User's Manual

OPS-3190027

Series 12010/20 Pulse/Pattern Generators

Picosecond Pulse Labs

www.picosecond.com

Picosecond Pulse Labs, Inc. (PSPL) – 2500 55th Street – Boulder, CO – 80301 – USA – (303) 209-8100

WARRANTY

Picosecond Pulse Labs, Inc., warrants this product to be free from defects in material and workmanship for a period of one (1) year from date of shipment.

Picosecond Pulse Labs, Inc., warrants the following items for 90 days from the date of shipment: probes, cables, software, rechargeable batteries, diskettes, and documentation.

During the warranty period, Picosecond Pulse Labs will, at its option, either repair or replace any product that proves to be defective.

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

LIMITATION OF WARRANTY

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

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Models 12010 and 12020
Pulse/Pattern Generator
User's Manual

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Safety Precautions

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

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

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

The types of product users are:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

The  symbol on an instrument shows that the surface may be hot. Avoid personal contact to prevent burns.

The  symbol indicates a connection terminal to the equipment frame.

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

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

Instrumentation and accessories shall not be connected to humans.

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

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

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

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Section 1

Getting Started

In this section:

General information

Contact information

If you have any questions after reviewing this information, please contact your local Picosecond Pulse Labs representative or call one of our applications engineers at 1-303-443-1249 within the U.S. and Canada. You can also visit the Picosecond Pulse Labs website at www.picosecond.com for updated worldwide contact information.

Inspection

Your model 12010 or 12020 Pulse/Pattern Generator was carefully inspected electrically and mechanically before shipment. After unpacking all items from the shipping carton, check for any obvious signs of physical damage that may have occurred during transit (there may be a protective film over the display lens, which can be removed). Report damage to the shipping agent immediately. Save the original packing carton for possible future shipment.

The following items are included with every instrument order:

- Pulse/Pattern Generator with line cord
- Rack mount/handle kit
- Accessories as ordered
- Product Information CD-ROM containing the Quick Start Guide, User's Manual, and any applicable release notes or addenda
- A printed copy of the Quick Start Guide

Model summary

The Model 12010 and 12020 Pulse/Pattern Generators give you extensive control over pulse parameters, including amplitude, offset, pulse width, and duty cycle. The Model 12020-1 is a single-channel, 1.6 GHz pulse/pattern generator; the Model 12020-2 includes a second signal output channel.

The operational flexibility and pattern generation capability of the Model 12010/12020 Pulse/Pattern Generators makes them suitable for use in many different applications, including simplified simulation of serial data patterns when testing devices to characterize their performance under suboptimal conditions.

Models 12010/12020 have jitter insertion incorporated into the design. Jitter insertion allows you to introduce controlled jitter stress for the simulation of real-world signal characteristics. Refer to the Jitter insertion section for detailed information.

Features

- Frequency output range: 15 MHz to 1.6 GHz
- Pulse amplitude: 2.5 V (50 Ω source impedance)
- Pulse width: Programmable from 250 ps to (period - 250 ps)
- Pulse output programmable as voltage amplitude and offset
- Output channels have differential output
- Jitter insertion options: Internal or external modulation
- Four operating modes: Pulse mode
  Burst mode
  Pattern mode
  External Width mode
- Internal clock and period source
- Save up to nine pulse/pattern generator setups in nonvolatile memory
- IEEE-488 (GPIB) and USB 2.0 interfaces
- 2RU (Rack Unit) height, full-rack design

Model number descriptions

Table 1-1
Model number descriptions

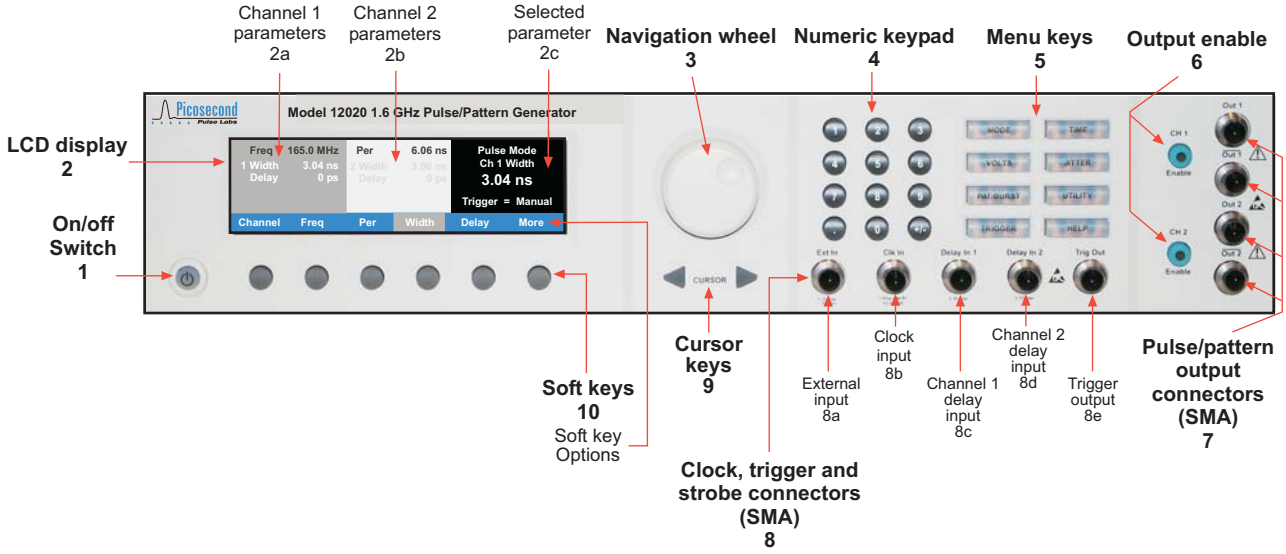
Model Number	Frequency Output Range	Single Channel	Dual Channel	Jitter Insertion
12010-1	15 MHz to 800 MHz	X		
12010-1-J	15 MHz to 800 MHz	X		X
12010-2	15 MHz to 800 MHz		X	
12010-2-J	15 MHz to 800 MHz		X	X
12020-1	15 MHz to 1.6 GHz	X		
12020-1-J	15 MHz to 1.6 GHz	X		X
12020-2	15 MHz to 1.6 GHz		X	
12020-2-J	15 MHz to 1.6 GHz		X	X

Front and rear panel familiarization

Front panel

The front panel of the Model 12020-2 is shown in Figure 1-1. The front panel controls and connectors for the Model 12020-1 are similar, except there is only one channel. For the Model 12020-1, disregard all references to the second channel.

Figure 1-1
Front panel (Model 12020-2 shown)



1. **On/off switch:** Push this button to turn the instrument on and off. The green indicator inside the button lights up when the instrument is on. Note that the main power switch on the rear-panel power module must also be in the on position (refer to Figure 1-2).
2. **LCD display:** The display is divided into three areas:
   a. Channel 1 parameters: Displays Channel 1 parameters for the selected function.
   b. Channel 2 parameters: Displays Channel 2 parameters for the selected function.
   c. Parameter value: Displays the value and related information of the selected parameter.
3. **Navigation wheel:** Rotate this wheel to increase or decrease the displayed parameter value.
4. **Numeric keypad:** Use this keypad to enter parameter values. After typing in a value, available options (for example, MHz range) are displayed as soft keys.
5. **Menu select keys:** The various menus are selected using these keys. The display then shows the parameters, options, and other choices available for the selected menu.
6. **Output enable:** This button turns output enable on and off (one exists for each channel). The green indicator inside the button lights up when the output is enabled. A trigger event will then start the output.
7. **Pulse/pattern output connectors:** Output for each channel is sent to these female SMA connectors.
8. **Clock and trigger connectors:** The following input/output female SMA connectors are provided:
   a. External input: Connect an external signal for external triggering.
   b. Clock input: Connect an external clock.
   c. Channel 1 delay input: Connect an external source for Channel 1 external jitter insertion.

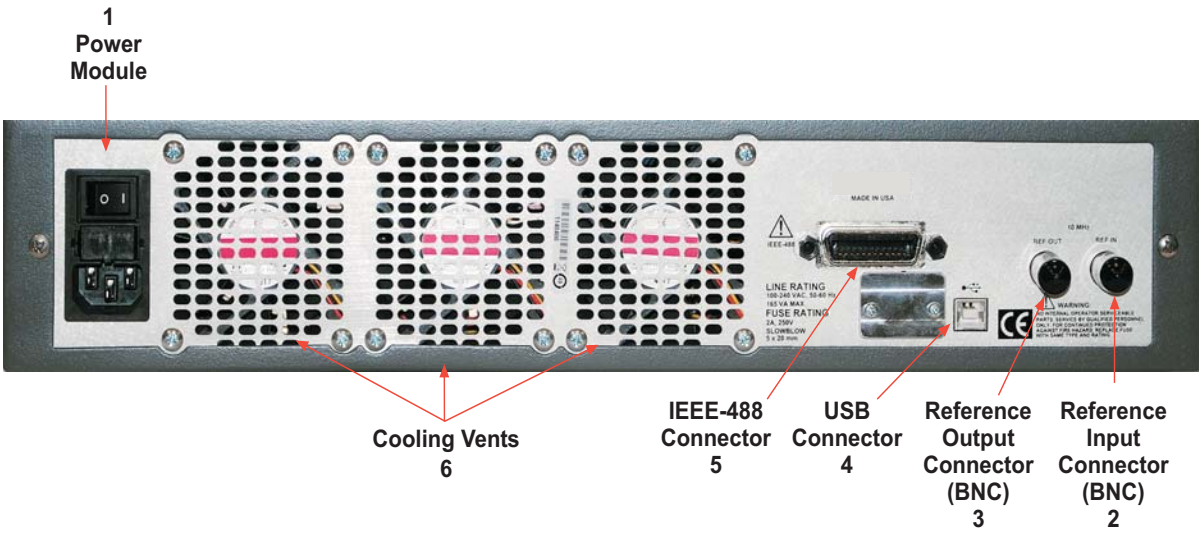
d. Channel 2 delay input: Connect an external source for Channel 2 external jitter insertion.
e. Trigger output: Connect to an external unit. This connector sends a single-ended voltage pulse.

9. **Cursor keys:** Use these keys to increment or decrement parameter values.
10. **Soft keys:** Soft key options that can be selected depend upon the enabled menu. The options are positioned in the display immediately above the soft keys.

Rear panel

The rear panel of the instrument is shown in Figure 1-2.

Figure 1-2
Rear panel



1. **Power module:** The module contains three elements:
   a. AC line receptacle: Plug the instrument power cord here.
   b. Power line fuse: This drawer houses two line fuses. Refer to the Line fuse replacement section for instruction.
   c. Power switch: This switch must be in the "1" (on) position to enable the front panel On/Off switch (refer to Figure 1-1).
2. **Reference input connector:** This female BNC connector accepts an external 10 MHz oscillator signal for clock reference.

NOTE *Use the REF IN and REF OUT connectors to connect multiple instruments for the purpose of using one internal clock as the period source.*

3. **Reference output connector**: A 10 MHz signal phase-locked to the internal clock is sent through this female BNC connector.
4. **USB connector:** For USB remote operation, use a USB cable to connect to the USB interface of the remote interface.
5. **IEEE-488 connector:** For GPIB remote operation, use a shielded cable.
6. **Cooling vents:** The instrument uses a cooling fan and vents to keep it from overheating. There is also a cooling vent on each side panel of the instrument. Refer to the Ventilation topic for details.

Power up

The Model 12010/12020 operates from a single-phase line voltage in the range of 100 V to 240 V at a frequency of 50 Hz or 60 Hz. Line voltage and line frequency are automatically sensed; there are no switches to set. Check to ensure the operating voltage in your area is compatible.

CAUTION **Operating the instrument on an incorrect line voltage may cause damage, possibly voiding the warranty.**

To connect the instrument to line power and turn it on:

1. Before plugging in the power cord, ensure the Model 12010/12020 is turned off and the rear panel power switch is in the off (0) position.
2. Connect the female end of the supplied power cord to the AC receptacle on the rear panel, and move the rear panel power switch to the on (1) position.

WARNING ***The power cord supplied with the Model 12010/12020 contains a separate ground for use with grounded outlets. When proper connections are made, the instrument chassis is connected to power line ground through the ground wire in the power cord. Failure to use a grounded outlet may result in personal injury or death due to electric shock.***

3. Power up the instrument by pressing the front-panel on/off button.

Line fuse replacement

Two line fuses are located in a drawer in the Power Module above the AC receptacle (refer to Figure 1-2). After turning the power switch off and removing the line cord, remove and inspect the fuses, and replace damaged fuses with this specific type only:

Fuse type: 2 A, 250 V, slow-blow, 5 mm x 20 mm

Ventilation

The Model 12010/12020 has a fan and cooling vents in the rear and side panels to keep it from overheating.

CAUTION **Observe the following precautions to maintain proper ventilation:**

Do not block the cooling vents.

Do not position any devices adjacent to the instrument that force air (heated or unheated) into or onto the instrument's surfaces or cooling vents. This additional airflow could compromise accuracy performance.

When rack mounting the instrument, ensure there is adequate airflow around the instrument rear and sides to ensure proper cooling. Adequate airflow enables air temperatures within approximately one inch of the instrument surfaces to remain within specified limits under all operating conditions.

Section 2

Setup and Pulse Generation Settings

In this section:

External instrument connections

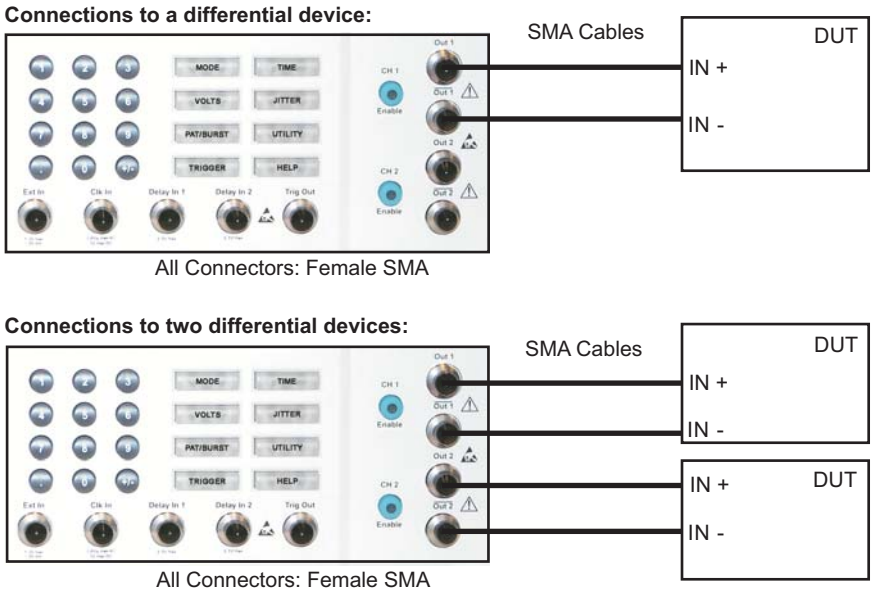
External instrument signal connections are made at the front and rear of the Models 12010/12020 Pulse/Pattern Generators. All front-panel connectors are female Sub-Miniature version A (SMA). The rear-panel connectors are female Bayonet Neil Concelman (BNC).

CAUTION **Instrument damage hazard. Electrostatic discharge could harm your instrument. Use approved antistatic devices when making device connections.**

Out 1 and Out 2 connections

Figure 2-1 shows how to connect the output channels of the Models 12010/12020 to one or two Device Under Test (DUT).

Figure 2-1
Out 1 and Out 2 connections

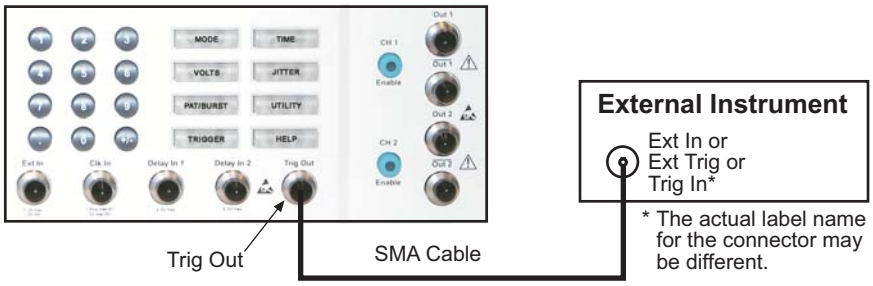


Trig Out and Ext In connections

Figure 2-2 shows connections for Trigger Output (Trig Out), and Figure 2-3 shows connections for External Input (Ext In). Trigger output marks each pulse or, for pattern mode, every eighth bit period. Trigger output is used to trigger an external instrument to start an operation (for example, trigger a scope to capture the waveform).

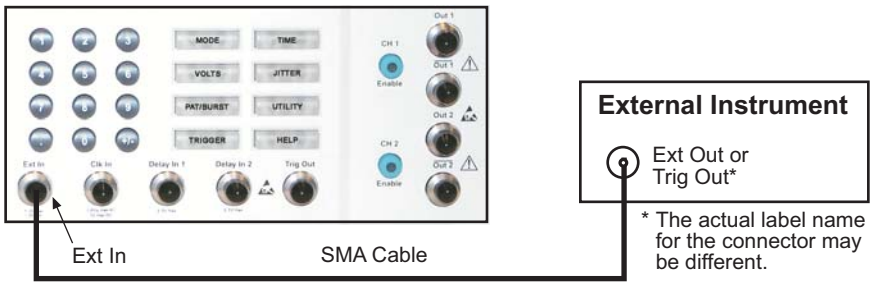
After an external instrument completes the operation (for example, waveform capture), it can send a trigger back to the Ext In of the Model 12010/12020 to output another pulse or bit. Setting Trig Out and Ext In together allows for synchronized operation between two instruments. Refer to each operating mode in Section 3 for triggering details.

Figure 2-2
Trig Out connections



External Instrument can be one of the following:
- Scope being triggered to capture a waveform.
- Another Model 12010/12020 being triggered to start Pulse, Burst, ExtWidth, or Pattern.
- Any other instrument being triggered to perform an operation.

Figure 2-3
Ext In connections



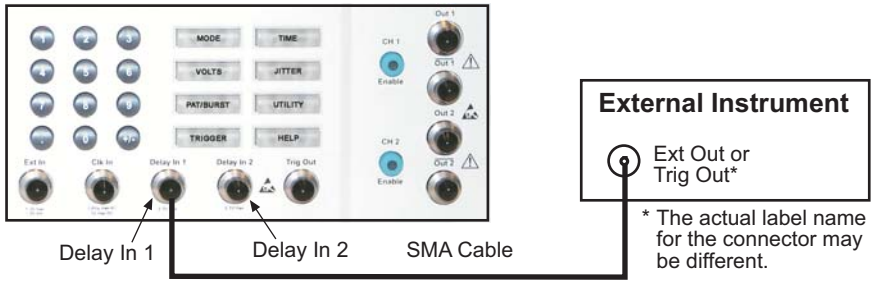
External Instrument can be one of the following:
- Scope triggering the Models 12010/12020 to start Pulse, Burst, ExtWidth, or Pattern.
- A second Series 12010/12020 triggering the first Series 12010/12020 to start Pulse, Burst, ExtWidth, or Pattern.
- Any other instrument triggering the Series 12010/12020 to start Pulse, Burst, ExtWidth, or Pattern.

Delay In connections

NOTE *Models 12010-1-J, 12010-2-J, 12020-1-J, and 12020-2-J have jitter insertion capabilities. Refer to the Jitter insertion section for details.*

A jitter insertion source may be internal or external. The Delay In connections are used to apply external jitter to the output signal. For the Models 12010-2-J and 12020-2-J, the Delay In 1 connection applies to Channel 1, and the Delay In 2 connection applies to Channel 2 (Figure 2-4).

Figure 2-4
Delay In connections



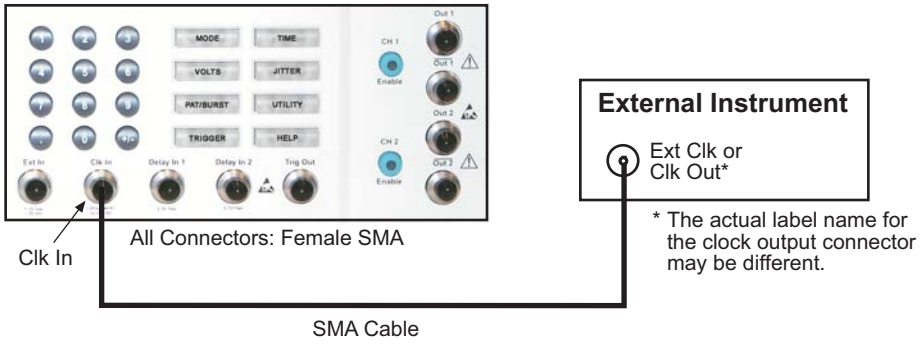
External Instrument can be one of the following:

- A second Series 12010/12020 to start jitter insertion.
- Any other frequency source to start jitter insertion.

Clk In connections

The period source can be provided by an external clock as shown in Table 2-5. Refer to each operating mode in Section 3 for triggering details.

Figure 2-5
Clk In connections

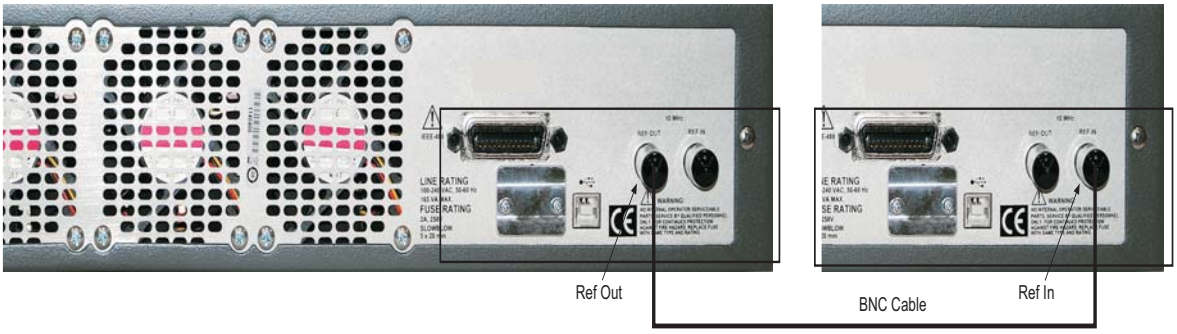


Ref Out and Ref In connections

When using multiple instruments in a system, the internal clock reference of a single unit may be shared (made common to all units) by connecting the Reference Output (Ref Out) connector of one unit to the Reference Input (Ref In) connector of another. In any multi-unit system, the unit with the most accurate clock reference is typically used as the governing unit. When multiple units share the same internal clock reference, the frequencies of all of the units are synchronized.

Figure 2-6 shows two Model 12010/12020 instruments connected together so that the second unit can use the internal clock reference of the first unit. In this configuration example, all but one Model 12010/12020 must be set for RefOsc = External under the Utility menu.

Figure 2-6
Ref Out and Ref In connections



Editing parameter values and settings

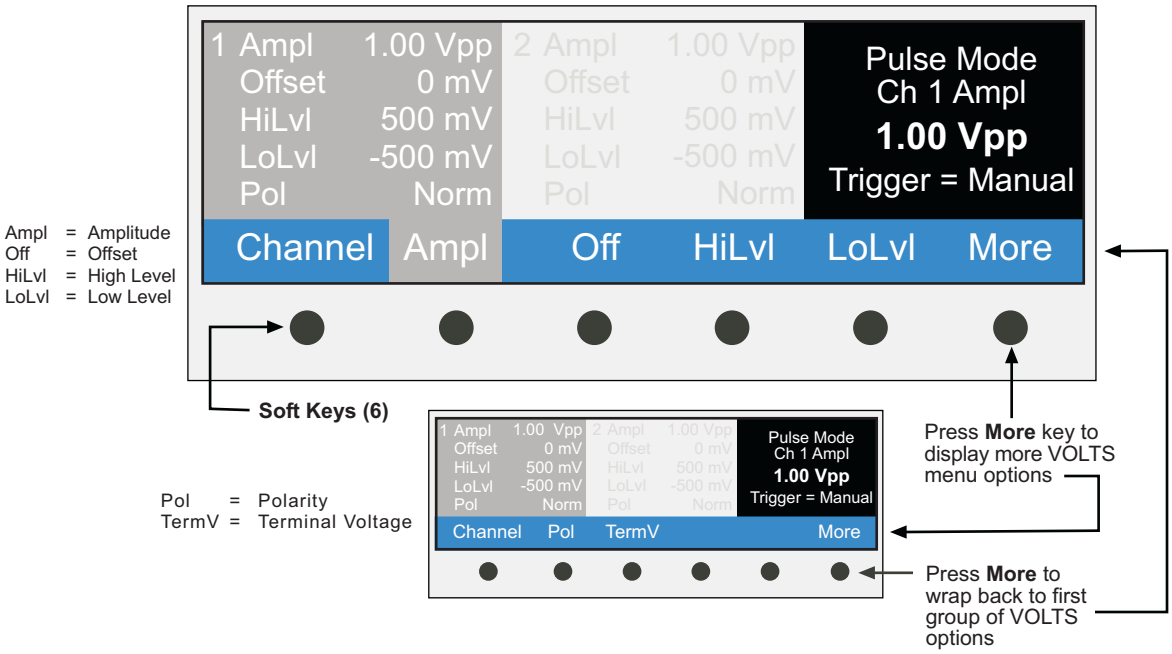
Display

The Model 12010/12020 has an LCD display to view and set the various pulse/pattern parameters. Each menu has its own set of parameters that are selected using the soft keys under each command. For example, Figure 2-7 shows display items for the VOLTS menu.

As shown, pressing the **More** soft key displays all options for the VOLTS menu. All of the menus are summarized in Table 2-4. For the Models 12010-2 and 12020-2, pressing the **Channel** soft key switches between the two channels to set parameters for the selected channel.

Power up default settings are shown in Table 2-5.

Figure 2-7
LCD display and soft keys (VOLTS menu shown)



To edit parameter values and settings:

1. Select a menu (**VOLTS,** for example). The menu keys are located next to the keypad.
2. Press the soft key of the parameter to be changed. Use the **More** key to display additional options. The parameter value or setting is displayed on the right side of the display.
3. Change a parameter value or setting as follows:

- **Parameter value**: If the parameter is a value, it can be changed using the navigation wheel or the keypad.
  Navigation wheel: Rotating the wheel increments or decrements the value.
  Keypad: When typing in a value, the available ranges (mV or V, for example) for the value will appear at the bottom of the display. After entering in the value, press a soft key to select the range.
  CURSOR keys: Press to increment or decrement values.
- **Parameter setting:** For a parameter setting, options may appear on the bottom of the display (for example, **Enable**, **Disable**, or **Cancel**) and can be selected by pressing a soft key.

Additional soft keys for menu navigation will display as needed:

Enter soft key: Press to enter the parameter setting or value.

Back soft key: Press to return to the previous menu view.

Cancel soft key: Press to cancel a menu selection. The menu returns to the previous view.

Invalid entry error message

Trying to enter an invalid parameter setting will result in the following message in the upper right corner of the display:

```
Error, Press Help
```

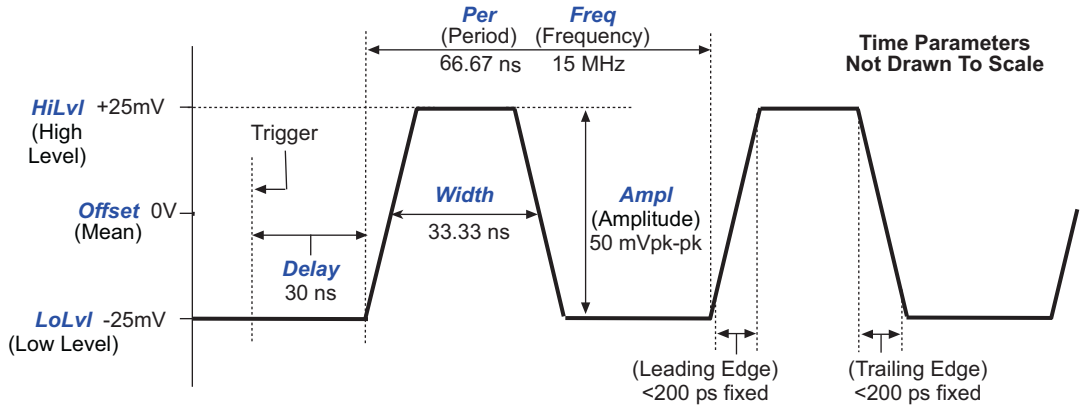
Press the **HELP** key to display a message that explains the error. Press any key to cancel the help message.

Basic pulse parameters

The instrument is in pulse mode with continuous triggering selected when it is powered up. Once a channel is enabled, it will continuously output pulses.

Figure 2-8 shows the first two pulses of the continuous pulse output using typical settings. The parameter names in italic text correspond to the parameter names in the front panel **VOLTS** and **TIME** menus.

Figure 2-8
Typical pulse level and timing parameter settings (pulse mode, continuous triggering)



The basic pulse level, timing, and triggering parameters are summarized in Table 2-1 and Table 2-2. The last column (Independent channel settings) in the two tables does not apply to single channel models.

Pulse level parameters

The following parameters (Table 2-1) are found under the Volts menu.

Table 2-1
Pulse level parameters

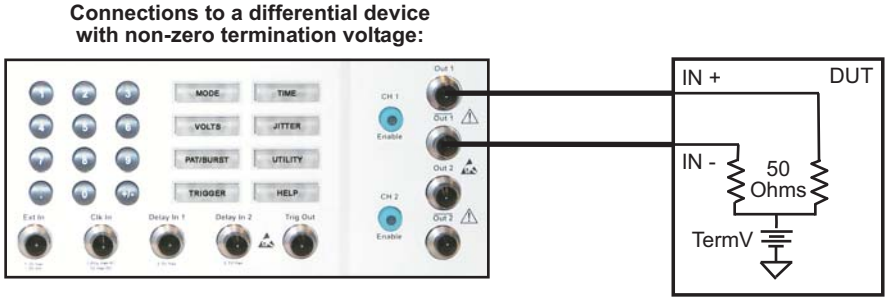
Parameter	Description	Independent channel settings* (12010-2 and 12020-2 only)
High level Low level	Configure the pulse high/low levels by setting the high level and the low level within the level window (-2 V to +3.3 V). Changing the high or low level will change the amplitude and offset.	Yes
Amplitude	Amplitude is the low-to-high magnitude of the pulse. Amplitude setting: 50 mV_{pk-pk} to 2.5 V_{pk-pk}. Changing the amplitude will change the high and low levels. Offset is not affected.	Yes
Offset	Offset is the mean (average) value of the high and low levels: Offset = (high level + low level) / 2. The offset can be set to any value that allows the pulse to fit within the level window. Changing the offset will change the high and low levels. Amplitude is not affected.	Yes
Polarity	Polarity can be set to **Norm** (normal) or **Comp** (complement).	Yes
Term voltage	Enter when the DUT has non-zero termination voltage (-2 V to +3.3 V).	Yes

* Yes = The parameter can be independently set for each channel of the Models 12010-2 and 12020-2.
No = The parameter setting applies to both channels.

Termination Voltage

Entering a non-zero termination voltage (**TermV**) will change the displayed values of **HiLvl**, **LoLvl** and **Offset** to be correct when the output is connected to a 50-ohm load that is not at 0V. Figure 2-9 shows a schematic of that termination.

Figure 2-9
Out 1 connected to a DUT with non-zero termination voltage



The Amplitude of the 12010/121020 output pulse does not change, but the display shows the correct levels and offset at the DUT given its termination voltage.

Pulse timing and triggering parameters

Table 2-2
Pulse timing and triggering parameters.

Parameters are found under the Time menu unless otherwise noted.

Parameter	Description	Independent Channel Settings[1] (12010-2 and 12020-2 only)
Frequency	Pulse cycle time can be set as frequency or period. Frequency can be set from 15 MHz to 1.6 GHz. [2]	No
Period	Period can be set from 625 ps to 66.67 ns. [2]	No
Width	Pulse width is measured at the 50% amplitude level of the pulse. Width can be set from 250 ps to (Period - 250 ps).	Yes
Delay	A delay between the trigger event and the start of each pulse can be set from 0 to Period.	Yes
Duty Cycle	The duty cycle may be set between 0.38% and 99.62%. Not applicable in NRZ format.	Yes
Crossing Point	The crossing point of NRZ data may be set between 30% and 70%.	Yes
Hold	Width or Duty Cycle is held constant as Frequency is changed.	Yes
Clock Source	The source for period generation can be **Internal** or an external clock input (**ClkIn**). (Under Utility menu.)	No
Trigger Source	Select the trigger source to start pulse output: **Cont** (continuous), **ExtIn** (external input), **Manual** or **Remote**. (Under Trigger menu.)	No
Trigger Type	Select the trigger type: **Edge** or **Level**. (Under Trigger menu.)	No

[1] Yes = The parameter can be independently set for each of the two channels of the Model 12010/12020.
No = The parameter setting applies to both channels of the Model 12010/12020.
[2] Model 12010 has maximum Frequency = 800 MHz and minimum Period = 1.25 ns.

Operating modes

The Model 12010/12020 Pulse/Pattern Generators have four operating modes: Pulse mode, Burst mode, Pattern mode, and External Width mode.

Pulse mode

Pulse mode delivers a single pulse to the output channel per trigger event. The basic pulse level, timing and triggering parameters are summarized in Table 2-1 and Table 2-2.

Burst mode

This mode is similar to the Pulse mode, except that each trigger event will deliver a series (burst) of *n* pulses. In Burst mode, 2 to 1,048,576 pulses can be delivered.

Pattern mode

Pattern mode delivers a user-configured or pre-configured bit pattern that consists of Logic 0's and 1's. The length of the bit pattern can be 8 to 16,777,216 bits. The pattern may be presented in R1 (return-to-one), RZ (return-to-zero), or NRZ (non-return-to-zero) format. In R1 and RZ modes, the duration (duty cycle) of the pattern pulse is programmable. In NRZ mode, the pattern crossing

point is programmable. Logic 0 represents the low pulse level, and Logic 1 represents the high pulse level.

Pattern data formats

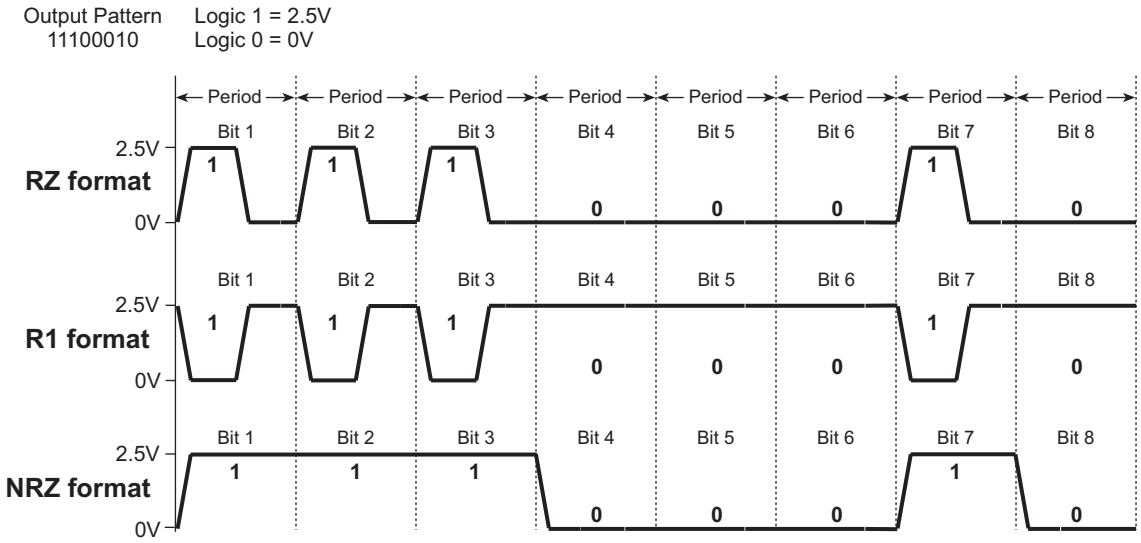
There are three data formats for output patterns: RZ (return-to-zero), R1 (return-to-one), and NRZ (non-return-to-zero). Figure 2-10 shows the difference between the three formats. The 8-bit pattern is the same for all three formats (11100010), and the logic levels are the same (Logic 0 = 0 V, Logic 1 = 2.5 V):

- RZ Format: For 50% duty cycle, a Logic 1 bit goes to 2.5 V for the first half of the period, and then returns to 0 V for the second half of the period (return-to-zero). A Logic 0 bit remains at 0 V for the entire period.
- R1 Format: A Logic 1 bit remains at 2.5 V for the entire period. A Logic 0 bit goes to 0 V for the first half of the period, and then returns to 2.5 V for the second half of the period (return-to-one).
- NRZ Format: A Logic 1 bit goes to 2.5 V and stays at 2.5 V for the entire period (non-return-to-zero). A Logic 0 bit goes to 0 V and remains at 0 V for the entire period.

NOTE *For any data format, the level for Logic 0 does not have to be 0V. It simply must be less positive (more negative) than Logic 1.*

Example 1:	*Example 2:*
Logic 1 = 2 V	*Logic 1 = 0 V*
Logic 0 = 1 V	*Logic 0 = -2 V*

Figure 2-10
Example output pattern for RZ, R1, and NRZ data formats



Pseudo Random Bit Sequence (PRBS)

The PRBS is used to output a pseudo random pattern for testing purposes. The number of bits for the PRBS output pattern can be set as follows:

PRBS length = 2^n-1 where n = 5 to 15, 23 or 31

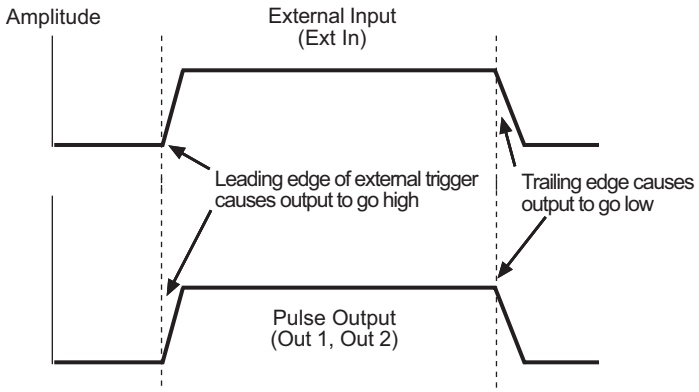
The R1, RZ, or NRZ data format can be used for the PRBS pattern. Refer to the *PRBSLen: Pseudo Random Bit Sequence Length* section for details.

External Width mode

In this mode, pulse output follows the edges of an external input trigger that is applied to the Ext In connector. As shown in Figure 2-11, a rising edge causes the output to go high, while a falling edge causes the output to go low.

The maximum range of external input trigger is -2 V to +3 V.

Figure 2-11
External Width mode



Additional pulse characteristics

The following are characteristics inherent to pulse generation and may or may not be affected by various instrument settings or load.

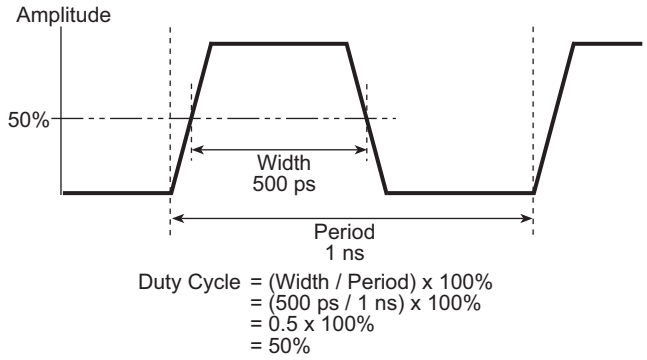
Duty cycle

The duty cycle is the amount of time (as a percentage of the pulse period) that the pulse is on or active (pulse width). Duty cycle (as a percentage) is calculated as follows:

Duty Cycle = (Width / Period) x 100

Figure 2-12 shows an example for duty cycle.

Figure 2-12
Example of 50% duty cycle



Jitter insertion

The Model 12010-1-J, 12010-2-J, 12020-1-J, and 12020-2-J Pulse/Pattern Generators are equipped with jitter insertion to help accurately simulate real-world signal characteristics. Jitter is the short-term instability of one edge relative to a reference edge. Jitter is typically specified as a Root-Mean-Square (RMS) value, which is one standard deviation (or sigma).

The reference edge for period jitter is the previous leading edge. The reference edge for delay jitter is the leading edge of the trigger output. Width jitter is the stability of the trailing edge with respect to the leading edge.

Sinusoidal, deterministic, random, and external jitter can be applied in any combination.

NOTE *The following restrictions apply to jitter insertion: Do Not enable SSC and Sine Jitter at the same time. Use SSC or Sine Jitte only with Internal Clock source and Continuous Trigger Type. Use Deterministic, Random, or External Input Jitter only with Continuous Trigger Type.*

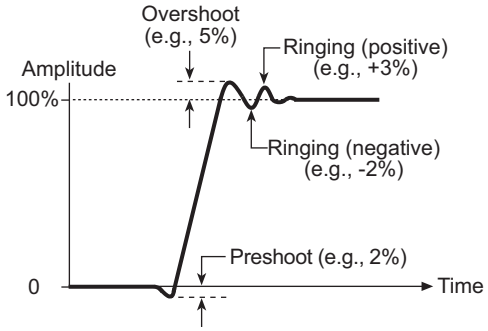
Table 2-3
Jitter insertion characteristics

Parameter	Specification
Jitter sources	Sinusoidal, deterministic, random, and external
Sinusoidal	Jitter by phase modulation of Clock: 10 kHz to 10 MHz 10 kHz: 40 ns $_{pk-pk}$ max. 30 kHz: 40 ns $_{pk-pk}$ max. 3 MHz: 0.6 ns $_{pk-pk}$ max. 10 MHz: 0.6 ns $_{pk-pk}$ max.
Deterministic jiter	Jitter by phase modulation of Output.
Square	1 Hz to 20 MHz, 0.45 UI $_{pk-pk}$ max.
Triangle	1 Hz to 4 MHz, 0.5 UI $_{pk-pk}$ max.
Sine	1 Hz to 20 MHz, 0.5 UI $_{pk-pk}$ max.
Random jitter	Gaussian noise, 80 MHz BW, 0.08 UI $_{rms}$ max.
External input	80 MHz BW, 0.5 UI $_{pk-pk}$ max. with 2 V_{pk-pk} input corresponding to 0.5 UI $_{pk-pk}$ max.

Distortion

Distortion includes preshoot, overshoot, and ringing. Preshoot and overshoot are peak distortions preceding/following an edge. Ringing is the positive-peak and negative-peak distortion (excluding overshoot) on pulse top or base. Distortion for a pulse is shown in Figure 2-13. A combined preshoot, overshoot, and ringing specification of 5% implies an overshoot and undershoot <5% of pulse amplitude.

Figure 2-13
Distortion – Preshoot, overshoot, and ringing



Menu summary

A brief description for each menu key is provided in Table 2-4.

Table 2-4
Menu summary

Menu Key	Menu Item	Description
MODE	Pulse	Select Pulse mode
	Pattern	Select Pattern mode
	Burst	Select Burst mode
	ExtWidth	External Width: Select External Width mode
VOLTS	Channel	12010-2 and 12020-2 only: Select channel
	Ampl	Amplitude: Set peak-to-peak amplitude
	Off	Offset: Set offset
	HiLvl	High Level: Set high level
	LoLvl	Low Level: Set low level
	Pol	Polarity: Set polarity: Norm (normal) or Comp (complement)
	TermV	Enter when the DUT has non-zero termination voltage
PAT/BURST	Channel	12010-2 and 12020-2 only: Select output channel
	Ch1BstCt	Channel 1 Burst Count: Set burst count for channel 1 burst mode
	Ch2BstCt	Channel 2 Burst Count: Set burst count for channel 2 burst mode
	Edit	Edit: Change bit to 0 or 1 (use **0**, **1** or **+/-** key)
	Bit#	Bit Number: Select the bit to be changed
	Length	Pattern Length: Set the number of bits of the pattern
	Type	Pattern Type: Select Data or PRBS
	Ch1Fmt	Channel 1 Format: Set channel 1 format (R1, RZ, or NRZ)
	Ch2Fmt	Channel 2 Format: Set channel 2 format (R1, RZ, or NRZ)
	PRBSLen	PRBS Length: Set the "n" in formula 2^n-1; n = 5 to 15, 23, 31
	BstPer	Burst Period: Set period in increments of 8
TRIGGER	TrgVolts	Refer to **VOLTS** menu above
	Source	Trigger Source: Select Continuous (**Cont**), External Input (**ExtIn**), **Manual** or **Remote**
	Type	Trigger Type: Select **Edge** or **Level**
	OutEvent	Output Event: Select **Per** (period) or **Patt/Bur** (pattern/burst)
TIME	Channel	12010-2 and 12020-2 only: Select channel
	Freq	Frequency: Set the clock frequency (Hz)
	Per	Period: Set the clock period(s)
	Width	Width: Set the duration of the pulse(s)
	Delay	Delay: Set the delay period between trigger and output(s)
	DutyCyc	Duty Cycle: Set the duty cycle (%); not applicable in NRZ data format
	CrossPt	Cross Point: Set the cross point (%); only applicable in NRZ data format
	SSC	Spread Spectrum Clocking: **Enable** or **Disable**; set frequency or amplitude
	Hold	Hold: Set width or duty cycle constant (when frequency changes)
JITTER	Sin	Sine: Select sinusoidal jitter insertion
	Det	Deterministic: Select deterministic jitter insertion
	Ran	Random: Select random jitter insertion
	Ext	External Delay: **Enable** or **Disable** external delay
	Hold	Hold: Select **UI** or **Sec** (seconds) as the hold parameter
UTILITY	ClkIn	Clock Input: Configure clock input: Termination (ClkIn **Term**; **AC** or **DC**), slope (ClkIn **Slope**; **Pos** or **Neg**) and termination voltage (ClkIn **TermV**; -2V to 3 V)

Table 2-4 (cont.)
Menu summary

Menu Key	Menu Item	Description
	ExtIn	External Input: Configure external input: Threshold (ExtIn **Threshold**; -2 V to 3 V), slope (ExtIn **Slope**; **Pos** or **Neg**), and termination voltage (ExtIn **TermV**; -2V to 3 V)
	ClkSrc	Clock Source: Select **Internal** or **ClkIn**
	RefOsc	Reference Oscillator: Select **Internal** or **External**
	System	System: Adjust display setting, select remote programming control port (**IOPort**: **GPIB** or **USB**), enter GPIB remote programming address (**GPIB add**), and enable or disable auto correct (**AutoCorr**; **Enable** or **Disable**)
	InstSave	Save and Recall instrument setups
	PattSave	Save and Recall patterns
HELP	N/A	Provides a brief description for the presently selected parameter (soft key). Press any menu key or soft key to cancel help.

Defaults

The power-up defaults are listed in Table 2-5.

Table 2-5
Power-up defaults

Menu	Parameter	Setting or Value
MODE	Operating mode	Pulse
TIME	Channel	1
	Frequency	15.000000 MHz
	Period	66.67 ns
	Width	10 ns
	Delay	0.0 ps
	Duty Cycle	15%
	Cross Point	50%
	Spread Spectrum Clocking	Disabled
	Hold	Width
VOLTS	Channel	1
	Amplitude	50 mV_{pk-pk}
	Offset	0 mV
	High Level	25 mV
	Low Level	-25 mV
	Polarity	Normal
	Termination Voltage	0 mV
PAT/BURST	Edit	Disabled
	Bit Number	8
	Length	8 bits
	Type	Data
	Ch1 Format	NRZ
	Ch 2 Format	NRZ
	PRBS Length	5
	Burst Period	8
	Ch 1 Burst Count	2
	Ch 2 Burst Count	2
UTILITY	Clock Input:	
	Termination	AC
	Termination Voltage	0 mV
	Slope	Positive
	External Input:	
	Slope	Positive
	Threshold	0 mV
	Termination Voltage	0 mV
	Clock Source	Internal

Menu	Parameter	Setting or Value
UTILITY (con't)	Reference Oscillator:	Internal
	System:	
	Display:	
	Bright	8
	Contrast	6
	GPIB Address	10*
	IOPort*	GPIB*
	Auto Correct	Disabled
TRIGGER	Trigger Volts:	
	Amplitude	50 mV_{pk-pk}
	Offset	0 mV
	Hi Level	25 mV
	Lo Level	-25 mV
	Termination Voltage	0 mV
	Source	Continuous
	Type	Edge
	Output Event	Pattern/Burst
JITTER	Sinusoidal Jitter:	
	Enable	Disabled
	Frequency	1 MHz
	A(s)	600 ps_{pk-pk}
	A(UI)	50 mUI_{rms}
	Deterministic Jitter:	
	Enable	Disabled
	A(s)	6.67 ns_{pk-pk}
	A(VI)	100 mUI_{pk-pk}
	Frequency	1 MHz
	Function	Sine
	Random Jitter:	
	Enable	Disabled
	A(s)	3.33 ns_{rms}
	A(VI)	50 mUI_{pk-pk}
	External Delay:	
	Enable	Disabled
	Hold	UI

* At the factory, the GPIB is selected as the remote programming interface, and the address is set to 10. Changes to the interace or address are saved in Non-Volatile Memory and will be recalled on subsequent power-up. You must cycle the power after changing any communication parameters to ensure that such parameters are applied.

Section 3

Pulse/Pattern Generators Operation

In this section:

Pulse/Pattern/Burst/External Width operation

After making connections to the Model 12010/12020 (refer to Section 2), the fundamental steps to operate Pulse, Pattern, Burst, and External Width modes are as follows:

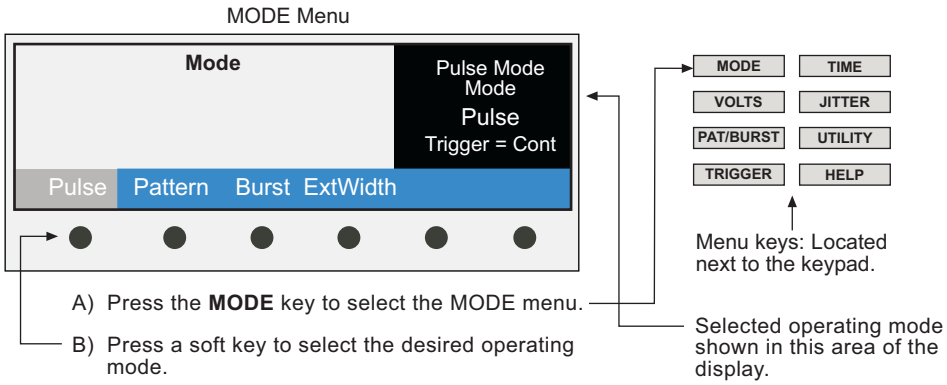
1. Select the operating mode by pressing the **MODE** key.
2. Configure the time and voltage parameters for the selected mode.
3. Configure triggering.
4. Enable the channel(s) and trigger the start of pulse output.
5. When finished, disable the output(s).

After selecting the operating mode, set the programmable parameters for that mode using the soft keys, navigation wheel and cursor keys, or the keypad. Refer to *Pulse/pattern parameters* for instruction.

NOTE *The Pulse/pattern parameters section contains details about all settable parameters. Each parameter is listed alphabetically by its soft key name.*

The two steps to select the operating mode are presented in Figure 3-1.

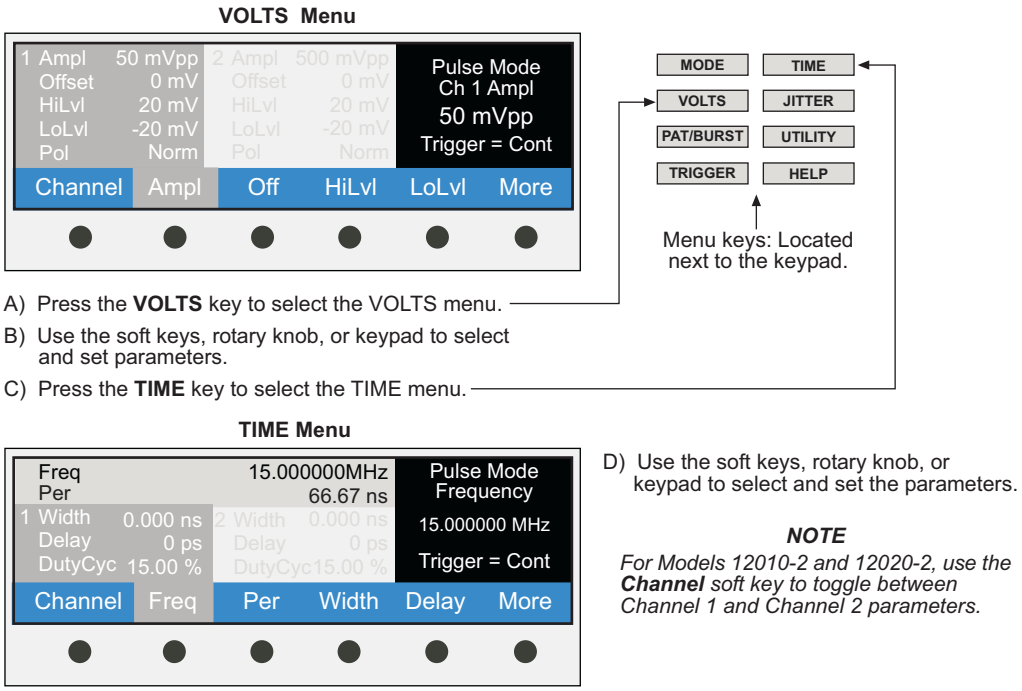
Figure 3-1
Select operating mode



Pulse mode

1. Select the Pulse mode as presented in Figure 3-1.
2. Perform the steps in Figure 3-2 to access the parameters in the **VOLTS** and **TIME** menus.

Figure 3-2
Configure Pulse mode parameters



3. Perform the steps in Figure 3-3 to access the triggering parameters. Refer to Table 3-1 for additional information.

Figure 3-3
Configure triggering

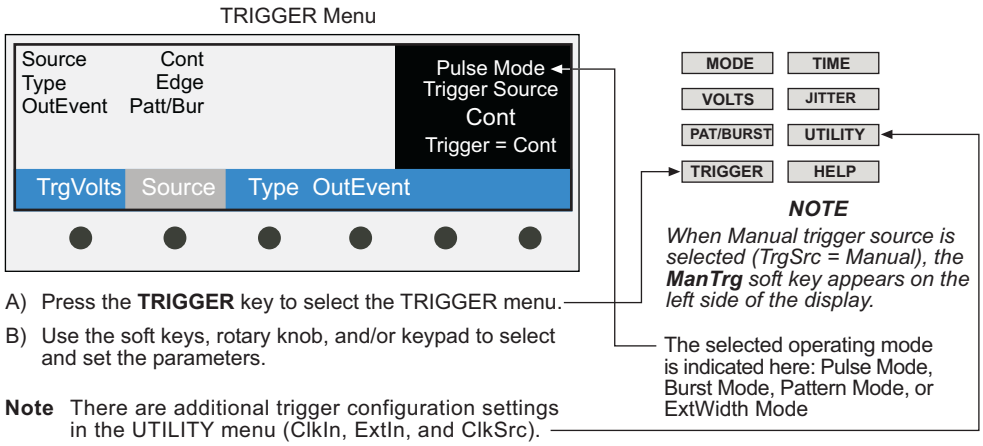


Table 3-1
Pulse mode triggering parameters

Trigger Source	Trigger Type	Pulse Mode
Continuous	Edge or Level	Pulses are continually produced at the set period (**Clk Src**: **Internal** or **Clk In**); one output pulse for each trigger pulse.
External Input	Edge	One pulse is produced for every valid edge on the **Ext In** signal (**Clk Src** is not applicable).
	Level	During the active (high) part of the signal, pulses are continually produced at the set period (**Clk Src**: **Internal** or **Clk In**). During the inactive (low) part of the signal, no pulses are produced.
Manual	Edge or Level	One pulse is produced for every press of the **Manual** key; one output pulse for each trigger pulse.
Remote	Edge or Level	One pulse is produced for every remote trigger command; one output pulse for each trigger pulse.
Trigger Output Event: Not applicable.		

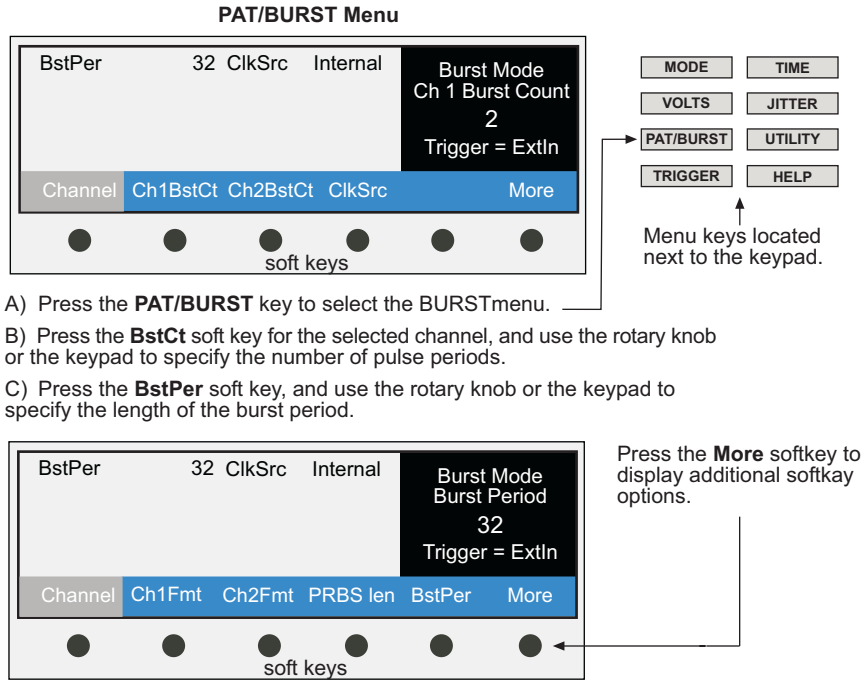
4. Press the key(s) located next to the output connector(s) to enable the channel(s): **CH1 Enable** and **CH2 Enable** (Models 12010-2 and 12020-2 only). A green indicator lights up to show that the channel is enabled.

   The enabled pulse output is triggered (output sequence started) according to the trigger configuration.
5. When finished, disable the output(s) by again pressing the **CH1 ENABLE** and **CH2 ENABLE** (Models 12010-2 and 12020-2) keys. The green indicator light(s) turns off.

Burst mode

1. Select the Burst mode as shown in Figure 3-1.
2. Perform the steps in Figure 3-4 to set the Burst count or Burst period. Burst count can be set from 2 to 1,048,576 pulse periods. Burst period length can be set from 8 to 1,048,576.

Figure 3-4
Setting Burst mode



3. Perform the steps in Figure 3-3 to access the triggering parameters. Refer to Table 3-2 for additional information.

Table 3-2
Burst mode triggering parameters

Trigger Source	Trigger Type	Burst Mode
Continuous	Edge or Level	Bursts are continually produced at the set period (**Clk Src**: **Internal** or **Clk In**).
External Input	Edge	One burst is produced for every valid edge on the **Ext In** signal (**Clk Src**: **Internal or Clk In**).
	Level	During the active (high) part of the signal, bursts are continually produced at the set period (**Clk Src**: **Internal** or **Clk In**). During the inactive (low) part of the signal, no bursts are produced.
Manual	Edge or Level	One burst is produced for every press of the **Manual** key (**Clk Src**: **Internal** or **Clk In**).
Remote	Edge or Level	One burst is produced for every remote trigger command (**Clk Src**: **Internal** or **Clk In**).
Trigger Output Event: **Per** - One trigger pulse for each pulse period. The number of trigger pulses per burst is equal to the burst period. **Patt/Bur -** One trigger pulse at the beginning of each burst. Trigger pulse duration is approximately four periods long.		

4. Press the key(s) located next to the output connector(s) to enable the channel(s): **CH1 Enable** and **CH2 Enable** (Model 12010-2 and 12020-2 only). A green indicator lights up to show that the channel is enabled.

   The enabled pulse output is triggered (output sequence started) according to the trigger configuration.
5. When finished, disable the output(s) by again pressing the **CH1 ENABLE** and **CH2 ENABLE** (Model 12010-2 and 12020-2) keys. The green indicator light(s) turns off.

Pattern mode

1. Select Pattern mode as presented in Figure 3-1.
2. Set up the desired pattern configuration including the pattern format, pattern length, and pattern bits.
   a. Select the pattern format: NRZ, RZ, or R1

      i. Use the **Channel** soft key to move the cursor to the desired channel: Ch 1 or Ch 2 (Model 12010-2 and 12020-2)

      ii. Use the **Ch1Fmt** soft key to select from the NRZ, RZ, or R1 pattern format for Channel 1. Do the same for Channel 2 (12010-2 and 12020-2 only).

   b. Set pattern length: 8 to 16,777,216 bits

      i. Press the **More** soft key to switch menus until the **Length** option is shown.

      iii. Press the **Length** soft key, and use the navigation wheel or keypad to enter the pattern length in multiples of 8. If using the keypad, key in the value and press the **Enter** soft key. All bits added to the pattern will be 0's unless the pattern was longer at a previous time, in which case the bits added will have their previous values.

      For Models 12010-2 and 12020-2, the pattern length applies to both channels.

   c. Edit pattern bits: (0 or 1)

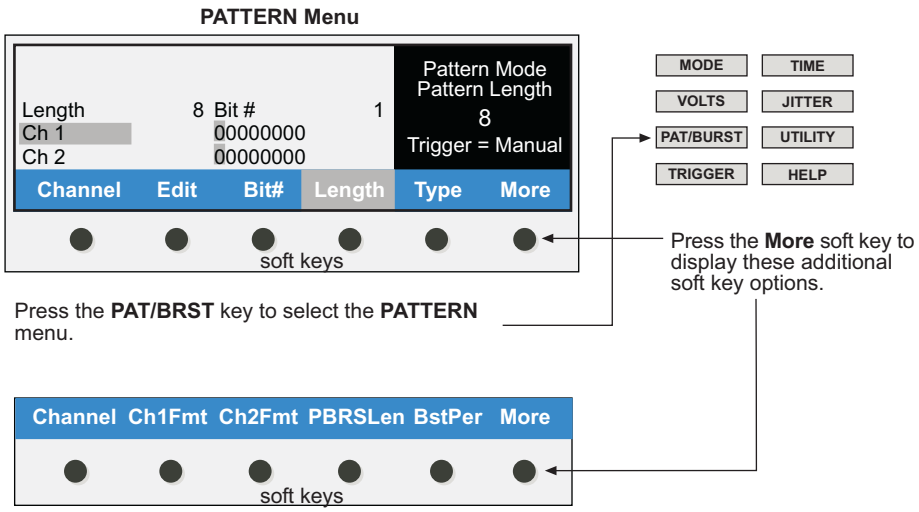
      i. To change cursor position, press the **Bit#** soft key, and use the navigation wheel or the keypad to place the cursor on the bit to be changed.

      ii. Press the **Edit** soft key, and press **0**, **1** or **+/-** on the keypad to set the bit (the **+/-** key toggles the bit value). The cursor moves (right) to the next bit, which can be changed in the same manner.

NOTE *Level and time parameters for Pattern mode are configured via the **TIME** and **VOLTS** menus. Refer to Pulse mode section for details.*

Figure 3-5 shows the Pattern mode selections from the **PAT/BURST** menu.

Figure 3-5
PATTERN menu



Pseudo random bit sequence (PRBS) length

Use PRBS to output a pseudo random pattern at the output. The bit length for the PRBS output pattern is determined by the binary sequence formula 2^n-1, where n = 5 to 15, 23, or 31. Refer to Figure 3-5 for soft key direction.

1. Select the format (RZ, NRZ, or R1) for the output pattern.
2. Use the **Type** softkey to set the pattern type to PRBS.
3. Press the **PRBSLen** softkey.
4. Use the navigation wheel or the keypad to set "n" for PRBS. If using the keypad, press the **Enter** soft key after keying in the value.

   The displayed parameter value is "n" for formula 2^n-1. Note that when the Type is set to PRBS, the PRBSLen parameter sets the pattern length and the Length parameter is not in use.
5. Perform the steps in Figure 3-3 to access the triggering parameters. Refer to Table 3-1 for additional information.

Table 3-3
Pattern mode triggering parameters

Trigger Source	Trigger Type	Pattern Mode
Continuous	Edge or Level	Patterns are continually produced at the set period (**Clk Src**: **Internal** or **Clk In**).
External Input	Edge	One pattern is produced for every valid edge on the **Ext In** signal (bit period: **Internal** or **Clk In**).
	Level	During the active (high) part of the signal, patterns are continually produced at the set bit period (bit period: **Internal** or **Clk In**). During the inactive (low) part of the signal, no patterns are produced. If the Ext In falls inactive during a pattern, the pattern will still complete.
Manual	Edge or Level	One pattern is produced for every press of the **ManTrg** key (bit period: **Internal** or **Clk In**).

Table 3-3
Pattern mode triggering parameters (cont.)

Trigger Source	Trigger Type	Pattern Mode
Remote	Edge or Level	One pattern is produced for every remote trigger command (bit period: **Internal** or **Clk In**).
Trigger Output Event: **Per** - One trigger pulse for each pattern. Pulse duration is half the clock period. **Patt/Bur -** • **Data**: One trigger pulse at the beginning of each pattern. Pulse duration is approximately four periods long. • **PRBS**: A trigger pulse is produced at the beginning of the first pattern and every eighth pattern thereafter. Trigger pulse duration is approximately 4 periods long. PRBS Trigger Note: When the Type is PRBS, "one pattern" consists of eight cycles of the PRBS sequence. Thus, for continuous trigger source, a trigger is output for every eight cycles of the PRBS sequence.		

6. Press the key(s) located next to the output connector(s) to enable the channel(s): **CH1 Enable** and **CH2 Enable** (Model 12010-2 and 12020-2 only). A green indicator lights up to show that the channel is enabled. The enabled pulse output is triggered (output sequence started) according to the trigger configuration.
7. When finished, disable the output(s) by again pressing the **CH1 ENABLE** and **CH2 ENABLE** (Model 12010-2 and 12020-2) keys. The green indicator light(s) turns off.

External Width mode

In External Width mode, the rising and falling edges of an external trigger connected to the Ext In connector control the output.

1. Select the **ExtWidth** mode as presented in Figure 3-1.
2. Time parameters for width, frequency, period, and delay are determined by the external trigger signal and are not programmable.
3. Triggering configuration is determined by the Ext Input and is not programmable.
4. Enable pulse output by pressing the channel enable key(s) located next to the BNC output connector(s): **CH1 Enable** and **CH2 Enable** (12010-2 and 12020-2 only). A green indicator lights up to show that the channel is enabled.
5. When finished, disable the output(s) by again pressing the **CH1 ENABLE** and **CH2 ENABLE** (Model 12010-2 and 12020-2) keys. The green indicator light(s) turns off.

Saving and recalling instrument setups

The Model 12010/12020 can save up to nine setups in non-volatile memory. In general, all the parameters for a setup are saved for later recall. For example, **Mem1** may be a setup for Pulse mode, **Mem2** may be a setup for Burst mode, **Mem3** may be a setup for Pattern mode, and so on. The instrument can also be returned to the power-up default settings at any time.

Saving a setup

1. Configure the Model 12010/12020 for the desired pulse/pattern operation.
2. Press the **UTILITY** menu key.
3. Press the **InstSave** soft key.
4. Press the **Save** soft key.
5. Save the setup to memory by pressing the appropriate soft key (**Mem1** through **Mem9**).

Recalling a setup

1. Press the **UTILITY** menu key.
2. Press the **InstSave** soft key.
3. Press the **Recall** soft key.
4. Return the instrument to a saved setup by pressing the appropriate soft key (**Mem1** through **Mem9**).

NOTE *When the instrument returns to a saved or the default setup, the output(s) will disable.*

Returning to default settings

Default settings are listed in Table 2-5.

1. Press the **UTILITY** menu key.
2. Press the **InstSave** soft key.
3. Press the **Recall** soft key.
4. Return the instrument to the default settings by pressing the **Default** soft key.

Saving and recalling patterns

The Model 12010/12020 can save up to nine patterns in non-volatile memory.

Saving a pattern

1. Configure the Model 12010/12020 for the desired pattern.
2. Press the **UTILITY** menu key.
3. Press the **PattSave** soft key.
4. Press the **Channel** soft key to choose the pattern in Channel 1 or Channel 2 (Models 12010-2 and 12020-2 only).
5. Press the **Save** soft key.
6. Save the pattern to memory by pressing the appropriate soft key (**Mem1** through **Mem9**).

Recalling a pattern

1. Press the **UTILITY** menu key.
2. Press the **PattSave** soft key.
3. Press the **Channel** soft key to choose the destination for the pattern in Channel 1 or Channel 2 (Models 12010-2 and 12020-2 only).
4. Press the **Recall** soft key.
5. Recall a saved pattern by pressing the appropriate soft key (**Mem1** through **Mem9**).

Pulse/pattern parameters

In Table 3-4, each parameter is listed alphabetically by its soft key name. Details follow the table that include applicable operating modes for the parameter and the menu where the parameter soft key is located.

Table 3-4
Soft key parameters

Parameter	Menu / Path
A(s): Deterministic Jitter Amplitude, sec	*Jitter (Det)*
A(UI): Deterministic Jitter Amplitude, UI	*Jitter (Det)*
A(s): Random Jitter Amplitude, sec	*Jitter (Ran)*
A(UI): Random Jitter Amplitude, UI	*Jitter (Ran)*
A(s): Sine Jitter Amplitude, sec	*Jitter (Sin)*
A(UI): Sine Jitter Amplitude, UI	*Jitter (Sin)*
Ampl: Amplitude	*Volts*
Ampl: SSC Amplitude	*Time (SSC)*
AutoCorr: Auto Correct	*Utility (System)*
Bit #	*Pattern/Burst*
BstPer: Burst Period	*Pattern/Burst*
CH1BstCnt: Channel 1 Burst Count	*Pattern/Burst*
CH2BstCnt: Channel 2 Burst Count	*Pattern/Burst*
CH1Fmt: Channel 1 Format	*Pattern/Burst*
CH2Fmt: Channel 2 Format	*Pattern/Burst*
Channel	*Volts*
CrossPt: Cross Point	*Time*
ClkSrc: Clock Source	*Utility*
Delay	*Time*
Display	*Utility (System)*
DutyCyc: Duty Cycle	*Time*
Edit	*Pat/Burst*
Enable: Deterministic Jitter Enable	*Jitter (Det)*
Enable: Random Jitter Enable	*Jitter (Random)*
Enable: Sine Jitter Enable	*Jitter (Sine)*
Enable: SSC Enable	*Time (SSC)*
Ext: External	*Jitter*
Freq: Deterministic Jitter Frequency	*Jitter (Det)*
Menu: JITTER (Det) Freq: Frequency	*Time*
Freq: Sine Jitter Frequency	*Jitter (Sin)*
Freq: SSC Frequency	*Time (SSC)*
Func: Deterministic Jitter Function	*Jitter (Det)*
Func: Deterministic Jitter Function	*Utility (System)*
HiLvl: High Level	*Volts*
Hold: UI or Sec: UI or Sec	*Jitter*
Hold: Hold Duty Cycle or Width: Hold DutyCyc or Width	*Time*
InstSave: Instrument Save / Recall	*Utility*
IOPort: I/O Port (interface)	*Utility (System)*
Length	*Pat/Burst*
LoLvl: Low Level	*Volts*
Off: Offset	*Volts*
OutEvent: Trigger Out Event	*Trigger*
PattSave: Pattern Save / Recall	*Utility*
Per: Period	*Time*
Pol: Polarity	*Volts*

Table 3-4
Soft key parameters (cont.)

Parameter	Menu / Path
PRBSLen: Pseudo Random Bit Sequence Length	*Pat/Burst*
RefOsc: Reference Oscillator	*Utility*
Slope: ClkIn Slope	*Utility (ClkIn)*
Slope: ExtIn	*Utility (ExtIn)*
Source: Trigger Source	*Trigger*
Term: ClkIn Termination	*Utiltiy (ClkIn)*
TermV: ClkIn Termination Voltage	*Utility (ClkIn)*
TermV: ExtIn Termination Voltage	*Utility (ExtIn)*
TermV: Output Termination Voltage	*Volts*
Threshold: ExtIn	*Utility (ExtIn)*
Type: Pattern Type	*Pat/Burst*
Type: Trigger Type	*Trigger*
Width	*Time*

A(s): Deterministic Jitter Amplitude, sec

Operating Mode: All
Menu: JITTER (Det) (Func)

Deterministic jitter is phase modulation of the output signal. The magnitude of the jitter may be specified in seconds or in UI. Deterministic jitter can be enabled on one or both channels. The maximum limit depends on the choice of jitter distribution. Calculate the maximum values of A(s) from the maxima listed in **A(UI): Deterministic Jitter Amplitude, UI**.

A(UI): Deterministic Jitter Amplitude, UI

Operating Mode: All
Menu: JITTER (Det) (Func)

Deterministic jitter is phase modulation of the output signal. The magnitude of the peak-to-peak jitter may be specified in seconds or in UI. Deterministic jitter can be enabled on one or both channels. The maximum limit depends on the type of jitter distribution selected.

A(UI) setting:		
	Sine:	0 UI to 0.5 UI
	Square:	0 UI to 0.45 UI
	Triangle:	0 UI to 0.5 UI

A(s): Random Jitter Amplitude, sec

Operating Mode: All
Menu: JITTER (Ran)

Random jitter is phase modulation of the output signal using an internal broadband white-noise source. Random jitter can be enabled on one or both channels. The magnitude (rms) of the Gaussian distribution may be specified in seconds or in UI. Calculate the maximum values of A(s) from the maxima listed in **A(UI): Random Jitter Amplitude, UI**.

A(UI): Random Jitter Amplitude, UI

Operating Mode: All
Menu: JITTER (Ran)

Random jitter is phase modulation of the output signal using an internal broadband white-noise source. Random jitter can be enabled on one or both channels. The magnitude (rms) of the Gaussian distribution may be specified in seconds or in UI.

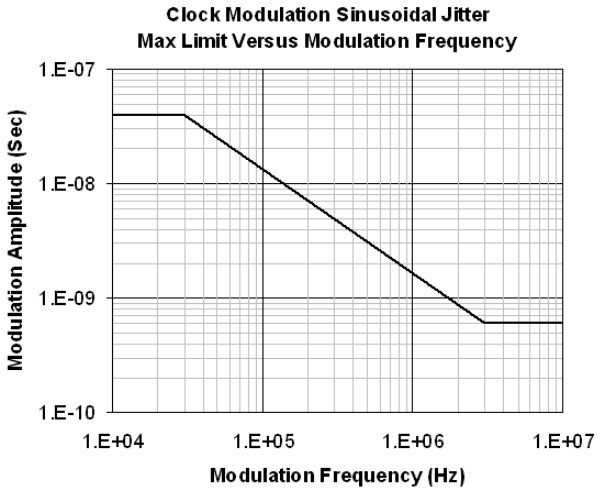
A(UI) setting: 0 UI to 0.08 UI

A(s): Sine Jitter Amplitude, sec

Operating Mode: Pulse, Pattern, or Burst
Menu: JITTER (Sin)

Sinusoidal jitter is phase modulation of the instrument clock using a sine function. Sinusoidal jitter is enabled on both channels. Sinusoidal Jitter and SSC can not be enabled simultaneously. The peak-to-peak jitter insertion amplitude may be specified in seconds or in UI. The graph in Figure 3-6 shows the limiting values for A(s) versus modulation frequency. Choose a combination of values below the limit line.

Figure 3-6
Limit of Modulation Amplitude versus Modulation Frequency



A(UI): Sine Jitter Amplitude, UI

Operating Mode: Pulse, Pattern, or Burst
Menu: JITTER (Sin)

Sinusoidal jitter is phase modulation of the instrument clock using a sine function. Sinusoidal jitter is enabled on both channels. Sinusoidal Jitter and SSC can not be enabled simultaneously. The peak-to-peak jitter insertion amplitude may be specified in seconds or in UI. Calculate the maximum values of A(s) from Figure 3-6.

Ampl: Amplitude

Operating mode: All
Menu: VOLTS, TRIGGER (TrgVolts)

The low-to-high magnitude is the peak-to-peak amplitude of the pulse and is calculated as follows:

Amplitude = (High Level) - (Low Level)

In Figure 2-8, amplitude is 50 mV: (25 mV) - (-25 mV) = 50 mV.

Changing the amplitude will also change the high and low levels. Offset is not affected. For example, if the amplitude in Figure 2-8 is changed to 500mV$_{pk-pk}$, the high level becomes 250 mV and low level becomes -250 mV.

Pulse amplitude can be independently set for each output channel and the trigger output of the Models 12010-2 and 12020-2 Pulse/Pattern Generator.

Ampl setting range: 50 mV$_{pk-pk}$ to 2.5 V$_{pk-pk}$

NOTE *Low voltage settings may be affected by the resolution specifications of the Model 12010/ 12020. For example, setting amplitude to 250 mV$_{pk-pk}$ with an offset of 0 V will display HiLvl and LoLvl levels of +120 mV and -120 mV (instead of ±125 mV). This is because the setting resolution is 10 mV.*

Ampl: SSC Amplitude

Operating Mode: Pulse, Pattern, or Burst
Menu: TIME (SSC)

Set the Amplitude (modulation depth) of the spread spectrum modulation as a percent of the clock frequency. The modulation is below the nominal clock frequency. For instance, a SSC amplitude of 1% on a 100 MHz clock will result in the clock frequency being modulated in the range of 99 MHz to 100 MHz. Range = 0% to 2%.

SSC setting range: 0% to 2%

AutoCorr: Auto Correct

Operating mode: Pulse, Burst, and Pattern
Menu: UTILITY

This function enables periodic automatic correction of pulse timing (width and delay) for temperature effects. This should normally be disabled (default) because the temperature correction may result in an interruption of the output data or pulses. Enable this only if automatic temperature correction is required and data discontinuities are acceptable. Note that temperature correction of the timing is performed every time a given timing parameter is set, regardless of the AutoCorr status.

AutoCorr settings: Enable or disable

Bit

Operating mode: Pattern
Menu: PAT/BRST

The **Bit#** soft key is used to position the cursor on a bit that is to be edited. After pressing the **Bit#** soft key, use the navigation wheel or keypad to place the cursor on the bit to be edited. The pattern can then be edited using the ***Edit*** soft key (refer to the *Pattern mode* section for more information).

BstPer: Burst Period

Operating mode: Burst
Menu: PAT/BURST

Burst period specifies the number of clock periods in the burst.

BstPer setting range: 8 to 1,048,576

CH1BstCnt: Channel 1 Burst Count
CH2BstCnt: Channel 2 Burst Count

Operating mode: Burst
Menu: PAT/BURST

Burst Count specifies the number of pulses in a burst. It must be less than or equal to the burst period.

BstCnt setting range: 2 to 1,048,576

CH1Fmt: Channel 1 Format
CH2Fmt: Channel 2 Format

Operating mode: Pattern
Menu: PAT/BRST

Bit patterns can be output in the RZ, NRZ, or R1 format. The format can be individually set for each channel. In Pattern mode for the Model 12010-2 and 12020-2, use the **Ch1Fmt** and **Ch2Fmt** soft keys to set the pattern format for each channel.

Format settings: RZ, NRZ, or R1

Channel

Operating mode: All
Menu: VOLTS, TIME, JITTER, and PAT/BRST

The Model 12010-2 and 12020-2 have two channels.

Some parameters can be independently set for each channel. The Channel soft key toggles between Channel 1 and Channel 2 for setting individual parameters.

12010-2 and 12020-2 Channel settings: 1 or 2

CrossPt: Cross Point

Operating mode: Pulse, Burst, and Pattern
Menu: TIME

The crossing point is the position of the crossing of the rising and falling transitions in an NRZ eye, in percent of the amplitude.

The crossing point may be set anytime but has effect only when the generator is set for NRZ patterns. The crossing point is calibrated for 50% duty cycle (equal number of 1s and 0s) pattern data. Over programming in the range of 20% to 80% is allowed.

CrossPt setting range: 30 to 70%

ClkSrc: Clock Source

Operating mode: Pulse, Burst, and Pattern
Menu: UTILITY

Select the generator's clock source from this menu.

Internal: Selects the internal clock source.

ClkIn: Selects the external clock source (connected at the front panel Clk In). After selecting this option, the ClkIn frequency can be measured and the generator settings updated (**MeasNow** softkey).

ClkSrc options: Internal and ClkIn

Delay

Operating mode: Pulse, Burst, and Pattern
Menu: TIME

Delay adjusts the time from the trigger output to the pulse output. Note that there is an intrinsic delay in addition to the adjustable delay. Thus, if delay is set to 0, trigger out and pulse out are not simultaneous. The delay can be independently set for each output channel of the 12010-2 and 12020-2 Pulse/Pattern Generator.

Delay setting range: 0 s to (Period setting)

Display

Operating mode: All
Menu: UTILITY (System)

The instrument has 10 display settings each for brightness and contrast for the backlight.

Bright and Contrast setting range: 1 to 10

DutyCyc: Duty Cycle

Operating mode: Pulse
Menu: TIME

The duty cycle is the ratio of the pulse width to the period. The result is expressed as a percent.

Duty Cycle can be adjusted anytime but has no effect when the generator is in NRZ format.

DutyCyc setting range: Any value that results in an allowable width setting

Edit

Operating mode: Pattern
Menu: PAT/BRST

The **Edit** soft key is used with the **Bit#** soft key to change one or more bits of a pattern:

1. Press the **Bit#** soft key, and use the navigation wheel or the keypad to place the cursor on the bit to be changed.
2. Press the **Edit** soft key, and then press the **0**, **1**, or **+/-** key to set the bit (**+/-** toggles the bit value). The cursor moves right to the next bit, which can then be edited.

NOTE *Refer to Pattern mode for details on pattern configuration.*

Enable: Deterministic Jitter Enable

Operating Mode: All
Menu: JITTER (Det)

Enable: Set the deterministic jitter to be enabled or disabled. Enable deterministic jitter only when the Trigger Source is Continuous.

Enable settings: Enable or Disable

Enable: Random Jitter Enable

Operating Mode: All
Menu: JITTER (Ran)

Enable: Set the random jitter to be enabled or disabled. Enable Random Jitter only when the Trigger Source is Continuous.

Enable settings: Enable or Disable

Enable: Sine Jitter Enable

Operating Mode: Pulse, Pattern, or Burst
Menu: JITTER (Sin)

Enable: Set the sinusoidal jitter to be enabled or disabled. Enable Sine Jitter only when the Clock Source is Internal and the Trigger Source is Continuous. Do not enable Sine Jitter and SSC simultaneously.

Enable settings: Enable or Disable

Enable: SSC Enable

Operating Mode: All
Menu: TIME (SSC)

Enable: When SSC is enabled, the internal clock is frequency modulated with a triangle function. SSC and Sinusoidal Jitter can not be enabled simultaneously. Frequency and Amplitude may be adjusted.

Enable settings: Enable or Disable

Ext: External

Operating mode: All
Menu: JITTER

External jitter is phase modulation from an external source connected at Delay In 1 or Delay In 2 on the front panel. External jitter can be enabled on one or both channels. Refer to the *Jitter insertion* section for detailed range specifications.

Channel: Select Channel 1 or Channel 2.

Enable: Set the external jitter to be enabled or disabled. Enable external jitter only when Trigger Source is Continuous.

Ext options: Enable or Disable

Freq: Deterministic Jitter Frequency

Operating Mode: Pulse, Pattern, or Burst
Menu: JITTER (Det) Freq: Frequency

Set the frequency of deterministic jitter in Hz.

Jitter Frequency ranges:	Sine:	1 Hz to 20 MHz
	Square:	1 Hz to 20 MHz
	Triangle:	1 Hz to 4 MHz

Freq: Sine Jitter Frequency

Operating Mode: Pulse, Pattern, or Burst
Menu: JITTER (Sin)

Sinusoidal jitter is phase modulation of the instrument clock using a sine function. Sinusoidal jitter is enabled on both channels. Sinusoidal Jitter and SSC can not be enabled simultaneously. The peak-to-peak jitter insertion amplitude may be specified in seconds or in UI. The graph in Figure 3-6 shows the limiting values for A(s) versus modulation frequency. Choose a combination of values below the limit line.

Freq: SSC Frequency

Operating Mode: Pulse, Pattern, or Burst
Menu: JITTER (SSC)

Set the modulation frequency of the spread spectrum modulation in Hz. Range = 1 kHz to 100 kHz.

Freq setting range: 1 kHz to 100 kHz

Func: Deterministic Jitter Function

Operating Mode: All
Menu: JITTER (Det)

Func: Set the deterministic jitter function as sine, square, or triangle.

GPIBAdd: GPIB Address

Operating mode: All
Menu: UTILITY (System)

The GPIB primary address of the Model 12010/12020 can be set from 0 to 30. At the factory, the primary address is set to 10.

GPIBAdd setting range: 0 to 30

NOTE *Changes to this setting take effect only after power is cycled.*

HiLvl: High Level

Operating mode: All
Menu: VOLTS, TRIGGER (TrgVolts)

Pulse high and low levels can be set. The pulse amplitude and offset will automatically adjust to correspond to the set high/low levels (refer to *Ampl: Amplitude* and *Off: Offset*).

High and low levels can be independently set for each output channel and the trigger output of the Model 12010-2 and 12020-2 Pulse/Pattern Generator.

High/Low Level setting range: -2 V to +3.3 V and resulting amplitude must be in allowed range.

Hold: UI or Sec

Operating mode: Pulse, Burst, and Pattern
Menu: JITTER

Sets whether the jitter amplitude is held constant in UI or Seconds during changes in clock frequency.

Hold settings: UI or Sec

Hold: Hold Duty Cycle or Width

Operating mode: All
Menu: TIME

Sets whether the pulse width is held constant in duty cycle or width during changes in frequency.

Hold settings: Width or Duty Cycle

InstSave: Instrument Save / Recall

Operating Mode: All
Menu: UTILITY

Saves or Recalls up to nine setups in non-volatile memory. In general, all the parameters for a setup are saved for later recall. The instrument can also be returned to the power-up default settings at any time.

InstSave settings: Save Mem1 through Mem9
Recall Mem1 through Mem9 and Default

IOPort: I/O Port (interface)

Operating mode: All
Menu: UTILITY (System)

Remote programming for the Model 12010/12020 can be performed using the GPIB or USB interface. At the factory, the GPIB interface is selected.

IOPort settings: GPIB or USB

NOTE *Changes to this setting take effect only after power is cycled.*

Length

Operating mode: Pattern
Menu: PAT/BRST

This parameter sets the length (number of bits) of the pattern. Both channels are set to the same length.

The pattern length setting has effect when the pattern type is Data. See PRBSLen: Pseudo Random Bit Sequence Length for length setting when the pattern type is PRBS.

Length setting range: 8 to 16,777,216 in multiples of 8

LoLvl: Low Level

Operating mode: All
Menu: VOLTS, TRIGGER (TrgVolts)

Refer also to *HiLvl: High Level*.

Off: Offset

Operating mode: All
Menu: VOLTS, TRIGGER (TrgVolts)

Offset is the mean (average) value of the high and low pulse levels and is calculated as follows:

Offset = (High Level + Low Level) / 2

Changing the offset will change the high and low levels. Amplitude is not affected. For example, assume the following levels:

High Level: 1 V
Low Level: -1 V
Amplitude: 2 V_{pk-pk} (1 V) - (-1 V) = 2 V_{pk-pk}
Offset: 0 V [(1 V) + (-1 V)] / 2 = 0 V

If offset is changed to 0.5 V, amplitude will remain at 2 V_{pk-pk}, but the high and low levels will increase by 0.5 V. The high level becomes 1.5 V (1 V + 0.5 V), and the low level becomes -0.5 V (-1 V + 0.5 V).

NOTE *Low voltage setting may be affected by the resolution specifications of the Model 12010/ 12020. For example, setting amplitude to 250 mV_{pk-pk} with an offset of 0 V will display HiLvl and LoLvl levels of +120 mV and -120 mV (instead of ±125 mV). This is because the setting resolution is 10 mV.*

OutEvent: Trigger Out Event

Operating mode: Burst and Pattern
Menu: TRIGGER

This parameter sets the trigger output correlation: Period or Pattern/Burst

Per - A trigger pulse is sent at the start of every pulse or bit.

Patt/Bur - A trigger pulse is sent at the start of every complete pattern or burst. An exception is in Pattern mode with Type = PRBS. In this case, a trigger pulse is sent at the start of every eight cycles of the PRBS pattern.

OutEvent setting range: Per or Patt/Bur

PattSave: Pattern Save / Recall

Operating Mode: Pulse, Pattern, or Burst
Menu: UTILITY

Saves or Recalls up to nine patterns in non-volatile memory.

InstSave settings:		
	Save	Mem1 through Mem9
	Recall	Mem1 through Mem9

Per: Period

Operating mode: Pulse, Burst, and Pattern
Menu: TIME

Sets the clock period. When setting the period, frequency is set according to the following calculation:

frequency = 1 / period

Refer also to *Menu: JITTER (Det) Freq: Frequency*.

Per setting range: 625 ps to 66.67 ns (Model 12020) or 1.25 ns to 66.67 ns (Model 12010)

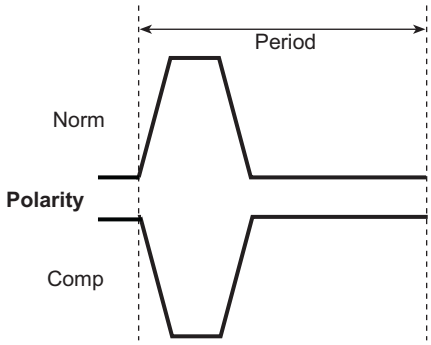
Pol: Polarity

Operating mode: All
Menu: VOLTS

Normal polarity (Norm) results in the time specified by the pulse width or a data 1 being at a high level. Complement polarity (Comp) inverts the output signal. Refer to Figure 3-7 for visual guidance.

Pol settings: Norm or Comp

Figure 3-7
Polarity



PRBSLen: Pseudo Random Bit Sequence Length

Operating mode: Pattern
Menu: PAT/BURST

The length (number of bits) for the pseudo random bit sequence (PRBS) is determined by "n" in the following equation: 2^n-1, where n can be set from 5 to 15, 23, or 31. The PRBSLen setting has effect when the pattern type is PRBS. See Length for length setting when the pattern type is Data.

PRBS n settings: n = 5 to 15, 23, or 31

RefOsc: Reference Oscillator

Operating mode: All
Menu: UTILITY

Select the generator's reference clock from this menu.

Internal: Selects the internal 10 MHz reference clock.

External: Selects the external 10 MHz reference clock source (connected at the rear panel Ref In).

RefOsc options: Internal and External

Slope: ClkIn Slope

Operating Mode: Pulse, Pattern, or Burst
Menu: UTILITY (ClkIn)

Slope: Clock input can be set to detect the positive (Pos) or negative (Neg) slope of the external clock pulses.

Slope settings: Pos or Neg

Slope: ExtIn

Operating Mode: Pulse, Pattern, or Burst
Menu: UTILITY (ExtIn)

Slope: External input can be set to select the positive (Pos) or negative (Neg) slope of the trigger.

Slope settings: Pos or Neg

Source: Trigger Source

Operating mode: Pulse, Burst, and Pattern
Menu: TRIGGER

Cont: The pulse/pattern generator is always triggered; pulses, bursts, or patterns are produced continuously.

ExtIn: Selects the ExtIn signal (from Ext In connector) as the Trigger Source.

Manual: Selects manual triggering; a trigger is generated when the **ManTrg** soft key is pressed.

Remote: Selects remote triggering; trigger events are provided by the GPIB or USB port.

Trigger source settings: Cont, ExtIn, Manual, or Remote

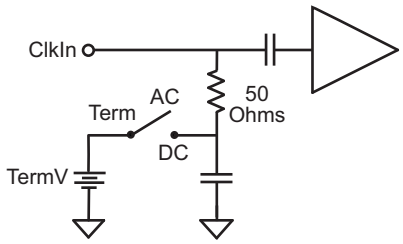
Term: ClkIn Termination

Operating Mode: Pulse, Pattern, or Burst
Menu: UTILITY (ClkIn)

Sets the coupling for the ClkIn signal. The clock input may be set to AC or DC. TermV has an effect only when DC Termination is selected. See Figure 3-8.

Term settings: AC or DC

Figure 3-8
Clock Input schematic



TermV: ClkIn Termination Voltage

Operating Mode: Pulse, Pattern, or Burst
Menu: UTILITY (ClkIn)

The external clock input can be set to correctly terminate a signal that requires a non-zero termination voltage. For example, ECL logic is often terminated through 50 ohms to -2 V. This parameter has an effect only when the termination setting is DC. See Figure 3-8.

TermV settings: -2V to +3V

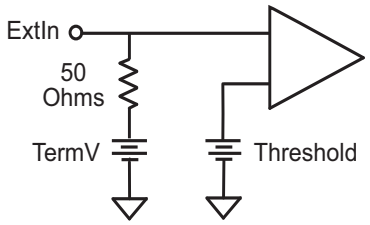
TermV: ExtIn Termination Voltage

Operating Mode: Pulse, Pattern, or Burst
Menu: UTILITY (ExtIn)

A signal at the Ext In connector is terminated through 50 ohms to a zero or non-zero termination voltage in the range from -2 V to +3 V. See Figure 3-9.

TermV settings: -2V to +3V

Figure 3-9
External Input schematic



TermV: Output Termination Voltage

Operating Mode: Pulse, Pattern, or Burst
Menu: VOLTS

The amplitude of the 12010/12020 does not change when this parameter is altered. The display changes to show the correct HiLvl, LoLvl, and Offset when the output is connected to a DUT with non-zero termination voltage.

TermV setting: -2 V to +3 V

Threshold: ExtIn

Operating Mode: Pulse, Pattern, or Burst
Menu: UTILITY (ExtIn)

This parameter sets the detection level for an external input. It sets the trigger trip voltage for a transition from low to high with positive slope selected, high to low with negative slope selected. Threshold may be in the range from -2 V to +3 V. See Figure 3-9.

Threshold setting: -2 V to +3 V

Type: Pattern Type

This page left blank intentionally.

Operating mode: Pattern
Menu: PAT/BURST

This parameter sets the pattern data: PRBS or user-programmed data.

Data – Output pattern data from the pattern memory.

PRBS – Output a PRBS pattern. Refer to the Pseudo Random Bit Sequence (PRBS) section for details.

Trigger type settings: Data or PRBS

Type: Trigger Type

Operating mode: Pulse, Burst, and Pattern
Menu: TRIGGER

This parameter sets the trigger mode: **Edge** or **Level**.

Edge – One trigger event is produced for every valid edge on the Ext In signal.

Level – When the Ext In signal is active, the generator is always triggered - pulses, patterns, or bursts are produced continuously. When the Ext In signal is inactive, triggering stops.

Trigger type settings: Edge or Level

Width

Operating mode: Pulse, Burst, and Pattern
Menu: TIME

Pulse width is the interval between leading-edge and trailing-edge medians. The median is the 50% level of the amplitude. Pulse width can be independently set for each output channel of the 12010-2 and 12020-2 Pulse/Pattern Generators.

Width has no effect in NRZ format.

Width setting range: 250 ps to 66.42 ns

Section 4

Remote Programming

In this section:

Introduction

This section provides detailed information on the remote programming of the Model 12010/12020.

Remote interfaces

The Model 12010/12020 has two remote interfaces: IEEE-488 and USB (Universal Serial Bus). You can use only one interface at a time.

NOTE *Cycle the power after selecting a different interface or making changes to the communication parameters.*

Selecting an interface

Select the interface to be used for remote operation (GPIB or USB):

1. On the front panel, press the **UTILITY** menu key and then the **System** soft key.
2. Press the **IOPort** soft key to display the present interface selection.
3. Press the **GPIB** or **USB** soft key.

IEEE-488 interface

The Model 12010/12020 can be connected to the IEEE-488 bus (also known as the GPIB or General Purpose Interface Bus) through a cable equipped with standard IEEE-488 connectors. The Model 12010/12020 conforms to the IEEE-488.2 and SCPI standards (Standard Commands for Programmable Instruments). IEEE standard 488.2 defines a syntax for sending data to and from instruments, how an instrument interprets this data, what registers should exist to record the state of the instrument, and a group of common commands. The SCPI standard defines a command language protocol; it defines a standard set of commands to control every programmable aspect of an instrument.

Connections

The Model 12010/12020 can be connected to the IEEE-488 bus through a cable equipped with standard IEEE-488 connectors. The connector can be stacked to allow a number of parallel connections to one instrument. Two screws are located on each connector to ensure that connections remain secure.

It is recommended that you stack no more than three connectors on any one unit to avoid possible mechanical damage.

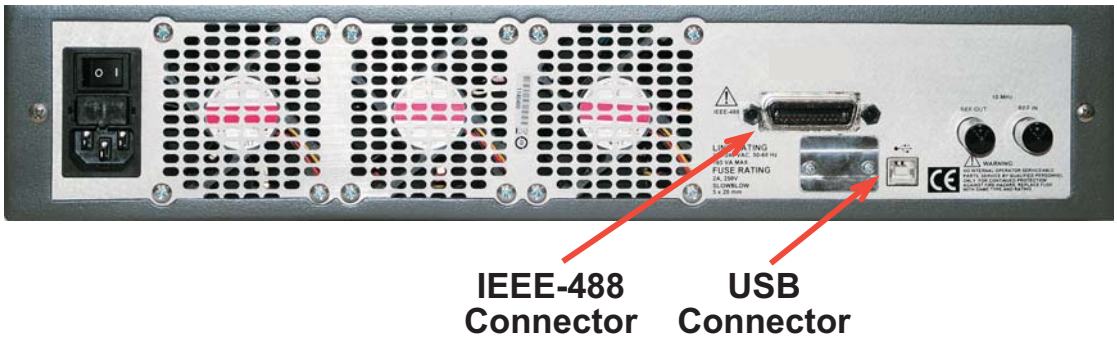
To minimize interference caused by electromagnetic radiation, use only shielded, IEEE-488 cables.

Connect the Model 12010/12020 to the IEEE-488 bus:

1. Line up the cable connector with the connector located on the rear panel. The connector is designed so that it will fit only one way. Figure 4-1 shows the location of the IEEE-488 connector on the instrument.
2. Tighten the screws securely, but do not overtighten them.
3. Add additional connectors from other instruments as required.
4. Make certain that the other end of the cable is properly connected to the controller. Most controllers are equipped with an IEEE-488-style connector, but a few may require a different type of connecting cable. Consult the instruction manual of your controller for the proper connecting method.

Note that the IEEE-488 bus is limited to a maximum of 15 devices, including the controller. The maximum cable length is 20 meters or two meters times the number of devices, whichever is less. Failure to observe these limits may result in erratic bus operation.

Figure 4-1
IEEE-488 and USB connector locations on rear panel



Address selection

The default primary address for the Model 12010/12020 is 10. The primary address may be set to any value between 0 and 30 as long as the address doesn't conflict with other instruments. Note that controllers are also given a primary address. Most frequently, controller addresses are 0 or 21, but you should consult the controller's instruction manual for details. Whatever primary address you choose, you must make certain that it corresponds with the value specified as part of the controller's programming language.

To check the present primary address or to change to a new one:

1. Press the **UTILITY** menu key on the front panel, and then press the **System** soft key.
2. Press the **GPIBAdd** soft key to display the current GPIB primary address.
3. Set the GPIB address to the desired value in the range of 0 to 30 using the navigation wheel and numeric keys.

NOTE *Reboot the instrument after selecting a different interface or making changes to the communication parameters.*

USB interface

The Models 12010 and 12020 are USB TMC-class devices. Before using the USB interface, be sure to disconnect a GPIB from the instrument, as only one interface can be used at a time.

Connections

The Model 12010/12020 includes a type B USB socket on the rear panel (refer to Figure 4-1). Typically, you will use a USB cable equipped with a type A plug on one end and a type B plug on the other end. Connect the type A plug to the type A USB socket on the host computer or USB hub. Connect the type B plug to the type B socket located on the rear panel of the Model 12010/12020.

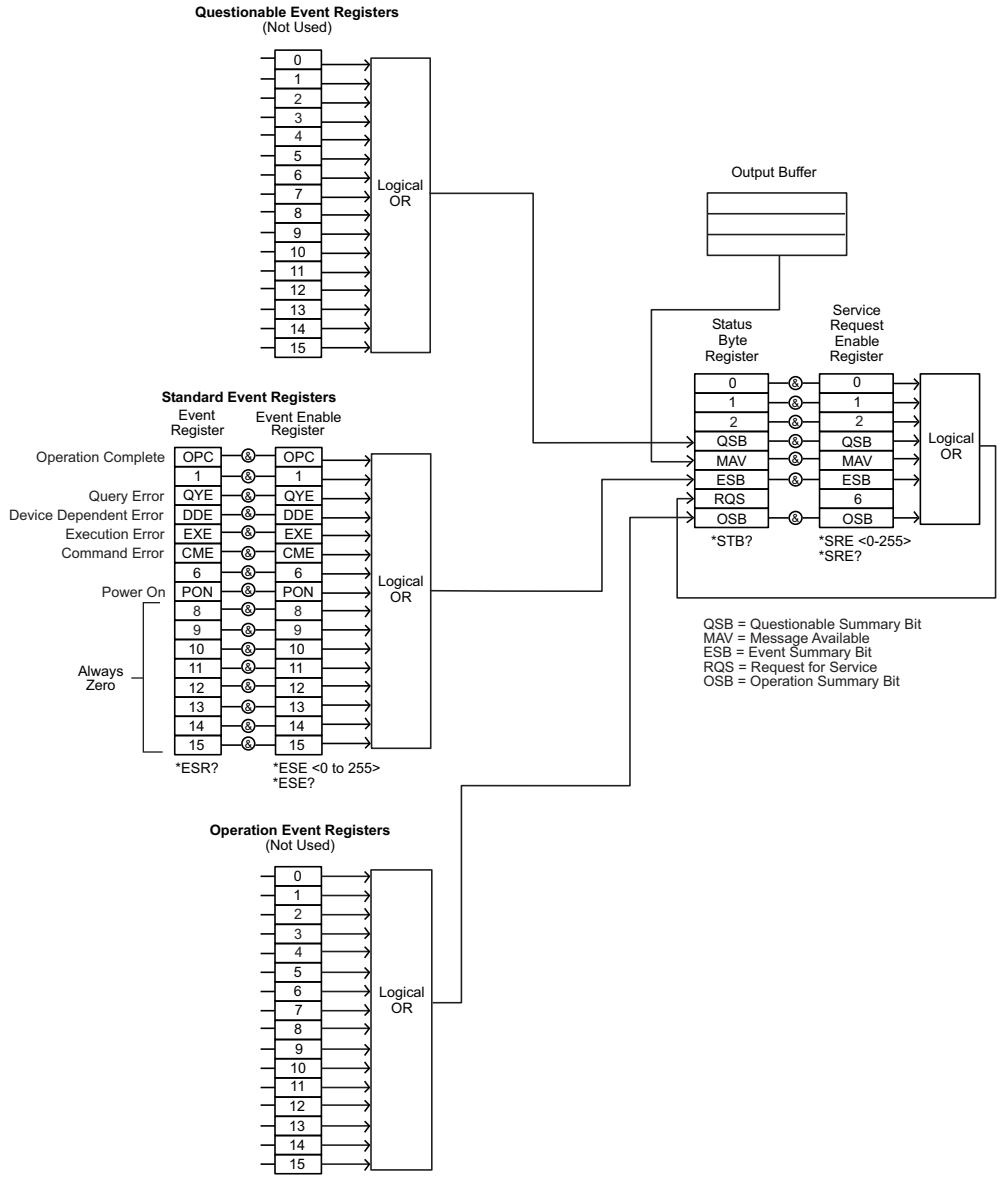
USB identifiers

Model 12010:	VID (Vendor ID) = 0x1857 PID (Product ID) = 0x2EEA
Model 12020:	VID (Vendor ID) = 0x1857 PID (Product ID) = 0x2EF4

Status model

The Model 12010/12020 has a number of status registers allowing you to monitor and manipulate the various instrument events. The status model is shown in Figure 4-2. The core of the status model is the Status Byte Register. This register can be read by your test program to determine if a service request (SRQ) has occurred and what event caused it.

Figure 4-2
Status model



Status register sets

The Operation Status Register set and Questionable Status Register set are each made up of a condition register, positive and negative transition filters, an event register, and an event enable register.

NOTE *The Operation Status group and Questionable Status group are not used by the Model 12010/12020. While these registers can still be accessed with corresponding SCPI commands for compatibility with other instruments, associated status register bits are not used and are always set to 0. Refer to "Command summary" (later in this section) for more information.*

Condition register: Contains the current status of the hardware and firmware, is continuously updated, and is not latched or buffered. Condition registers are read-only.

Event register: Latches transition events from the condition register. Event registers are cleared either by reading or with the *CLS command. Event registers are read-only, and bits are not buffered, so subsequent events are not recorded.

Enable register: Defines which bits in an event register are included in the logical OR into the summary bit. The enable register is logically ANDed with the event register and the resulting bits ORed into the summary bit. Enable registers are read-write and are not affected by *CLS or querying.

Status byte and service request (SRQ)

The Status Byte Register summarizes the information from all other status groups. The summary bit for the Status Byte Register is located in bit 6 (RQS). When RQS is set, it generates an SRQ on the IEEE-488 bus. The Status Byte Register is read using a serial poll sequence or with the *STB? query.

An SRQ is enabled by setting the associated bit in the Service Request Enable Register with the *SRE command. This register can be read using the *SRE? query.

Bits in the Status Byte Register and Service Request Enable Register are summarized in Table 4-1.

Table 4-1
Status byte register and service request enable register bits

Bit	Description
0	Not used (always 0)
1	Not used (always 0)
2	Not used (always 0)
3	Questionable Status Summary Bit (not used)
4	MAV: Message available in output buffer
5	Standard Event Status Summary bit
6	RQS: Request Service
7	Operation Status Summary Bit (not used)

Standard Event Status Register

Bits in the Standard Event Status Register are summarized in Table 4-2. Use *ESE to enable the corresponding register bit(s) and the *ESE? query to read the enable register. Use *ESR? to read the Standard Event Status Register bits.

Table 4-2
Standard event status register bits

Bit	Description
0	Operation Complete, set by *OPC
1	Not used (always 0)
2	Query Error
3	Device Dependent Error
4	Execution Error
5	Command Error
6	Not used (always 0)
7	Power On*

* Set bit indicates that a command/query has been sent or a front panel key has been pressed since the Model 12010/12020 has been turned on. Querying this bit resets it to zero, and it remains zero as long as the instrument remains on.

Operation Status group

The Operation Status group is not used by the Model 12010/12020. Bits in the associated status register are not used and are always set 0. For compatibility with other instruments, associated SCPI commands can still be used. Refer to "SCPI command reference" (later in this section) for more information.

Questionable Status group

The Questionable Status group is not used by the Model 12010/12020. Bits in the associated status register are not used and are always set 0. For compatibility with other instruments, associated SCPI commands can still be used. Refer to "SCPI command reference" (later in this section) for more information.

Service request programming example

To generate a service request when a Query Error occurs, send these commands:

```
*ESE 4
*SRE 32
```

Common commands

Command summary

IEEE-488.2 common commands supported by the Model 12010/12020 are summarized in Table 4-3. Many of these commands are associated with the status model. Refer to Status model (earlier in this section) for more information.

Table 4-3
Common commands

Command [1]	Description
*CLS	Clear status structure [2]
*ESE <0-255>	Set Standard Event Status Register mask
*ESE?	Read Standard Event Status Enable Register
*ESR?	Read Standard Event Status Event Register
*IDN?	Read Instrument's Identification string
*OPC	Set Operation Complete bit when all pending actions are completed[3]
*OPC?	Read status of the Operation Complete bit[3]
*RCL <0-9>	Recall complete instrument setting from memory
*RST	Reset instrument to standard settings
*SAV <1-9>	Save complete instrument setting to memory
*SRE <0-255>	Set Service Request Enable Mask
*SRE?	Read Service Request Enable Mask
*STB?	Read Status Byte
*TRG	Trigger instrument
*TST?	Execute instrument self-test. It will return a "0" if the Model 12010/ 12020 boots correctly.
*WAI	Wait until all pending actions are complete[3]

1. Commands with numerics enclosed in angle brackets <> indicate parameter ranges for those commands. Commands without angle brackets have no parameters.
2. Does not clear front panel errors (only remote programming errors). Error messages will continue to be displayed until you press HELP or any other key.
3. Models 12010 and 12020 use sequential commands. One command must finish before the next one starts.

Table 4-4
Command examples

Command	Description
*ESE 4	Set Standard Event Status Register mask to decimal 4
*RCL 5	Recall instrument setting # 5 from memory
*SAV 2	Save complete instrument setting to memory location #2
*SRE 8	Set Service Request Enable Mask to decimal 8

SCPI command reference

Command summary

SCPI commands are summarized by subsystem in Table 4-5.

General notes:

- Brackets ([ ]) are used to denote optional character sets. Do not use brackets in the program message.
- Angle brackets (< >) are used to indicate parameter type. Do not use angle brackets in the program message.
- Uppercase characters indicate the short-form version for each command word.
- Default - Listed parameters are the *RST defaults, unless noted otherwise.
- The command parameter to set on or off can be sent as follows:
  - ON or 1
  - OFF or 0.

  The response message for the queries will be 0 or 1.

Table 4-5
SCPI command summary

Command	Parameters	Default	Description	Page
:ARM			ARM subsystem	
[SEQuence]				
[:LAYer]				
:LEVel	<numeric>	100 mV	Set/query threshold level at EXT INPUT	4-13
:SENSe	EDGE | LEVel	EDGE	Set/query trigger type	4-13
:SLOPe	POSitive | NEGative	POS	Set/query slope at EXT INPUT	4-13
:SOURce	IMMediate| MANual| EXTernal| REMote	IMM	Set/query trigger source	4-13
:TERM	<numeric>	0 V	Set/query Ext In termination voltage	4-14
:DIGital			DIGital subsystem	
[:STIMulus]				
:PATTern				
:LENGth	<numeric>	8	Set/query pattern length	4-14
:TYPE	DATA | PRBS	DATA	Set/query pattern type	4-14
:PLENgth	<numeric>	5	Set/query PRBS length	4-15
:DIGital[1|2]			DIGital subsystem	
[:STIMulus]				
:PATTern				
:BDATa	<numeric>, <numeric>, <arbitrary block>	1000...	Set query pattern data in binary format	4-15

Table 4-5 (continued)
SCPI command summary

Command	Parameters	Default	Description	Page
:DATA	<numeric>, <numeric>, <arbitrary block>	1000...	Set/query pattern data	4-16
:HDATa	<numeric>, <numeric>, <abitrary block>	1000...	Set/query pattern data in hexadecimal character format	4-17
:SIGNal				
:CROSsover				
[:VALue]	<numeric>	50%	Set/query NRZ crossing point	4-17
:FORMat	RZ|NRZ|R1	NRZ	Set/query pattern format	4-18
:DISPlay			DISPlay subsystem	
:BRIGhtness	<numeric>	8	Set/query display brightness	4-18
:CONTrast	<numeric>	6	Set/query display contrast	4-18
:MEASure			MEASurement subsystem	
:FREQuency?	none	n/a	Query frequency applied to Clock In connector	4-19
:OUTPut[0]			OUTPut subsystem	
:SOURce	PERiodic | BITStream	PER	Set/query trigger out event	4-19
:OUTPut[1|2]				
[:STATe]	OFF | ON	OFF	Set/query channel output enable/disable status	4-19
:SENSe			SENSe subsystem	
:ROSCillator				
:SOURce	INTernal | EXTernal	INT	Set/query 10 MHz reference source	4-19
[:SOURce]			SOURce subsystem	
:FM				
[:INTernal]				
:DEViation	<numeric>	1%	Set/query SSC amplitude	4-20
:FREQuency	<numeric>	33 kHz	Set/query SSC frequency	4-20
:STATe	ON | OFF	OFF	Set/query enable/disable status of Spread Spectrum Clocking	4-20
:FREQuency				
[:CW | :FIXed]	<numeric>	15 MHz	Set/query clock frequency	4-20
:IMODe	PULSe | PATTern | BURSt | EWIDth	PULS	Set/query instrument mode	4-21
:PM				
:HOLD	UI | TIME	UI	Set/query jitter hold	4-21
:INTernal1				

Table 4-5 (continued)
SCPI command summary

Command	Parameters	Default	Description	Page
[:DEViation]	<numeric>	9.0 mUI_{pk-pk}	Set/query sinusoidal jitter amplitude	4-21
:FREQuency	<numeric>	1 MHz	Set/query sinusoidal jitter frequency	4-21
:STATe	ON | OFF	OFF	Set/query enable/disable status of sinusoidal jitter insertion	4-22
:PM [1|2]	ON | OFF	OFF		
:EXTernal				
:STATe	ON | OFF	OFF	Set/query enable/disable status of sinusoidal jitter insertion	4-22
:INTernal2				
[:DEViation]	<numeric>	50 mUI_{pk-pk}	Set/query random jitter amplitude	4-22
:STATe	ON | OFF	OFF	Set/query enable/disable status of random jitter insertion	4-22
:INTernal3				
[:DEViation]	<numeric>	100 mUI_{pk-pk}	Set/query deterministic jitter amplitude	4-23
:FREQuency	<numeric>	1 MHz	Set/query deterministic jitter frequency	4-23
:STATe	ON | OFF	OFF	Set/query enable/disable status of deterministic jitter insertion	4-23
:FUNCtion				
[:SHAPe]	SIN | SQU | TRI	SIN	Set/query deterministic jitter waveform shape	4-23
[:PULSe]				
:BPERiod	<numeric>	8	Set/query burst period	4-24
:COUNt[1|2]	<numeric>	2	Set/query burst count	4-24
:DCYCle[1|2]	<numeric>	15%	Set/query duty cycle	4-24
:DELay[1|2]	<numeric>	0 ns	Set/query delay	4-25
:HOLD	WIDTh | DCYCle	WIDT	Set/query pulse width hold	4-25
:PERiod	<numeric>	66.67 ns	Set/query pulse period	4-25
:POLarity[1|2]	NORM | COMP | INV	NORM	Set/query channel polarity	4-26
:WIDTh[1|2]	<numeric>	10 ns	Set/query pulse width	4-26
:VOLTage[0|1|2]				
[:LEVel]				
[:IMMediate]				
[:AMPLitude]	<numeric>	50 mV	Set/query trig/channel amplitude	4-26
:HIGH	<numeric>	25 mV	Set/query trig/channel high level	4-26
:LOW	<numeric>	-25 mV	Set/query trig/channel low level	4-27
:OFFSet	<numeric>	0 V	Set/query trig/channel offset	4-27
:TERMination	<numeric>	0 V	Set/query trig/channel termination	4-27
:Status				
:OPERation				
:CONDition?	none	n/a	Query operation condition register	
:ENABle	<numeric>	n/a	Set/query operation enable mask	
[:EVENT]?	none	n/a	Query operation event register	
:PRESet	none	n/a	Configure the status structure	

Table 4-5 (continued)
SCPI command summary

Command	Parameters	Default	Description	Page
:QUEStionable				
:CONDition?	none	n/a	Query questionable condition register	
:ENABle	<numeric>	n/a	Set/query questionable enable mask	
[:EVENt]?	none	n/a	Query questionable event register	
:SYSTem				
:ERRor				
[:NEXT]?	none	n/a	Query error queue	
:VERSion	none	n/a	Query SCPI revision	
:TRIGger			TRIGger subsystem	
:SLOPe	POSitive | NEGative	POS	Set/query CLK IN slope	4-28
:SOURce	IMMediate | EXTernal	IMM	Set/query clock source	4-30
:TERM	<numeric>	0V	Set/query CLK IN termination voltage	4-30
:STATe	AC | DC	AC	Set/query CLK IN termination type	4-30

Command descriptions

:ARM:LEV

:ARM[:SEQuence][:LAYer]:LEVel

Parameters Numeric

Suffix V with engineering prefixes

Default 100 mV

Query `:ARM:LEV?`

Description Use this command to program the Ext In threshold voltage.

Example `:ARM:LEV 1.5V` Set Ext In threshold voltage to 1.5 V

:ARM:SENS

:ARM[:SEQuence][:LAYer]:SENSe

Parameters EDGE | LEVel

Default EDGE

Query `:ARM:SENS?`

Description Use this command to select trigger type by choosing whether the instrument arms on the edge(s) or level of the arming signal.

Example `:ARM:SENS LEV` Set the trigger type to level

:ARM:SLOP

`:ARM[:SEQuence][:LAYer]:SLOPe`

Parameters `POSitive | NEGative`

- `POSitive`: Ext In responds to the rising edge.
- `NEGative:` Ext In responds to the falling edge.

Default `POS`

Query `:ARM:SLOP?`

Description Use this command to select the trigger slope for the arming signal when triggering on edges. If you are arming on levels, use this command to select whether the instrument triggers during the positive or negative cycle of the arming signal.

Example `:ARM:SLOP NEG` Signal is generated on the falling edge

:ARM:SOUR

`:ARM[:SEQuence][:LAYer]:SOURce`

Parameters `IMMediate | MANual | EXTernal | REMote`

The instrument provides the following trigger sources:

- IMMediate: The generated signal is always triggered; pulses, bursts, or patterns are produced continuously.
- MANual: Manual triggering. Press the ManTrg soft key to generate one trigger event.
- REMote: Remote triggering. Trigger events are provided by the GPIB or USB port.

- EXTernal: External triggering. Trigger events are provided by the signal applied to the Ext In port. Threshold, termination voltage, and Edge polarity of the Ext In port are adjustable.

Range coupling: Enable/Disable for:

- SSC
- Sinusoidal jitter
- Delay In
- Random jitter
- Deterministic jitter

These parameters may be enabled only if the Trigger source is set to IMMediate.

Default IMM

Query `:ARM:SOUR?`

Description Use this command to select the triggering source of the instrument.

Example `:ARM:SOUR MAN` Select manual arm source

:ARM:TERM

:ARM[:SEQuence][:LAYer]:TERM

Parameters Numeric

Suffix V with engineering prefixes

Default 0 mV

Query `:ARM:TERM?`

Description Use this command to program the Ext In termination voltage.

Example `:ARM:TERM -1.2V` Set Ext In termination voltage to -1.2 V

:DIG:PATT:LENG

`:DIGital[:STIMulus]:PATTern:LENGth`

Parameters Numeric

Default 8

Query `:DIG:PATT:LENG?`

Description Use this command to program the pattern length. This value is relevant with a DATA pattern type. The parameter is common to both channels and must be a multiple of eight. The instrument will automatically round the numeral to the nearest multiple of eight if entered incorrectly.

Example `:DIG:PATT:LENG 56` Set the pattern length to 56

:DIG:PATT:TYPE

`:DIGital[:STIMulus]:PATTern:TYPE`

Parameters `DATA | PRBS`

Default DATA

Query `:DIG:PATT:TYPE?`

Description Use this command to program the pattern type. The parameter is common to both channels.

Example `:DIG:PATT:TYPE PRBS` Set the pattern type to PRBS

:DIG:PATT:PLENgth

`:DIGital[:STIMulus]:PATTern:PLENgth`

Parameters Numeric

Limits 5 to 15, 23 or 31

Default 5

Query `:DIG:PATT:PLEN?`

Description Use this command to program the pattern PRBS length. This value is only relevant when the pattern type is PRBS. The parameter is common to both channels and is specified as 2^n-1, where n is the specified value.

Example `:DIG:PATT:PLEN 7` Set the pattern length to 2^7-1

:DIG:PATT:BDATa

:DIGital[1|2][:STIMulus]:PATTern:BDATa

Parameters <start address>, <bit count>, <data>

- Start address: The numeric bit number in pattern data memory of the first bit to write. The remainder follows consecutively.
- Bit count: The number of bits to write into pattern data memory.
- Data: An arbitrary block of program data as defined in IEEE Standard 488.2-1992, section 7.7.6.2. This data begins with a number symbol (#) and is followed by a single digit that represents the number of characters in the length, then one to five characters specifying the length as a decimal number, then lastly, the program data.

Default The first bit is 1, all other bits are 0

Query `:DIG[1|2]:PATT:BDAT?`

Description Use this command to program the pattern data memory using binary data format. Each byte of pattern data is a binary number representing 8 bits of pattern data. The value (<start address> + <bit count>) must be less than or equal to 16,777,217. The bit count can be any number, 1 to 131,072. The entire pattern data memory is accessible for reading or writing, even that outside the range of the current pattern length setting.

The bit count parameter must be equal to eight times the length of the data block or up to seven bits fewer. If it is fewer, then the extra bits in the last data byte are ignored by the instrument [(<start address> + <bit count>) must be less than or equal to 16,777,216].

Examples `:DIG1:PATT:BDAT 1,16#12AR`

This command:
Starts loading the data bit into location 1.
Specifies that 16 bits of data will be loaded.
#12AR

#	Start of the block
1	Number of characters in the length
2	Length of the data
AR	2 bytes of data

This example includes bytes that have an ASCII printable representation, but any byte value may be used. A is the hex byte 0x41 and R is the hex byte 0x52. Thus bits 1 through 16 in the Channel 1 pattern data memory will be set to 0100000101010010.

```
:DIG1:PATT:BDAT? 1,8
```

This query:
Reads 8 bits of Channel 1 pattern data starting from location 1.
Following the above example, the response would be #11A.

NOTE *If the query requests a number of bits that is not a multiple of eight, the remaining bits in the last byte will be zero and valueless.*

:DIG:PATT:DATA

:DIGital[1|2][:STIMulus]:PATTern:DATA

Parameters <start address>, <bit count>, <data>

- Start address: The numeric bit number in pattern data memory of the first bit to write. The remainder follows consecutively.
- Bit count: The number of bits to write into pattern data memory.
- Data: An arbitrary block of program data as defined in IEEE Standard 488.2-1992, section 7.7.6.2. This data begins with a number symbol (#) and is followed by a single digit that represents the number of characters in the length, then one to five characters specifying the length as a decimal number, then lastly, the program data.

Default The first bit is 1, all other bits are 0

Query `:DIG[1|2]:PATT:DATA?`

Description Use this command to program the pattern data memory. Each byte of pattern data is a character (0 or 1) representing one bit of pattern data. The value (<start address> + <bit count>) must be less than or equal to 16,777,217. The bit count can be any number, 1 to 16,384. The entire pattern data memory is accessible for reading or writing, even that outside the range of the current pattern length setting.

The bit count parameter and the length of the data block must match [(<start address> + <bit count>) must be equal to 16,777,217].

Examples

```
:DIG1:PATT:DATA 1,16#2160100000101010010
```

This command:
Starts loading the data bit into location 1.
Specifies that 16 bits of data will be loaded.
#2160100000101010010

#	Start of the block
2	Number of characters in the length
16	Length of the data
0100000101010010	16 bytes of data

Bits 1 through 16 in the Channel 1 pattern data memory will be set to 0100000101010010.

```
:DIG1:PATT:DATA? 1,8
```

This query:
Reads 8 bits of Channel 1 pattern data starting from location 1.
Following the above example, the response would be #1801000001.

:DIG:PATT:HDAT

:DIGital[1|2][:STIMulus]:PATTern:HDATa

Parameters <start address>, <bit count>, <data>

- Start address: The numeric bit number in pattern data memory of the first bit to write. The remainder follows consecutively.
- Bit count: The number of bits to write into pattern data memory.
- Data: An arbitrary block of program data as defined in IEEE Standard 488.2-1992, section 7.7.6.2. This data begins with a number symbol (#) and is followed by a single digit that represents the number of characters in the length, then one to five characters specifying the length as a decimal number, then lastly, the program data.

Default The first bit is 1, all other bits are 0

Query `:DIG[1|2]:PATT:HDAT?`

Description Use this command to program the pattern data memory using hexadecimal format. Each byte of pattern data is a hexadecimal character (0 to 9, A to F, or a to f) representing four bits of pattern data. The value (<start address> + <bit count>) must be less than or equal to 16,777,217. The bit count can be any number, 1 to 65,536. The entire pattern data memory is accessible for reading or writing, even that outside the range of the current pattern length setting.

The bit count parameter must be equal to four times the length of the data block or up to three bits fewer. If it is fewer, then the extra bits in the last data byte are ignored by the instrument [(<start address> + <bit count>) must be less than or equal to 16,777,217].

Examples `:DIG1:PATT:HDAT 1,16#144152`

This command:
Starts loading the data bit into location 1.
Specifies that 16 bits of data will be loaded.
#144152

#	Start of the block
1	Number of characters in the length
4	Length of the data
4152	4 bytes of data

Bits 1 through 16 in the Channel 1 pattern data memory will be set to 0100000101010010.

`:DIG1:PATT:HDAT? 1,8`

This query:
Reads 8 bits of Channel 1 pattern data starting from location 1.
Following the above example, the response would be #1241.

NOTE *If the query requests a number of bits that is not a multiple of four, the remaining bits in the last byte will be zero and valueless.*

:DIG:SIGN:CROS

`:DIGital[1|2][:STIMulus]:SIGNal:CROSover:[VALue]`

Parameters Numeric (value is%)

Default 50%

Query `:DIG[1|2]:SIGN:CROS?`

Description Use this command to adjust each channel's signal crossover point in PRBS or data mode (NRZ format only). The crossing point is accurate for 50% only. While the range of values is from 30% to 70%, over programming in the range 20% to 80% is allowed.

Example `:DIG1:SIGN:CROS 60` Set Channel 1 variable crossing point to 60%.

:DIG:SIGN:FORM

`:DIGital[1|2][:STIMulus]:SIGNal:FORMat`

Parameters RZ | NRZ | R1
Range Coupling: Period, Frequency

Default NRZ

Query `:DIG[1|2]:SIGN:FORM?`

Description Use this command to program the signal format for data and PBRS signals of Channels 1 and 2 when using Pattern mode. If you don't specify a channel number in the command, Channel 1 is assumed.

RZ: Return-to-zero.

For a "0" bit, the signal stays low. For a "1" bit, the signal pulses from the low level to the high level and back to low. Pulse width can be specified by the pulse width or duty cycle parameters.

NRZ: Non-return-to-zero.

For a "0" bit, the signal stays low for the entire bit period. For a "1" bit, the signal stays high for the entire bit period. Pulse width is not meaningful in this format. Crossing point may be adjusted in this format.

R1: Return-to-one.

For a "1" bit, the signal stays high. For a "0" bit, the signal pulses from the high level to the low level and back to high. Pulse width can be specified by the pulse width or duty cycle parameters.

Example `:DIG2:SIGN:FORM RZ` Set Channel 2 data format to RZ

DISP:BRIG

`:DISPlay:BRIGhtness`

Parameters Numeric

Limits 1 to 10

Default 8

Query `:DISP:BRIG?`

Description Use this command to set the LCD display screen brightness.

Example `:DISP:BRIG 7` Set brightness to 7

:DISP:CONT

`:DISPlay:CONTrast`

Parameters Numeric

Limits 1 to 10

Default 6

Query `:DISP:CONT?`

Description Use this command to set the LCD display screen contrast.

Example `:DISP:CONT 7` Set contrast to 7

:MEAS:FREQ?

`:MEASure:FREQuency?`

Parameters None

Default N/A

Query `:MEAS:FREQ?`

Description Use this to query the frequency at the Clk In connector. Execution of this command will also cause the generator to update the frequency parameter and any coupled parameters.

If the signal at the Clk In connector is out of range, the returned value will be zero, and the frequency parameter will not be updated.

Example `:MEAS:FREQ?` Measure the frequency at the Clk In connector

:OUTP:SOUR

`:OUTPut[0]:SOURce`

Parameters PERiodic | BITStream

Default PERiodic

Query `:OUTP:SOUR?`

Description Use this command to program the trigger out event.

- PERiodic: A trigger pulse will be output for each pulse or data/burst clock period.
- BITStream: A trigger pulse will be output for each complete pattern or burst. For PRBS patterns, a trigger is output for every eighth cycle of the PRBS.

Example `:OUTP0:SOUR BITS` Set the trigger out event to bitstream

:OUTP

`:OUTPut[1|2][:STATe]`

Parameters ON | OFF

Default OFF

Query `:OUTP[1|2]?`

Description Use this command to program the enable/disable status of the Channel 1 and 2 outputs.

Example `:OUTP1 ON` Enable Channel 1 output

SENSe subsystem

:SENS:ROSC:SOUR

`:SENSe:ROSCillator:SOURce`

Parameters INTernal | EXTernal

Default INT

Query :SENS:ROSC:SOUR?

Description Use this command to program the 10 MHz reference source.

Example :SENS:ROSC:SOUR INT Set the 10 MHz source to use the internal reference

:FM:DEV

[:SOURce]:FM[:INTernal]:DEViation

Parameters Numeric (value is percent)

Default 1%

Query :FM:DEV?

Description Use this command to select the Spread Spectrum Clocking (SSC) amplitude.

Example :FM:DEV 1.5 Set SSC amplitude to 1.5%

:FM:FREQ

[:SOURce]:FM[:INTernal]:FREQuency

Parameters Numeric

Suffix Hz with engineering prefixes

Default 33 kHz

Query :FM:FREQ?

Description Use this command to select the SSC frequency.

Example :FM:FREQ 40kHz Set SSC frequency to 40 kHz

:FM:STAT

[:SOURce]:FM:STATe

Parameters ON | OFF

Default OFF

Query :FM:STAT?

Description Use this command to select the SSC enable/disable state. The SSC can be enabled only if the trigger source is IMMediate and the clock source is INTernal. In addition, sine jitter must be disabled.

Example :FM:STAT OFF Disable SSC

:FREQ

[:SOURce]:FREQuency[:CW|:FIXed]

Parameters Numeric
Range coupling: Width, duty cycle, delay
Value coupling: Period, width, duty cycle

Suffix Hz with engineering prefixes

Default 15 MHz

Query :FREQ?

Description Use this command to program the internal clock frequency. This command also selects the internal clock as the time base if it is not already selected.

A query returns the last known clock frequency. If the clock source is INTernal, it will be up to date. If the clock source is Clock In, the last measured frequency of Clock In is returned. Or, if no measurement has been made, the last internal setting will be returned.

Example `:FREQ 1.2GHz` Set clock frequency to 1.2 GHz

:IMODe

`[:SOURce]:IMODe`

Parameters PULSe | PATTern | BURSt | EWIDth

Default PULS

Query `:IMOD?`

Description Use this command to program the high-level instrument operating mode. Other parameters will be relevant based on the selected mode. EWIDth means External WIDth.

Example `:IMOD PATT` Set instrument to pattern mode

:PM:HOLD

`[:SOURce]:PM:HOLD`

Parameters UI | TIME

Default UI

Query `:PM:HOLD?`

Description Use this command to program the jitter hold setting. This setting applies to all jitter amplitude parameters for both channels.

In UI hold, if the frequency is changed, the jitter amplitudes are held to a constant UI value. In TIME hold, if the frequency is changed, the jitter amplitudes are held to a constant time value.

Example `:PM:HOLD UI` Set jitter hold to UI

:PM:INT1

[:SOURce]:PM:INTernal1[:DEViation]

Parameters Numeric [S | UI]
Range coupling: Frequency, Period, and Sine jitter frequency

Default 9.0 mUI_{pk-pk}

Query `:PM:INT1? Query responses are always in S units.`

Description Use this command to program the sinusoidal jitter amplitude. The value is peak-to-peak. Sinusoidal jitter applies equally to both channels.

Example `:PM:INT1 0.3ns` Set the amplitude of sinusoidal jitter to 0.3 ns

:PM:INT1:FREQ

[:SOURce]:PM:INTernal1:FREQuency

Parameters Numeric
Range coupling: Frequency, Period, and Sine jitter amplitude

Suffix Hz with engineering prefixes

Default 1 MHz

Query `:PM:INT1:FREQ?`

Description Use this command to program the sinusoidal jitter frequency. Sinusoidal jitter applies equally to both channels.

Example `:PM:INT1:FREQ 1.3MHz` Set the frequency of sinusoidal jitter to 1.3 MHz

:PM:INT1:STATe

[:SOURce]:PM:INTernal1:STATe

Parameters ON | OFF
Range coupling: Frequency, Period, Sine jitter amplitude, and Sine jitter frequency

Default OFF

Query `:PM:INT1:STAT?`

Description Use this command to select the sinusoidal jitter enable/disable state. Sinusoidal jitter applies equally to both channels. Sinusoidal jitter can be enabled only if the trigger source is IMMediate and the clock source is INTernal. In addition, SSC must be disabled.

Example `:PM:INT1:STAT ON` Enable sinusoidal jitter

:PM:EXT:STATe

[:SOURce]:PM[1|2]:EXTernal:STATe

Parameters ON | OFF

Default OFF

Query `:PM[1|2]:EXT:STAT?`

Description Use this command to select the Delay In enable/disable state for Channel 1 and 2. Delay In can be enabled only if the trigger source is IMMediate.

Example `:PM2:EXT:STAT ON` Enable Channel 2 Delay In

:PM:INT2

[:SOURce]:PM[1|2]:INTernal2[:DEViation]

Parameters Numeric [S | Ul]
Range coupling: Frequency

Default 50 mUlrms

Query `:PM[1|2]:INT2? Query responses are always in UI units`

Description Use this command to program the random jitter amplitude. The value is root mean square.

Example `:PM1:INT2 25mUI` Set Channel 1 random jitter amplitude to 25 mUIrms

:PM:INT2:STATe

[:SOURce]:PM[1|2]:INTernal2:STATe

Parameters ON | OFF

Default OFF

Query `:PM[1|2]:INT2:STAT?`

Description Use this command to select the random jitter enable/disable state for Channel 1 and 2. Random jitter can be enabled only if the trigger source is IMMediate.

Example `:PM1:INT2:STAT ON` Enable Channel 1 random jitter

:PM:INT3

[:SOURce]:PM[1|2]:INTernal3[:DEViation]

Parameters Numeric [S | UI]
Range coupling: Frequency and Period

Default 100 mUI_{pk-pk}

Query `:PM[1|2]:INT3? Query responses are always in UI units`

Description Use this command to program the deterministic jitter amplitude. The value is peak-to-peak.

Example `:PM2:INT3?:` Query Channel 2 deterministic jitter amplitude

:PM:INT3:FREQ

[:SOURce]:PM[1|2]:INTernal3:FREQuency

Parameters Numeric
Range coupling: Deterministic jitter function

Suffix Hz with engineering prefixes

Default 1 MHz

Query `:PM[1|2]:INT3:FREQ?`

Description Use this command to program the deterministic jitter frequency. The maximum allowed frequency is dependent on the deterministic jitter function. See :PM:INT3:FUNC.

Example `:PM2:INT3:FREQ 2MHz` Set the Channel 2 frequency of deterministic jitter to 2 MHz

:PM:INT3:STATe

[:SOURce]:PM[1|2]:INTernal3:STATe

Parameters ON | OFF

Default OFF

Query `:PM[1|2]:INT3:STAT?`

Description Use this command to select the deterministic jitter enable/disable state for Channel 1 and 2. Deterministic jitter can be enabled only if the trigger source is IMMediate.

Example `:PM2:INT3:STAT ON` Enable Channel 2 deterministic jitter

:PM:INT3:FUNC

[:SOURce]:PM[1|2]:INTernal3:FUNCtion[:SHAPe]

Parameters SIN | SQU | TRI
Range coupling: Deterministic jitter frequency

Default SIN

Query `:PM[1|2]:INT3:FUNC?`

Description Use this command to select the function shape of deterministic jitter for Channel 1 and 2. There is an interaction between function shape and maximum deterministic jitter frequency:

- sine and square: 20 MHz
- triangle: 4 MHz

Example `:PM1:INT3:FUNC SQU` Set Channel 1 deterministic jitter shape to square

:BPER

[:SOURce][:PULSe]:BPERiod

Parameters Numeric
Range coupling: Burst count

Default 8

Query `:BPER?`

Description Use this command to program the burst period (set the number of clock cycles in a burst). Burst period is common to both channels and is relevant only in burst mode.

A burst consists of a number of clock cycles as set by the *Burst Period*. The first *Burst Count* of these cycles will output a pulse, the remainder do not. The burst period must be entered as a multiple of eight and must be greater than or equal to the burst count value.

NOTE *If the number entered is not a multiple of eight, the instrument will automatically round the number to the nearest multiple of eight.*

Example `:BPER 32` Set the burst period to 32

:COUN

[:SOURce][:PULSe]:COUNt[1|2]

Parameters Numeric
Range coupling: Burst period

Default 2

Query `:COUN[1|2]?`

Description Use this command to program the burst count (set the number of pulses in a burst) for Channel 1 or 2. Burst count is relevant only in burst mode.

A burst consists of a number of clock cycles as set by the *Burst Period*. The first *Burst Count* of these cycles will output a pulse, the remainder do not. The burst period must be a minimum of 2 and cannot be greater than the burst period value.

Example `:COUN2 5` Set the Channel 2 burst count to 5

:DCYC

[:SOURce][:PULSe]:DCYCle[1|2]

Parameters Numeric (value is in percent)
Range coupling: Frequency and period
Value coupling: Width

Default 15%

Query `:DCYC[1|2]?`

Description Use this command to program the duty cycle for Channel 1 or 2. Duty cycle is not relevant when in NRZ format or Ext Width mode.

Example `:DCYC1 41` Set the Channel 1 duty cycle to 41%

:DEL

[:SOURce][:PULSe]:DELay[1|2]

Parameters Numeric (value is in s)
Range coupling: Frequency and period

Suffix s with engineering prefixes

Default 0 s

Query `:DEL[1|2]?`

Description Use this command to program the delay for Channel 1 or 2.

Example `:DEL1 11ns` Set the Channel 1 delay to 11 ns

:HOLD

[:SOURce][:PULSe]:HOLD[1|2]

Parameters WIDTh | DCYCle

Default WIDTh

Query `:HOLD?`

Description Use this command to program the pulse width hold setting for Channel 1 or Channel 2. When set to WIDTh, if the frequency is changed, the pulse width is held to a constant value. When set to DCYCle, if the frequency is changed, the duty cycle is held to a constant value.

Example `:HOLD2 DCYCle` Set Channel 2 pulse width hold to constant duty cycle

:PER

[:SOURce][:PULSe]:PERiod

Parameters Numeric (value is in s)
Range coupling: Width, duty cycle, and delay
Value coupling: Frequency, period, width, and duty cycle

Suffix s with engineering prefixes

Default 66.67 ns

Query `:PER?`

Description Use this command to select the internal clock as the time base and program the internal clock period.

A query returns the internal clock frequency. If the clock source is Clk In, the last measured period of Clock In is returned.

Example `:PER 10ns` Set internal clock period to 10 ns

:POL

[:SOURce][:PULSe]:POLarity[1|2]

Parameters NORMal | COMPlement | INVerted

Default NORM

Query `:POL[1|2]?`

Description Use this command to program the polarity for Channel 1 and 2. COMP and INV are the same setting.

Example `:POL1 NORM` Set Channel 1 polarity to normal

:WIDT

[:SOURce][:PULSe]:WIDTh[1|2]

Parameters Numeric (value is in s)
Range coupling: Frequency and period
Value coupling: Duty cycle

Suffix s with engineering prefixes

Default 10 ns

Query `:WIDT[1|2]?`

Description Use this command to program the pulse width for Channel 1 and 2.

Example `:WIDT2 5.2ns` Set Channel 2 pulse width to 5.2 ns

:VOLT

`[:SOURce]:VOLTage[0|1|2][:LEVel][:IMMediate][:AMPLitude]`

Parameters Numeric
Value coupling: High level = offset + amplitude/2
Low level = offset – amplitude/2
Range coupling: Offset, high level, and low level

Suffix V with engineering prefixes

Default 50 mV

Query `:VOLT[1|2]?`

Description This command programs the amplitude of the signal for the trigger output and channels 1 and 2. For this command, the trigger output is treated as channel 0.

Example `:VOLT1 2V` Set Channel 1 amplitude to 2 V

:VOLT:HIGH

`[:SOURce]:VOLTage[0|1|2][:LEVel][:IMMediate]:HIGH`

Parameters Numeric
Value coupling: Amplitude = high level - low level
Offset = (high level + low level)/2
Range coupling: Low level, amplitude, and Offset

Suffix V with engineering prefixes

Default 25 mV

Query `:VOLT[1|2]:HIGH?`

Description This command programs the high level of the signal for the trigger output and channels 1 and 2. For this command, the trigger output is treated as channel 0.

Example `:VOLT1:HIGH 2V` Set Channel 1 high level voltage to 2 V

:VOLT:LOW

`[:SOURce]:VOLTage[0|1|2][:LEVel][:IMMediate]:LOW`

Parameters Numeric
Value coupling: Amplitude = high level - low level
Offset = (high level + low level)/2
Range coupling: High level, amplitude, and Offset

Suffix V with engineering prefixes

Default -25 mV

Query `:VOLT[1|2]:LOW?`

Description This command programs the low level of the signal for the trigger output and channels 1 and 2. For this command, the trigger output is treated as channel 0.

Example `:VOLT1:LOW 2V` Set Channel 1 low level voltage to 2 V

:VOLT:OFFS

`[:SOURce]:VOLTage[0|1|2][:LEVel][:IMMediate]:OFFSet`

Parameters Numeric
Value coupling: High level = offset + (amplitude/2)
Low level = offset - (amplitude/2)
Range coupling: Amplitude, high level, and low level

Suffix V with engineering prefixes

Default 0 mV

Query `:VOLT[1|2]:OFFS?`

Description This command programs the offset of the signal for the trigger output and channels 1 and 2. For this command, the trigger output is treated as channel 0.

Example `:VOLT1:OFFS -0.5 V` Set Channel 1 offset voltage to -0.5 V

:VOLT:TERM

`[:SOURce]:VOLTage[0|1|2][:LEVel][:IMMediate]:TERMination`

Parameters Numeric
Range coupling: High level, low level, amplitude, and offset
Value coupling: High level, low level, and offset

Suffix V with engineering prefixes

Default 0 V

Query `:VOLT[1|2]:TERM?`

Description This command programs the user-supplied termination voltage. This setting results in the high level, low level, and offset values being updated to reflect the correct levels at the load given its termination voltage.

Example `:VOLT2:TERM -1.0V` Set Channel 2 termination voltage to -1.0 V

:STAT:OPER:COND?

:STATus:OPERation:CONDition?

Parameters None

Default N/A

Query :STAT:OPER:COND?

Description Queries the operation condition register. This register is not used; the query always returns 0.

Example :STAT:OPER:COND? Query the operation condition register

:STAT:OPER:ENAB

:STATus:OPERation:ENABle

Parameters None

Default N/A

Query :STAT:OPER:ENAB?

Description Programs operation enable mask. This register is not used; the command form does nothing; the query always returns 0.

Example :STAT:OPER:ENAB? Query the operation enable mask

:STAT:OPER[:ENEV]?

:STATus:OPERation[:EVENt]?

Parameters None

Default N/A

Query :STAT:OPER[:ENEV]?

Description Queries the operation event register. This register is not used; the query always returns 0.

Example :STAT:OPER? Query the operation event register

:STAT:PRES

:STATus:PRESet

Parameters None

Default N/A

Query :STAT:PRES?

Description Presets the status structure. The registers this command impacts are not used; this command has no effect.

Example :STAT:PRES Preset the status structure

:STAT:QUES:COND?

:STATus:QUEStionable:CONDition?

Parameters None

Default N/A

Query :STAT:QUES:COND?

Description Queries the questionable condition register. This register is not used; the query always returns 0.

Example `:STAT:QUES:COND?` Query the questionable condition register

:STAT:QUES:ENAB

`:STATus:QUEStionable:ENABle`

Parameters None

Default N/A

Query `:STAT:QUES:ENAB?`

Description Programs questionable enable mask. This register is not used; the command form does nothing; the query always returns 0.

Example `:STAT:QUES:ENAB?` Query the questionable enable mask

:STAT:QUES[:EVEN]?

`:STATus:QUEStionable[:EVENt]?`

Parameters None

Default N/A

Query `:STAT:QUES[:EVEN]?`

Description Queries the questionable event register. This register is not used; the query always returns 0.

Example `:STAT:QUES?` Query the questionable event register

:SYST:ERR[:NEXT]?

`:SYSTem:ERRor[:NEXT]?`

Parameters None

Default N/A

Query `:SYST:ERR[:NEXT]?`

Description Queries the system error queue. Returns an integer representing the error number and a string in double quotes containing the error description. The integer and string are separated by a comma. The error queue may have multiple items that can be retrieved using multiple queries. If the queue is empty, the response will be: +0,"No error".

Example `:SYST:ERR?` Query the error queue

:SYST:VERS?

`:SYSTem:VERSion?`

Parameters None

Default N/A

Query `:SYST:VERS?`

Description Queries the SCPI version to which this instrument complies.

Example `:SYST:VERS?` Query the SCPI version

:TRIG:SLOP

:TRIGger:SLOPe

Parameters POSitive | NEGative

Default POS

Query :TRIG:SLOP?

Description This command programs the Clk In slope and commands whether the signal is generated at the rising (POSitive) or falling (NEGative) edge of the external clock input.

Example :TRIG:SLOP NEG Set the slope of the clock input to NEGative

:TRIG:SOUR

:TRIGger:SOURce

Parameters IMMediate | EXTernal

Default IMM

Query :TRIG:SOUR?

Description This command programs the clock source.
IMM: The internal oscillator is the clock source.
EXT: The clock source is provided by the signal at the Clk In connector. The frequency at the Clk In connector can be measured using the command: MEAS:FREQ?

Example :TRIG:SOUR IMM Select the clock source to the internal oscillator

:TRIG:TERM

:TRIGger:TERM

Parameters Numeric [mV | V]

Default 0 V

Query :TRIG:TERM?

Description This command programs the termination voltage for the external Clock In. This voltage is applied only if DC-coupled termination is enabled.

Example :TRIG:TERM 1V Sets the termination voltage of the signal applied to the external clock input to 1 V

:TRIG:TERM:STAT

:TRIGger:TERM:STATe

Parameters AC | DC

Default AC

Query :TRIG:TERM:STAT?

Description This command programs the termination type as AC or DC for the external Clock In.

Example :TRIG:TERM:STAT DC Set the coupling of the external clock input connector to DC

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