44 mV as the value of the applied dc offset. If +0.00000E+00 is returned, the dc offset is zero.

DHCP

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Enables/disables DHCP (Dynamic Host Configuration Protocol) for LAN operation.

Parameters: ON (enables DHCP operation)

OFF (disables DHCP operation)

DHCP?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Returns the current state of the DHCP enable setting.

Parameters: None

Response: ON DHCP enabled
OFF DHCP disabled (with static IP parameters)

Example: DHCP? Returns ON if DHCP is enabled.

DIAG

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Runs self-diagnostics. If any faults are detected, they are logged into the fault queue where they are read by the FAULT? or ERR? query commands. The response to faults that occur during remote-controlled diagnostics depends on the setting of the DIAG_FAULT command.

After you enter the DIAG command from the display, the Product prompts you to disconnect any cables you have attached.

Enter ADJ_NEXT to proceed to the next step.

The Product display shows **Press Continue to Begin**.

Enter ADJ_NEXT to begin.

Diagnostics take several minutes to run. You can use the ADJ_STEP? remote command to see which step is running. ADJ_STEP? will report IDLE when Diagnostics is complete.

Parameters: None

Example: DIAG

Runs internal self diagnostics.

DIAG_FAULT

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Sets the Calibrator response action to faults encountered when running self diagnostics. In all cases, the Product logs the fault encountered into the fault queue before the Calibrator takes any action as set by this command. The settings of this command are saved in nonvolatile memory.

Parameters: HALT (Halts and waits for ADJ_NEXT remote command to Continue or ADJ_ABORT remote command to abort diagnostics).

ABORT (Terminates diagnostics upon encountering a fault).

CONT (Diagnostics continues to completion, and logs faults as encountered)

Example: DIAG_FAULT ABORT Aborts diagnostics upon encountering a fault during self test.

DIAG_FAULT?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Returns the Calibrator response action to faults encountered when running self diagnostics.

Parameters: NONE

Example: DIAG_FAULT? Returns CONT.

Returns CONT, diagnostics continue to run to completion and logs any faults encountered to the error queue. Use the FAULT? or ERR? commands to return those errors.

DISP_BRIGHTNESS

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Sets the brightness of the display saved in the Calibrator non-volatile memory. (The Calibrator does not respond to remote commands for about 2 seconds while it saves configuration data in the non-volatile memory.)

Parameters: Integer, 0 to 100, where 0 is dimmest and 100 is brightest.

Example: `DISP_BRIGHTNESS 50`

Sets the display to half brightness (the default value).

DISP_BRIGHTNESS?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Returns the brightness setting.

Parameters: None

Example: `DISP_BRIGHTNESS` returns 75

The brightness of the display is set to 75.

DPF

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Displacement Power Factor command) Sets the displacement power factor (phase angle) between the Calibrator front-panel terminals OUTPUT and AUX. The OUTPUT terminal output is the phase reference. The phase offset is expressed as the cosine of the phase offset (0.000 to ± 1.000) and a LEAD (default) or LAG term, which determines whether the VI AUX output leads or lags the OUTPUT output.

Parameters: `<value>, LEAD`
`<value>, LAG`
`<value> (assumes lead)`

Example: `DPF .123, LEAD`

Set the current output on the Calibrator AUX terminals to lead the voltage output on the OUTPUT terminals by 82.93 degrees. (Cosine of 82.93 degrees is 0.123, nominal.)

DPF?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Displacement Power Factor query) Returns the displacement power factor (cosine of the phase angle) between the Calibrator front-panel OUTPUT and AUX terminals for sine wave outputs.

Responses: `<value>, LEAD`
`<value>, LAG`

Example: `DPF?` returns `5.00E-01, LEAD`

Returns a leading power factor of .5 when the current output on the Calibrator AUX terminals leads the voltage output on the OUTPUT terminals by 60 degrees. (Cosine of 60 degrees is 0.5.)

DUTY

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Duty Cycle command) Sets the duty cycle of the square wave output. The duty cycle is the percentage of time the waveform is in the positive part of its cycle (1.00 to 99.00 percent). Duty cycle applies only to single-output square waves.

Parameters: <value> of duty cycle with optional PCT (percent) unit

Example: DUTY 12.34 PCT

Set the square wave duty cycle to 12.34 %.

DUTY?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Duty Cycle query) Returns the value of the square wave output duty cycle (1.00 to 99.00).

Response: <value> of duty cycle in percent

Example: DUTY? returns 1.234E+01

Returns 12.34 % for the value of the square wave duty cycle.

EDIT

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Edit command) Sets the edit field to the primary, secondary or frequency field.

Parameters: PRI (edit the value in single output functions and the primary output value in dual output functions)

SEC (edit the secondary value in dual output functions)

FREQ (edit the frequency value in single ac output functions)

OFF (edit is off, which is the same as if you use the NEWREF command)

Example: EDIT FREQ

Load FREQ into the edit field to edit frequency.

EDIT?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Edit query) Returns the edit field setting.

Responses: (character) PRI (value in single output functions, and the primary output value in dual output functions is in edit)

(character) SEC (secondary value in dual output functions is in edit)

(character) FREQ (frequency value in single ac output functions is in edit)

(character) OFF (no value is in edit.)

Example: EDIT? returns OFF

Returns OFF when no value is in edit.

ENETPORT

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Sets the Ethernet port number.

Parameters: Port number

Example: `ENETPORT 3490` Sets the Ethernet port number to 3490.

ENETPORT?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Returns the Ethernet port number.

Parameters: None

Response: (Integer) Ethernet port number

Example: `ENETPORT?` Returns 3490 if the Ethernet port number is set to 3490.

EOLSTR

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Sets the end of line terminator for outgoing data for a specified remote port.

Parameters: 1. SERIAL, TELNET

2. CRLF, CR, LF

Example: `EOLSTR TELNET, CR`

Sets the end of line terminator for Telnet communication to CR.

EOLSTR?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Returns the end of line terminator for outgoing data for a specified remote port.

Parameters: 1. SERIAL, TELNET

Response: (CRD)

Example: `EOLSTR? SERIAL`

Returns CRLF if the serial end of line terminator is set to CRLF.

ERR?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Error query) Returns the first error code contained in the Calibrator error queue, then removes that error code from the queue. After the error code is an explanation of the error code, similar to but sometimes containing more specific information than the `EXPLAIN?` command. The explanation sent in response to this query can contain variables specific to a particular error event.

A zero value is returned when the error queue is empty. To read the entire contents of the error queue, repeat `ERR?` until the response `0, "No Error"` is returned. For terminal users, the error queue Returns for `ERR?` is always `0, "No Error"` because error messages are returned instead of queued.

Response: `<value>`, (error code value)
`<string>`(text string explaining the error)

Example: `ERR?` returns `0, "No Error"`

Returns `0, "No Error"` when the error queue is empty.

ERR_REF

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Chooses the error reference for error calculations.

Parameters: `NOMINAL` Sets the reference to the nominal value
`TRUEVALUE` Sets the reference to the output value

ERR_REF?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Returns the error reference for error calculations.

Response: `NOMINAL` The nominal value is used as the error reference
`TRUEVALUE` The output value is used as the error reference

ERR_UNIT

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(DUT Error Unit Threshold command) Chooses how DUT error is shown (this is nonvolatile).

Parameters: `GT1000` DUT error is displayed in % above 1000 ppm, ppm below
`GT100` DUT error is displayed in % above 100 ppm, ppm below
`GT10` DUT error is displayed in % above 10 ppm, ppm below
`PCT` DUT error is displayed in % always
`SCI` DUT error is displayed in Scientific Notation (default) always.

ERR_UNIT?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(DUT Error Unit Threshold query) Returns presently selected values of ERR_UNIT.

Responses:

GT1000	DUT error is displayed in % above 1000 ppm, ppm below
GT100	DUT error is displayed in % above 100 ppm, ppm below
GT10	DUT error is displayed in % above 10 ppm, ppm below
PCT	DUT error is displayed in % always
SCI	DUT error is displayed in Scientific Notation (default) always.

*ESE

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Event Status Enable command) Loads a byte into the Event Status Enable (ESE) register. (See [Event Status Enable \(ESE\) Register.](#))

Parameters: <value> (decimal equivalent of the ESE byte, 0 to 255)

Example: *ESE 140

Load decimal 140 (binary 10001100) to enable bits 7 (PON), 3 (DDE) and 2 (QYE).

*ESE?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Event Status Enable query) Returns the contents of the Event Status Enable (ESE) register. (See [Event Status Enable \(ESE\) Register.](#))

Response: <value> (decimal equivalent of the ESE byte, 0 to 255)

Example: *ESE? returns 133

Returns decimal 133 (binary 10000101) when bits 7 (PON), 2 (QYE), 1 (OPC) are enabled.

*ESR?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Event Status Register query) Returns the contents of the Event Status Register (ESR) and clears the register. (See [Event Status Enable \(ESE\) Register.](#))

Response: <value> (decimal equivalent of the ESR byte, 0 to 255)

Example: *ESR? returns 189

Returns decimal 189 (binary 10111101) when bits 7 (PON), 5 (CME), 4 (EXE), 3 (DDE), 2 (QYE) and 0 (OPC) are enabled.

EXPLAIN?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Explain Error query) Explains an error code. This command returns a string that explains the error code furnished as the parameter. The error code (same as the parameter) is originally obtained by sending the `FAULT?` query. (See *Err?* which returns both the error code and the explanation string.)

Parameters: <value> of the error code (an integer)

Response: <string> that explains the error code, with the parameter (if there is one)

Example: `EXPLAIN? 7007` returns `Cannot set Duty Cycle in this configuration`

Returns the explanation of error 7007: `Cannot set Duty Cycle in this configuration`

EXTGUARD

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(External guard command) Connects or disconnects the internal guard shield from the LO binding post.

Parameters: `ON` external guard is on, for example, external
`OFF` external guard is off, for example, internal

Once set, the Calibrator retains the external guard setting until power off or reset.

Example: `EXTGUARD ON`

EXTGUARD?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(External guard query) Returns whether the internal guard shields are connected or disconnected from earth (chassis) ground.

Response: (character) `ON` external guard is on, for example, external
(character) `OFF` external guard is off, for example, internal

Example: `EXTGUARD?` returns `ON`

EXTSENSE

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Selects internal or external sensing. The default is internal sensing.

Parameters: `ON` Sets the Calibrator to external sensing
`OFF` Sets the Calibrator to internal sensing

EXTSENSE?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Returns the status of internal or external sensing.

Parameters: None

Response: ON for external sensing, OFF for internal sensing.

FAULT?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Fault query) Returns the first error code contained in the Calibrator error queue, then removes that error from the queue. After obtaining the error code, use the `EXPLAIN?` command to view an explanation. A zero value is returned when the error queue is empty. To read the entire contents of the error queue, repeat `FAULT?` until the response is 0.

Response: <value> of the error code

Example: `FAULT?` returns 7007

Returns the first error code in the error queue, number 7007. To view an explanation of the error, enter the command `EXPLAIN? 7007`.

FORMAT

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Format command) Restores the contents of the nonvolatile memory device to factory defaults. The memory holds the configuration information for the various remote interfaces and setup parameters.

Parameters:	SERIAL	Restores the serial interface configuration back to the factory defaults.
	LAN	Restores the Ethernet interface configuration back to the factory defaults.
	GPIB	Restores the GPIB interface configuration back to the factory defaults.
	USBTMC	Restores the USBTMC interface configuration back to the factory defaults.
	DISP	Restores the display settings (display and LED brightness) back to the factory defaults.
	INST	Restores the Product settings back to the factory defaults. The FORMAT INST command also clears the *PUD string (see *PUD).
	DATE	Restores the Date and 12/24 format back to the factory defaults.
	LIMIT	Restores the voltage and current limits back to their factory defaults.
	SETUP	Restores all settings to factory defaults with the exception of model, password, scope option type, serial number, A9 PCA serial number, report string [3], display VCOM setting, certain LAN settings (MAC address, IP address, gateway address [4]) and calibration-related settings (verification date, zero adjust date, ohms-zero adjust date, main adjust date, scope adjust date, calibration count, internal and external verification temperatures, calibration unsecured date).
	CAL	Erases all calibration and resets all calibration-related settings (verification date, zero adjust date, ohms-zero adjust date, main adjust date, scope adjust date, calibration count, internal and external verification temperatures, calibration unsecured date). Requires unsecuring the unit.

Example: FORMAT SERIAL

Replace the RS-232 serial interface system parameters with the default setup values. See the Operators Manual for a full list of default values and settings.

FUNC?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Function query) Returns the present output, measurement, or calibration function. See the response below for output and measurement functions.

Responses:

DCV	(dc volts function)
ACV	(ac volts function)
DCI	(dc current function)
ACI	(ac current function)
RES	(ohms function)
CAP	(capacitance function)
RTD	(temperature with an rtd function)
TC_OUT	(temperature with a thermocouple function)
DC_POWER	(dc power function)
AC_POWER	(ac power function)
DCV_DC	(dual dc volts function)
ACV_AC	(dual ac volts function)
TC_MEAS	(measure temperature with a thermocouple)
SACV	(oscilloscope ac volts function)
SDCV	(oscilloscope dc volts function)
MARKER	(oscilloscope marker function)
LEVSINE	(oscilloscope leveled sine function)
EDGE	(oscilloscope edge function)
WAVEGEN	(oscilloscope wavegen function)
VIDEO	(oscilloscope video function)
PULSE	(oscilloscope pulse function)
MEASR	(oscilloscope resistance measurement function)
MEASC	(oscilloscope capacitance measurement function)
OVERLDAC	(oscilloscope overload AC function)
OVERLDCC	(oscilloscope overload DC function)
IND	(inductance function)
DCI_BOOST	(52120A amplified DCI function)
ACI_BOOST	(52120A amplified ACI function)

Example: FUNC? returns DCV_DC

Returns DCV_DC when the Calibrator output function dual dc volts.

GWADDR

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Sets the Ethernet gateway address for LAN communication when NOT in DHCP function. Contact your network administrator for assistance to get the correct address for your network.

Parameters: Gateway address (string consisting of 4 decimal values bound between 0-255 separated by periods).

Example: GWADDR 129.196.136.1

Sets the Ethernet gateway address to 129.196.136.1

GWADDR?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Returns the Ethernet gateway address for LAN communication when NOT in the DHCP function. When in the DHCP function, the response will be *default*.

Parameters: None

Response: String

Example: GWADDR?

Returns 129.196.136.1 if the gateway address is set to 129.196.136.1 and DHCP is not enabled. Returns *default* if DHCP is enabled.

HARMONIC

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Harmonic command) Makes the frequency of one output a multiple of another output for the ac voltage or ac power functions (sine waves only). For example, in dual ac voltage, have the frequency of the voltage output on the Calibrator front-panel OUTPUT terminals at 60 Hz and the frequency of the voltage output on the AUX terminals at the 7th harmonic (420 Hz). The range for the harmonics is 1 to 50.

Parameters: <value>, PRI (fundamental at Product OUTPUT terminals)
<value>, SEC (fundamental at Product AUX terminals)

Example: HARMONIC 5, PRI

Load the fundamental frequency at the primary (PRI) output (OUTPUT terminals), and the 5th harmonic frequency is at the secondary output (AUX terminals). For example, if the fundamental frequency output is 60 Hz, the harmonic frequency output is 300 Hz.

HARMONIC?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Harmonic query) Returns the present instrument harmonic characteristic and location of the fundamental output PRI (primary, the OUTPUT terminals) or SEC (secondary, the AUX terminals).

Response: <value>, PRI (harmonic value, fundamental at primary output)
<value>, SEC (harmonic value, fundamental at secondary output)

Example: HARMONIC? returns 5, SEC

Returns that the 5th harmonic frequency is selected, and the fundamental is at the secondary output (AUX terminals). Therefore, the harmonic frequency appears at the primary, or OUTPUT terminals.

ID?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Return detailed instrument ID and software version information.

Parameter:

MAIN	Display the default version information
FW	Display version information of source/measurement boards
SERIAL	Display serial numbers of source/measurement boards
ALL	Display information returned by MAIN + FW + SERIAL
[If the parameter is omitted]	Same as ID? MAIN

Example: ID?

```
Model: MODEL_5560A
Serial#: 1234567
OG Version: v23.34.5 DEV
OG Build Date: 2023-08-25-11:13:57-0700
IG Version: v4.19.0000
IG Build Date: 2023-08-25-09:10:11
OS Version: 5.4.13-altera
OS Build Date: 2022-11-11
FPGA Version: v8
FPGA Build Date: 2021-02-18
Touch Screen Info: SBest Technology SiS HID Touch Controller v0111
All MSP Version: 1.01
```

*IDN?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Identification query) Returns instrument model number, serial number, and firmware revision levels for the main and inguard CPUs.

Responses: (Indefinite ASCII) A message containing four fields separated by commas as follows:

1. Manufacturer
2. Model number
3. Serial number
4. Firmware revision levels for the Main CPU inguard FPGA

Example: *IDN? returns FLUKE,5560A,5248000,1.0+1.8

Returns Fluke manufacturer, model 5560A, serial number 5248000, main firmware version 1.0 and inguard FPGA 1.8.

INCR

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Increment command) Increments or decrements the output (as selected with the `EDIT` command, or defaults to the primary output) in base units and enters error mode; the same as if you use the Calibrator output adjustment knob in local operation.

Parameters: `<+ value>` (increment value)
`<-value>` (decrement value)

Example: `INCR 1.2E-6`

Load the error mode and increment the selected edit field by .000012 units. When in volts, this increments the value by 1.2 μ V.

IPADDR

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Sets the IP address for LAN communication when NOT in the DHCP function and with static IP addressing. Contact the network administrator for a static IP address to be used exclusively by the Calibrator.

Parameters: IP address (string consisting of 4 decimal values bound between 0-255 separated by periods).

Example: `IPADDR 129.196.136.119`

Sets the Ethernet IP static address to 129.196.136.119

IPADDR ?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Returns the IP address for LAN communication. When DHCP is enabled, this address will be the address allocated by the DNS server. When DHCP is disabled, this address is entered value of the static IP address.

Parameters: None

Response: String

Example: `IPADDR?` Returns 129.196.137.45 if DHCP is enabled and the DNS server has allocated this address to the Calibrator, or returns 129.196.136.119 if DHCP is disabled and the static address has been previously set to that address.

ISCE

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Instrument Status Change Enable command) Loads two bytes into the two 16-bit ISCE mask registers (ISCE1 and ISCE0). (See [Instrument Status Change Enable Registers.](#))

Parameters: <value> (decimal equivalent of the 16 bits, 0 to 32767)

Example: ISCE 6272

Load decimal 6272 (binary 0001010001000000) to enable bits 12 (SETTLED), 10 (REMOTE) and 6 (HIVOLT). This is equivalent to sending the commands ISCE0 6272 and ISCE1 6272 (see below).

ISCE?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Instrument Status Change Enable query) Returns the two bytes from the two 16-bit ISCE mask registers (ISCE1 and ISCE0). (See [Instrument Status Change Enable Registers.](#))

Response: <value> (decimal equivalent of the 16 bits, 0 to 32767)

Example: ISCE? returns 6272

Returns decimal 6272 (binary 0001010001000000) if bits 12 (SETTLED), 10 (REMOTE), and 6 (HIVOLT) are set to 1.

ISCE0

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Instrument Status 1 to 0 Change Enable command) Loads the two bytes into the 16-bit ISCE0 register. (See [Instrument Status Change Enable Registers.](#))

Parameters: <value> (decimal equivalent of the 16 bits, 0 to 32767)

Example: ISCE0 6272

Load decimal 6272 (binary 0001010001000000) to enable bits 12 (SETTLED), 10 (REMOTE) and 6 (HIVOLT).

ISCE0?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Instrument Status 1 to 0 Change Enable query) Returns the two bytes from the 16-bit ISCE0 register. (See [Instrument Status Change Enable Registers.](#))

Response: <value> (decimal equivalent of the 16 bits, 0 to 32767)

Example: ISCE0? returns 6272

Returns decimal 6272 (binary 0001010001000000) if bits 12 (SETTLED), 10 (REMOTE), and 6 (HIVOLT) are set to 1.

ISCE1

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Instrument Status 0 to 1 Change Enable command) Loads the two bytes into the 16-bit ISCE1 register. (See [Instrument Status Change Enable Registers](#).)

Parameters: <value> (decimal equivalent of the 16 bits, 0 to 32767)

Example: ISCE1 6272

Load decimal 6272 (binary 0001010001000000) to enable bits 12 (SETTLED), 10 (REMOTE) and 6 (HIVOLT).

ISCE1?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Instrument Status 0 to 1 Change Enable query) Returns the two bytes from the 16-bit ISCE1 register. (See [Instrument Status Register \(ISR\)](#).)

Response: <value> (decimal equivalent of the 16 bits, 0 to 32767)

Example: ISCE1? returns 6272

Returns decimal 6272 (binary 0001010001000000) if bits 12 (SETTLED), 10 (REMOTE), and 6 (HIVOLT) are set to 1.

ISCR?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Instrument Status Change Register query) Returns and clears the contents of the Instrument Status 1 to 0 Change Register (ISCR0) and Instrument Status 0 to 1 Change Register (ISCR1). (See [Instrument Status Register \(ISR\)](#).)

Response: <value> (decimal equivalent of the 16 bits, 0 to 32767)

Example: ISCR? returns 6272

Returns decimal 6272 (binary 0001010001000000) if bits 12 (SETTLED), 10 (REMOTE), and 6 (HIVOLT) are set to 1.

ISCR0?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Instrument Status 1 to 0 Change Register query) Returns and clears the contents of the Instrument Status 1 to 0 Change Register.

Response: <value>(decimal equivalent of the 16 bits, 0 to 32767)

Example: ISCR0? returns 6272

Returns decimal 6272 (binary 0001010001000000) if bits 12 (SETTLED), 10 (REMOTE), and 6 (HIVOLT) are set to 1.

ISCR1?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Instrument Status 0 to 1 Change Register query) Returns and clears the contents of the Instrument Status 0 to 1 Change Register.

Response: <value>(decimal equivalent of the 16 bits, 0 to 32767)

Example: ISCR1? returns 6272

Returns decimal 6272 (binary 0001010001000000) if bits 12 (SETTLED), 10 (REMOTE), and 6 (HIVOLT) are set to 1.

ISR?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Instrument Status Register query) Returns contents of the Instrument Status Register.

Response: <value>(decimal equivalent of the 16 bits, 0 to 32767)

Example: ISR? returns 6272

Returns decimal 6272 (binary 0001010001000000) if bits 12 (SETTLED), 10 (REMOTE), and 6 (HIVOLT) are set to 1.

LCOMP_52120

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Inductive compensation command) Activates or deactivates inductive load compensation for 52120 AC current output. See the 52120 specifications for frequency and amplitude levels where LCOMP_52120 is available.

Parameters: OFF (turns off the inductive load compensation circuitry)
ON (turns on the inductive load compensation circuitry)

Example: LCOMP_52120 ON

LCOMP_52120?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Inductive compensation query) Returns whether inductive load compensation for 52120 AC current output is active.

Responses: (character) OFF (Inductive load compensation circuitry is off)
(character) ON (Inductive load compensation circuitry is on)

Example: LCOMP_52120? returns ON

LED_BRIGHTNESS

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Sets the output block LED ring brightness saved in the Calibrator non-volatile memory. (The Calibrator does not respond to remote commands for about 2 seconds while it saves configuration data in the non-volatile memory.)

Parameters: Integer, 0 to 100, where 0 is dimmest and 100 is brightest.

Example: `LED_BRIGHTNESS 50`

Sets the output block LED display to half brightness (the default value).

LED_BRIGHTNESS?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Description Returns the output block LED ring brightness setting.

Parameters: None

Example: `LED_BRIGHTNESS` returns 75

The the output block LED ring brightness is set to 75.

LFREQ?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Inductance Frequency query) Returns the optimal frequency for stimulus when measuring or calibrating inductance output.

Response: <value> of the optimal frequency

Example: `LFREQ?` returns `1.0E+2`

Returns 100 Hz as the optimal frequency for the selected inductance output (1.0 μ H for this example). The return is 0 if not sourcing inductance.

LIMIT

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Limit command) Sets the maximum permissible output magnitude, negative and positive, for voltage and current, which is saved in the Calibrator non-volatile memory. (While saving configuration data in the non-volatile memory, a period of about 2 seconds, the Calibrator does not respond to remote commands.) Both negative and positive values must be entered. Once set, the Calibrator retains the limit settings until either another limit is entered, or the `FORMAT LIMIT` command resets the limits (and all other defaults) to the factory settings (± 1020 V, ± 30.2 A). See Format.

The magnitude of the limit has the following effect on different waveforms:

dc	magnitude of limit
ac (sine wave)	magnitude of limit (rms)
ac (non-sine wave)	magnitude of limit x 3 (peak-to-peak)
ac (with dc offset)	magnitude of limit x 2.4 (absolute peak) (volts only)

Parameters: <positive value>, <negative value>

Example: `LIMIT 100V, -100V`

Limit the voltage output to ± 100 V dc, 100 V ac rms, 300 V peak-to-peak, 240 V peak.

Example: `LIMIT 1A, -1A`

Limit the current output to ± 1 A dc, 1 A ac rms, 3 A peak-to-peak.

LIMIT?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Limit query) Returns the programmed output magnitude limits for voltage and current.

Response: <positive value voltage>, <negative value voltage>,
<positive value current>, <negative value current>

Example: `LIMIT?`

returns `1020.0000, -1020.0000, 30.2000, -30.2000`

Returns the present value of the voltage and current limits (reset values shown).

LOCAL

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Local command) Puts the Calibrator into the local state, clearing the remote state (see REMOTE) and front-panel lockout (see LOCKOUT). This command duplicates the IEEE-488.1 GTL (Go To Local) message.

Parameters: (None)

Example: `LOCAL`

Set the instrument into the local state, clearing the remote state and front-panel lockout (if enabled).

LOCKOUT

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Lockout command) Puts the Calibrator into the lockout state when in remote control (see REMOTE). This means no local operation at the front panel is allowed during remote control. To clear the lockout condition, use the LOCAL command. This command duplicates the IEEE-488.1 LLO (Local Lockout) message.

Parameters: (None)

Example: LOCKOUT

Set the Product into the front-panel lockout state. The front-panel controls cannot be used.

LOWS

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Low Potential Output Terminals command) Selects whether or not the Calibrator front-panel OUTPUT LO terminal and SENSE LO terminal are internally tied together (default) or are open. This feature is used for ac power, dc power, dual dc volts and dual ac volts outputs. Once set, the Calibrator retains the LO setting until power off or reset.

Parameters: OPEN (disconnect OUTPUT LO and SENSE LO terminals)

TIED (connect OUTPUT LO and SENSE LO terminals)

Example: LOWS TIED

Tie the front-panel OUTPUT LO and SENSE LO terminals together.

LOWS?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Low Potential Output Terminals query) Returns whether or not the Calibrator front-panel OUTPUT LO terminal and SENSE LO terminal are internally tied together (default) or are open.

Response: OPEN (disconnected OUTPUT LO and SENSE LO terminals)

TIED (connected OUTPUT LO and SENSE LO terminals)

Example: LOWS? returns OPEN

Returns OPEN when the Calibrator front-panel OUTPUT LO and SENSE LO terminals are not tied together.

MACADDR?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Returns the MAC/HW address for LAN communication. The MAC address is a unique assigned value and cannot be changed.

Parameters: None

Response: String

Example: `MACADDR?` Returns six groups of hexadecimal numbers separated by colons (for example, `01:23:45:67:89:ab`)

MULT

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Multiply command) Multiplies the reference magnitude (as selected with the `EDIT` command or default to the primary output). The reference magnitude is the present reference in either direct mode or in error mode.

Parameters: <value> (multiplier expressed as a floating point number)

Example: `MULT 2.5`

Multiply the existing reference by 2.5, creating a new reference. For example, an existing reference of 1 V is multiplied to 2.5 V.

NEWREF

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(New Reference command) Sets the new reference to the present Calibrator output value and exit the error mode (if selected). For example, you might edit the Calibrator output with the `EDIT` and `INCR` commands, and then use the `NEWREF` command to establish a new reference point and exit the error mode.

Parameters: (None)

Example: `NEWREF`

Set the reference value to the current Calibrator output value.

OL_TRIP?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Returns the number of seconds before overload protection was tripped. Returns 0 if protection has not been tripped or if `OVERLDAC` and `OVERLDDC` are inactive.

Parameters: (None)

Example: `OL_TRIP?`

Returns 2.6E+00 when the scope detected an overload condition in 2.6 seconds.

OLDREF

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Old Reference command) Sets the Calibrator output to the reference value and exit the error mode (if selected). If you edit the output with the `EDIT` and `INCR` commands and you want to return to the reference value, use the `OLDREF` command. If you edit the output and you want to make the edited value the new reference, use the `NEWREF` command.

Parameters: (None)

Example: `OLDREF`

Set the output to the existing reference value, clearing editing changes.

ONTIME?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Returns the number of minutes since the calibrator was turned on.

Parameters: None

Example: `ONTIME?` returns 135 (the calibrator has been on for 2 hours and 15 minutes).

*OPC

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Operations Complete command) Sets bit 0 (OPC) of the Event Status Register to 1 when all pending device operations are complete. Also see `*ESR?`.

Parameters: (None)

Example: `*OPC`

Set bit 0 of the Event Status Register to 1 when all pending device operations are done.

*OPC?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Operations Complete query) Returns a 1 after all pending operations are complete. This command causes program execution to pause until operations are complete. (See `*WAI`)

Response: 1 (all operations are complete)

Example: `*OPC?` returns 1

Returns 1 when all pending operations are complete.

OPER

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Operate command) Activates the Calibrator output if it is in standby. This is the same as **OPERATE**.

Parameters: (None)

Example: OPER

Connect the selected output to the Calibrator front-panel terminals. Also lights the OPERATE annunciator on.

OPER?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Operate query) Returns the operate/standby setting.

Response: 1(Operate)

0(Standby)

Example: OPER? returns 1

Returns 1 when the Calibrator is in operate.

*OPT?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Options command) Returns a list of the installed hardware and software options.

Responses: <option string>,<option string>,...(options list, separated by commas)

0(no options are installed)

Example: *OPT? returns SC600

Returns SC600 when the Oscilloscope Calibration Option is installed.

OUT

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Output command) Sets the output of the Calibrator and establishes a new reference point for the error mode. If only one amplitude is supplied, the Calibrator sources a single output. If two amplitudes are supplied, the Calibrator sources two outputs. The second amplitude will be sourced at the AUX terminals for dual voltage outputs. If the frequency is not supplied, the Calibrator will use the frequency that is presently in use.

To source or measure a temperature, select the desired sensor and sensor parameters first. (See the TSENS_TYPE).

To source a signal with the Calibrator scope options, refer to the SCOPE command in [Remote Commands](#).

If you change the frequency of an ac function and the harmonic output is not explicitly set at the same time with the HARMONIC command, the harmonic will be set to 1.

Use prefixes for example, k, M, μ with the OUT command, as desired.

Parameters:<value> V	Volts dc or update volts ac
<value> DBM	Volts ac dBm update
<value> V, <value> Hz	Volts ac or volts dc with 0 Hz
<value> DBM, <value> Hz	Volts ac in dBm
<value> A	Current dc or update current ac
<value> A, <value> Hz	Current ac
<value> OHM	Resistance
<value> F	Capacitance
<value> CEL	Temperature (Celsius)
<value> FAR	Temperature (Fahrenheit)
<value> HZ	Update frequency
<value> V, <value> A	Power dc or update power ac
<value> V, <value> A, <value> HZ	Power ac
<value> V, <value> V	Dual volts dc or update dual ac
<value> V, <value> V, <value> HZ	Dual volts ac in volts
<value>	For single output, changes amplitude keeping unit and frequency the same.

Examples: OUT 15.2 V	(volts; 15.2 V @ same frequency)
OUT 20 DBM	(volts; 20 dBm @ same frequency)
OUT 10 V, 60 Hz	(volts ac; 10 V @ 60 Hz)
OUT 10 DBM, 50 HZ	(volts ac; 10 dBm @ 50 Hz)
OUT 1.2 MA	(current; 1.2 mA @ same frequency)
OUT 1 A, 400 HZ	(current ac; 1 A @ 400 Hz)
OUT 1 KOHM	(ohms; 1 k Ω)
OUT 1 UF	(capacitance; 1 μ F)
OUT 100 CEL	(temperature; 100 $^{\circ}$ C)
OUT 32 FAR	(temperature; 32 $^{\circ}$ F)
OUT 60 HZ	(frequency update; 60 Hz)
OUT 10 V, 1 A	(power; 10 watts @ same frequency)
OUT 1 V, 1 A, 60 HZ	(power ac; 1 watts @ 60 Hz)
OUT 1 V, 2 V	(dual volts; 1 V, 2 V @ same freq.)
OUT 10 MV, 20 MV, 60 HZ	(dual volts; .01 V, .02 V @ 60 Hz)

Each example shows a value and unit, for example, -15.2 V. If a value is entered without a unit, the value of the existing output is changed, when logically allowed.

OUT?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Output query) Returns the output amplitudes and frequency of the Calibrator. Prefixes (for example, K or M) are not used in the response.

Parameters: V (optional for ac voltage and TC functions)
 DBM (optional for ac voltage functions)
 CEL (optional for RTD and TC functions, Celsius)
 FAR (optional for RTD and TC functions, Fahrenheit)
 OHM (optional for RTD functions, ohms)

Response: <primary amplitude value>,<primary units>,
 <secondary amplitude value>,<secondary units>,
 <fundamental frequency value>

Examples: OUT? returns -1.520000E+01,V,0E+00,0,0.00E+00
 OUT? returns 1.88300E-01,A,0E+00,0,4.420E+02
 OUT? returns 1.23000E+00,V,2.34000E+00,V,6.000E+01
 OUT? returns 1.92400E+06,OHM,0E+00,0,0.00E+00
 OUT? returns 1.52000E+01,V,1.88300E-01,A,4.420E+02
 OUT? DBM returns 2.586E+01,DBM,0E+00,A,4.420E+02
 OUT? returns 1.0430E+02,CEL,0E+00,0,0.00E+00
 OUT? FAR returns 2.19740000E+02,FAR,0E+00,0,0.00E+00
 OUT? V returns 4.2740E-03,V,0E+00,0,0.00E+00
 OUT? OHM returns 1.40135E+02,OHM,0E+00,0,0.00E+00

The respective values for the above examples are:

-15.2 V
 188.3 mA, 442 Hz
 1.23 V, 2.34 V, 60 Hz
 1.924 M Ω
 15.2 V, 188.3 mA, 442 Hz
 25.86 dBm, 442 Hz (25.86 dBm = 15.2 V at 600 Ω)
 104.3 $^{\circ}$ C
 219.74 $^{\circ}$ F (same value as 104.3 $^{\circ}$ C, in Fahrenheit)
 4.274 mV (same value as 104.3 $^{\circ}$ C for a K-type thermocouple, in volts)
 140.135 Ω (same value as 104.3 $^{\circ}$ C for a pt385 RTD, in ohms)

The primary and secondary units are: V, DBM, A, OHM, F, CEL, FAR. The units for the <frequency value> is always assumed to be Hz.

OUT_ERR?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Output Error query) Returns the DUT error and units computed by the Calibrator after shifting the output with the INCR command. The return units are SCI (Scientific Notation, default), PPM (parts per million), PCT (percent), DB (decibels) or 0 if there is no error. The DUT error is not computed when editing frequency.

Response: <value of error>,<units>

Example: OUT_ERR? returns 1.00000E+01,PCT

Returns -10% when the DUT is reading low by 10 %.

OUT_IMP

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Sets the output impedance of the SCOPE BNC.

Parameters: Z50 Set scope output impedance to 50 Ω

Z1M Set scope output impedance to 1 M Ω

Example: SCOPE ACV; OUT_IMP Z50

Select the SCOPE > ACV function and set the BNC output impedance to 50 Ω .

OUT_IMP?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Returns the output impedance of the SCOPE BNC (50 Ω or 1 M Ω).

Parameters: NONE

Example: SCOPE ACV; OUT_IMP?

Z1M

The BNC output impedance is set to 1 M Ω (Z1M).

PHASE

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Phase Difference command) Sets a phase difference between the Calibrator front-panel OUTPUT and AUX or 30A terminals for ac power and ac dual voltage outputs. The OUTPUT terminal output is the phase reference. The range is 0.00 to ± 180.00 degrees, with + for a leading phase difference and - for a lagging phase difference.

Parameters: <phase value> DEG (DEG, for degree, is optional)

Example: PHASE -60 DEG

Set the phase difference so the frequency output at the AUX terminals lags the frequency output at the OUTPUT terminals by 60 degrees.

PHASE?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Phase Difference query) Returns the phase difference between the Calibrator front-panel OUTPUT and AUX terminals for ac power and ac dual voltage outputs.

Response: <phase value>

Example: PHASE? returns -6.000E+01

Returns -60 when the frequency output at the AUX terminals is lagging the frequency output at the OUTPUT terminals by 60 degrees.

POST_52120

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Sets the output terminals for all attached 52120As.

Parameters: 1. LO

HI

Example: POST_52120 LO Selects the low current output terminals for all attached 52120As.

POST_52120?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Returns the selected output terminals for all attached 52120As.

Parameters: None

Response: LO

HI

Example: POST_52120? Returns HI if the high current output terminals are selected for all attached 52120As.

POWER?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Calculate Power Output query) Returns the equivalent real power for ac and dc power outputs, based on the voltage and current settings, and power factor (ac only). If the output is not ac or dc power, the return is 0E+00 (zero) watts.

Response:<value> (in watts)

Example: POWER? returns 1.00000E+01

Returns 10 when the output voltage is 10 V dc and output current 1 A dc, for 10 watts real power.

Example: POWER? returns 1.00000E+01

Returns 10 when the output voltage is 10 V ac and output current 2 A ac and power factor is .5, for 10 watts real power.

*PUD

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Protected User Data command) Stores a string of 64 characters (maximum), which is saved in the Calibrator non-volatile memory. (The Calibrator does not respond to remote commands for about 2 seconds while it saves configuration data in the non-volatile memory). The Calibrator must be in the unsecured state. Include a line feed (RS-232) character to terminate the block data or End or Identify (EOI) command (IEEE-488).

Parameters: #2<nn><nn characters string> (definite length)
 #0<character string> (indefinite length)
 "<character string>" (character string, within double-quotes, this format must be used if the character string contains commas)

Example: *PUD #0CAL LAB NUMBER 1

Store the string CAL LAB NUMBER 1 in the protected user data area using the indefinite length format.

Example: *PUD #216CAL LAB NUMBER 1

Store the string CAL LAB NUMBER 1 in the protected user data area using the definite length format, where #2 means two digits follow which represent the number of text characters nn in CAL LAB NUMBER 1 (including spaces=16).

Example: *PUD "CAL LAB NUMBER 1"

Store the string CAL LAB NUMBER 1 in the protected user data area using the character string format.

*PUD?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Protected User Data query) Returns the contents of the *PUD (Protected User Data) memory in definite length format.

Response: #2nn<nn characters>

Example: *PUD? returns #216CAL LAB NUMBER 1

Returns #2 (the number of digits in the character count field which follows next), then 16 (the length of the character field which follows next), then 16 characters of text (including spaces) stored in the nonvolatile memory.

RANGE

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Set the Calibrator range when in PULSE or MEASR scope functions.

Switch between MEASC and MEASR scope functions.

Switch between OVERLDAC and OVERLDDC scope functions.

Parameters: TP0DB	Selects the 2.5 V range in PULSE
TP8DB	Selects the 1.0 V range in PULSE
TP20DB	Selects the 250 mV range in PULSE
TP28DB	Selects the 100 mV range in PULSE
TP40DB	Selects the 25 mV range in PULSE
TP48DB	Selects the 10 mV range in PULSE
TZ50OHM	When in MEASC, switch to MEASR
TZ1MOHM	When in MEASC, switch to MEASR
TZCAP	When in MEASR, switch to MEASC
TOLAC	When in OVERLDDC, switch to OVERLDAC
TOLDC	When in OVERLDAC, switch to OVERLDDC

Example: SCOPE PULSE; RANGE TP20DB

Select the PULSE scope function and set the 250 mV range.

Note

The MEASR function cannot be locked to either range and will always auto-range. The TZ500OHM and TZ1MOHM Parameters are present to maintain backwards compatibility with previous products but will not actually set the range.

RANGE?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Range query) Returns the present output ranges. Both the primary output and secondary outputs are returned. If there is no secondary output, 0 is returned.

Response: <primary output>, <secondary output>

Examples: DC120MV, 0 (dc volts 120 mV range)
DC12MA_A, 0 (dc current 12 mA range)
AC12V, 0 (ac volts 12 V range)
AC120MA, 0 (ac current 120 mA range)
R120OHM, 0 (ohms 120 Ω range)
C1_2UF, 0 (capacitance 1.2 μ F range)
TCS_LO, 0 (temperature thermocouple source)
RTD_R120OHM, 0 (temperature RTD 120 Ohm range)
DC1_2V, DC1_2A (dc power 1.2 V, 1.2 A ranges)
AC120V, AC12A (ac power 120 V, 12 A ranges)
DC120MV, DC12V (dual dc volts 120 mV, 12 V ranges)
AC120V, AC12V (dual ac volts 120 V, 12 V ranges)

Returns the symbolic name of the single or first output, and return the symbolic name of the second output (0 if there is no second output).

RANGELCK

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Range Lock command) Locks in the present range, or selects auto ranging for dc voltage and dc current single outputs. The range automatically unlocks if the output function changes, for example from dc volts to dc current. When RANGELCK is on, this is equivalent to the **Range Lock** softkey showing locked. When RANGELCK is off, this is equivalent to the **Range Lock** softkey showing auto.

Parameters: ON (Locks the dc volts or dc current range)
OFF (Unlocks the dc volts or dc current range for autoranging)

Example: RANGELCK OFF

Set the range lock off to allow autoranging for dc volts or dc current.

RANGELCK?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Range Lock query) Returns whether or not the preset dc volts or dc current single output range is locked.

Response: ON (range is locked and autoranging is not allowed)
OFF (range is not locked and autoranging is allowed)

Example: RANGELCK? returns OFF

Returns OFF when the range for dc volts or dc current is not locked (autoranging enabled).

REFCLOCK_D

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Reference Clock Default command) Sets the power-up and reset default for the reference clock source (internal or through the 10 MHz IN BNC connector).

Parameters INT (Sets internal reference clock)
EXT (Sets external reference clock)

The reference clock is set to the default at power on, reset, and when going into an ac function.

Example: REFCLOCK_D INT

REFCLOCK_D?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Reference Clock Default query) Returns the power-up and reset default for the reference clock source (internal or through the 10 MHz IN BNC connector).

Responses: (character) INT (Reference clock is internal)
(character) EXT (Reference clock is external)

Example: REFCLOCK_D? returns INT

REFOUT?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Reference Output query) Returns the present value of the reference when editing the output (error mode). If you do not edit the output with the INCR command, the return is 0 (0E+00). The reference value is set with the OUT, NEWREF or MULT commands. To determine which quantity is being edited, use the EDIT? and OUT? commands.

Response: <reference value>

Example: REFOUT? returns 0E+00

Returns 0 when the output is not being edited.

Example: REFOUT? returns 2.500000E-01

Returns .250 when the output is being edited and the reference is, for example, 250 mV.

REFPHASE

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Reference Phase command) If two Calibrators are synchronized with 10 MHz IN/OUT, this sets the phase difference between the primary channel on the Calibrator relative to the sync pulse on the 10 MHz IN or OUT terminal. The primary channel is the OUTPUT, AUX, or 30A terminal for single outputs and the OUTPUT terminal for ac power and ac dual voltage outputs. The sync pulse on the 10 MHz IN or OUT terminal is the phase reference. The set range is 0.00 to ± 180.00 degrees, with + for a leading phase difference and – for a lagging phase difference.

Parameters: Phase with optional prefix and DEG unit

Example: REFPHASE 1.5 DEG (1.5 degrees)

On either Calibrator, set the phase of the primary channel to lead the sync pulse by 1.5 degrees.

REFPHASE?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Reference Phase query) If two Calibrators are synchronized with 10 MHz IN/OUT, this returns the phase difference between the primary channel on the Calibrator and the sync pulse on the 10 MHz IN or OUT terminal.

Response: (float) Phase in degrees

Example: REFPHASE? returns 1.50E+00 (1.5 degrees)

REFPHASE_D

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Reference Phase Default command) If two Calibrators are synchronized with 10 MHz IN/OUT, this sets the power-up and reset default phase difference between the primary channel on the Calibrator relative to the sync pulse on the 10 MHz IN or OUT terminal. The primary channel is the OUTPUT, AUX, or 30A terminal for single outputs and the OUTPUT terminal for ac power and ac dual voltage outputs. The sync pulse on the 10 MHz IN or OUT terminal is the phase reference. The set range is 0.00 to ± 180.00 degrees, with + for a leading phase difference and - for a lagging phase difference.

Parameters: Phase with optional prefix and DEG unit

Example REFPHASE_D 1.5 DEG (1.5 degrees)

On either Calibrator, set the power-up and reset default phase of the primary channel to lead the sync pulse by 1.5 degrees.

REFPHASE_D?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Reference Phase Default query) If two Calibrators are synchronized with 10 MHz IN/OUT, this returns the power-up and reset default phase difference between the primary channel on the Calibrator and the sync pulse on the 10 MHz IN or OUT terminal.

Response: (Float) Phase in degrees

Example: REFPHASE_D? returns 1.50E+00 (1.5 degrees)

REMOTE

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Remote command) Places the Calibrator into the remote state. This command duplicates the IEEE-488.1 REN (Remote Enable) message. When in the remote state, the display shows the **Go to Local** softkey. Tap this softkey to return the Calibrator to local operation. If the front panel is locked out, the display shows the **Locked** softkey. (See LOCKOUT.) To unlock the front panel, use the LOCAL command, or cycle the Calibrator power switch.

Parameters: (None)

Example: REMOTE

Place the Calibrator in the remote state and show this state on the display with a **REMOTE CONTROL** softkey.

RPT_STR

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Report String command) Loads the user report string. The user report string appears on calibration reports. The Calibrator must be in the unsecured state. (Sequential command.)

Parameters: String of up to 40 characters

RPT_STR?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Report String query) Returns the user report string. The user report string appears on calibration reports. (Sequential command.)

Parameters: None

Response: (String) Up to 40 characters

***RST**

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Reset Instrument command) Resets the Calibrator to the power-up state. *RST holds off execution of subsequent commands until the reset operation is complete. This command is the same as pushing **Reset**.

A reset action evokes these commands and values:

Note

Changes made to the setup menus that are not saved in memory are discarded on reset.

Command	Value	Command	Value
COILTURNS	COILTURNS_D value>	RTD_TYPE	<RTD_TYPE_D value>
COILTYPE	<COILTYPE_D value>	SCOPE	OFF
DBMZ	<DBMZ_D value>	STBY	(No output)
DC_OFFSET	0V	TC_OFFSET	0
DUTY	50PCT	TC_OTCD	ON
EXTGUARD	OFF	TC_REF	INT
HARMONIC	1, PRI	TC_TYPE	<TC_TYPE_D value>
LCOMP_52120		TEMP_STD	<TEMP_STD_D value>
LOWS	TIED	TLIMIT	<TLIMIT_D value>
OUT	0V, 0HZ	TRIG	OFF
OUT_IMP	Z1M	TSENS_TYPE	TC
PHASE	0DEG	WAVE	NONE, NONE
RANGELCK	OFF	ZCOMP	OFF
REFPHASE	<REFPHASE_D value>		

Response: (None)

Example: *RST

Place the Calibrator in a reset condition, evoking the commands and values shown above.

RTD_TYPE

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Resistance Temperature Detector Type command) Sets the Resistance Temperature Detector (RTD) sensor type.

Before you use `RTD_TYPE`, select `RTD` with the `TSENS_TYPE` command. After you use `RTD_TYPE`, select the output temperature with the `OUT` command. Changes in temperature sensors changes the output to 0 °C. At power off or reset and when entering the TC Measure or TC source functions, the thermocouple type reverts to the default thermocouple type specified within Instrument Setup.

Parameters:

<code>PT385</code>	(100-ohm RTD, curve $\alpha=0.00385$ ohms/ohm/°C)
<code>PT385_200</code>	(200-ohm RTD, curve $\alpha=0.00385$ ohms/ohm/°C)
<code>PT385_500</code>	(500-ohm RTD, curve $\alpha=0.00385$ ohms/ohm/°C)
<code>PT385_1K</code>	(1000-ohm RTD, curve $\alpha=0.00385$ ohms/ohm/°C)
<code>PT3926</code>	(100-ohm RTD, curve $\alpha=0.003926$ ohms/ohm/°C)
<code>PT3916</code>	(100-ohm RTD, curve $\alpha=0.003916$ ohms/ohm/°C)
<code>CU10</code>	(10-ohm RTD, empirical curve)
<code>CU50</code>	(50-ohm RTD, empirical curve)
<code>CU100</code>	(100-ohm RTD, empirical curve)
<code>NI120</code>	(120-ohm RTD, empirical curve)

Example: `RTD_TYPE PT3926`

Set the RTD type to a 100-ohm type, with the `pt3926` curve ($\alpha=0.003926$ ohms/ohm/°C). The resistance of 100 ohms refers to the ice point characteristic, (the resistance of the RTD at 0 °C (32 °F)).

RTD_TYPE?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Resistance Temperature Detector Type query) Returns the Resistance Temperature Detector (RTD) type used for RTD temperature simulations.

Responses:

<code>PT385</code>	(100-ohm RTD, curve $\alpha=0.00385$ ohms/ohm/°C)
<code>PT385_200</code>	(200-ohm RTD, curve $\alpha=0.00385$ ohms/ohm/°C)
<code>PT385_500</code>	(500-ohm RTD, curve $\alpha=0.00385$ ohms/ohm/°C)
<code>PT385_1K</code>	(1000-ohm RTD, curve $\alpha=0.00385$ ohms/ohm/°C)
<code>PT3926</code>	(100-ohm RTD, curve $\alpha=0.003926$ ohms/ohm/°C)
<code>PT3916</code>	(100-ohm RTD, curve $\alpha=0.003916$ ohms/ohm/°C)
<code>CU10</code>	(10-ohm RTD, empirical curve)
<code>CU50</code>	(50-ohm RTD, empirical curve)
<code>CU100</code>	(100-ohm RTD, empirical curve)
<code>NI120</code>	(120-ohm RTD, empirical curve)

Example: `RTD_TYPE?` returns `PT3926`

Returns `PT3926` when a 100-ohm RTD with curve $\alpha=0.003926$ ohms/ohm/°C is set as the RTD type.

RTD_TYPE_D

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Resistance Temperature Detector Type Default command) Sets the default Resistance Temperature Detector (RTD) at power on and reset, which is saved in the Calibrator non-volatile memory. (While saving configuration data in the non-volatile memory, a period of about 2 seconds, the Calibrator does not respond to remote commands.)

Parameters: PT385 (100-ohm RTD, curve $\alpha=0.00385$ ohms/ohm/°C)
PT385_200 (200-ohm RTD, curve $\alpha=0.00385$ ohms/ohm/°C)
PT385_500 (500-ohm RTD, curve $\alpha=0.00385$ ohms/ohm/°C)
PT385_1K (1000-ohm RTD, curve $\alpha=0.00385$ ohms/ohm/°C)
PT3926 (100-ohm RTD, curve $\alpha=0.003926$ ohms/ohm/°C)
PT3916 (100-ohm RTD, curve $\alpha=0.003916$ ohms/ohm/°C)
CU10 (10-ohm RTD, empirical curve)
CU50 (50-ohm RTD, empirical curve)
CU100 (100-ohm RTD, empirical curve)
NI120 (120-ohm RTD, empirical curve)

Example: RTD_TYPE_D PT3926

Set the RTD default type to a 100-ohm RTD with curve $\alpha=0.003926$ ohms/ohm/°C.

RTD_TYPE_D?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Resistance Temperature Detector Type Default query) Returns the default Resistance Temperature Detector (RTD) used at power on and reset.

Responses: PT385 (100-ohm RTD, curve $\alpha=0.00385$ ohms/ohm/°C)
PT385_200 (200-ohm RTD, curve $\alpha=0.00385$ ohms/ohm/°C)
PT385_500 (500-ohm RTD, curve $\alpha=0.00385$ ohms/ohm/°C)
PT385_1K (1000-ohm RTD, curve $\alpha=0.00385$ ohms/ohm/°C)
PT3926 (100-ohm RTD, curve $\alpha=0.003926$ ohms/ohm/°C)
PT3916 (100-ohm RTD, curve $\alpha=0.003916$ ohms/ohm/°C)
CU10 (10-ohm RTD, empirical curve)
CU50 (50-ohm RTD, empirical curve)
CU100 (100-ohm RTD, empirical curve)
NI120 (120-ohm RTD, empirical curve)

Example: RTD_TYPE_D? returns PT3926

Returns PT3926 when the RTD default type is a 100-ohm RTD with curve $\alpha=0.003926$ ohms/ohm/°C.

SCOPE

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Select the scope function.

Parameters: VOLT ACV

Select the ACV scope function: programs 20 mV p-p, 1 kHz, output at the SCOPE BNC, output impedance 1 M Ω , in standby if from OFF or previously in standby. SCOPE? returns VOLT, FUNC? returns SACV.

Example: SCOPE VOLT; OUT 4 V, 1 kHz

(AC voltage, 4 v peak-to-peak, 1 kHz.)

DCV

Select the DCV scope function: programs 20 mV output at the SCOPE BNC, output impedance 1 M Ω , in standby if from OFF or previously in standby. SCOPE? returns VOLT, FUNC? returns SDCV.

Example: SCOPE DCV; OUT 10V

(DC voltage, 10 V.)

EDGE

Select the EDGE scope function: programs 25 mV peak-to-peak, 1 MHz output at the SCOPE BNC, output impedance 50 Ω , in standby if from OFF or previously in standby. SCOPE? or FUNC? return EDGE.

Example: SCOPE EDGE; OUT 0.5 V, 5 kHz

(Edge, 0.5 V peak-to-peak, 5 kHz.)

LEVSINE

Select the LEVSINE scope function: programs 30 mV p-p, 50 kHz, output at the SCOPE BNC, in standby if from OFF or previously in standby. SCOPE? or FUNC? return LEVSINE.

Example: SCOPE LEVSINE; OUT 1 V, 50 kHz

(Leveled sine wave, 1 V peak-to-peak, 50 kHz.)

MARKER

Select the MARKER scope function: programs the period to 1 μ s spike wave, output at the SCOPE BNC, in standby if from OFF or previously in standby. SCOPE? or FUNC? return MARKER.

Example: SCOPE MARKER; OUT 2MS

(Marker, period of 2 ms.)

WAVEGEN	<p>Select the WAVEGEN scope function: programs 20 mV p-p, square wave, 1 kHz, no offset, output at the SCOPE BNC, in standby if from OFF or previously in standby. SCOPE? or FUNC? return WAVEGEN.</p> <p>Example: SCOPE WAVEGEN; OUT 1 V, 1 kHz (Wave generator, 1 V peak-to-peak, 1 kHz.)</p>
VIDEO	<p>Select the VIDEO scope function: Programs 100 % output (1 V p-p), line marker 10, video format NTSC, output at the SCOPE BNC, in standby if from OFF or previously in standby. SCOPE? or FUNC? return VIDEO.</p> <p>Examples: SCOPE VIDEO; OUT 90 (Video, 90 % output.) SCOPE VIDEO; OUT -70 (Video, -70 % output, inverse video.)</p>
PULSE	<p>Select the PULSE scope function: programs 100 ns pulse width, 1,000 ns period, 2.5 V range, output at the SCOPE BNC, in standby if from OFF or previously in standby. SCOPE? or FUNC? return PULSE.</p> <p>Example: SCOPE PULSE; OUT 50 ns, 500 ns; RANGE TP8DB (Pulse, 50 ns pulse width, 500 ns period, 1.5 V range.)</p>
OVERLDAC	<p>Select the OVERLDAC scope function: programs 5 VAC p-p, positive square wave, 1 kHz, output at the SCOPE BNC for up to 10 seconds, in standby if from OFF or previously in standby. SCOPE? or FUNC? return OVERLDAC.</p> <p>Example: SCOPE OVERLDAC; OUT 7 V (Overload, 7 V output, AC range.)</p>
OVERLDDC	<p>Select the OVERLDDC scope function: programs 5 V dc, output at the SCOPE BNC for up to 10 seconds, in standby if from OFF or previously in standby. SCOPE? or FUNC? return OVERLDDC.</p> <p>Example: SCOPE OVERLDDC; OUT 9 V (Overload, 9 V output, DC range.)</p>

MEASR	Select the MEASR scope function: programs resistance measurement of scope input. <code>SCOPE?</code> or <code>FUNC?</code> return MEASR. Example: <code>SCOPE MEASR</code> (Measure resistance of scope input.)
MEASC	Select the MEASC scope function: programs capacitance measurement of scope input. <code>SCOPE?</code> or <code>FUNC?</code> return MEASC. Example: <code>SCOPE MEASC</code> (Measure capacitance of scope input.)
OFF	Exit the active scope function. Turns the oscilloscope output off and programs 0 V, 0 HZ (DCV) at the NORMAL terminals, reverts to standby.

SCOPE?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Returns the active oscilloscope function (`VOLT`, `EDGE`, `LEVSINE`, `MARKER`, `WAVEGEN`, `VIDEO`, `PULSE`, `MEASR`, `MEASC`, `OVERLDAC`, `OVERLDDC`), or `OFF` if no oscilloscope function is active. When `VOLT` is returned, use `FUNC?` to determine if in AC (`SACV`) or DC (`SDCV`).

Parameters: NONE

Example: `SCOPE?`

Returns `LEVSINE` if the leveled sine scope function is active.

SP_SET

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Serial Port Set command) Sets the RS-232-C settings for the Calibrator rear-panel RS-232 serial port, which is saved in the Calibrator non-volatile memory. (The Calibrator does not respond to remote commands for about 2 seconds while it saves configuration data in the non-volatile memory.) The factory default values are shown below in **bold** type. (To return to the factory defaults, see `FORMAT`.)

The interface selection sets the command response, with command echo back for commands and error messages with `TERM` (terminal) or no echo back with `COMP` (computer).

Parameters: <baud rate value>, **9600**, 19200, 38400, 57600, 115200
 <interface>, **TERM** (terminal), `COMP` (computer)
 <flow control>, **XON** (xon/xoff), `NOSTALL` (none), `RTS` (rts/cts)
 <number data bits>, **DBIT7** (7 bits) or **DBIT8** (8 bits)
 <number stop bits>, **SBIT1** (1 bit) or **SBIT2** (2 bits)
 <parity>, **PNONE** (none), `PODD` (odd), `PEVEN` (even), `PIGNORE`
 (ignore parity bit)
 <end of line char.> **CR** (carriage return), `LF` (line feed),
 CRLF (carriage return/line feed)

Example: `SP_SET 9600,TERM,XON,DBIT8,SBIT1,PNONE,CRLF`

Set the parameters for the rear-panel RS-232 serial port to the factory default values.

SP_SET?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Serial Port Set query) Returns the RS-232-C settings for the Calibrator rear-panel RS-232 serial port. The factory default values are shown below in **bold** type. (To return to the factory defaults, see FORMAT.)

Responses: <baud rate value>, **9600**, 19200, 38400, 57600, 115200
<interface>, **TERM** (terminal), COMP (computer)
<flow control>, **XON** (xon/xoff), NOSTALL (none), RTS (rts/cts)
<number data bits>, **DBIT7** (7 bits) or **DBIT8** (8 bits)
<number stop bits>, **SBIT1** (1 bit) or **SBIT2** (2 bits)
<parity>, **PNONE** (none), **PODD** (odd), **PEVEN** (even)
<end of line char.> **CR** (carriage return), **LF** (line feed),
CRLF (carriage return/line feed)

Example: SP_SET? returns 9600, TERM, XON, DBIT8, SBIT1, PNONE, CRLF

Returns the parameters for the rear-panel RS-232 serial port, as shown, when set to the factory default values.

SPEC_CONFIDENCE

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Set the calibration specification confidence level (95% or 99%)

Parameters: C95 (Sets the specification confidence level to 95%)

C99 (Sets the specification confidence level to 99%)

Example: SPEC_CONFIDENCE C99

Set the specification confidence level to 99%

SPEC_CONFIDENCE?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Get the calibration specification confidence level (95% or 99%)

Example: SPEC_CONFIDENCE? returns C95.

Returns C95 when the calibration specification confidence is set to 95%.

SPLSTR?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Serial Poll Response String query) Returns the string programmed for Serial Poll response. For values, enter a ^P (<cntl> p) character.

Response: <string>

Example: SPLSTR? returns SPL: %02x %02x\n

Returns the SPLSTR string format.

***SRE**

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Service Request Enable command) Loads a byte into the Service Request Enable (SRE) register. (See Service Request Enable Register (SRE)). Since bit 6 is not used (decimal value 64), the maximum entry is $255 - 64 = 191$.

Parameters: <value> (the decimal equivalent of the SRE byte, 0 to 191)

Example: *SRE 56

Enable bits 3 (EAV), 4 (MAV), and 5 (ESR).

***SRE?**

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Service Request Enable query) Returns the byte in the Service Request Enable (SRE).

Response: <value> (the decimal equivalent of the SRE byte, 0 to 191)

Example: *SRE? returns 56

Returns 56 when bits 3 (EAV), 4 (MAV), and 5 (ESR) are enabled.

SRQSTR?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Service Request String query) Returns the string programmed for Serial Mode SRQ response. This is the format of the Service Request String; actual values come from the registers.

Response: <string>

Example: SRQSTR? returns SRQ: %02x %02x\n

Returns the SRQSTR string format.

***STB?**

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Status Byte Register query) Returns the byte for the Status Byte Register. (See Status Byte Register (STB).)

Response: <value>(the decimal equivalent of the STB byte, 0 to 255)

Example: *STB? returns 72

Returns 72 if bits 3 (EAV) and 6 (MSS) are set.

STBY

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Standby command) Deactivates the Calibrator output if it is in operate. This is the same as pushing **STANDBY**.

Parameters: (None)

Example: STBY

Disconnect the selected output from the Calibrator front-panel terminals.

SUBNETMASK

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Sets the Ethernet subnet mask for LAN communication when NOT in the DHCP function. Consult your network administrator for the correct subnet mask for your network.

Parameters: Subnet mask (string consisting of 4 decimal values bound between 0-255 separated by periods).

Example: SUBNETMASK 255.255.0.0 Sets the Ethernet subnet mask to 255.255.0.0

SUBNETMASK?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Returns the Ethernet subnet mask for LAN communication.

Parameters: None

Response: String

Example: SUBNETMASK?

Returns 255.255.0.0 if the subnet mask was previously set to this value.

SYNCOUT

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Synchronization Pulse command) Sends a synchronization pulse out to a secondary Calibrator through the 10 MHZ OUT BNC connector.

Parameters: (None)

Example: SYNCOUT

TC_MEAS

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Thermocouple Measure command) Selects the measure thermocouple function.

Parameters: CEL (Celsius) (optional)
 FAR (Fahrenheit) (optional)

Example: TC_MEAS CEL

Measure the thermocouple temperature that is attached to the Calibrator TC terminals, in Celsius. When you enter the TC Measure or TC Source functions, the thermocouple type reverts to the default thermocouple type specified within Instrument Setup.

TC_OFFSET

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Thermocouple Temperature Measurement Offset command) Adds or subtracts a temperature offset to thermocouple measurements. This command does not apply to thermocouple sourcing.

Parameters: <value>

Example: TC_OFFSET +10

Subtracts a temperature offset of +10 degrees to the thermocouple measurements.

TC_OFFSET?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Thermocouple Temperature Measurement Offset query) Returns the temperature offset used for thermocouple measurements.

Responses: <value>

Example: TC_OFFSET? returns 1.000E+01

Returns 10 when a temperature offset of +10 degrees has been added to the thermocouple measurements.

TC_OTCD

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Thermocouple Open Detection command) Activates or deactivates the open thermocouple detection circuit in thermocouple measurement function. Once set, the Calibrator retains open thermocouple detection circuit setting until power off or reset.

Parameters: ON (turn on thermocouple detection circuit) (default)
 OFF (turn off thermocouple detection circuit)

Example: TC_OTCD ON

Activate the open thermocouple detection circuit. If an open thermocouple is detected, this condition is shown on the front panel.

TC_OTCD?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Thermocouple Open Detection query) Returns the status of the open thermocouple detection circuit in thermocouple measurement function.

Responses: ON (thermocouple detection circuit is on)
OFF (thermocouple detection circuit is off)

Example: TC_OTCD? returns ON

Returns ON when the open thermocouple detection circuit is activated.

TC_REF

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Thermocouple Reference command) Sets whether the internal temperature sensor (INT) or an external reference value (EXT) is used for Thermocouple (TC) outputs and measurements. If the first parameter is EXT, the second parameter must be the temperature value to use as the reference for the thermocouple reference junction temperature. Once set, the Calibrator retains reference setting until power off or reset.

Parameters: INT
EXT, <value of external reference> CEL (or FAR)

Example: TC_REF EXT, 25.6 CEL

Set the thermocouple reference to external, with a value of 25.6 °C.

TC_REF?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Thermocouple Reference query) Returns the source and value of the temperature being used as a reference for thermocouple simulation and measurement (in Celsius, CEL, or Fahrenheit, FAR, depending on active units). The choices are Internal reference (INT) or External reference (EXT).

If INT is returned, the reference temperature return is 0 unless you are in a thermocouple function of operation and the Calibrator is in Operate.

Responses: INT, <value of reference temperature>,CEL (or FAR)
EXT, <value of reference temperature>,CEL (or FAR)

Example: TC_REF? returns INT, 2.988E+01, CEL

Returns Internal, 29.88, Celsius, when the thermocouple reference is internal and at 29.88 °C. (If the temperature return for the internal reference is 0 (0.00E+00), the Calibrator is not in Operate, and/or the Calibrator is not in a thermocouple function.)

TC_TYPE

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Thermocouple Type command) Sets the Thermocouple (TC) temperature sensor type. The TC type is used when the output is set to a temperature value with the `OUT` command and the temperature sensor type is set to `TC` with the `TSENS_TYPE` command. When the thermocouple type is changed while simulating a temperature output, the temperature is changed to 0 °C. At power off or reset and when entering the RTD Source function, the RTD type reverts to the default RTD type specified within Instrument Setup.

Parameters:

A1	(A1-type thermocouple)
B	(B-type thermocouple)
C	(C-type thermocouple)
D	(D-type thermocouple)
E	(E-type thermocouple)
G	(G-type thermocouple)
J	(J-type thermocouple)
K	(K-type thermocouple) (default)
L	(L-type thermocouple)
N	(N-type thermocouple)
R	(R-type thermocouple)
S	(S-type thermocouple)
T	(T-type thermocouple)
U	(U-type thermocouple)
X	(10 μ V/°C linear output)
XK	(XK-type thermocouple)
Z	(1 mV/°C linear output)

Example: `TC_TYPE J`

Returns the thermocouple type for simulating a temperature output to a J-type thermocouple.

TC_TYPE?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Thermocouple Type query) Returns the Thermocouple (TC) temperature sensor type. When the thermocouple type is changed while simulating a temperature output, the temperature is changed to 0 °C.

Responses:

A1	(A1-type thermocouple)
B	(B-type thermocouple)
C	(C-type thermocouple)
D	(D-type thermocouple)
E	(E-type thermocouple)
G	(G-type thermocouple)
J	(J-type thermocouple)
K	(K-type thermocouple) (default)
L	(L-type thermocouple)
N	(N-type thermocouple)
R	(R-type thermocouple)
S	(S-type thermocouple)
T	(T-type thermocouple)
U	(U-type thermocouple)
X	(10 μ V/°C linear output)
XK	(XK-type thermocouple)
Z	(1 mV/°C linear output)

Example: TC_TYPE? returns K

Returns K when the thermocouple type for simulating a temperature output is a K-type thermocouple.

TC_TYPE_D

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Thermocouple Type Default command) Sets the default thermocouple (TC) sensor type, which is saved in the Calibrator non-volatile memory. (The Calibrator does not respond to remote commands for about 2 seconds while it saves configuration data in the non-volatile memory.) The TC type is set to the default at power on, reset, and whenever a TC function activates

Responses:

A1	(A1-type thermocouple)
B	(B-type thermocouple)
C	(C-type thermocouple)
D	(D-type thermocouple)
E	(E-type thermocouple)
G	(G-type thermocouple)
J	(J-type thermocouple)
K	(K-type thermocouple) (default)
L	(L-type thermocouple)
N	(N-type thermocouple)
R	(R-type thermocouple)
S	(S-type thermocouple)
T	(T-type thermocouple)
U	(U-type thermocouple)
X	(10 μ V/ $^{\circ}$ C linear output)
XK	(XK-type thermocouple)
Z	(1 mV/ $^{\circ}$ C linear output)

Example: TC_TYPE_D J

Set the thermocouple type default to a type-J thermocouple.

TC_TYPE_D?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Thermocouple Type Default query) Returns the default thermocouple (TC) sensor type.

Responses:

A1	(A1-type thermocouple)
B	(B-type thermocouple)
C	(C-type thermocouple)
D	(D-type thermocouple)
E	(E-type thermocouple)
G	(G-type thermocouple)
J	(J-type thermocouple)
K	(K-type thermocouple) (default)
L	(L-type thermocouple)
N	(N-type thermocouple)
R	(R-type thermocouple)
S	(S-type thermocouple)
T	(T-type thermocouple)
U	(U-type thermocouple)
X	(10 μ V/ $^{\circ}$ C linear output)
XK	(XK-type thermocouple)
Z	(1 mV/ $^{\circ}$ C linear output)

Example: TC_TYPE_D? returns K

Returns K when the thermocouple type default is a type-K thermocouple.

TEMP_STD

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Temperature Degree Standard command) Selects the temperature standard ipts-68 (1968 International Practical Temperature Scale) or its-90 (International Temperature Scale) which is saved in the Calibrator non-volatile memory. (The Calibrator does not respond to remote commands for about 2 seconds while it saves configuration data in the non-volatile memory.) The default is its-90.

Parameters: IPTS_68
ITS_90

Example: TEMP_STD ITS_90

See the temperature standard to ITS-90.

TEMP_STD?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Temperature Degree Standard command) Returns the temperature standard ipts-68 (1968 International Practical Temperature Scale) or its-90 (International Temperature Scale).

Parameters: IPTS_68
 ITS_90

Example: TEMP_STD? returns ITS_90

Returns ITS_90 when the temperature degree standard is the 1990 International Temperature Standard.

TEMP_STD_D

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Temperature Degree Standard command) Selects the default temperature standard ipts-68 (1968 International Practical Temperature Scale) or its-90 (International Temperature Scale) at power on or reset which is saved in the Calibrator non-volatile memory. (The Calibrator does not respond to remote commands for about 2 seconds while it saves configuration data in the non-volatile memory.) The default is its-90.

Parameters: IPTS_68
 ITS_90

Example: TEMP_STD_D ITS_90

Set the temperature standard to ITS-90.

TEMP_STD_D?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Temperature Degree Standard command) Returns the temperature standard ipts-68 (1968 International Practical Temperature Scale) or its-90 (International Temperature Scale) used at power on or reset.

Parameters: IPTS_68
 ITS_90

Example: TEMP_STD_D? returns ITS_90

Returns ITS_90 when the temperature degree standard is the 1990 International Temperature Standard.

TEMP_UNIT_D

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Sets the default temperature units of the Product to either CEL or FAR

Parameters: 1. CEL, FAR

Example: TEMP_UNIT_D CEL

Sets the default temperature units for TC Source, TC Measure and RTD Source to CEL.

TEMP_UNIT_D?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Returns the default temperature units of the Product.

Parameters: NONE

Response: (CRD)

Example: TEMP_UNIT_D?

Returns CEL if the default temperature units are set to Celsius.

TIMEFMT

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Sets the time format that is shown on the front panel. This setting is kept in non-volatile memory. This command does not affect the CLOCK or CLOCK? commands.

Parameters: HOUR12, HOUR24

Example: TIMEFMT HOUR24

Sets the time format as displayed on the front panel to 24-hour format.

TIMEFMT?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Returns the present time format setting.

Parameters: None

Responses: (CRD)

Example: TIMEFMT?

HOUR12 for 12-Hour format, HOUR24 for 24 Hour format.

TLIMIT

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

When in OVERLDAC or OVERLDDC, sets the OPERATE time limit, in seconds. The Calibrator automatically returns to STANDBY if the DUT protection trips within this interval or at the end of this interval if the protection has not tripped.

Parameters: 1 to 60 Time limit, in seconds.

Example: TLIMIT 30

Go to STANDBY in 30 seconds if the DUT protection has not tripped.

TLIMIT?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Returns the OPERATE time limit used by OVERLDAC and OVERLDDC, in seconds.

Parameters: NONE

Example: TLIMIT?

Returns 30.0 if the overload time limit is set to 30 seconds

TLIMIT_D

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Sets the default OPERATE time limit (TLIMIT) for the OVERLDAC and OVERLDDC scope functions.

Parameters: 1 to 60 Time limit, in seconds.

Example: TLIMIT_D 15

When you enter the OVERLDAC or OVERLDDC scope functions, initialize the TLIMIT value to 15 seconds (go to **STANDBY** in 15 seconds when the DUT protection does not trip).

TLIMIT_D?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Returns the default OPERATE time limit for the OVERLDAC and OVERLDDC scope functions.

Parameters: NONE

Example: TLIMIT?

Returns 11.0 if the default overload time limit is set to 11 seconds

TMWAVE

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Selects the waveform for the scope **MARKER** function.

Parameters: SINE Sine wave (0.477 ns to 18 ns)
 SQUARE Square wave with 50 % duty cycle (7.5 ns to 5.5 s)
 SPIKE Spike wave (18 ns to 5.5 s)
 SQ20PCT Square wave with 20 % duty cycle (85 ns to 5.5 s)

Example: SCOPE MARKER; OUT 8 ns; TMWAVE SQUARE

Select the **MARKER** scope function, 8 ns period, square wave.

TMWAVE?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Returns the **MARKER** scope function waveform.

Parameters: NONE

Example: TMWAVE?

Returns **SPIKE** if the spike waveform is used by the **MARKER** scope function.

TRIG

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Programs the oscilloscope's trigger output BNC.

Parameters: DIV1 Turn the trigger output on. Trigger frequency is the same as the signal at the SCOPE BNC.
 DIV10 Turn the trigger output on. Trigger frequency is 1/10 of the signal at the SCOPE BNC.
 DIV100 Turn the trigger output on. Trigger frequency is 1/100 of the signal at the SCOPE BNC.
 DIV128 Turn the trigger output on. Trigger frequency is 1/128 of the signal at the SCOPE BNC.
 OFF Turn the trigger output off.

Example: TRIG DIV10

Turn the trigger output on. Trigger frequency is 1/10 of the signal at the SCOPE BNC.

TRIG?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Returns the output setting of oscilloscope's trigger output BNC.

Parameters: NONE

Example: TRIG?

Returns DIV100 if the trigger is enabled with a frequency 1/100 of the signal at the SCOPE BNC.

*TRG

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Trigger Thermocouple Measurement command) Triggers a thermocouple temperature measurement and return the value of the measurement. Also changes the operating function to thermocouple measurement if this is not already the operating function. (This command is equivalent to sending TC_MEAS; *WAI; VAL?) When in MEASR or MEASC scope functions, triggers and returns an updated resistance or capacitance measurement.

Responses: <measurement value>,CEL (value is in Celsius)
 <measurement value>,FAR (value is in Fahrenheit)
 0.00E+00, OVER (value is over or under capability)
 0.00E+00, OPENTC (open thermocouple)
 0.00E+00, NONE (wrong function or no measurement)

Example: *TRG returns +2.500E+01, CEL

Trigger a thermocouple measurement and return 25.00 Celsius when the thermocouple temperature measurement is 25 °C.

TSENS_TYPE

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Temperature Source command) Selects the either the Thermocouple (TC) or Resistive Temperature Detector (RTD) source function. The Calibrator simulates the RTD temperature as a resistance output on the NORMAL terminals, and simulates the thermocouple temperature as a dc voltage output on the TC terminals. Subsequent use of the out command (for example, OUT 20 cel) or front panel keyboard entry (20 CEL <enter>) will use the previously selected TSENS_TYPE choice.

Parameters: TC (Thermocouple)

 RTD (Resistance Temperature Detector)

Example: TSENS_TYPE RTD

Set the temperature sensor type to an RTD.

*TST?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Self Test command) Initiates self-test and returns a 0 for pass or a 1 for fail. If any faults are detected, they are shown on screen (terminal mode) or are logged into the fault queue where they can be read by the ERR? query (computer mode).

Response: 0 (pass self test)
1 (fail self test)

Example: *TST? returns 0

Returns 0 when self test is successful.

UNCERT?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Uncertainties command) Returns specified uncertainties for the present output. If there are no specifications for an output, returns zero. Specification is based on the adjustment interval (90 day, 1 year, 2 year) and confidence level (95%, 99%).

Parameters: 1. (optional) Preferred unit of primary output uncertainty: SCI, PCT, or PPM
2. (optional) Preferred unit of secondary output uncertainty: SCI, PCT, or PPM

Response: 1. (float) specified uncertainty of primary output in SCI or preferred unit.
2. (character) Unit of primary output uncertainty.
3. (float) specified uncertainty of secondary output in SCI or preferred unit.
4. (character) Unit of secondary output uncertainty.

Example: out 1v,1a

UNCERT? returns 2.000E-04, V, 4.600E-04, A

UNCERT? PPM returns 2.0000E+02, PPM, 4.6000E+02, PPM

UNCERT? PCT returns 2.00E-02, PCT, 4.60E-02, PCT

VAL?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Measurement Value command) Returns the last value of the thermocouple temperature, or scope impedance measurement. The unit returns indicates the status of the reading.

Parameters: (Optional) Units to return

Responses: 1. (Float) Measured temperature
2. (Character) CEL, FAR, OHM, F, OVER (value is over or under capability),
OPENTC (open thermocouple), or NONE (wrong function or no measurement)

Example: VAL? returns 0.00E+00, NONE

Returns 0 and NONE when there is no recent measurement either because the Calibrator is not in a measurement function, or because no measurement has been made yet.

VIDEOFMT

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Selects the video format for the VIDEO scope function.

Parameters: NTSC Selects the NTSC video format.
 PAL Selects the PAL video format.
 PALM Selects the PAL-M video format.
 SECAM Selects the SECAM video format.

Example: VIDEOFMT PALM

Select the PAL-M video format.

VIDEOFMT?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Returns the video format selected for the VIDEO scope function.

Parameters: NONE

Example: VIDEOFMT?

Returns NTSC if the NTSC video format is selected for the VIDEO scope function.

VIDEOMARK

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Sets the line number location to mark for the VIDEO scope function.

Parameters: Line Marker Number Selects the line number location to mark within the frame of the selected video format.

Example: VIDEOMARK 31

Place the line marker on line 31 of the video frame.

VIDEOMARK?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Returns the line number location marked by the VIDEO scope function.

Parameters: NONE

Example: VIDEOMARK?

Returns 43 if line 43 is marked by the VIDEO scope function.

VVAL?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Thermocouple Measurement Voltage command) Returns the last value of the thermocouple temperature measurement in volts. If the last measurement was an overload or open thermocouple condition, or there is no measurement, returns 0E+00.

Responses: <measurement value in volts>(valid measurement)

0E+00 (overload, open TC, or no measurement)

Example: VVAL? returns 1.1047E-03 (1.1047 mV, equivalent to 50 °C with type K thermocouple and TC reference = 23.0 °C)

*WAI

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Wait-to-Continue command) Prevents further remote commands from being executed until all previous remote commands have been executed. For example, if you send an OUT command, you can cause the Calibrator to wait until the output has settled before continuing on to the next command if you follow OUT with a *WAI command. The *WAI command is useful with any overlapped command, preventing the Calibrator from processing other commands until the overlapped command is processed.

Example: *WAI

Process all existing commands before continuing.

WAVE

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Waveform command) Sets the waveforms for ac outputs. If the Calibrator is sourcing one output, one parameter is required. If the Calibrator is sourcing two outputs, two parameters are required or one parameter to set the waveform to both outputs. Waveform choices are SINE (sine wave), TRI (triangle wave), SQUARE (square wave), TRUNCS (truncated sine wave).

Parameters: <1st waveform> ,(SINE, TRI, SQUARE, TRUNCS)
<2nd waveform>(SINE, TRI, SQUARE, TRUNCS)

Example: WAVE SINE, SQUARE

Set the waveforms for a dual output to Sine wave on the primary output (Calibrator front-panel OUTPUT terminals) and Square wave on the secondary output (front-panel AUX or 30A terminals).

Note

If you change the waveform to square, triangle, or truncated results in the AC Representation changing to PkPk. See the AC_REP? command for more information.

WAVE?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Waveform query) Returns the waveform types for ac outputs. Waveform choices are SINE (sine wave), TRI (triangle wave), SQUARE (square wave), TRUNCS (truncated wave), or NONE (waveform does not apply).

Responses: <1st waveform> ,(SINE, TRI, SQUARE, TRUNCS, NONE)
<2nd waveform>(SINE, TRI, SQUARE, TRUNCS, NONE)

Example: WAVE? returns SQUARE, NONE

Returns SQUARE when the ac primary output (Calibrator front-panel OUTPUT terminals) is a square wave and NONE when there is no secondary output on the front-panel AUX terminals.

ZCOMP

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Impedance Compensation command) Activates or deactivates 2-wire or 4-wire impedance compensation. Compensation is allowed for many impedance values. For some higher values, the compensation is NONE or WIRE4 and attempts to use other parameters results in the error message *Can't change compensation now*. For RTD temperature simulation, compensation is allowed for all temperatures.

Parameters: NONE (Turns off or uses internal impedance compensation circuitry)
WIRE2 (Turns on the 2-wire impedance compensation circuitry)
WIRE4 (Turns on the 4-wire impedance compensation circuitry)

Example: ZCOMP WIRE2

Set 2-wire impedance compensation for the Calibrator DUT connection.

ZCOMP?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

(Impedance Compensation query) Returns status of 2-wire or 4-wire impedance compensation.

Responses: NONE (impedance compensation is off or internal)
WIRE2 (2-wire impedance compensation is on)
WIRE4 (4-wire impedance compensation is on)

Example: ZCOMP? returns NONE

Returns NONE when no impedance compensation is applied to the resistance, capacitance, inductance, or RTD output.

ZERO_MEAS

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

When in the MEASC scope function, measure the contribution to the capacitance value due to the cable connecting the SCOPE BNC to the DUT to ensure the reported capacitance represents that of the input BNC connector of the DUT.

Parameters: None

Example: ZERO_MEAS

Updates measurement of the capacitance contributed by the external cable that connects the SCOPE BNC to the DUT BNC.

ZERO_MEAS?

IEEE-488 USBTMC RS-232 Ethernet Sequential Overlapped Coupled Lockout

Returns the offset capacitance of the cable connecting the SCOPE OUTPUT BNC to the UUT. This value is used by the MEASC scope function to calculate the capacitance at the BNC input connector of the DUT.

Parameters: NONE

Example: ZERO_MEAS?

Returns $-1.7261E-10$, FARAD if line the capacitance of the connecting cable is 172.61 picofarads.

Error Codes

The subsequent is a list of the Calibrator error messages.

- Error 0 result No error
- Error -440 result 488.2 query after indefinite response
- Error -430 result 488.2 I/O deadlock
- Error -420 result 488.2 unterminated command
- Error -410 result 488.2 interrupted query
- Error -376 result Command only allowed on synchronous (for example, gpib/usb-tmc) interface type
- Error -375 result Command only allowed on asynchronous (for example, serial/telnet) interface type
- Error -374 result GPIB/488.1 unspecified error
- Error -373 result GPIB/488.1 write operation timeout
- Error -372 result GPIB/488.1 read/write operation aborted
- Error -371 result GPIB/488.1 board address error
- Error -370 result GPIB/488.1 system call has failed
- Error -369 result LAN port encountered error while reading data
- Error -368 result Fatal error occurred while accessing the LAN port
- Error -367 result USB-TMC encountered error while reading data
- Error -366 result GPIB/488.1 encountered error while reading data
- Error -365 result Fatal error occurred while accessing the serial port
- Error -363 result Input Buffer Overrun
- Error -361 result RS-232 framing/parity/overrun error detected
- Error -350 result Too many errors
- Error -302 result Command execution locked out
- Error -301 result Restricted Command
- Error -224 result Characters must be A-Z, 0-9, - or _
- Error -223 result Character string was more than limit
- Error -222 result Illegal data value was entered
- Error -193 result No entry in list to retrieve
- Error -192 result Too many dimensions to be returned
- Error -191 result Parameter type detection error
- Error -190 result Parameter is not a boolean type
- Error -157 result Unmatched bracket
- Error -154 result String size is beyond limit
- Error -153 result Parameter is not an unquoted string type
- Error -152 result Parameter is not an quoted string type
- Error -150 result Invalid string data
- Error -140 result Parameter is not a character type
- Error -138 result Too many suffixes in command header
- Error -137 result Invalid suffix in command header
- Error -130 result Suffix Error. Wrong units for parameter
- Error -127 result Invalid dimensions in a channel list

- Error -126 result Numeric value is real
- Error -125 result Numeric value is negative
- Error -124 result Numeric value overflowed its storage
- Error -122 result Parameter is not a numeric type
- Error -120 result Numeric value is invalid
- Error -117 result Wrong type of parameter(s)
- Error -115 result Missing or wrong number of parameters
- Error -102 result Syntax error
- Error 1000 result Illegal Parameter
- Error 1001 result Failed to save data to non-volatile storage
- Error 1002 result Failed to read data from non-volatile storage
- Error 1003 result Remote Port Configuration Invalid
- Error 1004 result Units Must Be The Same
- Error 1005 result Limit Too Small or Large
- Error 1006 result Cannot Get Range Data
- Error 1007 result Cannot Find Range
- Error 1008 result Cannot Send Sync Pulse
- Error 1009 result Writing PCA serial number failed
- Error 1201 result Feature not available
- Error 1202 result Failed self-test [VALUE]
- Error 1203 result Command presently unavailable (in response to TRG command when in some scope functions [*TRG can be used in MEASR and MEASC])
- Error 1300 result Cannot change the LAN settings now
- Error 1500 result Failed to set DAC to desired value
- Error 1501 result Cannot change the monitor now
- Error 1502 result Cannot find that cal constant
- Error 1503 result Cannot save cal constant
- Error 1504 result Cannot Store, Cal is Secured
- Error 1506 result Cannot Change the Date While Instrument is Secured
- Error 1507 result Continue command ignored
- Error 1508 result Backup command ignored
- Error 1509 result Cannot execute procedure backup request now
- Error 1510 result Cannot execute procedure abort request now
- Error 1511 result Cannot execute procedure start request now
- Error 1512 result Cannot execute procedure step skip request now
- Error 1513 result Cannot execute procedure section jump request now
- Error 1514 result Cannot start diagnostics now
- Error 1515 result Cannot Change the Temperature While Instrument is Secured
- Error 1516 result Cannot Change the Report String While Instrument is Secured
- Error 1517 result Cannot sync scope capacitance offset
- Error 1600 result Invalid Time or Time Setting
- Error 1601 result Invalid Date or Date Setting
- Error 1700 result Cannot communicate with 52120

Error 4001 result Overvoltage on the 12V amplifier
Error 4002 result Overvoltage on the millivolt output
Error 4003 result Power up, line power fault
Error 4004 result External clock failure
Error 4005 result Overcurrent on the 12V amplifier
Error 4006 result PLL unlocked, missing 10 MHz reference
Error 4007 result Excess output current or common mode voltage on the guard terminal
Error 4008 result Overvoltage or overcurrent condition
Error 4009 result Scope Option PLL unlocked
Error 4100 result Compliance voltage exceeded
Error 4101 result Specification exceeded
Error 4102 result Compliance current limit exceeded
Error 4103 result Output settling timed out
Error 4200 result Temperature monitoring has failed
Error 4201 result Compliance voltage monitoring has failed
Error 4202 result Compliance voltage above threshold
Error 4300 result Zero Cal nulling operation exceeded maximum attempts to converge
Error 4301 result Zero Cal convergence write failed
Error 4302 result Zero Cal failed to take measurement
Error 4303 result Zero Cal no starting value provided
Error 4304 result Zero Cal pre-checkpoint sequence failed
Error 4305 result Zero Cal failed to take checkpoint measurement
Error 4404 result Unknown hardware fault
Error 4500 result Cannot open 52120 control port
Error 4501 result DAC counts out of range
Error 4502 result Out current limit has been exceeded
Error 4503 result External voltage detected on Output post
Error 4504 result External voltage detected on VI AUX post
Error 4505 result Thermocouple output voltage exceeds hardware limits
Error 4506 result Could not start LED test
Error 4507 result Json deserialization failed
Error 5000 result Error while reading 52120A cal store
Error 5001 result Expected a 52120A but it was gone
Error 5002 result 52120A cal store corrupted
Error 5003 result Value out of range of 52120A
Error 5004 result Unknown error reported by 52120A
Error 5005 result 52120A added or removed
Error 5006 result 52120A forcibly turned off
Error 5007 result 52120A detected over compliance
Error 5008 result 52120A detected over range
Error 5009 result 52120A detected over temperature
Error 6001 result Cal constant does not exist
Error 6002 result Cal correction is missing an input value

Error 6003 result Attempted to divide by zero
Error 6004 result Attempted to reverse an irreversible calculation
Error 6005 result Cal parameter does not exist
Error 6006 result Cal correction is value only
Error 6007 result Calculated corrector out of tolerance
Error 7001 result Frequency must be > 0.0 Hz
Error 7002 result Function does not permit a frequency below [VALUE]
Error 7003 result Cannot specify more than one frequency
Error 7004 result Cannot specify more than two magnitudes
Error 7005 result Units are required for multiple entries
Error 7006 result Not applicable
Error 7007 result Cannot set Duty Cycle in this configuration
Error 7008 result Cannot set Offset in this configuration
Error 7009 result Range Lock disabled in this configuration
Error 7010 result Compensation not available for this function
Error 7011 result Cannot enable compensation in this configuration
Error 7012 result Harmonic not available for this function
Error 7013 result Fundamental not available for this function
Error 7014 result Setting Range not available for this function
Error 7015 result Cannot change polarity for this function
Error 7016 result This value cannot be slewed
Error 7017 result Cannot change Phase for this function
Error 7018 result Validation of requested attributes failed
Error 7019 result Offset range not found
Error 7020 result Read only mode for calibration control
Error 7021 result Must be in read only mode to execute this command
Error 7022 result Cannot enter watts by itself
Error 7023 result Value not available
Error 7024 result Harmonic not available for non-sine waveforms
Error 7025 result TC offset can only be set while in TC Measurement function
Error 7026 result Temperature Scale can only be set while sourcing or measuring temperature
Error 7027 result RTD type can only be set while in RTD Source function
Error 7028 result TC type can only be set while in TC Source/Measure function
Error 7029 result Coupled command queue limit exceeded
Error 7500 result Cannot have magnitude above [VALUE] in function [FUNCTION]
Error 7501 result Cannot have magnitude below [VALUE] in function [FUNCTION]
Error 7502 result No appropriate range found in function
Error 7503 result Magnitude exceeds boundaries of selected range
Error 7504 result Incorrect units for selected function [FUNCTION]
Error 7505 result Invalid second range selected for function [FUNCTION]
Error 7506 result Current post/range mismatch for function [FUNCTION]
Error 7507 result Cannot have frequency above [VALUE] in this configuration
Error 7509 result Cannot have both Duty Cycle and DC Offset

Error 7510 result Duty Cycle must be between 1 and 99
Error 7511 result Duty Cycle is only available with Square Wave
Error 7512 result Requested offset exceeds the maximum allowed for this output range and waveform
Error 7513 result Cannot accept non-coupled command while coupled-commands are queued
Error 7514 result External sense not available for this function
Error 7515 result Harmonic must be greater than zero
Error 7516 result Cannot enable 2 wire compensation below [VALUE] in function [FUNCTION]
Error 7517 result Thermocouple reference must be specified as a temperature
Error 7518 result Thermocouple offset must be specified as a temperature
Error 7519 result Cannot have reference below [VALUE] in function [FUNCTION]
Error 7520 result Cannot have reference above [VALUE] in function [FUNCTION]
Error 7521 result Thermocouple offset is limited to +/- [VALUE]
Error 7522 result Cannot use external sense on selected range
Error 7523 result Function not available
Error 7524 result Line Marker can range from 1 through [VALUE] with the selected frame format in function [FUNCTION]
Error 7525 result Cannot enable external reference in this function
Error 7526 result Trigger Option not available with given primary magnitude
Error 7527 result Cannot change Power Factor for this function
Error 7528 result Cannot change Phase Angle Sign for this function
Error 7530 result The magnitude representation cannot be changed in this function
Error 7531 result Cannot set wave now
Error 7532 result Cannot enable 2 wire compensation above [VALUE] in function [FUNCTION]
Error 7533 result Watts requires AC Power and a sine waveform
Error 7534 result Power factor must be ≥ -1.0 and ≤ 1.0
Error 7535 result Cannot have magnitude between -1mV and 1mV in SACV
Error 7536 result Cannot have magnitude above [VALUE] in function [FUNCTION] with this impedance setting
Error 7537 result Cannot have magnitude below [VALUE] in function [FUNCTION] with this impedance setting
Error 7538 result Feature not available
Error 7539 result Cannot set requested impedance value (in response to the OUT_IMP {Z50 | Z1M} command)
Error 7540 result Cannot have secondary magnitude in function [FUNCTION]
Error 7541 result Cannot have primary magnitude in function [FUNCTION]
Error 7542 result Cannot have frequency in function [FUNCTION]
Error 7543 result dBm only allowed in single sine ACV
Error 7544 result Requested waveform not available in this configuration
Error 7545 result Offset cannot be greater than 50 % of the primary output in function [FUNCTION]
Error 7600 result Cannot use boost amplifier now
Error 7601 result Cannot select boost amplifier post now
Error 7602 result Can only output that current on the HIGH post
Error 7603 result Valid Pulse amplitudes are 2.5V, 1V, 250mV, 100mV, 25mV, 10mV

Error 8001 result Power up was less than 30 minutes ago
Error 8002 result Zero adjustment is required every [VALUE] days
Error 8003 result Ohms zero adjustment is required every [VALUE] hours
Error 8012 result Zero adjustment is required every [VALUE] days
Error 8013 result Ohms zero adjustment is required every [VALUE] hours
Error 8101 result Size of X and Y should be the same for Polyfit
Error 8102 result Failed matrix reduction using Gauss-Jordan elimination
Error 8103 result Cannot read coefficients from the matrix
Error 8104 result Missing required input for calculation
Error 8106 result Failed to read matrix coefficients
Error 8107 result TC Measurement is invalid
Error 8108 result Lag bath input needs to be between -10 °C and 70 °C
Error 8109 result Entered value out of bounds
Error 8110 result Wrong unit for reference
Error 8111 result Cannot store cal constants during this step
Error 10001 result Exception happened during json serialization
Error 10002 result Exception happened during RPC communication
Error 10003 result Unhandled exception:
Error 10101 result Memory allocation error:
Error 10201 result Unknown command:
Error 10301 result Unknown string Id:
Error 11001 result Duplicate Setting
Error 11002 result Setting not found
Error 11003 result Unable to read clock
Error 11004 result Unable to set clock
Error 11005 result Entered value is outside allowable limits
Error 11006 result Invalid password
Error 11007 result The passcode must be 1 to 8 digits in length
Error 65535 result Unknown Error
Error 65536 result Default Error