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Series 3400 Pulse Pattern Generators

User's Manual

3400S-900-01 Rev. B / January 2007

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WARRANTY

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

Keithley Instruments, Inc. warrants the following items for 90 days from the date of shipment: probes, cables, rechargeable batteries, diskettes, and documentation.

During the warranty period, we will, at our option, either repair or replace any product that proves to be defective.

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

LIMITATION OF WARRANTY

This warranty does not apply to defects resulting from product modification without Keithley Instruments' 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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Pulse/Pattern Generators
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Manual Print History

The print history shown below lists the printing dates of all Revisions and Addenda created for this manual. The Revision Level letter increases alphabetically as the manual undergoes subsequent updates. Addenda, which are released between Revisions, contain important change information that the user should incorporate immediately into the manual. Addenda are numbered sequentially. When a new Revision is created, all Addenda associated with the previous Revision of the manual are incorporated into the new Revision of the manual. Each new Revision includes a revised copy of this print history page.

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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.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

The  symbol 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 Keithley Instruments. Standard fuses, with applicable national safety approvals, may be used if the rating and type are the same. Other components that are not safety related may be purchased from other suppliers as long as they are equivalent to the original component. (Note that selected parts should be purchased only through Keithley Instruments to maintain accuracy and functionality of the product.) If you are unsure about the applicability of a replacement component, call a Keithley Instruments office for information.

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

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Section 1

Pulse/Pattern Generators Overview

In this section:

Series 3400 summary

The Series 3400 Pulse/Pattern Generators, currently available in two basic models, offer extensive control over pulse parameters - including amplitude, offset, leading and trailing edge times, pulse width and duty cycle. The Model 3401 is a single-channel, 165MHz pulse/pattern generator; the Model 3402 is similar, but includes a second signal output channel.

NOTE *Each basic model is available with connectors located on the front panel (Model 3401-F and Model 3402-F) or with all connectors located on the rear panel (Model 3401-R and Model 3402-R).*

The operational flexibility and pattern generation capability of the Series 3400 Pulse/Pattern Generators makes them readily suitable to the specific needs of many different applications, including simplified simulation of serial data patterns when testing devices to characterize their performance under sub-optimal conditions.

Features

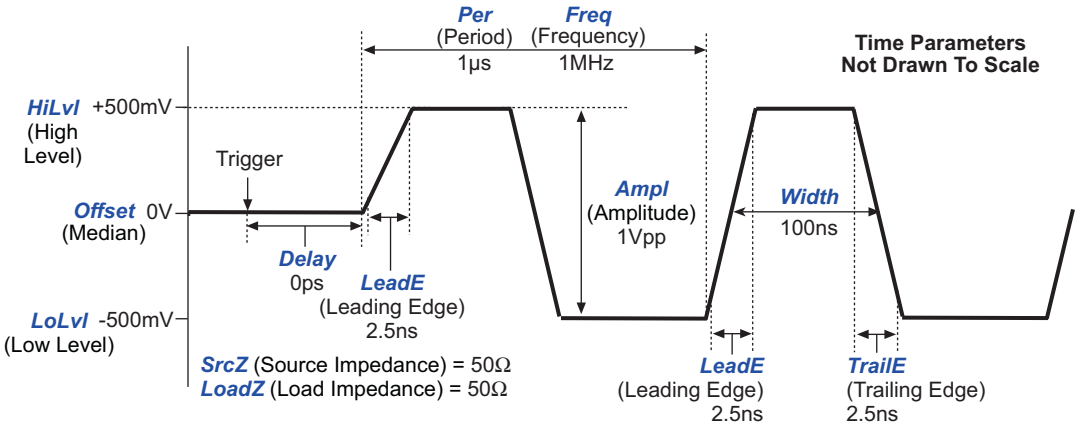
- Frequency Output Range: 1mHz to 165MHz
- Pulse Amplitude: ±10V (50Ω source impedance)
  ±20V (1kΩ source impedance)
- Pulse Width: Programmable from 3.02ns to (Period - 3.02ns)
- Leading and Trailing Edge Times: Programmable from 2.0ns to 200ms
- Pulse output programmable as voltage or current
- Four Operating Modes: Pulse mode
  Burst mode
  Pattern mode
  External Width mode
- Channel Add (Model 3402 only): Make complex waveforms by adding pulse output for Channel 1 and Channel 2
- Internal PLL and VCO period sources
- Save up to nine pulse/pattern generator setups in non-volatile memory
- GPIB and USB interfaces
- 2U full-rack design

Basic pulse parameters

On power-up, the instrument is in the Pulse mode with continuous triggering selected. When a channel is enabled, it will continuously output pulses.

Figure 1-1 shows the first two pulses of the continuous pulse output. Shown are the fundamental default settings. The parameter names in italic correspond to the parameter names in the front panel VOLTS and TIME menus.

Figure 1-1
Default pulse level and timing parameter settings (Pulse mode, continuous triggering)



The basic pulse level, timing and triggering parameters are summarized in Table 1-1 and *Table 1-2*. The last column ("yes" or "no") in the two tables does not apply to the Model 3401.

Pulse level parameters

Table 1-1
Pulse level parameters

Parameter	Description	Independent Channel Settings* (3402 only)
Output Function	Configure pulse output as **Current** or **Voltage**.	Yes
Source Impedance	Set the source impedance of the Series 3400 for **50 Ohms** or **1k Ohms**.	Yes
Load Impedance	The allowable setting ranges for pulse parameters are specified for a 50Ω load. However, the load impedance setting of the Series 3400 can be set to match the impedance of the DUT. Load impedance can be set from **0.1 Ohm to 1M Ohm**.	Yes
High Level Low Level	Configure the pulse high/low levels by setting the **High Level** and the **Low Level**. Setting range depends on the source impedance setting: 50Ω into 50Ω **0 to ±10V** (or **0 to ±200mA**) 1kΩ into 50Ω **0 to ±20V** (or **0 to ±400mA**) Changing the high and/or low level may change the amplitude and offset.	Yes
Amplitude	Amplitude is the low-to-high magnitude of the pulse. The Amplitude setting range depends on the source impedance setting: 50Ω into 50Ω **100mV to 10Vpp** (or **2mApp to 200mApp**) 1kΩ into 50Ω **200mV to 20Vpp** (or **4mApp to 400mApp**) Changing the amplitude will change the high and low levels. Offset is not affected.	Yes
Offset	Offset is the median (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. For a 100mVpp amplitude, offset can be programmed up to 9.95V. Changing the offset will change the high and/or low levels. Amplitude is not affected.	Yes
Polarity	Polarity can be set to **Norm** (normal) or **Comp** (complement). Complement means that the pulse transitions from the **High Level** to the **Low Level**.	Yes
Channel Add	3402 Only – **Enable** or **Disable** Channel Add. When enabled, Channel 1 pulse output is added to Channel 2 pulse output. The complex result is available on channel 1; Channel 2 is disabled.	No
Pulse Level Limits	To protect DUT, high and low limits can be set for pulse output. Limits can be enabled (**On**) or disabled (**Off**). The Hi Lim and Lo Lim setting ranges are the same as the setting ranges for High Level and Low Level.	Yes

* Yes = The parameter can be independently set for each of the two channels of the Model 3402.
No = The parameter setting applies to both channels of the Model 3402.

Pulse timing and triggering parameters

Table 1-2
Pulse timing and triggering parameters

Parameter	Description	Independent Channel Settings* (3402 only)
Frequency Period	Pulse cycle time can be set as frequency or period. Frequency can be set from **1mHz to 165MHz**. Period can be set from **6.06ns to 1000s**.	No
Width	Pulse width is measured at the 50% amplitude level of the pulse. Width can be set from **3.02ns to (Period - 3.02ns)**.	Yes
Delay	A delay between the trigger event and the start of each pulse can be set from **0 to (Period - 3.02ns)**.	Yes
Leading Edge Trailing Edge	Time intervals between corresponding 10% and 90% amplitude points on the leading/trailing edge of the pulse. Leading and trailing edge times (**LeadE** and **TrailE**) can be individually set from **2ns to 200ms**.	Yes Yes
Pulse Number	With **Single** pulse selected, one pulse per period will be output. With **Double** pulse selected, two pulses per period will be output.	No
Period Source	The source for period generation can be **PLL**, **VCO** or an external clock input (**ClkIn**).	No
Trigger Source	Select the trigger source to start pulse output: **ExtIn** (external input), **PLL** or **Manual**.	No
Trigger Mode	Select the trigger mode: **Cont** (continuous), **Trig'd** (triggered) or **Gated**.	No
Trigger Frequency Trigger Period	Trigger speed for the PLL trigger source can be set as frequency or period. **Trigger Frequency** can be set from **1mHz to 165MHz**. Trigger **Period** can be set from **6.06ns to 1000s**.	No No

* Yes = The parameter can be independently set for each of the two channels of the Model 3402.
No = The parameter setting applies to both channels of the Model 3402.

Operating modes

The Series 3400 Pulse/Pattern Generators have four operating modes: Pulse mode, Burst mode, Pattern mode and External Width mode.

Pulse mode

Outputs a single pulse or continuous pulses per trigger event to the two output channels. The basic pulse level, timing and triggering parameters are summarized in Table 1-1 and Table 1-2.

Burst mode

This mode is similar to the Pulse mode, except that each trigger event will output a series (burst) of pulses. In Burst mode, two to 65,536 pulses can be output.

Pattern mode

Each channel can output a user configured bit pattern that consists of Logic 0's and 1's. The length of the bit pattern can be two to 16,384 bits.

The two channels of a Model 3402 can have different bit patterns, but must be the same length. Logic 0 represents the low pulse level (e.g., 0V) and Logic 1 represents the high pulse level. The following example shows different 8-bit output patterns for the two channels:

Channel 1 Output Pattern: 00110011

Channel 2 Output Pattern: 11100010

Pattern data formats

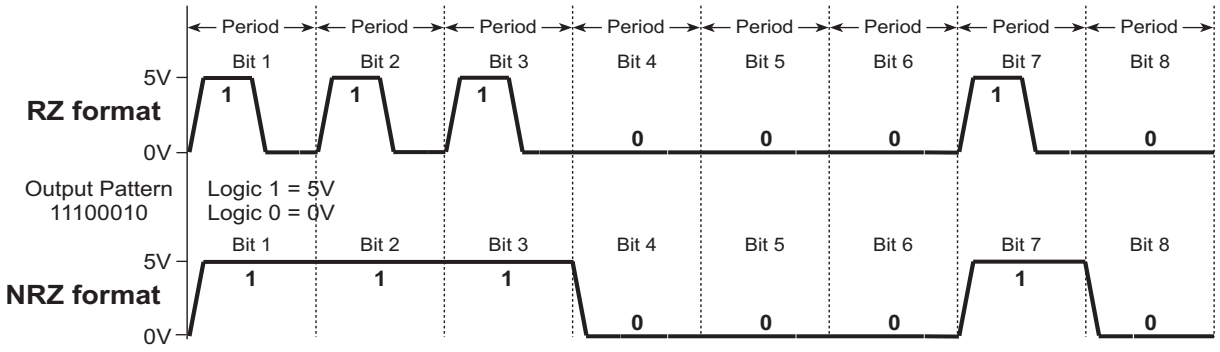
There are two data formats for output patterns: RZ (return-to-zero) and NRZ (non-return-to-zero). Figure 1-2 shows the difference between the RZ format and the NRZ format. The 8-bit pattern is the same for both formats (11100010), and the logic levels are the same (Logic 0 = 0V, Logic 1 = 5V):

- RZ Format – For 50% duty cycle, a Logic 1 bit goes to 5V for the first half of the period, then returns to 0V for the second half of the period (return-to-zero). A Logic 0 bit remains at 0V for the entire period.
- NRZ Format – A Logic 1 bit goes to 5V and stays at 5V for the entire period (non-return-to-zero). A Logic 0 bit goes to 0V and remains at 0V for the entire period.

NOTE *For either 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 = 4V	*Logic 1 = 0V*
Logic 0 = 1V	*Logic 0 = -3V*

Figure 1-2
Example output pattern for RZ and NRZ data formats



Pseudo Random Bit Sequencer (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 size = 2^n-1 where n = 5 to 14

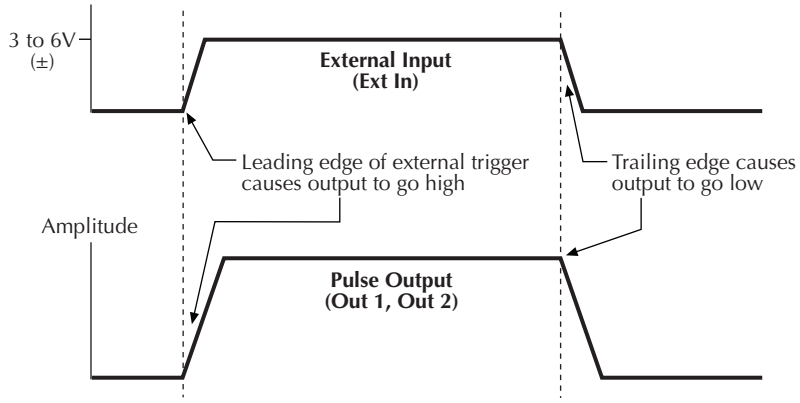
The RZ or NRZ data format can be used for the PRBS pattern.

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 1-3, a rising edge causes the output to go high, while a falling edge causes the output to go low.

The external input trigger can be positive or negative polarity up to 6V. However, the external input trigger voltage must be at least ±10mV in order to be detected by the pulse/pattern generator as a valid trigger.

Figure 1-3
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 and/or the load.

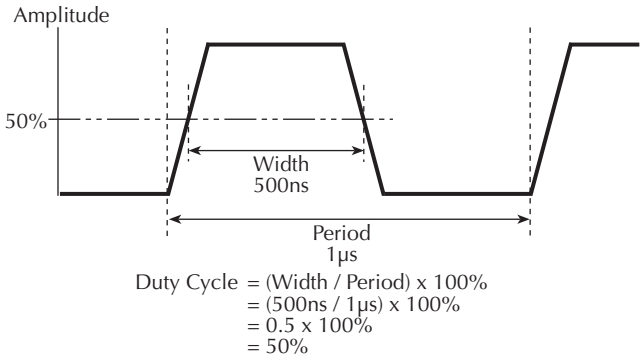
Duty cycle

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

Duty Cycle = (Width / Period) x 100

Figure 1-4 shows an example for duty cycle.

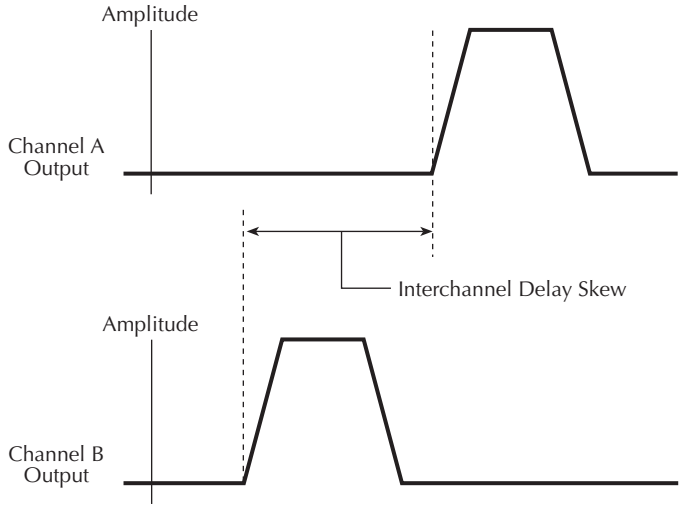
Figure 1-4
Example of 50% duty cycle



Interchannel delay (skew)

As shown in Figure 1-5, interchannel delay is the time interval between the leading pulse edge of the two Model 3402 output channels (Channel 1 and Channel 2). Skew can be adjusted through the use of the pulse Delay for each individual channel.

Figure 1-5
Interchannel delay (skew)



Jitter

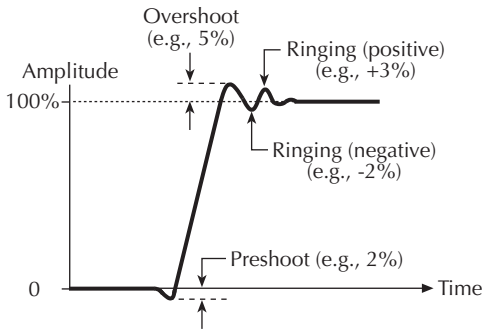
Jitter is the short-term instability of one edge relative to a reference edge. Jitter is usually specified as an RMS value, which is one standard deviation (or sigma). If distribution is assumed Gaussian, six sigma represents 99.74% of peak-to-peak jitter.

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.

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 1-6. A combined preshoot, overshoot and ringing specification of 5% implies an overshoot and undershoot <5% of pulse amplitude.

Figure 1-6
Distortion – Preshoot, overshoot and ringing



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Section 2
Getting Started

In this section:

General information

Warranty information

Warranty information is located at the front of this manual. Should your instrument require warranty service, contact the Keithley representative or authorized repair facility in your area for further information. When returning the instrument for repair, be sure to fill out and include the service form at the back of this manual to provide the repair facility with necessary information.

Keithley Instruments website – contact information

Visit the Keithley website at www.keithley.com for information on contacting Keithley for your customer service needs, such as calibration and repair.

Inspection

The instrument 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 any damage to the shipping agent immediately. Save the original packing carton for possible future shipment. The following items are included with every instrument order:

- Series 3400 with line cord.
- Rack Mount/Handle Kit
- Accessories as ordered.
- CD with the Quick Start Guide, User's Manual and any Release Notes
- Hardcopy of the Quick Start Guide

Options and accessories

Cables/adapters

- Model 7051-2 General Purpose BNC to BNC Cable (2 ft)
- Model 7007-1 Shielded GPIB Cable, 1m
- Model 7007-2 Shielded GPIB Cable, 2m
- Model 7051-2 General Purpose BNC to BNC Cable, 0.6m (2 ft)
- Model 7051-5 General Purpose BNC to BNC Cable, 1.5 (5 ft)
- 7755 50Ω Feed-Through Terminator

Communication interfaces

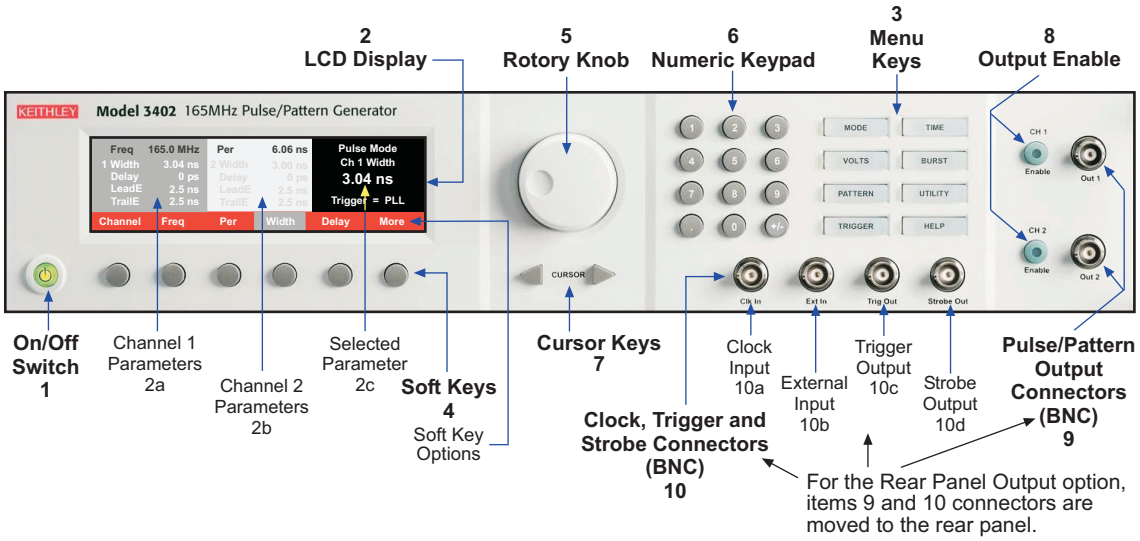
- Model KPCI-488 GPIB/IEEE488 Interface Board for PCI Bus
- Model KUSB-488 USB-to-GPIB interface adapter for USB
- When using USB directly, use one of the following USB cables:
  - USB-B-1 USB Cable Type A to B, 1m
  - USB-B-3 USB Cable Type A to B, 3m

Front and rear panel familiarization

Front panel

The front panel of the Model 3402-F is shown in Figure 2-1. The front panel controls and connectors for the Model 3401-F single-channel pulse/pattern generator are similar except there is only one channel. For the Model 3401, disregard all references to the second channel.

Figure 2-1
Front panel familiarization (Model 3402-F)



1. **On/Off Switch** – Push button switch toggles instrument on and off. When on, the green indicator in the button turns on. Note that the main power switch for the rear panel Power Module must be on (refer to Figure 2-2).
2. **LCD Display** – On the Time and Volts menu keys, 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 of the selected parameter. Also displays related information.
3. **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.
4. **Soft Keys** – The options that can be selected depend on the selected menu and are positioned in the display immediately above the soft keys.
5. **Rotary Knob** – Use this knob to modify (increase or decrease) the displayed parameter value.
6. **Numeric Keypad** – Use this keypad to enter parameter values. After keying in a value, available options (e.g., MHz range) are displayed as soft keys.
7. **Cursor Keys** – Use to increment/decrement parameter values.
8. **Output Enable** – Push button toggles output enable for each channel on and off. When on, the green indicator in the button turns on. A trigger event will then start pulse/pattern output.
9. **Pulse/Pattern Output Connectors** – Output for the two channels is available at these female BNC connectors. For the Rear Panel Output option, these connectors are moved to the rear panel for greater convenience in rack-mounted environments.

10. **Clock, Trigger and Strobe Connectors** – The following input/output female BNC connectors are provided:

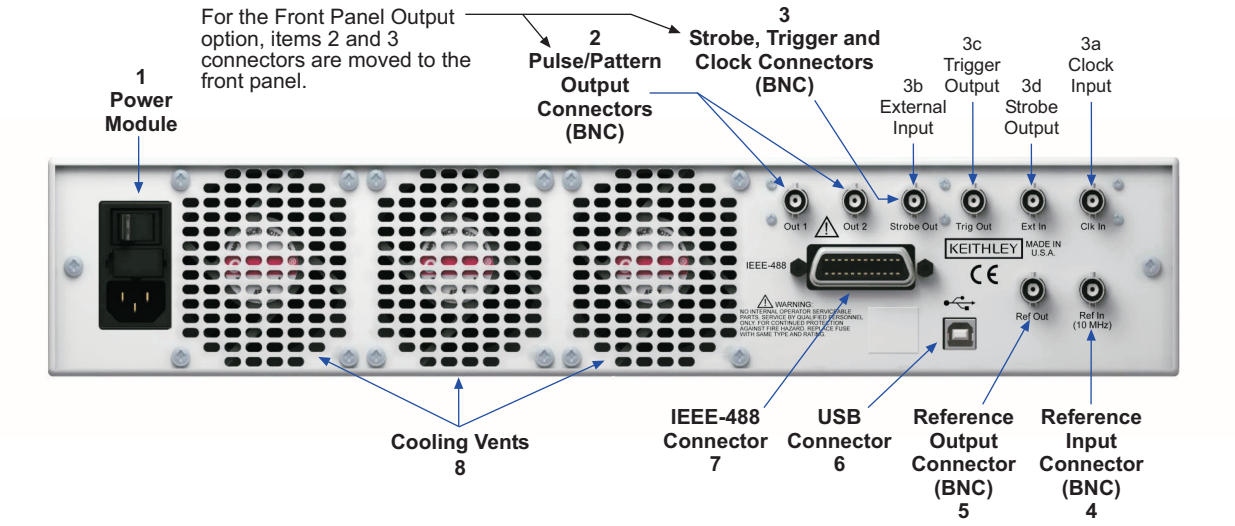
NOTE *For the Rear Panel Output option, these connectors are moved to the rear panel for greater convenience in rack-mounted environments:*

a. Clock Input – Connect an external clock.
b. External Input – Connect an external signal for external triggering.
c. Trigger Output – Provides a trigger pulse on each period.
d. Strobe Output – Programmable NRZ in Pattern mode, marks burst width in Burst mode.

Rear panel

The rear panel of the Model 3402-R is shown in Figure 2-2. The connectors for the Model 3401-R single-channel pulse/pattern generator are similar except there is only one pulse/pattern output channel. For the Model 3401, disregard all references to the second channel.

Figure 2-2
Rear panel familiarization (Model 3402-R)



1. **Power Module** – Contains the AC line receptacle, main power switch and the power line fuse. Uses a toggle switch for AC power. The "0" position is off, and the "1" position is on. This toggle switch must be in the "1" (on) position to enable the front panel On/Off Switch (refer to Figure 2-1).
2. **Pulse/Pattern Output Connectors** – Output for the two channels is available at these female BNC connectors. For the Rear Panel Output option, these connectors are moved to the rear panel for greater convenience in rack-mounted environments:
3. **Clock, Trigger and Strobe Connectors** – The following input/output female BNC connectors are provided:

NOTE *For the Rear Panel Output option, these connectors are moved to the rear panel for greater convenience in rack-mounted environments.*

a. Clock Input – Connect an external clock.
b. External Input – Connect an external signal for arming.
c. Trigger Output – Provides a trigger pulse on each period.
d. Strobe Output – Programmable NRZ in Pattern mode, marks burst width in Pulse mode.

4. **Reference Input Connector** – This female BNC connector accepts an external 10MHz oscillator signal for PLL reference.

   NOTE*Use the Ref In and Ref Out to daisy-chain multiple Series 3400 units for the purpose of using one PLL as the period source.*

5. **Reference Output Connector** – This female BNC connector provides 10MHz single phase locked to PLL.
6. **USB Connector** – For USB remote operation. Use a USB cable (Model USB-B-1 or USB-B-3) to connect to the USB interface of the PC.
7. **IEEE-488 Connector** – For GPIB remote operation. Use a shielded cable (Model 7007-1 or 7007-2).
8. **Cooling Vents** – The instrument uses a cooling fan and vents to keep it from overheating. Note that there is also a cooling vent on each side panel of the unit. Refer to "Ventilation" for information on maintaining proper ventilation for the instrument.

Power-up

The Series 3400 operates from a line voltage in the range of 100 to 240V single phase at a frequency of 50 or 60Hz. Line voltage and line frequency are automatically sensed. Therefore, there are no switches to set. Check to be sure the operating voltage in your area is compatible.

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

Perform the following steps to connect the Series 3400 to line power and turn it on:

1. Before plugging in the power cord, make sure the Series 3400 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 return the power switch to the on (1) position.

WARNING ***The power cord supplied with the Series 3400 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. Turn on 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 2-2). After turning the power switch off and removing the line cord, remove the fuses and replace a blown fuse with the following type:

Keithley Instruments Part Number: FU-81

Fuse Type: 2A, 250V, SlowBlo, 5mm x 20mm

Ventilation

The Series 3400 uses a fan and cooling vents in the rear panel and side panels to keep it from overheating.

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

Keep the cooling vents from becoming blocked.

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

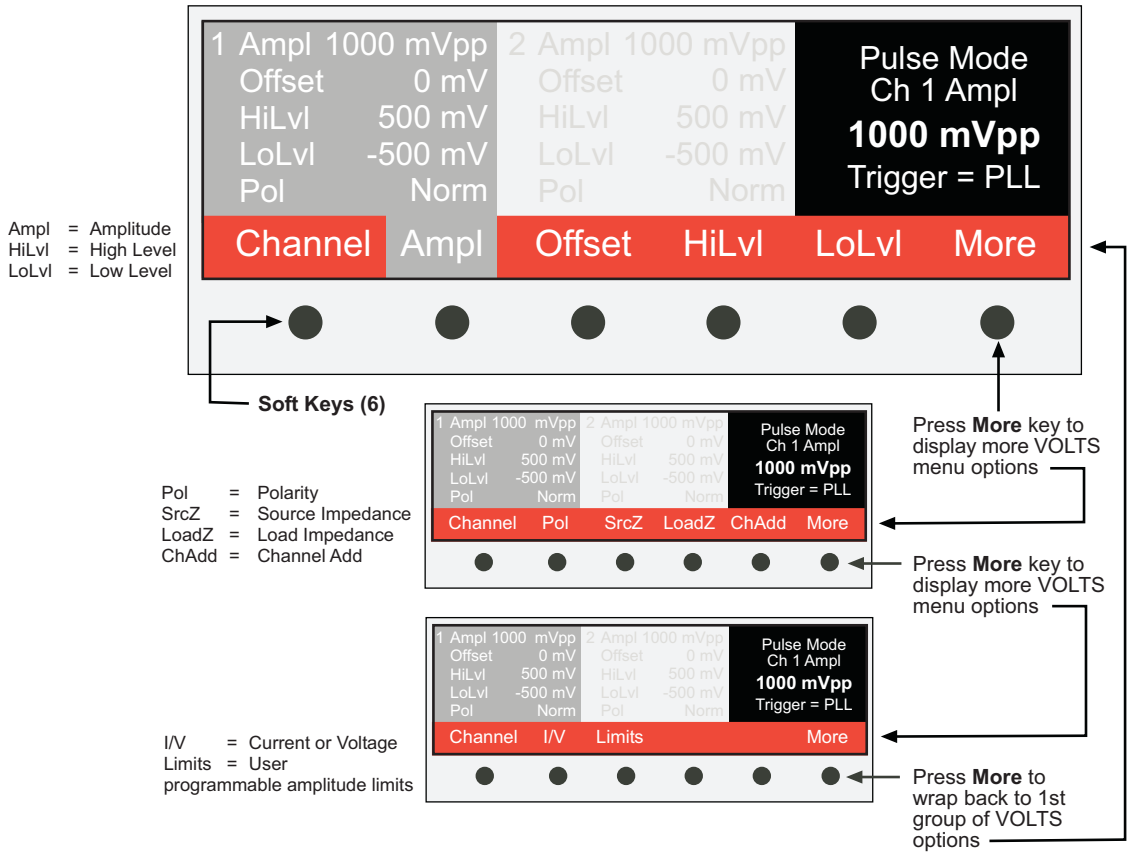
When rack mounting the instrument, make sure there is adequate airflow around the rear and sides to ensure proper cooling. Adequate airflow enables air temperatures within approximately one inch of the instrument surfaces to remain within specified limits under all operating conditions.

Display

The Series 3400 uses an LCD display to view and set the various pulse/pattern parameters. The parameters that are displayed pertain to the selected menu. Figure 2-3 shows the default display items for the VOLTS menu. The pulse output for these default parameter settings are shown in Figure 1-1.

As shown, the **More** soft key is used to display all the various options for the VOLTS menu. All of the menus are summarized in Table 2-1. For the Model 3402, the **Channel** soft key is used to toggle between the two channels. Parameters are then set for the selected channel.

Figure 2-3
VOLTS menu options (default parameters)



The displays for the other menus (MODE, TIME, BURST, PATTERN, UTILITY, TRIGGER and HELP) are similar in structure to the VOLTS menu, but use different parameter options.

A summary for all the menus is provided in Table 2-1.

Table 2-1
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	3402 only – Select channel
	Ampl	Amplitude – Set peak-to-peak amplitude
	Offset	Set offset
	HiLvl	High Level – Set high level
	LoLvl	Low Level – Set low level
	Pol	Polarity – Set polarity – Norm (normal) or Comp (complement)
	SrcZ	Source Impedance – Select source impedance – 50 Ohms or 1k Ohms
	LoadZ	Load Impedance – Set load impedance
	ChAdd	Channel Add (3402 only) – Enable or Disable Channel Add
	I/V	Current or Voltage – Select Current (I) or Voltage (V) output
	Limits	Set and control (On/Off) high and low limits (Hi Volt, Lo Volt, Hi Cur and Lo Cur)
PATTERN	Channel	Select output channel or Strobe
	Format	Set format (RZ or NRZ) for selected channel
	Edit	Change bit for to 0 or 1 (use "0", "1" or "+" key)
	Length	Set the number of bits of the pattern
	Bit #	Select the bit to be edited
	PRBS n	Set PRBS length by setting the "n" in formula 2^n-1; n = 5 to 14.
	Block	Edit pattern using Fill 0, Fill 1, Invert, Ins Bit and Del Bit
	Update	Update pattern continuously (Cont) or when Now soft key is pressed
TRIGGER	TrgSrc	Trigger Source – Select trigger source: External input (ExtIn), PLL or Manual
	TrgMode	Trigger Mode – Select trigger mode; Continuous (Cont), triggered (Trig'd) or Gated
	TrgFreq	Trigger Frequency – Set frequency for PLL trigger source
	TrgPer	Trigger Period – Set period for PLL trigger source
	TrgSlope	Trigger Slope – Set trigger slope; Pos, Neg or Both.
TIME	Channel	3402 only – Select channel
	Freq	Frequency – Set pulse/pattern speed as frequency (Hz)
	Per	Period – Set pulse/pattern speed as period (time)
	Width	Set time for pulse width
	Delay	Set delay time
	LeadE	Leading Edge – Set transition time for leading edge
	TrailE	Trailing Edge – Set transition time for trailing edge
	Double	Enable (On) or disable (Off) double pulses per period
	PerSrc	Period Source – Select period source – VCO, PLL or clock input (ClkIn)
BURST	Brst Cnt	Burst Count – Set burst count for Burst mode

Table 2-1 (continued)
Menu summary

Menu Key	Menu Item	Description
UTILITY	ClkIn	Clock Input – Configure clock input – Termination (ClkInTrm; 50 Ohm or 10 kOhm), slope (ClkInSlp; Pos or Neg) and threshold (ClkInThr)
	ExtIn	External Input – Configure external input – Termination (ExtInTrm; 50 Ohm or 10 kOhm) and threshold (ExtInThr).
	Save	Save instrument setup in memory – Save to Mem1 to Mem9.
	Recall	Recall instrument setup from memory – Recall from Mem1 to Mem9, or return to Default settings.
	PLLRef	PLL Reference – Select Internal PLL or use Auto to check for PLL at REF IN connector.
	System	System settings for Display, Calibration (Cal), GPIB address (GPIBAdd), IOPort (GPIB or USB) and Emulation (Emul).
HELP	N/A	Provides a brief description for the presently selected parameter (soft key). Press any menu key or soft key to cancel help.

Editing parameter values and settings

NOTE *For the Model 3402, the soft key for* ***Channel*** *toggles the display between Channel 1 and Channel 2.*

1. Select a menu (e.g. VOLTS). The menu keys are located next to the keypad.
2. Press the soft key for the parameter to be edited. 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 rotary knob or the keypad.

  Rotary Knob – The knob increments or decrements the value.

  Keypad – When keying in a value, the available ranges (e.g., mV, V) for the value will appear at the bottom of the display. After keying in the value, use a soft key to select the range.

  Cursor keys – Use to increment or decrement values.
- **Parameter setting** – For a parameter setting, options (e.g., Enable, Disable, Cancel, etc.) may appear on the bottom of the display and can be selected by pressing a soft key.

Additional soft keys for menu navigation will appear as needed:

Enter soft key – Use to enter the parameter setting or value.

Back soft key – Use to back up to the previous menu view.

Cancel soft key – Use to cancel a menu selection. 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-hand corner of the display:

Error, Press Help

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

Defaults

The power-on defaults are listed in Table 2-2.

Table 2-2
Power-on defaults

Menu	Parameter	Setting or Value
MODE	Operating mode	Pulse
TIME	Channel	1
	Frequency	1.000MHz
	Period	1.000µs
	Width	100.0ns
	Delay	0.0ps
	Leading Edge	2.5ns
	Trailing Edge	2.5ns
	Double Pulse	Off
	Period Source	VCO
VOLTS	Channel	1
	Amplitude	1000mVpp
	Offset	0mV
	High Level	500mV
	Low Level	-500mV
	Polarity	Normal
	Source Impedance	50Ω
	Load Impedance	50Ω
	Channel Add (3402)	Disabled
	I/V	Voltage
	Limits	Off, ± 500mV, ±10mA
BURST	Burst Count	2 bits

Menu	Parameter	Setting or Value
PATTERN	Channel	1
	Format	RZ
	Pattern Length	2 bits
	Update	Cont
	PRBS Length	5
UTILITY	Clock Input:	
	Clock Input Terminator	50Ω
	Clock Input Slope	Positive
	Clock Input Threshold	1.0V
	External Input:	
	External Input Terminator	50Ω
	External Input Threshold	1.0V
	PLL Reference	Auto
	System:	
	Display:	
	Bright	8
	Contrast	6
	Timeout (in secs)	30
	GPIB Address*	10*
	IOPort*	GPIB*
	Emulation Mode	Off
TRIGGER	Trigger Source	ExtIn
	Trigger Mode	Cont
	Trigger Frequency	100kHz
	Trigger Period	10µs
	Trigger Slope	Positive

* At the factory, the GPIB is selected as the remote programming interface and the address is set to 10. Changing the interace or address is saved in NVRM, and will therefore be remembered on subsequent power-on. You must reboot the instrument after changing any communication parameters to ensure that such parameters are applied.

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Section 3
Signal Connections

In this section:

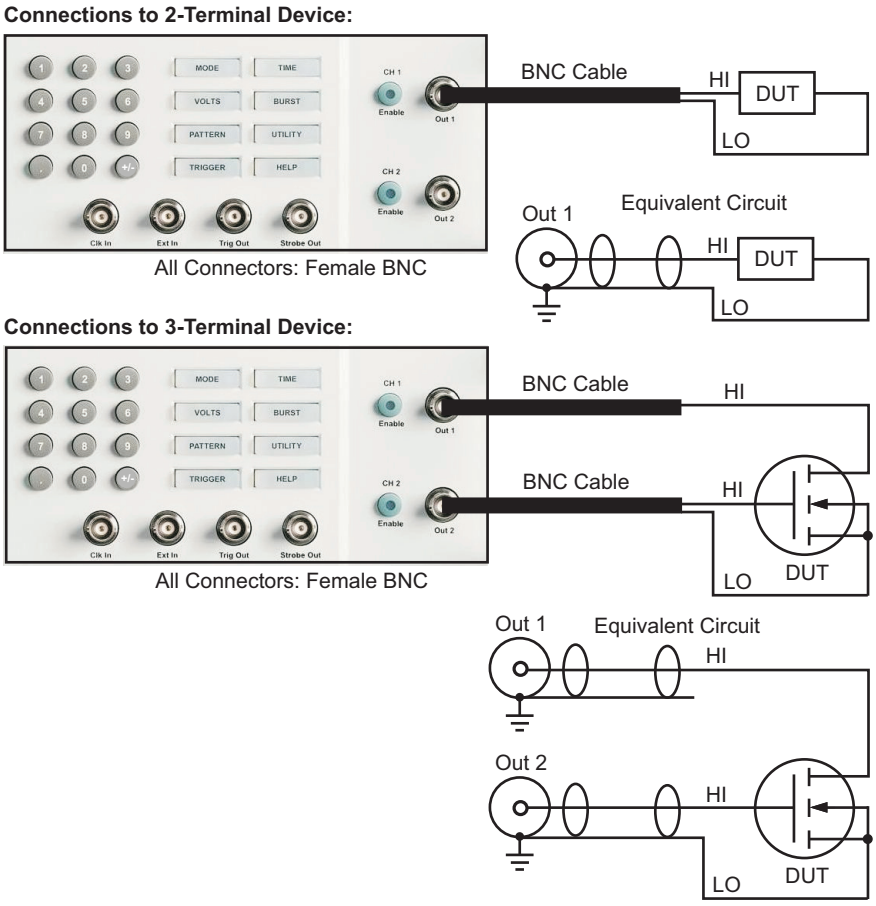
Introduction

For the Series 3400 Pulse/Pattern Generators front panel output option, signal connectors (except Ref Out and Ref In) are located on the front panel. For the rear panel output option, all connectors are on the rear panel to facilitate convenience for rack mounting. All signal connectors are female BNC.

Out 1 and Out 2 connections

Figure 3-1 shows how to connect an output channel of the Series 3400 to a 2-terminal DUT. It also shows an example of using both channels of a Model 3402 to pulse the gate and drain of a field-effect transistor (FET).

Figure 3-1
Out 1 and Out 2 connections

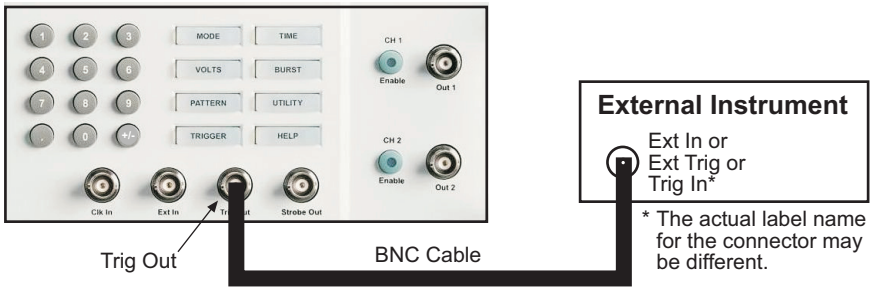


Trig Out and Ext In connections

Figure 3-2 shows connections for Trig Out, and Figure 3-3 shows connections for Ext In. Trigger output (Trig Out) marks each pulse or bit period (for Pattern mode). Trigger output is used to trigger an external instrument to start an operation (e.g., trigger scope to capture the waveform).

After an external instrument completes the operation, (e.g., waveform capture), it can send a trigger back to Ext In of the Series 3400 to output another pulse or bit. Using Trig Out and Ext In in this manner together allows for synchronized operation between two instruments. Refer to Section 5 for details on triggering.

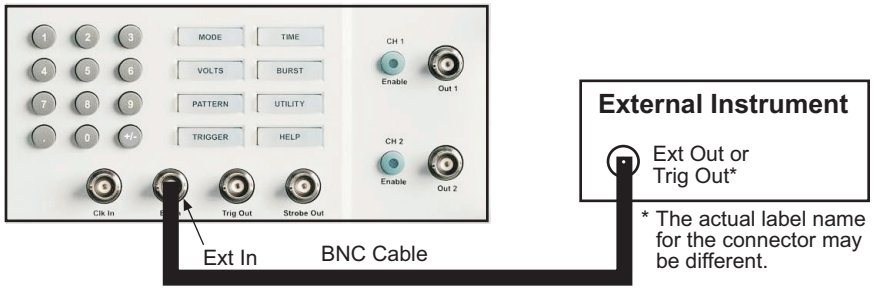
Figure 3-2
Trig Out connections



External Instrument can be one of the following:

- Scope being triggered to capture a waveform.
- Another Series 3400 being triggered to start Pulse, Burst, ExtWidth, or Pattern.
- Any other instrument being triggered to perform an operation.

Figure 3-3
Ext In connections



External Instrument can be one of the following:

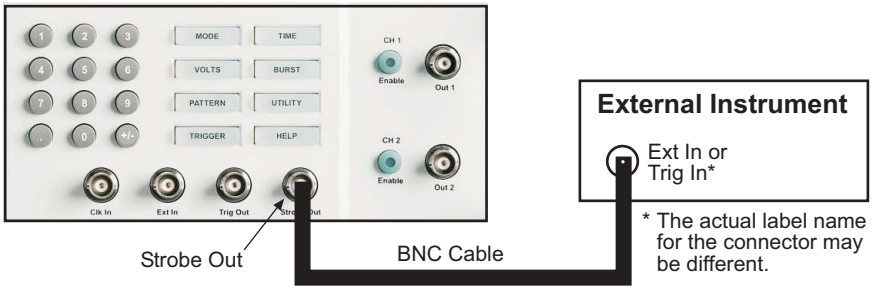
- Scope triggering the Series 3400 to start Pulse, Burst, ExtWidth or Pattern.
- A second Series 3400 triggering the first Series 3400 to start Pulse, Burst, ExtWidth, or Pattern.
- Any other instrument triggering the Series 3400 to start Pulse, Burst, ExtWidth, or Pattern.

Strobe Out connection

Figure 3-4 shows the connections for Strobe Out. Strobe Out is available for the Burst and Pattern modes. In Burst mode, strobe output marks the beginning and end of a burst. Strobe Out rises at the leading edge of the first pulse of the burst, and falls at the leading edge of the last pulse of the burst period. In Pattern mode, strobe output is bit programmable but is always NRZ format.

Strobe output is used to trigger an external instrument to start an operation (e.g., trigger scope to capture the waveforms). After the external instrument finishes its operation, it can then trigger the Series 3400 to start another burst or pattern, as shown in Figure 3-3. Refer to Section 5 for details on triggering.

Figure 3-4
Strobe Out connections



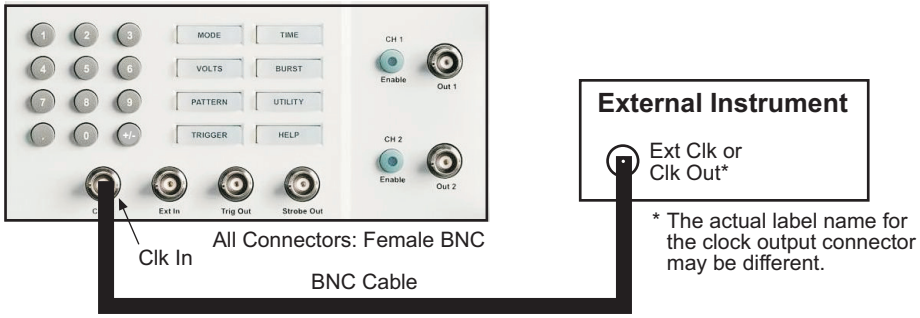
External Instrument can be one of the following:

- Scope being triggered to capture a waveform.
- Another Series 3400 being triggered to start Pulse, Burst, ExtWidth, or Pattern.
- Any other instrument being triggered to perform an operation.

Clk In connections

The period source can be provided by an external clock, as shown in Figure 3-5. Refer to Section 5 for details on triggering.

Figure 3-5
Clk In connections

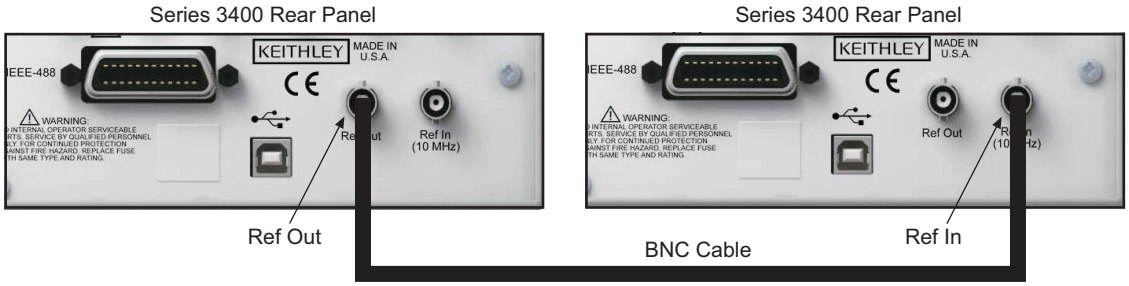


Ref Out and Ref In connections

When using multiple Series 3400s in a test, the PLL reference of a single unit may be shared (made common to all units) by daisy-chaining the Ref Out of one unit to Ref In of another. Figure 3-6 shows two units connected together for using the PLL reference of the first unit.

In a multi-unit system sharing a single PLL reference, all but one Series 3400 must be set for External PLL Reference (refer to "PLL reference (PLLRef)" in Section 5). Note, when multiple units share the same PLL reference, the frequencies of all of the units are synchronized.

Figure 3-6
Ref Out and Ref In connections



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Section 4

Pulse/Pattern Generators Operation

In this section:

Topic	Page

Pulse, Burst and External Width operation

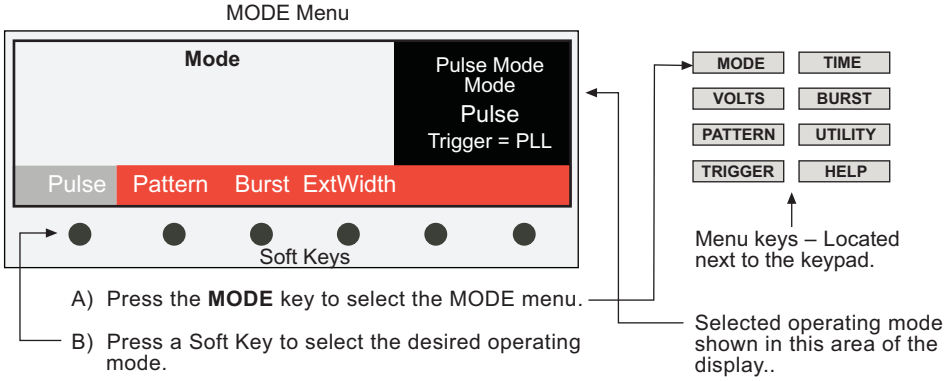
NOTE *For optimum performance, it is good practice to routinely perform self-calibration to correct for internal zero drift due to changes in ambient temperature – Press* ***UTILITY*** *> Press* ***System*** *> Press* ***Cal*** *> Press* ***Cal Now****. For details, see Cal – calibration.*

After making connections to the Series 3400 (refer to Section 3), the fundamental steps to operate Pulse, Burst and External Width are as follows:

1. Select the operating mode:
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).

The two steps to select the operating mode are explained in Figure 4-1.

Figure 4-1
Select operating mode



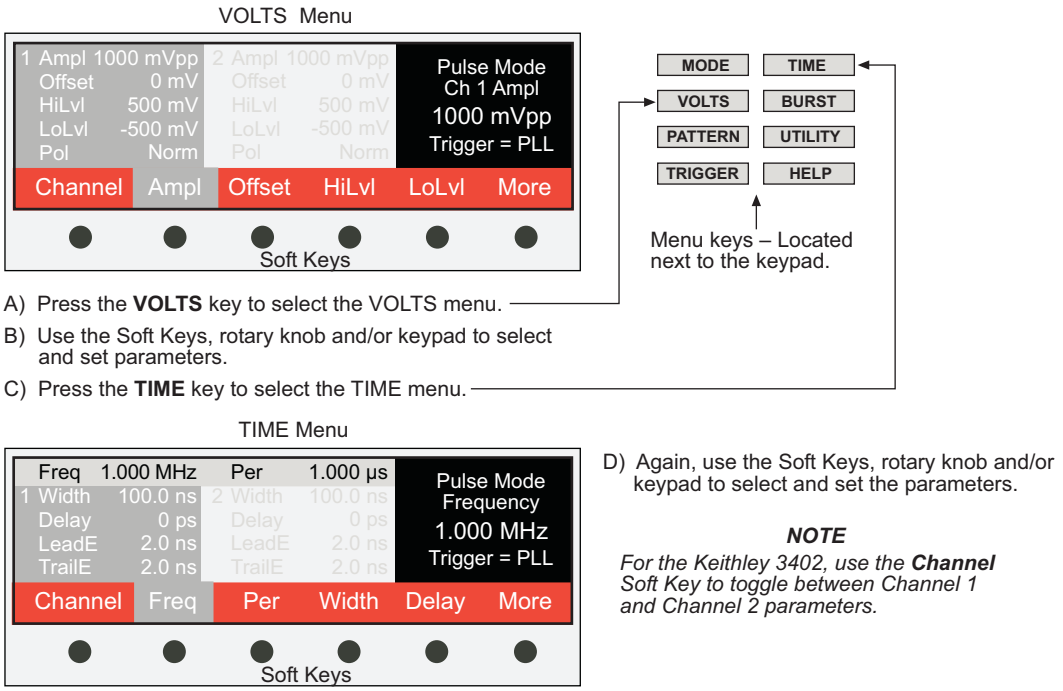
After selecting the operating mode, programmable parameters for that mode are set using the soft keys, rotary knob and the keypad and/or cursor keys. Details on the methods to edit parameter values and settings are provided on Page 2-8.

NOTE *Refer to "Pulse/pattern parameters" for details about the parameters. Each parameter is listed alphabetically by its soft key name.*

Pulse mode

1. Select the Pulse mode as explained in Figure 4-1.
2. Perform the steps in Figure 4-2 to configure the parameters in the VOLTS and TIME menus.

Figure 4-2
Configure Pulse mode parameters



3. Perform the steps in Figure 4-3 to configure triggering. Table 4-2 summarizes the trigger configurations. Refer to Section 5 for details on triggering.

Figure 4-3
Configure triggering

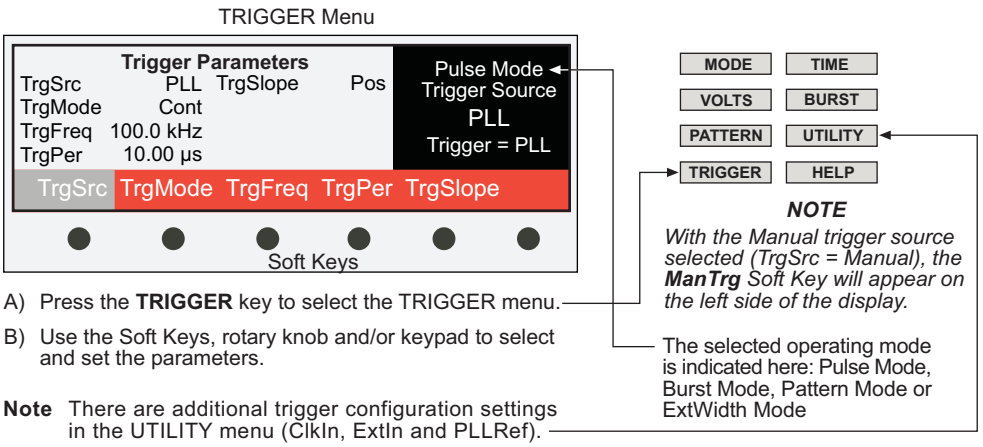


Table 4-1
Pulse mode triggering

TrgMode	TrgSrc	PerSrc	Trigger effect on Pulse Mode output (assuming channel already enabled)
Cont	ExtIn or Manual	VCO, PLL or ClkIn	Continuous pulse period output starts immediately.
Trig'd	ExtIn	N/A	The active edge of an external trigger applied to the EXT IN connector triggers a single pulse period.
	Manual	N/A	Pressing the **ManTrg** soft key triggers one single pulse period.
Gated	ExtIn	VCO, PLL, ClkIn	The leading edge of an external trigger applied to the EXT IN connector triggers the first pulse period. The trailing edge trigger marks the last pulse period.

N/A = Not Applicable (setting is not significant).

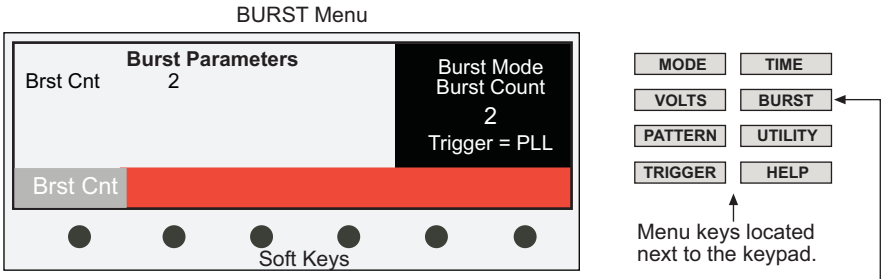
4. Enable channel(s) by pressing the key(s) located next to the BNC output connector(s): **CH1 Enable** and **CH2 Enable** (3402 only). A green indicator light in the key turns on to indicate that the channel is enabled.

   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/or **CH2 ENABLE** (3402) keys. The green indicator light(s) turns off.

Burst mode

1. Select the Burst mode as explained in Figure 4-1.
2. Perform the steps in Figure 4-4 to set the Burst count. Burst count can be set from 2 to 65,536 pulse periods.

Figure 4-4
Setting Burst mode count



A) Press the **BURST** key to select the BURSTmenu.
B) Press the **Brst Cnt** soft key, and use the rotary knob and/or the keypad to specify the number of pulse periods.

3. Perform the steps in Figure 4-3 to configure triggering. Table 4-2 summarizes the trigger configurations. Refer to Section 5 for details on triggering.

Table 4-2
Burst mode triggering

TrgMode	TrgSrc	PerSrc	Trigger effect on Pulse Mode output (assuming channel already enabled)
Cont	N/A	VCO, PLL or ClkIn	Burst pulse period output starts immediately. Each burst of pulse periods is repeated continuously.
Trig'd	ExtIn	VCO, PLL or ClkIn	The active edge of an external trigger applied to the EXT IN connector triggers a single burst of pulse periods.
	PLL	VCO	The internal VCO triggers each burst of pulse periods. The PLL triggers the burst. The VCO controls pulse period of each pulse/bit in the burst.
	Manual	VCO, PLL or ClkIn	Pressing the **ManTrg** soft key triggers a single burst of pulse periods.
Gated	ExtIn	VCO, PLL, ClkIn	The edge of an external trigger applied to the EXT IN connector triggers the first burst of pulse periods. The trailing edge trigger marks the last burst of pulse periods.

N/A = Not Applicable (setting is not significant).

4. Enable pulse output by pressing the channel enable key(s) located next to the BNC output connector(s): **CH1 Enable** and **CH2 Enable** (3402 only). The green indicator light in the key shows that the channel is enabled.

   The enabled output is triggered (started) according to the trigger configuration.
5. When finished, disable the output(s) by again pressing the **CH1 ENABLE** and/or **CH2 ENABLE** (3402) keys. The green indicator light(s) turns off.

External Width mode

With the External Width mode selected (as explained in Figure 4-1), the rising and falling edges of an external trigger connected to the Trig In connector controls the output.

1. Select the ExtWidth mode as explained in Figure 4-1.
2. Time parameters for width, frequency, period and delay are determined by the external trigger signal and are not programmable.
3. Perform the steps in Figure 4-3 to configure triggering. Table 4-3 summarizes the trigger configuration. For external triggering (ExtIn), make sure to set the input termination and threshold voltage. These parameters are set using the ExtIn soft key from the UTILITY menu. Menu structure is shown in Table 2-1. Refer to Section 5 for details on triggering.

   The enabled output is triggered (started) according to the trigger configuration.

Table 4-3
External Width mode triggering

TrgMode	TrgSrc	PerSrc	Trigger effect on Pulse Mode output (assuming channel already enabled)
N/A	ExtIn	N/A	The output pulse level follows the edges of an external trigger applied to the EXT IN connector. A rising edge trigger causes the output to go high and a falling edge trigger causes the output to go low.

N/A = Not Applicable (setting is not significant).

4. Enable pulse output by pressing the channel enable key(s) located next to the BNC output connector(s): **CH1 Enable** and **CH2 Enable** (3402 only). The green indicator light in the key shows that the channel is enabled.
5. When finished, disable the output(s) by again pressing the **CH1 ENABLE** and/or **CH2 ENABLE** (3402) keys. The green indicator light(s) turns off.

Pattern operation

NOTE *For optimum performance, it is good practice to routinely perform self-calibration to correct for internal zero drift due to changes in ambient temperature – Press **UTILITY** > Press **System** > Press **Cal** > Press **Cal Now**. For details, see Cal – calibration.*

After making connections to the Series 3400 (refer to Section 5), the fundamental steps to operate the pulse/pattern generator are as follows:

Step 1) Select the Pattern operating mode:
Step 2) Configure the parameters for the Pattern mode.
Step 3) Configure triggering.
Step 4) Enable the channel(s) and trigger the start of pattern output.
Step 5) When finished, disable the outputs.

Step 1) Select Pattern mode

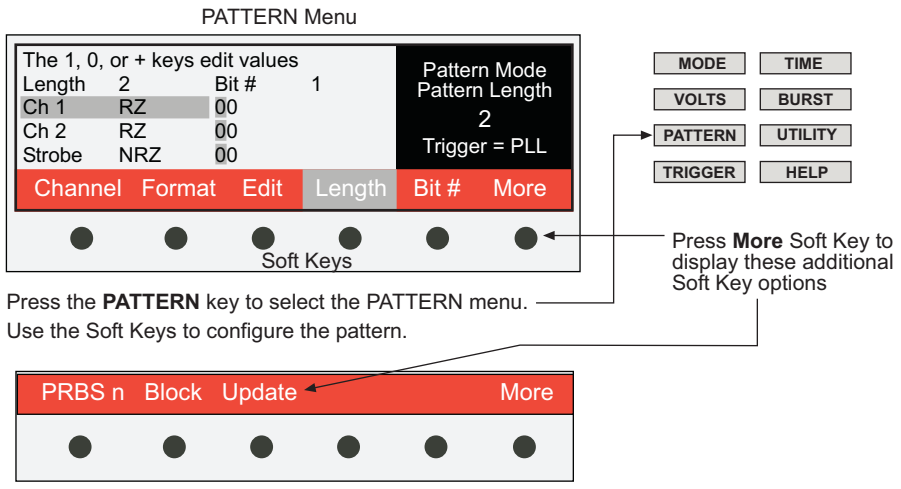
The Pattern mode is selected from the MODE menu. The two steps to select the Pattern mode are explained in Figure 4-1.

Step 2) Pattern configuration

NOTE *Level and time parameters for pattern mode are configured via the TIME and VOLTS keys. Refer to "See "Pulse mode" on page 4-4 for more information. for details.*

Figure 4-5 shows how to select the PATTERN menu. For the default menu, the cursors (grey highlighting) are positioned on "Ch 1 RZ" and the first column of bits (all 0's).

Figure 4-5
PATTERN menu



A) Select Format for Pattern

An output channel can be set for the NRZ or RZ format:

1. Use the **Channel** soft key to move the cursor to the desired channel: Ch 1, or Ch 2 (3402).
2. Use the **Format** soft key to toggle between the NRZ and RZ pattern format.
   The pattern format for Strobe output is always NRZ and cannot be changed.

B) Set pattern Length

The length of a pattern can be set from 2 to 16,384 bits:

Press the **Length** soft key, and use the rotary knob or keypad to enter the pattern length. If using the keypad, key in the value and press the **Enter** soft key. All added bits to the pattern will be 0's.

The set pattern length is the same for the output channel(s) and strobe output.

C) Edit bits as desired (0 or 1)

Each pattern bit for the selected channel (or Strobe output) can be set to 0 or 1:

1. Initially, the cursor will be located on the first bit. To change cursor position, press the **Bit #** soft key and use the rotary knob or the keypad to place the cursor on the bit to be changed.
2. 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 then be changed in the same manner.

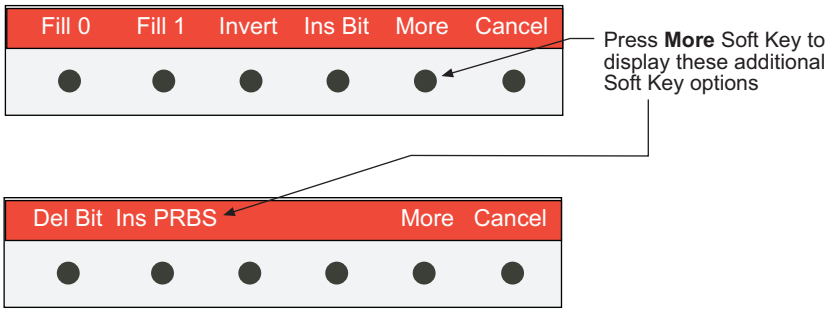
Advanced editing (Block)

The **Block** soft key (shown in Figure 4-5) can be used to edit a group of bits to 0s or 1s, or invert the bits within that group. A pattern bit can also be inserted or deleted.

Perform the following steps to edit a group of bits:

1. Use the **Bit #** soft key to position the cursor on the first bit to be edited (refer to step C1 above). That bit and all the bits to the right are edited as a group.
2. Press the **Block** soft key to display the soft key options shown in Figure 4-6:
   – Press the **Fill 1** soft key to set all bits in the group to 1.
   – Press the **Fill 0** soft key to set all bits in the group to 0.
   – Press the **Invert** soft key to invert each bit within the group. A 1 becomes a 0, and a 0 becomes a 1.

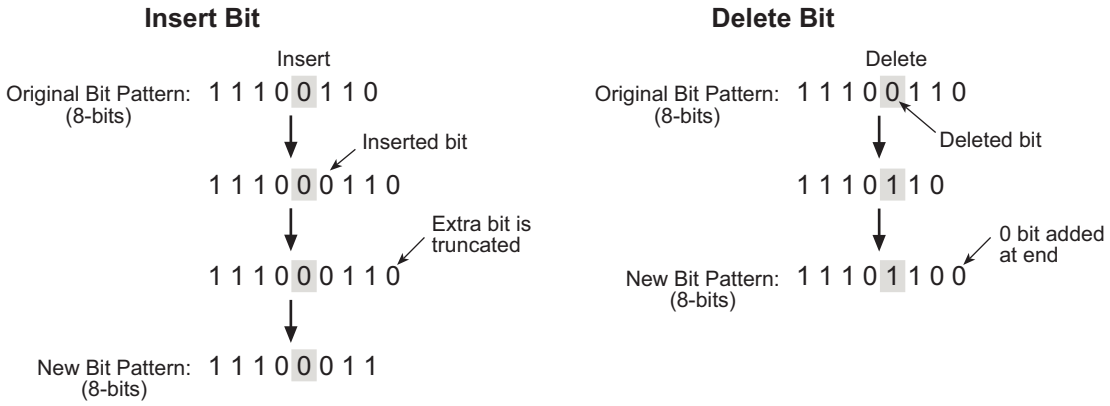
Figure 4-6
Block soft key options



A bit in the pattern can be inserted or deleted (insertions and deletions do not change the length of the pattern). Press the **Ins Bit** soft key to insert a bit to right of the cursor. and press the **Del Bit** soft key to delete the bit at the present cursor position.

Figure 4-7 shows examples of the insert and delete process with the cursor on bit #4. After a bit is inserted, the extra bit is truncated in order to maintain an 8-bit pattern. If bit #4 had been a 1, then a 1 would have been inserted. After a bit is deleted, an extra bit (0) is added to maintain an 8-bit pattern.

Figure 4-7
Insert bit and delete bit examples



Output Update

A pattern can be modified while it is available at an output. A pattern can be continuously updated as it is being modified, or the update can be performed as a separate action:

1. Press the **Update** soft key shown in Figure 4-5. Two soft key options will then appear on the display: **Now** and **Cont**.
2. Press the **Cont** soft key for continuos pattern update, or press **Now** when you are ready to update the pattern.

Pseudo random bit sequencer (PRBS)

PRBS is used 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 14 (which is set by the user). The RZ or NRZ data format can be used for the PRBS pattern:

1. Select the format (RZ or NRZ) for the output pattern (refer to step A above).
2. Use the **Length** soft key to set an appropriate pattern length (refer to step B above). Keep in mind that the length of the random bit sequence will not exceed the set pattern length. Any PRBS bits that exceed the pattern length are truncated.
3. Use the **Bit #** soft key to indicate the starting bit position for the random bit sequence.
4. Press the **PRBS n** soft key (shown in Figure 4-5).
5. Use the rotary knob 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 (5 to 14) is "n" for formula 2^n-1. Table 4-4 shows the maximum bit length for each "n" value of the formula. Again, the random bit sequence will not exceed the pattern length set in step 2.
6. Press the **Block** soft key, and then press the **Ins PRBS** soft key to insert the random bit sequence into the pattern.

Table 4-4
PRBS length settings

PRBS Length Setting	Length Calculation	Length (# of bits)	PRBS Length Setting	Length Calculation	Length (# of bits)
5	2^5 - 1	31	**10**	2^{10} - 1	1,023
6	2^6 - 1	63	**11**	2^{11} - 1	2,047
7	2^7 - 1	127	**12**	2^{12} - 1	4,095
8	2^8 - 1	255	**13**	2^{13} - 1	8,191
9	2^9 - 1	511	**14**	2^{14} - 1	16,383

Step 3) Configure triggering

Perform the steps in Figure 4-3 to configure triggering. Table 4-5 summarizes the trigger configurations. Refer to Section 5 for details on triggering.

Table 4-5
Pattern mode triggering

TrgMode	TrgSrc	PerSrc	Trigger effect on Pulse Mode output (assuming channel already enabled)
Cont	N/A	VCO, PLL or ClkIn	Pattern pulse period output starts immediately. Each pattern of pulse periods is repeated continuously.
Trig'd	ExtIn	VCO, PLL or ClkIn	The active edge of an external trigger applied to the EXT IN connector triggers a single pattern of pulse periods.
	PLL	VCO	The internal VCO triggers each pattern of pulse periods. The PLL triggers the entire pattern. The VCO controls the individual pulse period.
	Manual	VCO, PLL or ClkIn	Pressing the **ManTrg** soft key triggers a single pattern of pulse periods.
Gated	ExtIn	VCO, PLL, ClkIn	The leading edge of an external trigger applied to the EXT IN connector triggers the first pattern of pulse periods. The trailing edge trigger marks the last burst of pulse periods.

N/A = Not Applicable (setting is not significant).

Step 4) Enable channel(s) and start pattern output

Enable pattern output by pressing the channel enable key(s) located next to the BNC output connector(s): **CH1 Enable** and **CH2 Enable** (3402 only). The green indicator light in the key shows that the channel is enabled.

The enabled output is triggered (started) according to the trigger configuration.

Step 5) Disable output(s)

When finished, disable the output(s) by again pressing the **CH1 ENABLE** and/or **CH2 ENABLE** (3402) keys. The green indicator light(s) turns off.

Saving and recalling setups

The Series 3400 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-on default settings at any time.

Saving a setup

1. Configure the Series 3400 for the desired pulse/pattern operation.
2. Press the **UTILITY** menu key.
3. Press the **SAVE** soft key.
4. 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 **Recall** soft key.
3. 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

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

Pulse/pattern parameters

As shown in Table 4-6, each parameter is listed alphabetically by its soft key name. Details follow the table that included applicable operating modes for the parameter and the menu where the parameter soft key is located.

Table 4-6
Soft key parameters

Parameter	Parameter
Ampl – amplitude	Limits
Bit #	LoadZ – load impedance
Block	Lo Cur – low current limit
Brst Cnt – burst count	LoLvl – low level
Cal – calibration	Lo Volt – low voltage limit
ChAdd (3402 only) – channel add	Offset
Channel	On/Off (limits)
ClkIn – clock input	Per – period
Delay	PerSrc – period source
Display	Pol – polarity
Double	PLLRef – PLL reference
Edit	PRBS n – pseudo random bit sequence
Emul – emulation	Recall
ExtIn – external input	Save
Format	SrcZ – source impedance
Freq – frequency	System
GPIBAdd – GPIB address	TrailE – trailing edge
Hi Cur – high current limit	TrgFreq – trigger frequency
HiLvl – high level	TrgMode – trigger mode
Hi Volt – high voltage limit	TrigPer – trigger period
IOPort – I/O port (interface)	TrgSlope – trigger slope
I/V – current or voltage	TrgSrc – trigger source
LeadE – leading edge	Update
Length	Width

Ampl – amplitude

Operating mode: All
Menu: VOLTS

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 1-1, amplitude is 1Vpp: |500mV| + |-500mV| = 1V.

Changing the amplitude will also change the high and low levels. Offset is not affected. For example, if the amplitude in Figure 1-1 is changed to 500mVpp, the magnitudes of the high and low level will each decrease by 250mV (500mV / 2). The high level becomes 250mV and low level becomes -250mV.

The amplitude setting range is dependent on the selected source impedance (50Ω or 1kΩ) and the impedance of the load. Pulse amplitude can be independently set for each output channel of the Model 3402 Pulse/Pattern Generator.

Ampl setting range:	50Ω into 50Ω:	100mVpp to 10Vpp 2.0mApp to 200mApp
	1kΩ into 50Ω:	200mVpp to 20Vpp

4mApp to 400mApp

NOTE *Low voltage and current settings may be affected by the resolution specifications of the Series 3400. For example, setting an amplitude of 250mVpp with an offset of 0V will display HiLvl and LoLvl levels of +120mV and -120mV (instead of ±125mV). This is because the setting resolution is 10mV.*

Bit

Operating mode: Pattern
Menu: PATTERN

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 rotary knob or keypad to place the cursor on the bit to be edited. The pattern can then be edited using the Edit soft key or the options of the Block soft key.

NOTE *Refer to Step 2 of "See "Pattern operation" on page 4-8 for more information.*

Block

Operating mode: Pattern
Menu: PATTERN

Options of the **Block** soft key can be used to edit a group of pattern bits to 0s or 1s, or invert the bits within that group. A pattern bit can also be inserted or deleted.

NOTE *Refer to "See "Advanced editing (Block)" on page 4-9 for more information." for details on using the **Block** soft key.*

Brst Cnt – burst count

Operating mode: Burst
Menu: BURST

Burst count specifies the number of pulse periods to output when a trigger event occurs.

Brst Cnt setting range: 2 to 65,536

Cal – calibration

Operating mode: All
Menu: UTILITY (System)

The Series 3400 has a self-calibration feature to optimize performance. Self-calibration should be performed for the following conditions:

- Perform self-calibration after the Series 3400 is turned on and allowed to warm up for at least one hour.
- Perform self-calibration when the ambient temperature has changed.
- Perform self-calibration after an extended period of time since the last self-calibration.

NOTE *Cables can be left connected to the Series 3400 when performing a self-calibration*

Cal: Cal Now

ChAdd (3402 only) – channel add

Operating mode: All
Menu: VOLTS

When enabled, Channel Add is used to add the pulse output of Channel 1 to the pulse output of Channel 2. The complex result is available on Channel 1, and Channel 2 output is disabled.

With Channel Add enabled, changing the source and/or load impedance of either Channel 1 or Channel 2 will change the source and/or load impedance of the output.

ChAdd settings: Enable or Disable

Channel

Operating mode: All
Menu: VOLTS, TIME and PATTERN

The Model 3402 has two channels. There are parameters that can be independently set for each channel.

For the Pulse, Burst and External Width modes, the **Channel** soft key toggles between Channel 1 and Channel 2. With Channel 1 selected, the display for Channel 1 settings is activated. With Channel 1 selected, the display for Channel 2 settings is activated.

In Pattern mode for the Model 3402, the **Channel** soft key is also used along with the **Format** soft key to set the pattern format for each channel.

3402 Channel settings: 1 or 2

ClkIn – clock input

Operating mode: Pulse, Burst and Pattern
Menu: UTILITY

When using an external clock for pulse period generation, the terminator (input impedance of the ClkIn connector terminal), slope and threshold voltage need to be set. The external clock is connected to the Clk In connector and the period source (PerSrc) is set for ClkIn.

Terminator – The clock input terminator setting needs to match the impedance of the external clock (50Ω or 10kΩ).

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

Threshold – The threshold sets the trigger level (-3V to 3V) that will detected by the Series 3400 as a valid clock input pulse.

ClkIn settings:	Terminator:	50Ω or 10kΩ
	Slope:	Pos or Neg
	Threshold:	-3V to 3V

Delay

Operating mode: Pulse, Burst and Pattern (RZ only)
Menu: TIME

After the programmed Trigger event occurs, pulsing will start after the programmed Delay period expires. Delay can be independently set for each output channel of the 3402 Pulse/Pattern Generator.

Delay setting range: 0s to (Period – 3.02ns)

Display

Operating mode: All
Menu: UTILITY (System)

There are display settings for brightness, contrast and timeout for the backlight. There are 10 settings each for brightness and contrast. Timeout is set in minutes. With timeout enabled (Entimeout = on) the backlight will turn off when the timeout period expires.

Bright and Contrast setting range:	1 to 10
EnTimeout:	Off or On
Timeout setting:	Set in minutes

Double

Operating mode: Pulse and Burst
Menu: TIME

Each channel can be set to output one or two pulses per period. With Double disabled (Off), the channel will output a single pulse per period. With Double enabled (On), each channel will output two pulses per period.

Double settings: Off or On

Edit

Operating mode: Pattern
Menu: PATTERN

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 rotary knob 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 Step 2 of "See "Pattern operation" on page 4-8 for more information." for details on pattern configuration.*

Emul – emulation

Operating mode: All
Menu: UTILITY (System)

The emulation mode can be used to allow the Series 3400 to operate like the Agilent 81110A with the 81111A module installed. With emulation on, the *IDN? and *OPT? query commands will respond with messages that indicate that it is an Agilent 81110A with the 81111A module installed:

*IDN? response:	"Hewlett-Packard, HP81110A"
*OPT? response:	3401-"81111A" 3402-"81111A, 81111A"

NOTE *Emulation is provided for code compatibility only.*

Emul settings: Off or On

NOTE *Changing this setting requires a system reboot.*

ExtIn – external input

Operating mode: Pulse, Burst or Pattern
Menu: UTILITY

For external triggering, the input impedance and threshold need to be set. The external trigger is connected to the Ext In connector and the trigger source (TrgSrc) is set for ExtIn.

Terminator – The terminator setting (input impedance) needs to match the impedance of the external trigger (50Ω or 10kΩ).

Threshold – The threshold sets the trigger level (-3V to 3V) that will detected by the Series 3400 as a valid clock trigger pulse.

ExtIn settings:	Terminator:	50Ω or 10kΩ
	Threshold:	-3V to 3V

Format

Operating mode: Pattern
Menu: PATTERN

Bit patterns can be output in the RZ or NRZ format. The pattern can be individually set for each channel.

Format settings: RZ or NRZ

Freq – frequency

Operating mode: Pulse, Burst and Pattern
Menu: TIME

Pulse speed can be set as frequency (Hz) or period (time). When setting the frequency, period is set according to the following calculation:

period = 1 / frequency

Refer to "Per – period" for details on setting pulse speed as time.

Freq setting range: 1mHz to 165MHz

GPIBAdd – GPIB address

Operating mode: All
Menu: UTILITY (System)

The GPIB primary address of the Series 3400 can be set from 0 to 30. At the factory, the primary address is set to 10. The controller address is typically 0 or 21.

GPIBAdd setting range: 0 to 30

NOTE *Changing this setting requires a system reboot.*

Hi Cur – high current limit

Operating mode: All
Menu: VOLTS

Refer to "Limits"

HiLvl – high level

Operating mode: All
Menu: VOLTS

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 "Offset").

The high and low setting ranges are dependent on the selected source impedance (50Ω or 1kΩ) and the impedance of the load.

High and low levels can be independently set for each output channel of the Model 3402 Pulse/ Pattern Generator.

High/Low Level setting range*:		
50Ω into 50Ω	0 to ±10V 0 to ±200mA
1kΩ into 50Ω	0 to ±20V 0 to ±400mA

* The low-to-high magnitude (which is the amplitude) cannot be set to exceed the following window levels:

- 50Ω source impedance, 50Ω load impedance: 10Vpp or 200mApp
- 1kΩ source impedance, 50Ω load impedance: 20Vpp or 400mApp

Hi Volt – high voltage limit

Operating mode: All
Menu: VOLTS

Refer to "Limits"

IOPort – I/O port (interface)

Operating mode: All
Menu: UTILITY (System)

Remote programming for the Series 3400 can be performed using the GPIB or USB interface. At the factory, the GPIB interface is selected.

IOPort settings: GPIB or USB

NOTE *Changing this setting requires a system reboot.*

I/V – current or voltage

Operating mode: All
Menu: VOLTS

Pulse levels can be set as voltage (V) or current (I).

I/V settings: Current or Voltage

LeadE – leading edge

Operating mode: All
Menu: TIME

Transition times (leading edge and trailing edge) are the intervals between corresponding 10% and 90% amplitude points on the rising/falling edge of the pulse. The leading edge time and trailing edge time can be set independently for each output channel of the 3402 Pulse/Pattern

Generator. Also, there are ranges on which transition times can be independently set. Refer to Appendix A: Specifications for specific ranges.

Changing the leading edge time may also change the trailing edge time. Therefore, after changing the leading edge time, check the trailing edge time (refer to "TrailE – trailing edge") and change it as needed.

LeadE setting range: 2ns to 200ms

Length

Operating mode: Pattern
Menu: PATTERN

Sets the length (number of bits) of the pattern. Both channels are set to the same length.

Format settings: 2 to 16,384

NOTE *Limits*

Operating mode: All
Menu: VOLTS

Each channel can be independently set for high and/or low limits (voltage and current). Limits restrict the user from programming amplitude, high level and low level beyond certain values. However, if the programmed load impedance (LoadZ) does not match the actual load impedance, then output voltages could exceed the programmed limits.

After pressing the **Limits** soft key, the following soft keys display. After selecting a limit, use the keypad or rotary knob to set the limit.

On/Off Hi Volt Lo Volt More

On/Off – Use to turn limits on or off.
Hi Volt – Use to set the high limit for voltage
Lo Volt – Use to set the low limit for voltage

More – Use to display the following soft keys to set current limits:

Hi Cur Lo Cur

Hi Cur – Use to set the high limit for current
Lo Cur – Use to set the low limit for current

Limits are only valid assuming correct programming of source and load impedance.

Limits settings: Hi Volt and Lo Volt, and Hi Cur and Lo Cur:
Same setting ranges as HiLvl and LoLvl

On/Off: Off or On

LoadZ – load impedance

Operating mode: All
Menu: VOLTS

The Series 3400 specifications are rated for a source impedance of 50Ω or 1kΩ into a 50Ω load impedance (refer to "SrcZ – source impedance" to set source impedance).

For non-50Ω load impedances, the load impedance setting of the Series 3400 needs to be adjusted to match the actual impedance of the load in order for the output amplitude to match the programmed amplitude. For example, if the actual impedance of the DUT is 40Ω, load impedance (LoadZ) needs to be set to 40Ω

LoadZ setting range: 0.1Ω to 1MΩ

Figure 4-8 shows the simplified output diagrams for the two source impedance settings (50Ω and 1kΩ). With load impedance (LoadZ) set to 50Ω (default), the programmed voltage will be the actual voltage sourced to a 50Ω DUT.

Figure 4-8
Series 3400 output diagrams

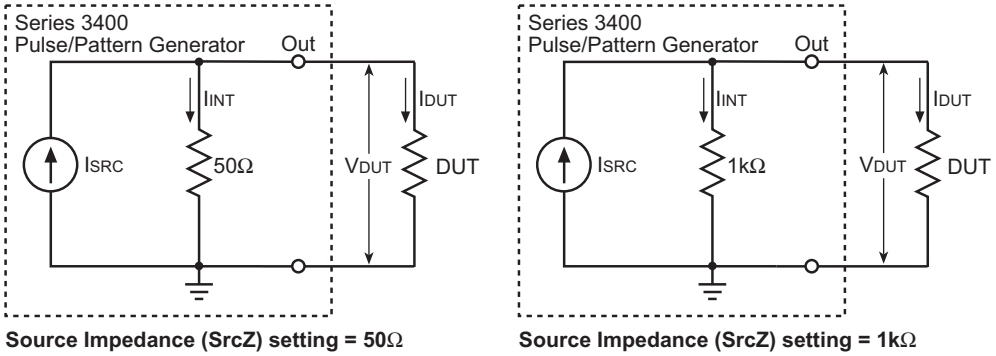


Table 4-7 shows the actual sourced voltage for various DUT impedances. The programmed voltage is 5V and load impedance (LoadZ) is set to 50Ω

For a 50Ω DUT, the programmed voltage (5V) will be sourced to the DUT. The voltage sourced to the DUT increases as the actual impedance of the DUT increases. The voltage sourced to the DUT decreases as the actual impedance of the DUT decreases.

Changing the load impedance (LoadZ) setting increases or decreases the current (I_{SRC}) to compensate for a non-50Ω load.

With Channel Add (Model 3402 only) enabled, changing the source and/or load impedance of either Channel 1 or Channel 2 will change the source and/or load impedance of the output (refer to "ChAdd (3402 only) – channel add").

Example

Assume you want to source 5V to a 40Ω load, and source impedance (SrcZ) and load impedance (LoadZ) are both set to 50Ω (defaults).

As shown by the first row of data in Table 4-7, 4.44V (not 5V) will be sourced to the 40Ω DUT. To source 5V, set the load impedance to 40Ω The current source (I_{SRC}) will increase to 225mA to force 125mA through the DUT (I_{DUT}):

V_{DUT} = 125ma x 40Ω = 5V

Table 4-7
Programmed voltage vs. actual voltage (V_{DUT}) for DUT impedance variations

Prgm Voltage	Prgm Source Z	Prgm Load Z	Actual DUT Z	I_{SRC}	I_{INT}*	I_{DUT}*	V_{DUT}
5V	50Ω	50Ω	40Ω	200mA	89mA	111mA	4.44V
5V	50Ω	50Ω	45Ω	200mA	95mA	105mA	4.74V
5V	50Ω	50Ω	50Ω	200mA	100mA	100mA	5.00V
5V	50Ω	50Ω	55Ω	200mA	105mA	95mA	5.24V
5V	50Ω	50Ω	60Ω	200mA	109mA	91mA	5.45V
5V	1kΩ	50Ω	40Ω	105mA	4mA	101mA	4.04V
5V	1kΩ	50Ω	45Ω	105mA	4.5mA	100.5mA	4.52V
5V	1kΩ	50Ω	50Ω	105mA	5mA	100mA	5.00V
5V	1kΩ	50Ω	55Ω	105mA	5.5mA	99.5mA	5.47V
5V	1kΩ	50Ω	60Ω	105mA	6mA	99mA	5.94V

* I_{INT} is the current through the internal Source Z.
I_{DUT} is the current through the external Load Z.

Lo Cur – low current limit

Operating mode: All
Menu: VOLTS

Refer to "Limits"

LoLvl – low level

Operating mode: All
Menu: VOLTS

Refer to "HiLvl – high level"

Lo Volt – low voltage limit

Operating mode: All
Menu: VOLTS

Refer to "Limits"

Offset

Operating mode: All
Menu: VOLTS

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

Offset = (High Level + Low Level) / 2

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

High Level: 1V
Low Level: -1V
Amplitude: 2Vpp |1V| + |-1V| = 2Vpp
Offset: 0V (1V + -1V) / 2 = 0V

If offset is changed to 0.5V, amplitude will remain at 2Vpp but the high and low levels will shift up (increase) by 0.5V. The high level becomes 01.5V (1V + 0.5V) and the low level becomes -0.5V (-1V + 0.5V).

The offset can be set to any value that allows the pulse to fit within the level window. Keep in mind that minimum amplitude is 100mVpp. For a 100mVpp amplitude, offset can be programmed up to 9.95V.

NOTE *Low voltage and current settings may be affected by the resolution specifications of the Series 3400. For example, setting an amplitude of 250mVpp with an offset of 0V will display HiLvl and LoLvl levels of +120mV and -120mV (instead of ±125mV). This is because the setting resolution is 10mV.*

On/Off (limits)

Operating mode: All
Menu: VOLTS

Refer to "Limits"

Per – period

Operating mode: Pulse, Burst and Pattern
Menu: TIME

Pulse speed can be set as period (interval at which the pulse repeats) or frequency. When setting the period, frequency is set according to the following calculation:

frequency = 1 / period

Refer to "Freq – frequency" for details on setting pulse speed as frequency.

Per setting range: 6.06ns to 1000s

PerSrc – period source

Operating mode: Pulse, Burst and Pattern
Menu: TIME

There are two internal period sources that can be used for period generation: PLL or VCO. The the trigger speed for the internal PLL is adjustable, and can be set as frequency (refer to "TrgFreq – trigger frequency") or period (refer to "TrigPer – trigger period"). The PLL period source and PLL trigger source cannot be used cannot be used together at the same time.

An external period source connected to the Clk In connector can be used instead of an internal period source.

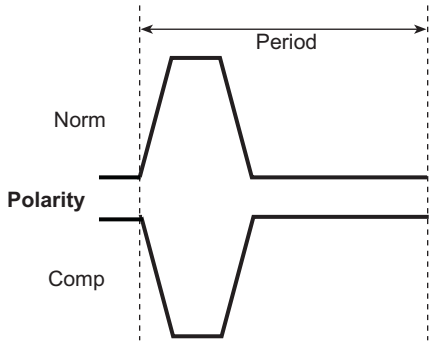
PerSrc settings: VCO, PLL or ClkIn

Pol – polarity

Operating mode: All
Menu: VOLTS

With normal polarity (Norm) selected, pulses/patterns are output from low level to high level as depicted In Figure 4-9. With complement (Comp) selected, pulses/patterns are output from high level to low level:

Figure 4-9
Polarity



Pol settings: Norm or Comp

PLLRef – PLL reference

Operating mode: Pulse, Burst and Pattern
Menu: UTILITY

PLLRef – The **PLLRef** soft key (accessed from the UTILITY menu) is used to select the following options for multiple Series 3400 units that are daisy-chained using the Ref Out and Ref In connectors:

- External - The Series 3400 uses the externally supplied signal as the reference for the PLL.
- Internal – The Series 3400 will use its internal frequency reference source for the PLL.

PLLRef settings: External or Internal

PRBS n – pseudo random bit sequence

Operating mode: Pattern
Menu: PATTERN

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 14. Table 4-4 lists the length of the PRBS for each "n" setting.

PRBS n settings: n = 5 to 14

Recall

Operating mode: All
Menu: Utility

Up to nine instrument setups can be saved in memory (refer to "Save"). An instrument setup can be restored to a saved setup using the **Recall** soft key.

After pressing the **Recall** soft key, select the memory location of the saved setup. The instrument will return to that setup. The instrument can also be returned to the default settings.

Recall options: Default, Mem1, Mem2, Mem3, Mem4, Mem5, Mem6, Mem7, Mem8 or Mem9

Save

Operating mode: All
Menu: Utility

Up to nine instrument setups can be saved in memory. After configuring the instrument as desired, use the **Save** soft key to save the setup to one of the nine memory locations.

Use the **Recall** soft key to return the instrument to a saved setup (refer to "Recall").

Save options: Mem1, Mem2, Mem3, Mem4, Mem5, Mem6, Mem7, Mem8, Mem9

SrcZ – source impedance

Operating mode: All
Menu: VOLTS

The Series 3400 specifications are rated for a source impedance of 50Ω or 1kΩ into a 50Ω load impedance.

Refer to "LoadZ – load impedance" for details on load impedance and source impedance.

SrcZ settings: 50 Ohms or 1 kOhms

System

Operating mode: All
Menu: UTILITY

The **System** soft key displays the following soft key options for system based operations:
Refer to "Display"
Refer to "Cal – calibration"
Refer to "GPIBAdd – GPIB address"
Refer to "IOPort – I/O port (interface)"
Refer to "Emul – emulation"

TrailE – trailing edge

Operating mode: All
Menu: TIME

Transition times (leading edge and trailing edge) are the intervals between corresponding 10% and 90% amplitude points on the rising/falling edge of the pulse. The leading edge time and trailing edge time can be set independently for each output channel of the Model 3402 Pulse/Pattern Generator. Also, there are ranges on which transition times can be independently set.

Changing the trailing edge time may also change the leading edge time. Therefore, after changing the trailing edge time, check the leading edge time (refer to "LeadE – leading edge") and change it as needed.

TrailE setting range: 2ns to 200ms

TrgFreq – trigger frequency

Operating mode: Pulse, Burst and Pattern
Menu: TRIGGER

Sets the frequency of the PLL trigger source. When setting the trigger frequency, trigger period (time) is set according to the following calculation:

trigger period = 1 / trigger frequency

Refer to "TrigPer – trigger period" for details on setting trigger speed as time.

TrgFreq setting range: 1mHz to 165MHz

TrgMode – trigger mode

Operating mode: Pulse, Burst and Pattern
Menu: TRIGGER

Sets the trigger mode: Continuous, triggered or gated.

Continuous – For continuous (Cont), continuous pulse output starts when the channel is enabled.

Triggered – For triggered (Trig'd), the trigger source (TrgSrc) triggers a single pulse period, or a burst of pulse periods, or a pattern of bits (periods).

Gated – For Gated, the leading edge of an external trigger (ExtIn) triggers the first pulse, burst or pattern of pulse periods. The trailing edge trigger marks the last pulse, burst or pattern of pulse periods

TrgMode settings: Cont, Trig'd or Gated

TrigPer – trigger period

Operating mode: Pulse, Burst and Pattern
Menu: TRIGGER

Sets the period (time) of the PLL trigger source. When setting the trigger frequency (Hz), trigger period is set according to the following calculation:

trigger frequency = 1 / trigger period

Refer to "TrgFreq – trigger frequency" for details on setting trigger speed as frequency.

TrigPer setting range: 6.06ns to 1000s

TrgSlope – trigger slope

Operating mode: Pulse, Burst and Pattern
Menu: TRIGGER

With the ExtIn or PLL trigger source selected, the positive-edge, negative-edge (or both) of the source will trigger a pulse/pattern period.

TrgSlope settings: Pos, Neg or Both

TrgSrc – trigger source

Operating mode: Pulse, Burst and Pattern
Menu: TRIGGER

For non-continuous operation, pulsing is controlled by a trigger source: External, PLL or Manual.

External – For external triggering (ExtIn), the external trigger source is connected to the Ext In connector.

PLL – For internal triggering, the PLL is used for triggering. Note that the PLL period source (PerSrc) and PLL trigger source (TrgSrc) cannot be used together.

Manual – For manual triggering (Manual), a trigger is generated when the **ManTrg** soft key is pressed.

TrgSrc settings: ExtIn, PLL or Manual

Update

Operating mode: Pattern
Menu: PATTERN

A pattern can be edited while it is being sourced. With continuous (Cont) updating, the output pattern will update immediately when it is changed. Otherwise, the pattern will not update until the **Now** soft key is pressed.

Update settings: Now or Cont

Width

Operating mode: Pulse, Burst and Pattern (RZ only)
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 3402 Pulse/Pattern Generator.

Width setting range: 3.02ns to (Period – 3.02ns)

Section 5
Triggering

In this section:

Triggering overview

The Series 3400 has three triggering modes for Pulse, Burst and Pattern: Continuous, Triggered and Gated. For the External Width mode, triggering is controlled by an external trigger. Table 5-1 summarizes the triggering capability of the Series 3400.

NOTE *Timing diagrams are used throughout this section to show the relationship between the trigger signals and the channel output(s).*

Table 5-1
Triggering summary

TrgMode:	Continuous (Cont)			Triggered (Trig'd)			Gated			N/A
Operating Mode[1]:	Pulse	Burst	Pattern	Pulse	Burst	Pattern	Pulse	Burst	Pattern	ExtWidth
Double pulse:	Single or Double		N/A[2]	Single or Double		N/A[2]	Single or Double		N/A[2]	
PerSrc:	VCO, PLL or ClkIn			N/A[2]	VCO, PLL[3] or ClkIn		VCO, PLL[3] or ClkIn			N/A[2]
TrgSrc:	N/A[2]			ExtIn or Manual	ExtIn, PLL[3] or Manual		ExtIn			ExtIn
Trig Out:	Marks each pulse period or bit period									
Strobe Out[4]:	—	1st and last	Bit Pattern	—	1st and last	Bit Pattern	—	1st and last	Bit Pattern	—

1) For Pulse and Burst, output (PulseNum) can be single or double pulses. For Pattern, bit output format can be NZ or NRZ.
2) N/A = Not Applicable (setting not significant).
3) PLL cannot be used as the period source (PerSrc) and trigger source (TrgSrc) at the same time.
4) Strobe Out:
   Pulse – Not used.
   Burst – Goes high when first pulse of burst is triggered. Goes low when last pulse is triggered.
   Pattern – Bit pattern programmed by the user.
   ExtWidth – Not used.

Double pulse

The Series 3400 can be set for Single or Double pulse output. For Single, a channel will output one pulse per period. For Double, a channel will output two pulses per period.

The pulse number is set from the **Double** soft key (accessed from the TIME menu). From this menu select Single or Double.

Period source (PerSrc)

The Series 3400 can use one of two internal period sources (VCO or PLL), or an external clock (ClkIn) for pulse period generation. The **PerSrc** soft key (accessed from the TIME menu) is used select and configure the period source:

PLL and VCO – The PLL is more accurate than the VCO, but the VCO is more precisely triggered (startable). See specifications for accuracy differences. The PLL period source and the PLL trigger source (TrgSrc) cannot be used at the same time.

ClkIn – The external clock signal (connected to Clk In) can be ±6V. Series 3400 settings for an external clock include the following:

- Input impedance (ClkInTerm): 50Ω or 10kΩ
- Slope (ClkInSlp): Pos or Neg
- Threshold (ClkInThr): -3V to +3V

Trigger source (TrgSrc)

For non-continuous triggering, Pulse, Burst or Pattern output can be controlled by external triggering (ExtIn), the **Manual** soft key (Manual) or the internal PLL. The **TrgSrc** soft key (accessed from the TRIGGER menu) is used select and configure the trigger source:

ExtIn – The external trigger (connected to Ext In) can be ±6V. Series 3400 settings for an external trigger include the following:

- Input impedance (ExtInTrm): 50Ω or 10kΩ (UTILITY menu)
- Threshold (ExtInThr): -3V to +3V (UTILITY menu)

Manual – When Manual is selected as the trigger source and TrgMode = Trig'd, the **ManTrg** soft key appears on the display. It is used to control triggering.

PLL – After PLL is selected as the trigger source, the trigger period (TrgPer) can be set from 6.06ns to 1000s. When set as frequency (TrgFreq), it can be set from 1mHz to 165MHz.

Trigger slope (TrgSlope) – With the ExtIn or PLL trigger source selected, the positive-edge, negative-edge (or both) of the source will trigger a pulse/pattern period. Trigger slope can be set for Pos, Neg or Both. The TrgSlope soft key is accessed from the TRIGGER menu.

Trigger Out and Strobe Out

Trigger Out is available for all operating modes and marks each pulse or bit. Each output trigger sent to an external instrument triggers it to perform an operation. If the external instrument is a scope, a waveform capture will be performed. If the external instrument is another Series 3400, a Pulse, Burst or Pattern will be started.

Strobe Out is available in Burst mode and marks the first pulse and last pulse of each burst. It is similar to Trigger Out, but will trigger the external instrument to start an operation when the last pulse of the burst has started. Strobe Out is also available in Pattern mode and is bit programmable by the user.

Trig Out and Strobe Out provide TTL (0V/2.4V) levels that have a 50Ω output impedance.

PLL reference (PLLRef)

When using multiple Series 3400s in a test system, the PLL in one Series 3400 can be used by all the other Series 3400 units. Using one PLL provides synchronized period source generation for all the units in the test system:

PLLRef – The PLLRef soft key (accessed from the UTILITY menu) is used to select the following options:

- External - The series 3400 uses the externally supplied signal as the reference for the PLL.
- Internal – The Series 3400 will use its internal frequency reference source for the internal PLL.

Ref In and Ref Out connectors – When using multiple Series 3400s in a test, the PLL reference of a single unit may be shared (made common to all units) by daisy-chaining the Ref Out of one unit to Ref In of another. Figure 3-6 shows two units connected together for using the PLL reference of the first unit.

Continuous

In the continuous trigger mode, output starts immediately as soon as a channel is enabled, and continues until the channel is disabled.

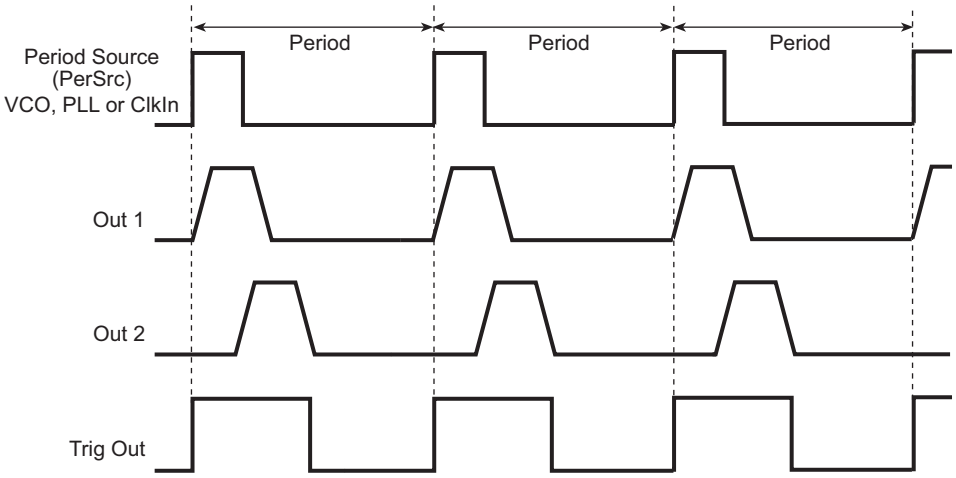
Continuous Pulse mode

Timing for the continuous Pulse mode is shown in Figure 5-1:

Period Source – Pulse output is synchronized to the selected period source: VCO, PLL or Clk In.

Trig Out – A TTL level pulse is generated for every pulse period.

Figure 5-1
Continuous Pulse mode



Continuous Burst mode

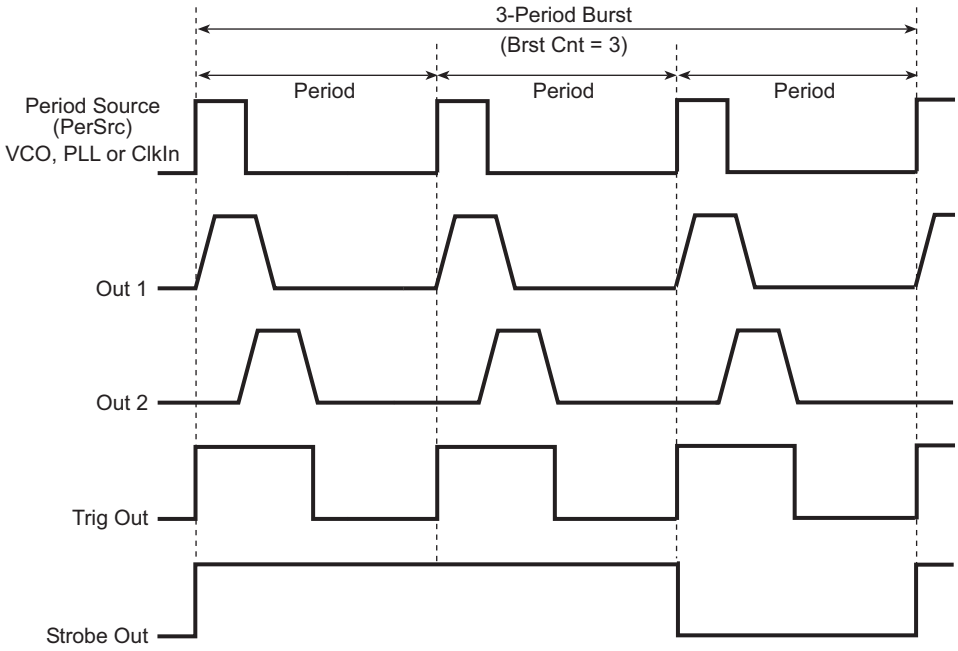
Timing for the continuous Burst mode is shown in Figure 5-2:

Period Source – Pulse output is synchronized to the selected period source: VCO, PLL or Clk In.

Trig Out – A TTL level pulse is generated for every pulse period.

Strobe Out – TTL level goes high at the start of the first pulse period for the burst, and goes low at the start of the last pulse period.

Figure 5-2
Continuous Burst mode



Continuous Pattern mode

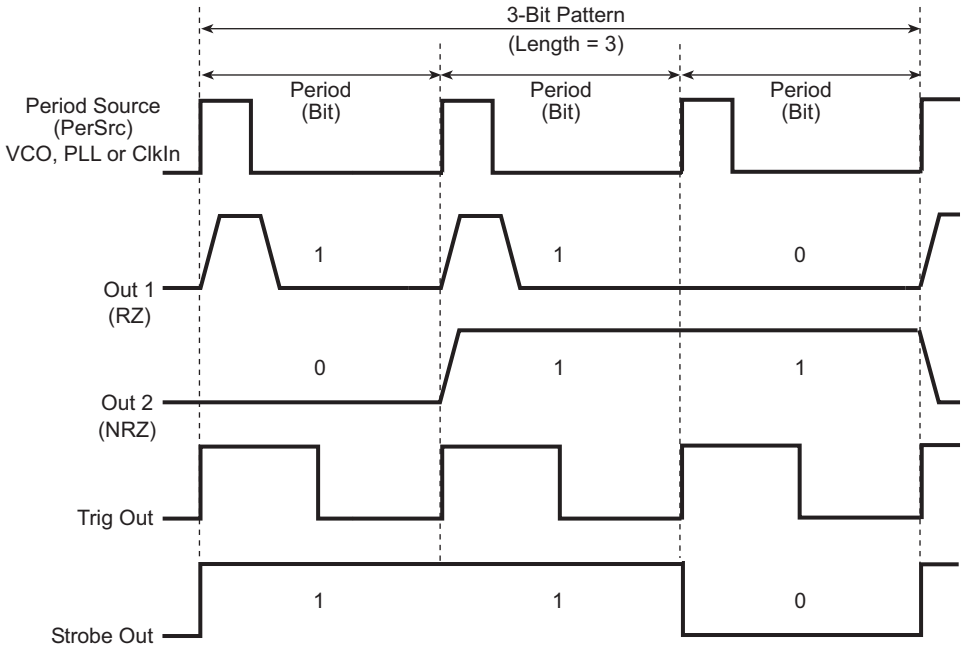
Timing for the continuous Pattern mode is shown in Figure 5-3:

Period Source – Bit output is synchronized to the selected period source: VCO, PLL or Clk In.

Trig Out – A TTL level pulse is generated for every bit (period).

Strobe Out – TTL level output that is bit-programmable using the NRZ format.

Figure 5-3
Continuous Pattern mode



Triggered

In triggered, an enabled channel output is controlled by a trigger source. Each trigger will start a single Pulse, Burst or Pattern.

Triggered Pulse mode

Timing for the triggered Pulse mode is shown in Figure 5-4, Figure 5-5, and Figure 5-6.

Trigger Source – A single pulse period is triggered by an external trigger (ExtIn), the internal PLL, or by pressing the **Manual** soft key (Manual):

- ExtIn – A pulse period is started by the active edge of an external trigger connected to the Ext In connector. The active edge could be the positive (Pos) slope of the trigger source (Figure 5-4), the negative (Neg) slope (Figure 5-5) or Both (Figure 5-6).
- PLL – Each positive slope edge of the internal PLL triggers a pulse period (refer to Figure 5-4). The trigger period (TrgPer) can be set from 6.06ns to 1000s. When set as frequency (TrgFreq), it can be set from 1mHz to 165MHz.
- Manual – When the Manual trigger source is selected and TrgMode = Trig'd, the **ManTrg** soft key appears on the display. Pressing this soft key starts a single pulse period.

Trig Out – A TTL level pulse is generated for every pulse period.

Figure 5-4
Triggered Pulse mode (positive slope)

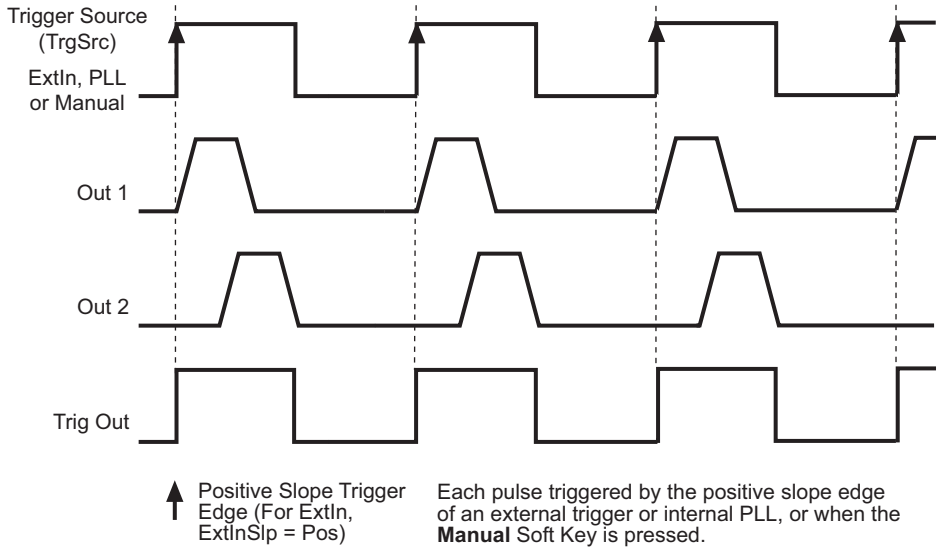


Figure 5-5
Triggered Pulse mode (negative slope)

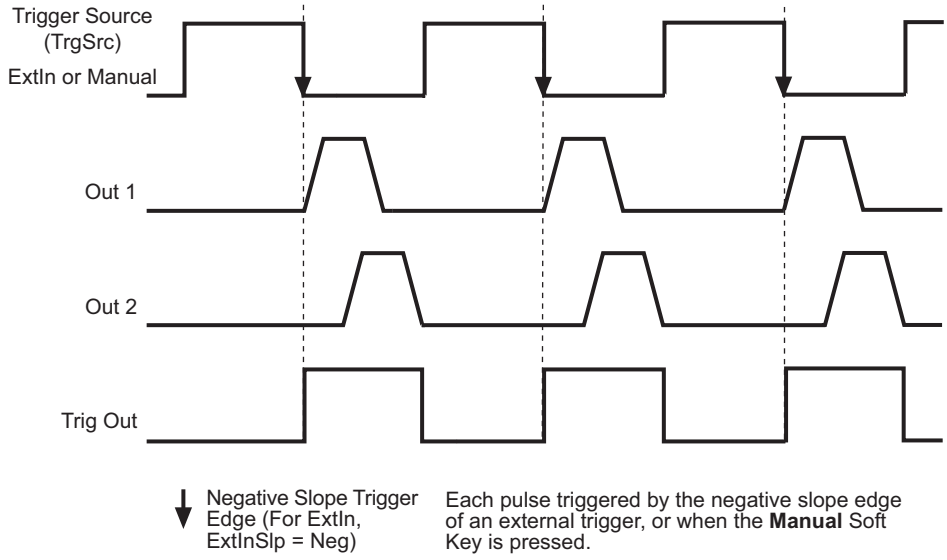
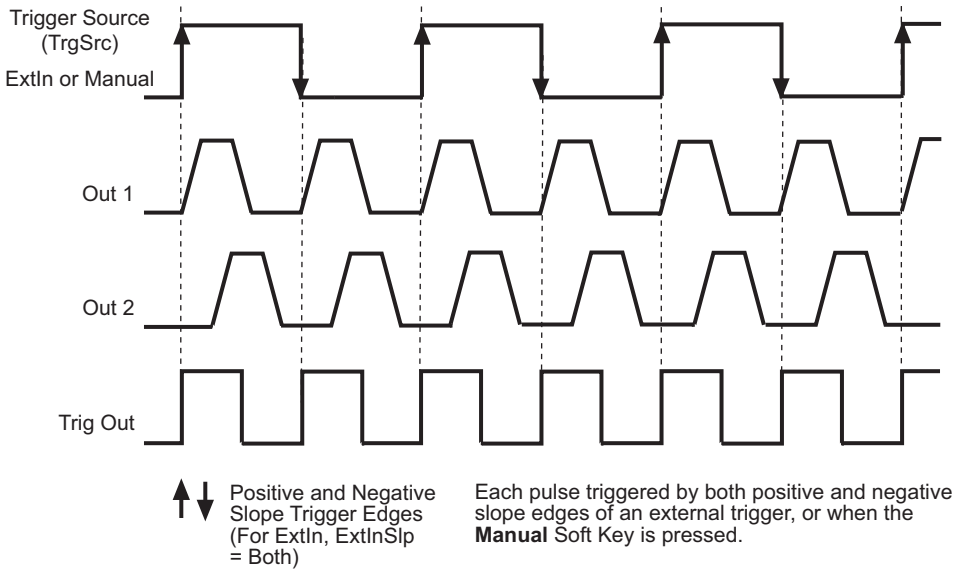


Figure 5-6
Triggered Pulse mode (positive and negative slope)



Triggered Burst mode

Timing for the triggered Burst mode is shown in Figure 5-7 (VCO period source) and Figure 5-8 (PLL or ClkIn period source). Note in Figure 5-8 that the PLL and ClkIn period sources are not synchronized to the external trigger source (ExtIn). The delay between trigger and start of the period is calculated as follows:

Delay = n x Period where, $1 < n \leq 2$

Trigger Source – A single burst of pulse periods is triggered by an external trigger (ExtIn), the internal PLL or by pressing the **Manual** soft key (Manual):

- ExtIn – A burst of pulse periods is started by the active edge of an external trigger connected to the Ext In connector. The active edge could be the positive (Pos) slope of the trigger source, the negative (Neg) slope or Both.
- PLL – Each positive slope edge of the internal PLL triggers a burst of pulse periods. The trigger period (TrgPer) can be set from 6.06ns to 1000s. When set as frequency (TrgFreq), it can be set from 1mHz to 165MHz. Note that the PLL trigger source and PLL period source cannot be used at the same time.
- Manual – When the Manual trigger source is selected and TrgMode = Trig'd, the **ManTrg** soft key appears on the display. Pressing this soft key starts a single burst of pulse periods.

Period Source – Pulse output is synchronized to the selected period source: VCO, PLL or Clk In. Note that the PLL period source and PLL trigger source cannot be used at the same time.

Trig Out – A TTL level pulse is generated for every pulse period.

Strobe Out – TTL level goes high at the start of the first pulse period of the burst, and goes low at the start of the last pulse period.

Figure 5-7
Triggered Burst mode (VCO period source)

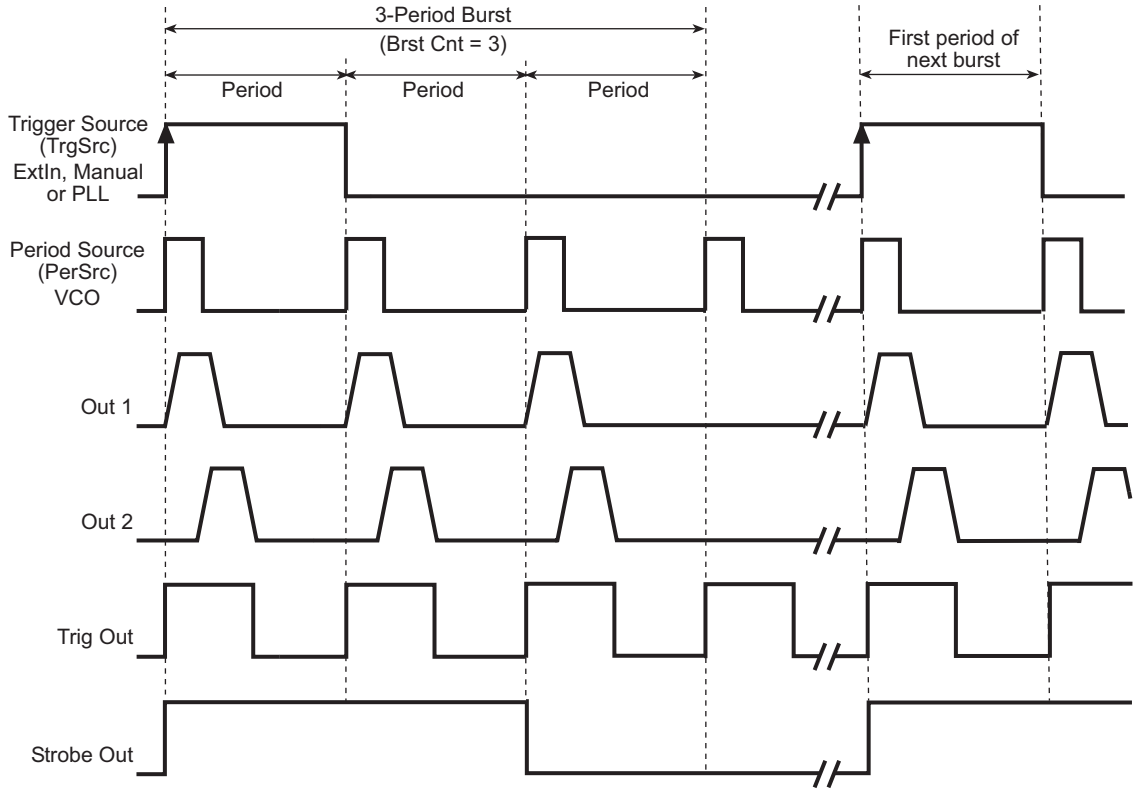
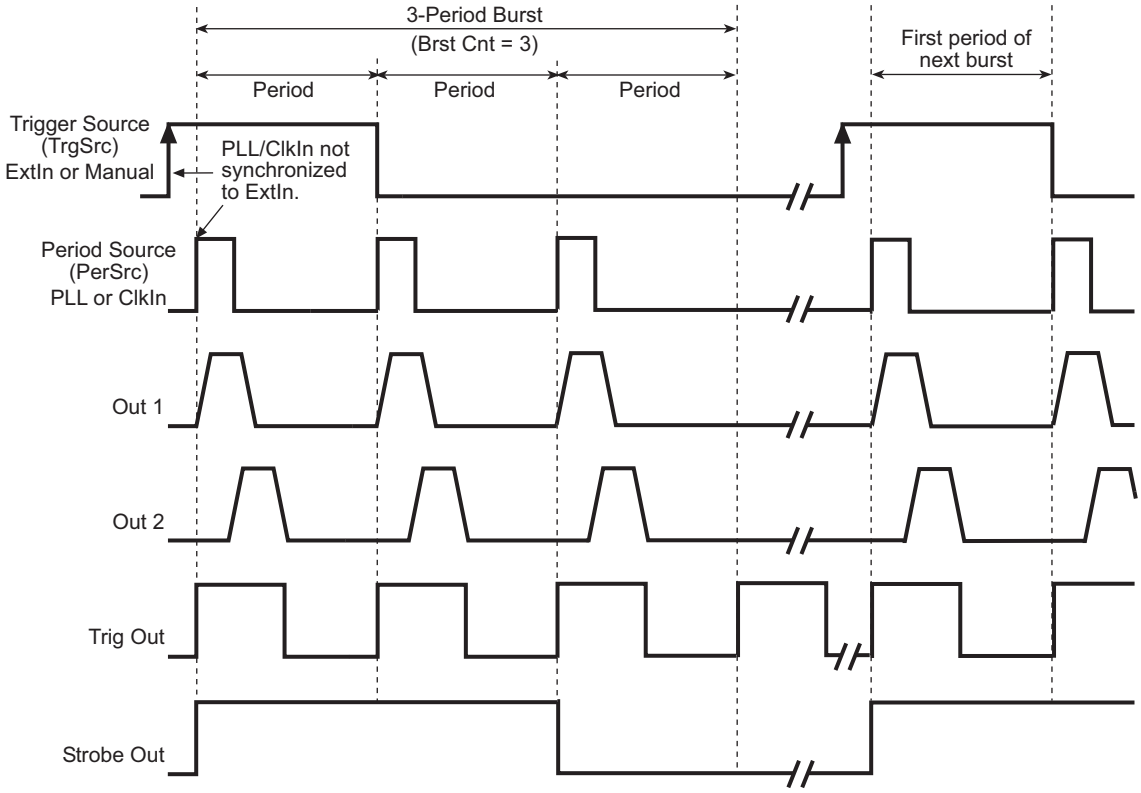


Figure 5-8
Triggered Burst mode (PLL or ClkIn period source)



Triggered Pattern mode

Timing for the triggered Pattern mode is shown in Figure 5-9 (VCO period source) and Figure 5-10 (PLL or ClkIn period source). Note in Figure 5-10 that the PLL and ClkIn period sources are not synchronized to the external trigger source (ExtIn). The delay between trigger and start of the period is calculated as follows:

Delay = n x Period where, $1 < n \leq 2$

Trigger Source – A single pattern of bits (periods) is triggered by an external trigger (ExtIn), the internal PLL or by pressing the **Manual** soft key (Manual):

- ExtIn – A pattern of bit periods is started by the active edge of an external trigger connected to the Ext In connector. The active edge could be the positive (Pos) slope of the trigger source, the negative (Neg) slope or Both.
- PLL – Each positive slope edge of the internal PLL triggers a pattern of bits. The trigger period (TrgPer) can be set from 6.06ns to 1000s. When set as frequency (TrgFreq), it can be set from 1mHz to 165MHz. Note that the PLL trigger source and PLL period source cannot be used at the same time.
- Manual – When the Manual trigger source is selected, the **Manual** soft key appears on the display. Pressing this soft key starts a single pattern of bits.

Period Source – Pattern output is synchronized to the selected period source: VCO, PLL or Clk In. Note that the PLL period source and PLL trigger source cannot be used at the same time.

Trig Out – A TTL level pulse is generated for every pulse period.

Strobe Out – TTL level output that is bit-programmable using the NRZ format.

Figure 5-9
Triggered Pattern mode (VCO period source)

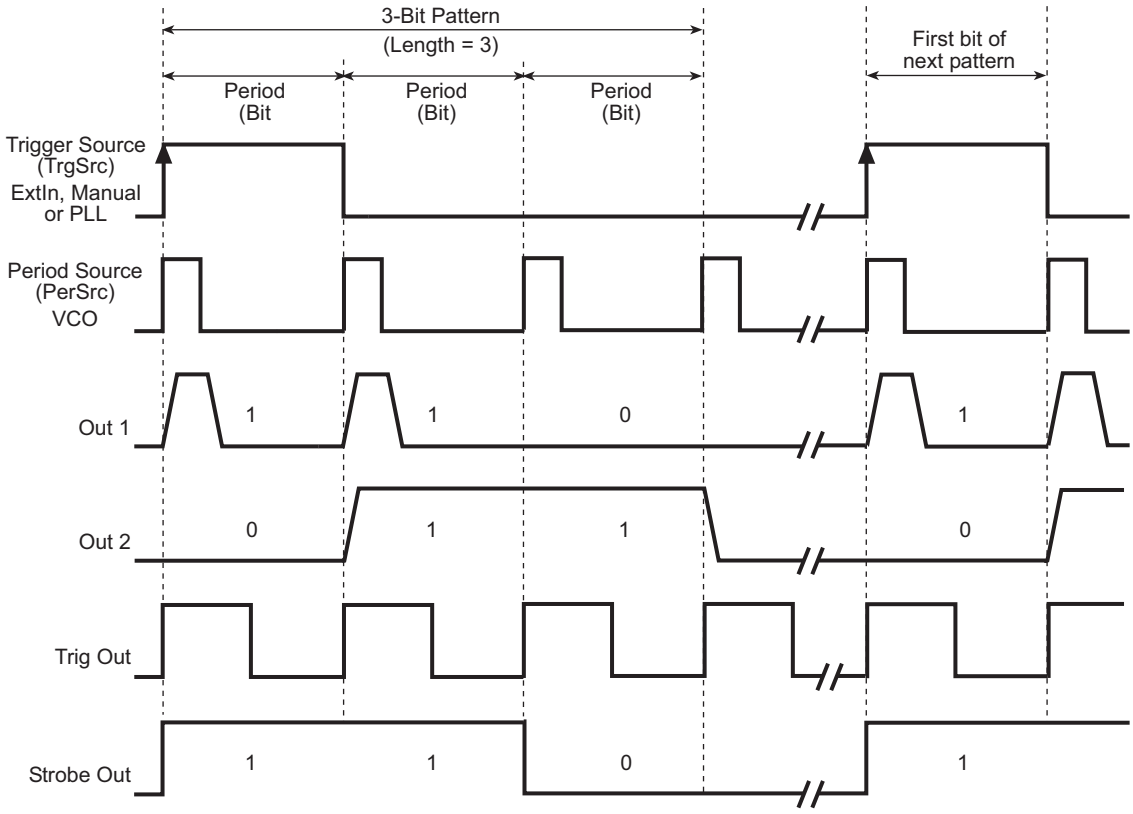
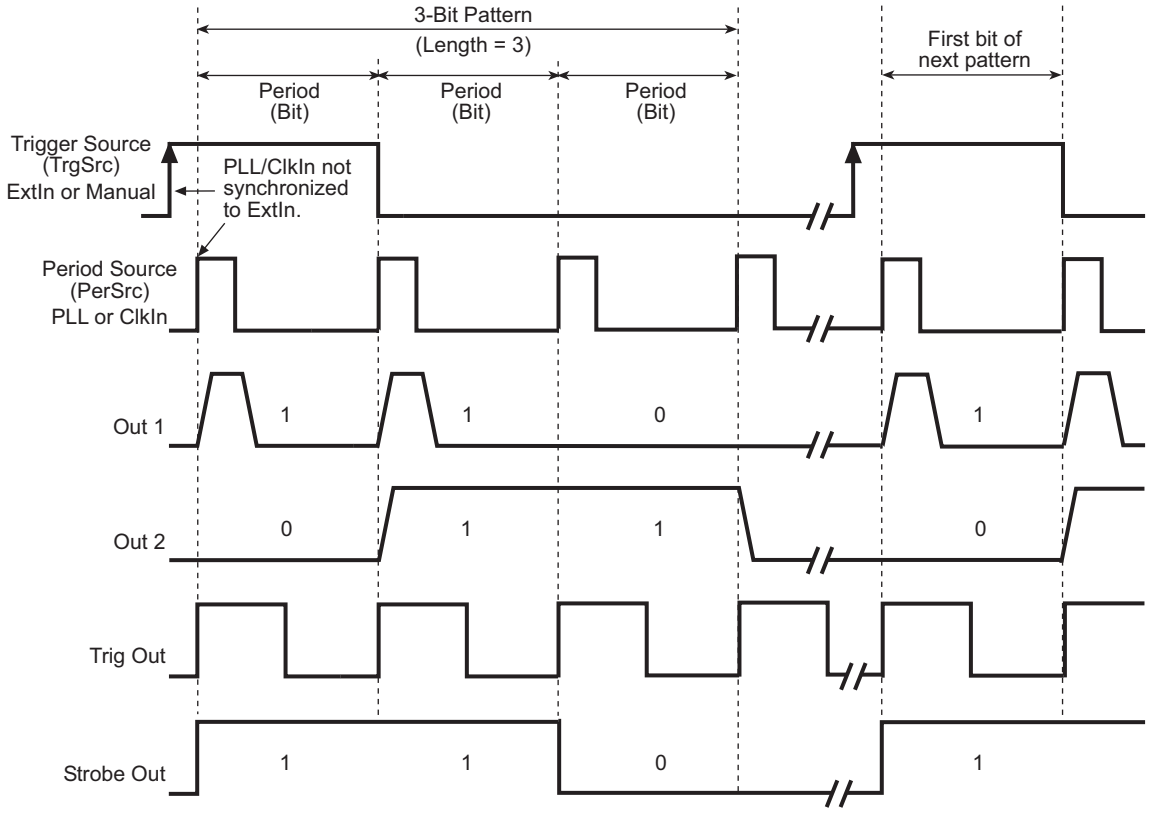


Figure 5-10
Triggered Pattern mode (PLL or ClkIn period source)



Gated

In the gated trigger mode, an enabled channel output is controlled by the leading and trailing edge on an external trigger.

Gated Pulse mode

Timing for the gated Pulse mode is shown in Figure 5-11 (VCO period source) and Figure 5-12 (PLL or ClkIn period source). Note in Figure 5-12 that the PLL and ClkIn period sources are not synchronized to the external trigger source (ExtIn). The delay between trigger and start of the period is calculated as follows:

Delay = n x Period where, $1 < n \leq 2$

Trigger Source – Pulse periods start when the rising edge of an external trigger (ExtIn) is detected. The falling edge of the trigger marks the last pulse period. In Figure 5-11 and Figure 5-12, three pulse periods are started by each gated trigger.

Period Source – Pulse output is synchronized to the selected period source: VCO, PLL or Clk In.

Trig Out – A TTL level pulse is generated for every pulse period.

Figure 5-11
Gated Pulse mode (VCO period source)

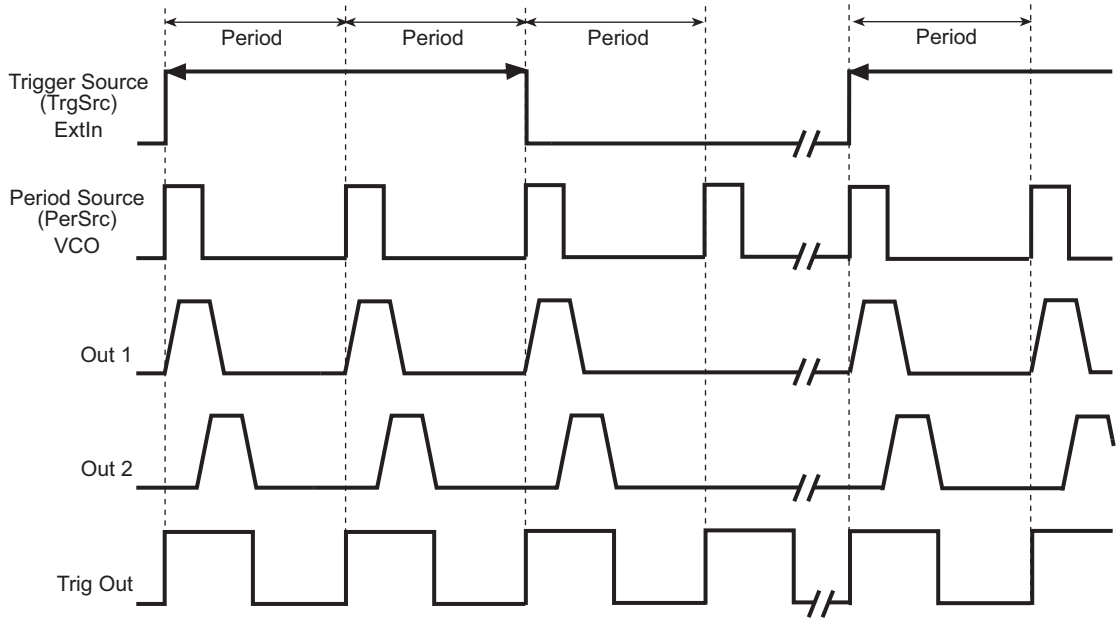
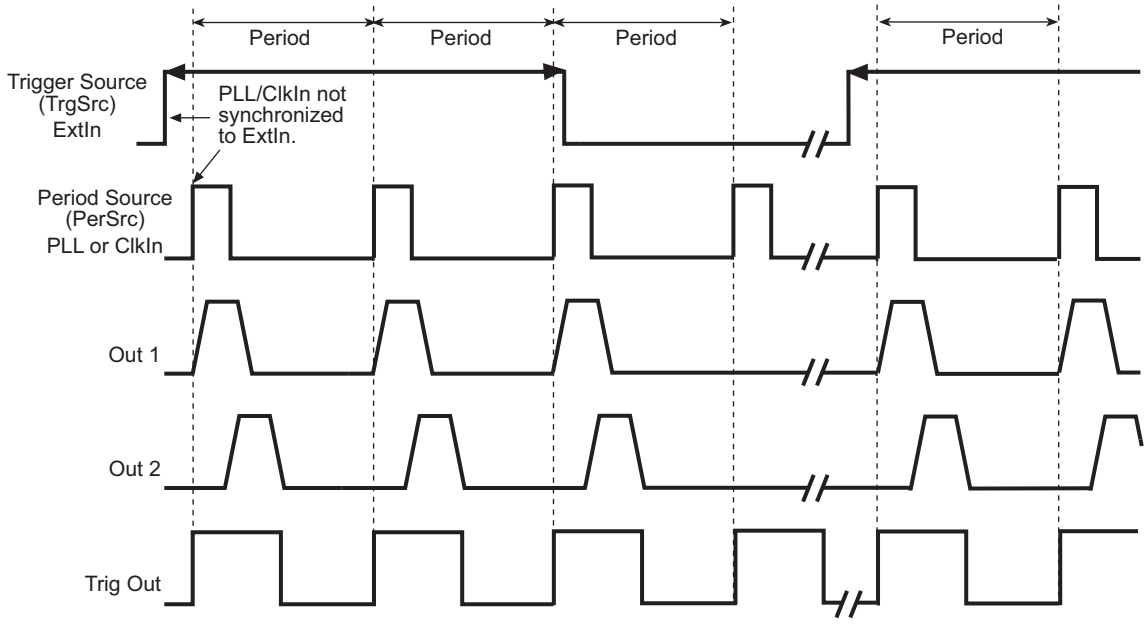


Figure 5-12
Gated Pulse mode (PLL or ClkIn period source)



Gated Burst mode

Timing for the gated Burst mode is shown in Figure 5-13 (VCO period source) and Figure 5-14 (PLL or ClkIn period source). Note in Figure 5-14 that the PLL and ClkIn period sources are not synchronized to the external trigger source (ExtIn). The delay between trigger and start of the period is calculated as follows:

Delay = n x Period where, $1 < n \leq 2$

Trigger Source – Pulse periods for a burst start when the rising edge of an external trigger (ExtIn) is detected. The falling edge of the trigger marks the last burst. In Figure 5-13 and Figure 5-14, the Burst count is 2. Two 3-period bursts are started by each gated trigger.

Period Source – Pulse output is synchronized to the selected period source: VCO, PLL or Clk In.

Trig Out – A TTL level pulse is generated for every pulse period.

Strobe Out – TTL level goes high at the start of the first pulse period for the burst, and goes low at the start of the last period for the Burst.

Figure 5-13
Gated Burst mode (VCO period source)

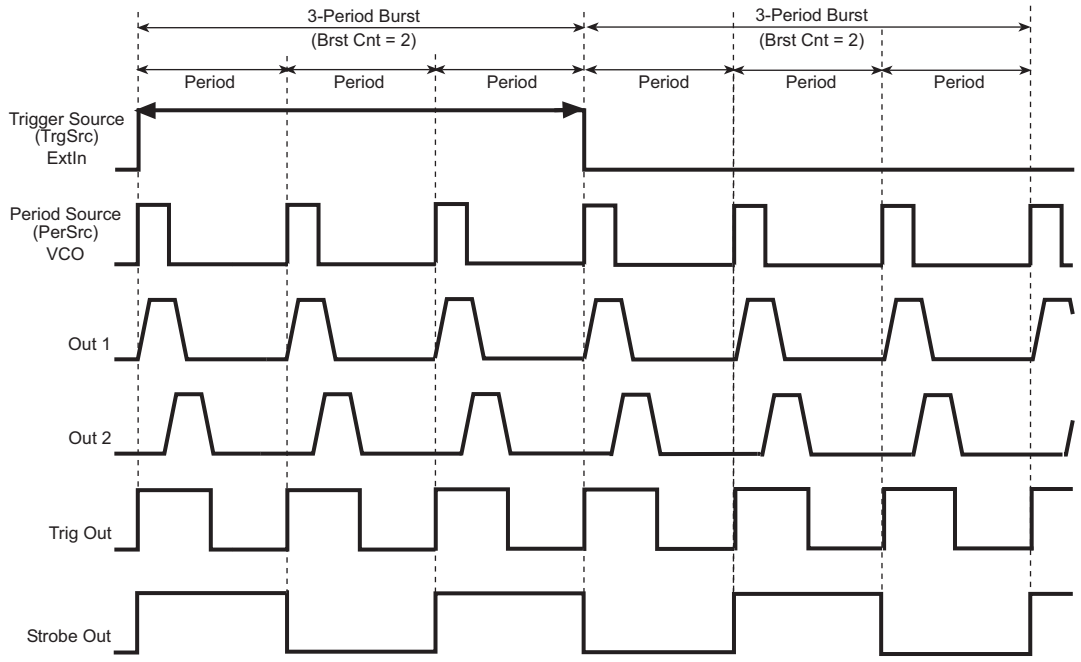
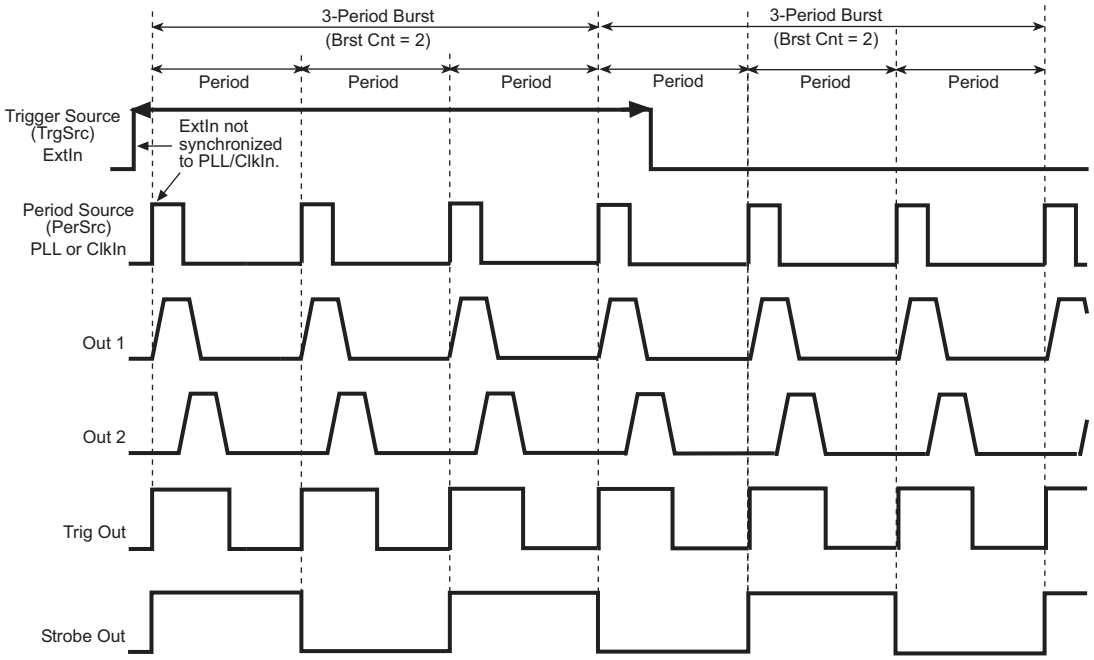


Figure 5-14
Gated Burst mode (PLL or ClkIn period source)



Gated Pattern mode

Timing for the gated Pattern mode is shown in Figure 5-15 (VCO period source) and Figure 5-16 (PLL or ClkIn period source). Note in Figure 5-16 that the PLL and ClkIn period sources are not synchronized to the external trigger source (ExtIn). The delay between trigger and start of the period is calculated as follows:

Delay = n x Period where, $1 < n \leq 2$

Trigger Source – Bit periods for a pattern start when the rising edge of an external trigger (ExtIn) is detected. The falling edge of the trigger marks the last pattern. In Figure 5-15 and Figure 5-16, the Pattern length is 3 bits. Two 2-bit patterns are started by each gated trigger.

Period Source – Pattern output is synchronized to the selected period source: VCO, PLL or Clk In.

Trig Out – A TTL level pulse is generated for every bit period.

Strobe Out – Strobe output is programmable by the user.

Figure 5-15
Triggered Pattern mode (VCO period source)

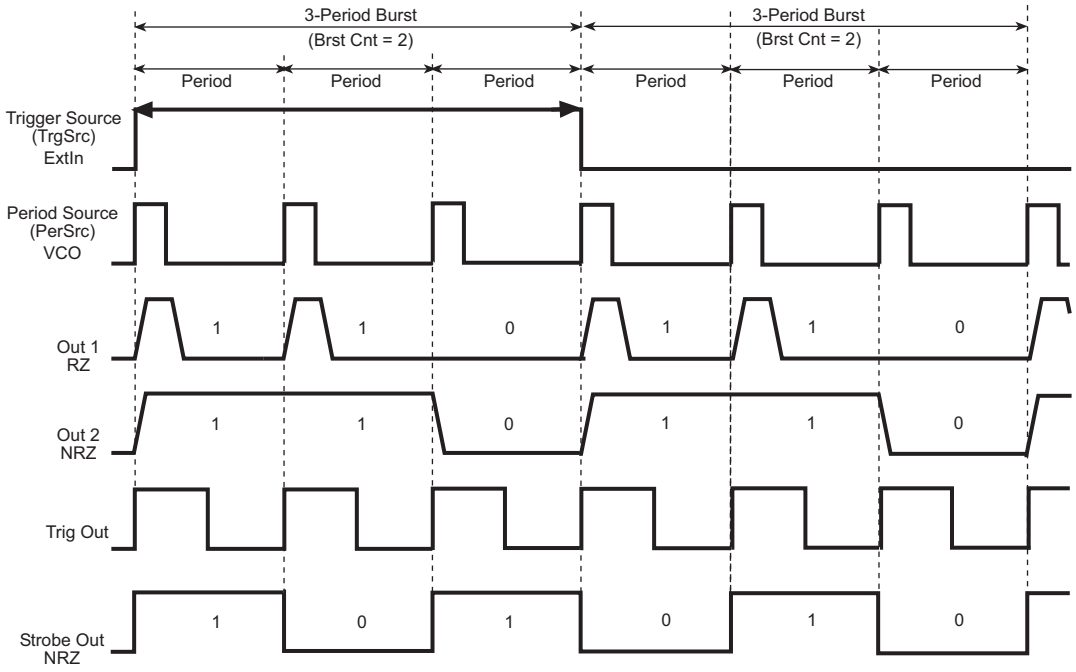
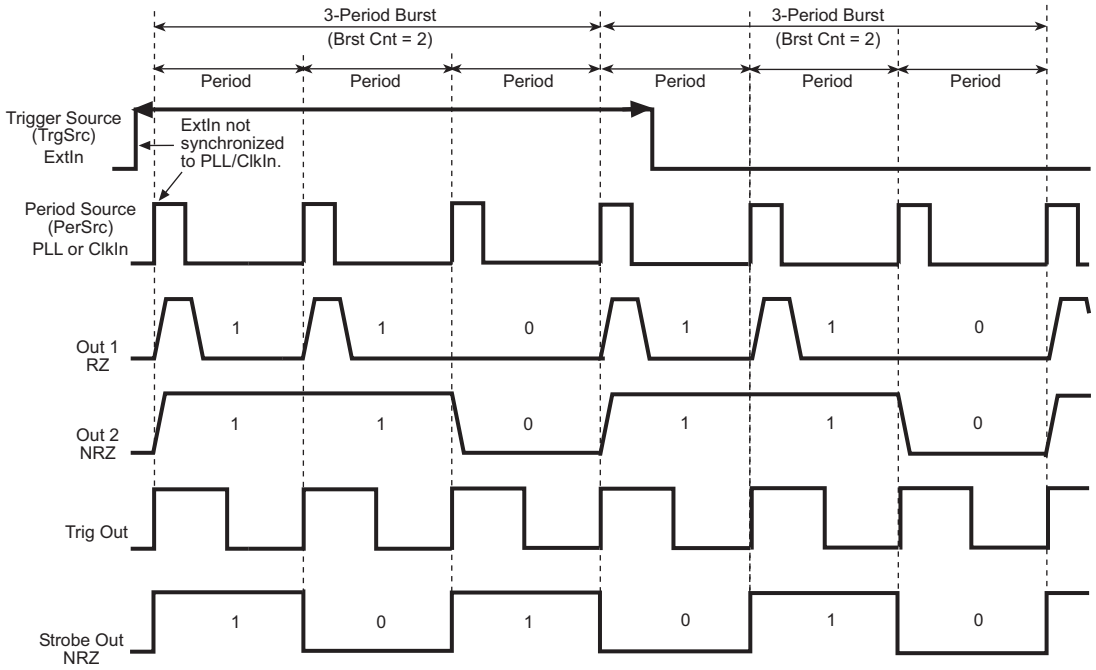


Figure 5-16
Triggered Pattern mode (PLL or ClkIn period source)



External Width

Trigger Source – In the External Width operating mode, the pulse width is controlled by an external trigger:

ExtIn – The pulse level follows the edges of an external trigger. A rising edge causes the output to go high, while a falling edge causes the output to go low.

User Interface and remote programming mapping

Remote programming commands don't always map as expected to the front panel settings of the User Interface (UI). Table 5-2 provides the mapping between commands and UI settings.

- If TrigMode = Cont or :ARM:SOUR is set to IMM, the user can set :ARM:SENS to EDGE or LEV. The TrigSrc parameter on the front panel can be set to either ExtIn PLL or Manual, with the exception of Pulse mode, where PLL cannot be used as the trigger source. The :ARM:SENS setting or TrgSrc setting is ignored.
- If TrigMode ≠ Cont or :ARM:SOUR is set to either EXT or INT2 or MAN, the :ARM:SENS command will be restricted. For example, if :ARM:SOUR is set to MAN, :ARM:SENS EDGE is the only acceptable condition — an error will occur if :ARM:SENS LEV is sent. This is because a manual gated condition cannot exist for the Series 3400.

Table 5-2
Mapping for User Interface settings and remote programming commands

User Interface Setting*		Remote Command
TrigMode = Cont	maps to	**:ARM:SOUR IMM**
TrigMode = Trig'd	maps to	**:ARM:SENS EDGE**
TrigMode = Gated	maps to	**:ARM:SENS LEV**
TrigSrc = ExtIn	maps to	**:ARM:SOUR EXT**
TrigSrc = PLL	maps to	**:ARM:SOUR INT2**
TrigSrc = Man	maps to	**:ARM:SOUR MAN**
PerSrc = VCO	maps to	**:TRIG:SOUR IMM**
PerSrc = PLL	maps to	**:TRIG:SOUR INT2**
PerSrc = ClkIn	maps to	**:TRIG:SOUR EXT2**

* Trigmode and TrigSrc are set from the TRIGGER menu. PerSrc is set from the TIME menu.

Section 6
Remote Programming

In this section:

Introduction

This section provides detailed information on the remote programming of the Series 3400.

Remote interfaces

The Series 3400 has two remote interfaces: IEEE-488 and USB. Note that you can use only one interface at a time.

NOTE *The instrument must be rebooted after selecting a different interface or making any 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 Series 3400 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 Series 3400 conforms to the IEEE-488.2 and SCPI standards (Standard Commands for Programmable Instruments). IEEE-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 goes one step farther than IEEE-488.2 and defines a standard set of commands to control every programmable aspect of an instrument.

Connections

The Series 3400 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.

Although any number of connectors could theoretically be stacked on one instrument, it is recommended that you stack no more than three connectors on any one unit to avoid possible mechanical damage.

In order to minimize interference caused by electromagnetic radiation, it is recommended that only shielded IEEE-488 cables be used. The Models 7007-1 and 7007-2 shielded IEEE-488 cables are available from Keithley Instruments.

Connect the Series 3400 to the IEEE-488 bus as follows:

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 6-1 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 for 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 6-1
IEEE-488 and USB connector locations on rear panel

Address selection

The default primary address for the Series 3400 is 10. The primary address may be set to any value between 0 and 30 as long as address conflicts with other instruments are avoided. Note that controllers are also given a primary address, so do not use that address either. 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, perform the following procedure:

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 knob and/or numeric keys.

NOTE *You must reboot the instrument after making changes to communication parameters.*

USB interface

Before using the USB (Universal Serial Bus) interface, be sure to disconnect the GPIB from the instrument, as only one interface can be used at a time.

Connections

The Series 3400 includes a type B USB socket located on the rear panel (refer to Figure 6-1). Typically, you will use a USB cable equipped with a type A plug on one 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 Series 3400.

USB identifiers

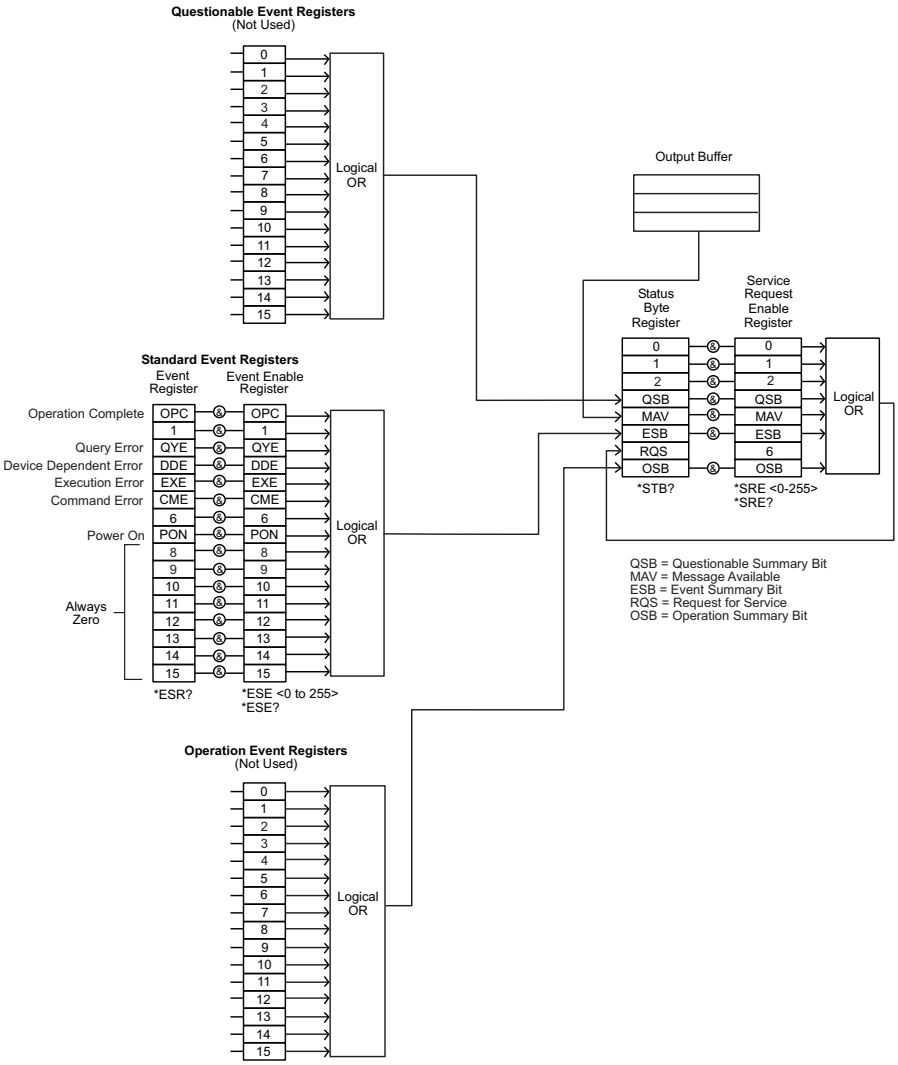
Model 3401-F and 3401-R: VID (Vender ID) = 0x05E6
PID (Product ID) = 0x3401

Model 3402-F and 3402-R: VID (Vender ID) = 0x05E6
PID (Product ID) = 0x3402

Status model

The Series 3400 provides a number of status registers allowing the operator to monitor and manipulate the various instrument events. The status model is shown in Figure 6-2. The heart of the status model is the Status Byte Register. This register can be read by the user's test program to determine if a service request (SRQ) has occurred, and what event caused it.

Figure 6-2
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 Series 3400. While these registers can still be accessed with corresponding SCPI commands for compatibility with other instruments, associated status register bits are not used and always set to 0. Refer to "SCPI command reference" (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.

Transition filters: Used to detect changes of state in the condition register and set the corresponding bit in the event register. Transition filter bits can be set to detect positive transitions (PTR), negative transitions (NTR) or both. These registers are read-write registers and are not affected by *CLS.

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 6-1.

Table 6-1
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 6-2. 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 6-2
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 Series 3400 has been turned on. Querying this bit resets it to zero, and remains zero as long as the instrument remains on.

Operation Status group

The Operation Status group is not used by the Series 3400. Bits in the associated status register are not used and 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 Series 3400. Bits in the associated status register are not used and 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 Series 3400 are summarized in Table 6-3. Many of these commands are associated with the status model. Refer to "Status model" (earlier in this section) for more information.

Table 6-3
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[3]
*OPC	Set Operation Complete bit when all pending actions are completed
*OPC?	Read status of the Operation Complete bit
*OPT?	Returns "K13401" for the Model 3401 or"K13402" for the Model 3402[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

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.The *IDN? and *OPT? queries have different responses when Emulation mode is enabled. Refer to **Emul** in Section 4 of this manual.

Table 6-3 (continued)
Common commands

Command [1]	Description
*TRG	Trigger instrument
*TST?	Execute instrument self-test. It will return a "0" if the Series 3400 boots correctly.
*WAI	Wait until all pending actions are complete

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.The *IDN? and *OPT? queries have different responses when Emulation mode is enabled. Refer to **Emul** in Section 4 of this manual.

Command examples

```
*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 6-4.

General notes:

- Brackets ([ ]) are used to denote optional character sets. These optional characters do not have to be included in the program message. 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 a state (on or off), can be sent as follows:
  - ON or 1 (for the on state)
  - OFF or 0 (for the off state).

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

Table 6-4
SCPI command summary

Command	Parameters	Default	Description	Page
:ARM			ARM subsystem	6-14
[SEQuence[1] | :STARt]				
[:LAYer[1]]				
:EWIDth				
[:STATe]	ON | OFF | 1 | 0	0	Set/query External Width Mode	6-14
:FREQuency	<numeric>	100kHz	Set/query trigger frequency with internal PLL used as source	6-14
:IMPedance	<numeric>	50Ω	Set/query impedance at EXT INPUT	6-15
:LEVel	<numeric>	+1.0V	Set/query threshold level at EXT INPUT	6-15
:PERiod	<numeric>	10.0µs	Set/query trigger period with internal PLL used as source	6-15
:SENSe	EDGE | LEVel	EDGE	Set/query trigger on edge or on level	6-16
:SLOPe	POS | NEG | EITH	POS	Set/query trigger slope at EXT INPUT	6-16
:SOURce	IMM | INT[1] | INT2 | EXT[1] | MAN	IMM	Set/query trigger source (VCO | PLL | EXT INPUT | ManTrg key)	6-16
:CHANnel			CHANnel subsystem	6-18
:MATH	OFF | PLUS	OFF	Set/query addition of Ch 1 and Ch 2 at Ch 1 output	6-18
:CALibration[:ALL]			CALibration subsystem Set/query calibration of period (VCO), delay, and width circuits	6-18
:DIGital			DIGital subsystem	6-19
[:STIMulus]				
:PATTern				
:DATA[1|2|3]	[<start>], data	#1200	Set/query pattern data, from bit <start>	6-19
:PRBS[1|2|3]	[<n>], <length>		Set PRBS 2^n-1 data (n = 5 to 14)	6-20
[:STATe]	OFF | ON | 0 | 1	0	Set/query pattern mode state of on/off	6-20
:UPDate	OFF | ON | 0 | 1 ONCE	1	Set/query pattern mode update setting	6-20
:SIGNal[1|2]				
:FORMat	RZ | NRZ	RZ	Set/query pattern format of designated output channel	6-20

Table 6-4 (continued)
SCPI command summary

Command	Parameters	Default	Description	Page
:DISPlay			DISPlay subsystem	6-21
:BRIGhtness	<numeric>	8	Set display brightness	6-21
:CONTrast	<numeric>	6	Set display contrast	6-21
:TIMeout				
:DELay	<numeric>	30	Set display backlight-saver timer	6-22
[:STATe]	OFF | ON | 0 | 1	1	Enable or disable display backlight-saver timer	6-22
:OUTPut [1|2]			OUTPut subsystem	6-22
[:NORMal]				
[:STATe]	OFF | ON | 1 | 0	0	Set/query normal output state	6-22
:IMPedance				
[:INTernal]	<numeric>	50Ω	Set/query internal source impedance of output	6-23
:EXTernal	<numeric>	50Ω	Set/query external load impedance	6-23
:POLarity	NORM | INV	NORM	Set/query output polarity	6-24
[:SOURce]			SOURce subsystem	6-24
:CURRent [1|2]				6-24
[:LEVel]				
[:IMMediate]				
[:AMPlitude]	<numeric>	20mA	Set/query channel current amplitude	
:OFFSet	<numeric>	0.0µA	Set/query channel current offset	6-25
:HIGH	<numeric>	+10mA	Set/query channel current high level	6-25
:LOW	<numeric>	-10mA	Set/query channel current low level	6-26
:LIMit				
[:HIGH]	<numeric>	+10mA	Set/query channel current max limits	6-26
:LOW	<numeric>	-10mA	Set/query channel current min limits	6-26
:STATe	ON | OFF | 1 | 0	0	Enable/disable channel current limits	6-27
:FREQuency				
[:CW | :FIXed]	<numeric>	1MHz	Set/query pulse frequency	6-27
:AUTO	ONCE		Measure frequency at CLK IN	6-27
:HOLD [1|2]	VOLT | CURR	VOLT	Switch between VOLTage and CURRent targeted commands	6-28
:PHASe [1|2]				
[:ADJust]	<numeric>	0.0	Set/query channel phase	6-28

Table 6-4 (continued)
SCPI command summary

Command	Parameters	Default	Description	Page
[:SOURce]			SOURce subsystem (cont.)	
:PULSe				
:DCYCle [1|2]	<numeric>	10.0%	Set/query channel duty cycle	6-28
:DELay [1|2]	<numeric>	0.0	Set/query channel delay	6-29
:HOLD	TIME | PRATio	TIME	Hold absolute delay or delay as percent of period fixed with varying frequency	6-29
:UNIT	S | SEC | PCT | DEG | RAD	S	Set/query delay units	6-30
:DOUBle [1|2]				
[:STATe]	OFF | ON | 0 |1	0	Enable/disable double pulses	6-30
:DELay	<numeric>	0ps	Set/query delay between double pulses	6-30
:HOLD	TIME | PRATio	TIME	Hold absolute delay or delay as percent of period fixed with varying frequency	6-31
:UNIT	S | SEC | PCT	S	Set/query delay units	6-31
:HOLD [1|2]	WIDTh | DCY-Cle | TDELay	WIDTh	Hold width|duty cycle|trailing edge delay fixed with varying frequency	6-32
:PERiod	<numeric>	1µs	Set/query pulse period	6-32
:AUTO	ONCE		Measure pulse period at CLK IN	6-32
:TDELay [1|2]	<numeric>	100ns	Set/query trailing edge delay	6-33
:TRANsition [1|2]				
:HOLD	TIME | WRATio	TIME	Hold absolute transitions transitions as width ration fixed with varying width	6-33
:UNIT	S | SEC | PCT	S	Set/query transition time units	6-33
[:LEADing]	<numeric>	2ns	Set/query leading edge transition	6-34
:TRAiling	<numeric>	2ns	Set/query trailing edge transition	6-34
:AUTO	OFF | ON | 0| 1 ONCE	1	Couple trailing edge to leading edge	6-34
:WIDTh [1|2]	<numeric>	100ns	Set/query channel pulse width	6-35
:ROSCillator				
:SOURce	INTernal | EXTernal	EXT	Set/query PLL reference source	6-35

Table 6-4 (continued)
SCPI command summary

Command	Parameters	Default	Description	Page
:SOURce]			SOURce subsystem (cont.)	
:VOLTage [1|2]				
[:IMMediate]				
[:AMPLitude]	<numeric>	1000mV	Set/query channel amplitude voltage	6-36
:OFFSet	<numeric>	0.0mV	Set/query channel offset voltage	6-36
:HIGH	<numeric>	+500mV	Set/query channel high level voltage	6-37
:LOW	<numeric>	-500mV	Set/query channel low level voltage	6-37
:LIMit				
[:HIGH]	<numeric>	+500mV	Set/query max voltage limit	6-38
:LOW	<numeric>	-500mV	Set/query min voltage limit	6-38
:STATe	ON | OFF | 1 | 0	0	Enable/disable voltage limits	6-39
:STATus			STATus subsystem	
:OPERation				6-39
[:EVENt]?	<numeric>		Query operation event register	
:CONDition	<numeric>		Query operation condition register	
:ENABle	<numeric>		Set/query operation enable register	
:NTRansition	<numeric>		Set/query operation negative transition register	
:PTRansition	<numeric>		Set/query operation positive transition register	
:PREset				6-39
:QUEStionable				6-39
[:EVENt]?	<numeric>		Query questionable event register	
:CONDition?	<numeric>		Query questionable condition register	
:ENABLe	<numeric>		Set/query questionable enable register	
:NTRansition	<numeric>		Set/query questionable negative transition register	
:PTRansition	<numeric>		Set/query questionable positive transition register	

Table 6-4 (continued)
SCPI command summary

Command	Parameters	Default	Description	Page
:SYSTem			SYSTem subsystem	6-40
:CHECk[:ALL][:STATe]	OFF | ON| 0 | 1	1	Disable or enable error checking.	6-40
:ERRor?			Query error queue	6-40
:PRESet			No function	
:VERSion?			Query SCPI compliance setting	6-40
:TRIGger			TRIGger subsystem	6-40
[:SEQuence [1]|:STARt]				
:COUNt	<numeric>	1	Set/query number of triggered periods to ge generated per ARM event	6-40
:IMPedance	<numeric>	50Ω	Set/query impedance at CLK IN	6-41
:LEVel	<numeric>	1.00V	Set/query threshold level at CLK IN	6-42
:SLOPe	POS | NEG	POS	Set/query trigger slope at CLK IN	6-42
:SOURce	IMM | INT[1] | INT2 | EXT[2]	IMM	Set/query trigger source (IMM | VCO | PLL | CLK IN)	6-42

Command descriptions

ARM subsystem

:ARM:EWID

`:ARM[:SEQuence[1]|:STARt][:LAYer]:EWIDth[:STATe]`

Parameters ON | OFF | 1 | 0

Default 0

Query `:ARM:EWID?`

Description Use this command to enable the EXT WIDTH trigger mode available on the Mode/Trigger screen. When EXT WIDTH mode is switched on, the rest of the :ARM and :TRIG system is disabled. In EXT WIDTH mode a signal applied to the EXT INPUT determines the width and period of the output signal(s) from the instrument. You can still control the edge transition times and levels of the output signal(s).

Example `:ARM:EWID ON`

:ARM:FREQ

`:ARM[:SEQuence[1]|:STARt][:LAYer]:FREQuency[:CW][:FIXed]`

Parameters Numeric

Suffix HZ with engineering prefixes, e.g.: MHZ is Megahertz

Limits 1mHz to 165MHz

Default 100kHz

Query `:ARM:FREQ?`

Description Use this command to program the frequency of the PLL (INTernal2) when it is used as the :ARM:SOURce for internal triggering of pulses, bursts or patterns. If you are using the PLL as :TRIGger:SOURce to set the pulse frequency, use the [:SOURce]:FREQuency[:CW|:FIXed] command.

Example To set up bursts of four 100MHz pulses occurring at a burst rate of 10MHz:

```
:TRIG:SOUR INT          Select internal osc. as pulse-period source
:FREQ 100MHZ            Set pulse frequency to 100MHz
:ARM:SOUR INT2          Select PLL as triggering source
:ARM:SENS EDGE          Sense edge of PLL signal
:ARM:FREQ 10 MHZ        Set triggering frequency to 10 MHZ
:TRIG:COUNT 4           Set burst length to 4
```

:ARM:IMP

:ARM[:SEQuence[1]|:STARt][:LAYer]:IMPedance

Parameters Numeric

Suffix OHM with engineering prefixes, e.g.: MOHM is Megohms

Limits 50Ω or 10kΩ

Default 50Ω

Query :ARM:IMP?

Description Use this command to program the input impedance of the EXT INPUT connector. Note that only two settings are available. If you try to program any other value, it will be rounded down to one of the specified values.

Example

```
:ARM:IMP 50OHM          Set EXT INPUT impedance to
                        50Ω
```

:ARM:LEV

:ARM[:SEQuence[1]|:STARt][:LAYer]:LEVel

Parameters Numeric

Suffix V with engineering prefixes

Limits -3V to +3V

Default +1.0V

Query :ARM:LEV?

Description Use this command to program the triggering threshold of the EXT INPUT connector.

Example

```
:ARM:LEV 2.5V           Set EXT INPUT threshold to 2.5 V
```

:ARM:PER

:ARM[:SEQuence[1]|:STARt][:LAYer]:PERiod

Parameters Numeric

Suffix S or SEC with engineering prefixes

Limits 6.06ns to 1000s

Default 10.00µs

Query :ARM:PER?

Description Use this command to program the period of the PLL (INTernal2) when it is used as the `:ARM:SOURce` for internal triggering of pulses, bursts or patterns. If you are using the PLL as `:TRIGger:SOURce`, use the `[:SOURce]:PULSe:PERiod` command to set the pulse period.

Example To set up bursts of four 10-ns pulses occurring every 100ns:

```
:TRIG:SOUR INT          Select internal osc. as pulse-period source
:PER 10 NS              Set pulse period to 10ns
:ARM:SOUR INT2          Select PLL as triggering source
:ARM:SENS EDGE          Sense edge of PLL signal
:ARM:PER 100ns          Set triggering period to 100ns
:ARM:TRIG:COUNT 4       Set burst length to 4
```

:ARM:SENS

`:ARM[:SEQuence[1]|:STARt][:LAYer]:SENSe`

Parameters EDGE | LEVel

Default EDGE

Query `:ARM:SENS?`

Description Use this command to select Triggered or Gated mode by choosing whether the instrument arms on the edge(s) or level of the arming signal. When sensing edges, the instrument triggers when the arming signal crosses the selected threshold level (`:ARM:LEV`) in the selected direction (`:ARM:SLOP`). This corresponds to the Triggered mode selected on the Mode/Trigger screen when using the front panel. When sensing levels, the instrument triggers as long as the arming signal is above (`:ARM:SLOP POS`), or below `(:ARM:SLOP NEG`) the selected threshold level `(:ARM:LEV`). This corresponds to the Gated mode selected on the Mode/Trigger screen when using the front panel.

Example

```
:ARM:SENS EDGE          Select edge sensing
```

:ARM:SLOP

`:ARM[:SEQuence[1]|:STARt][:LAYer]:SLOPe`

Parameters POSitive | NEGative | EITHer

Default POS

Query `:ARM:SLOP?`

Description Use this command to select the trigger slope for the arming signal when triggering on edges. Use EITHer to trigger on both the positive and negative edges of the arming signal. This allows you to trigger at twice the frequency of the arming signal. 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           Select negative slope
```

:ARM:SOUR

`:ARM[:SEQuence[1]|:STARt][:LAYer]:SOURce`

Parameters IMMediate | INTernal[1] | INTernal2 | EXTernal[1] | MANual

Default IMM

Query `:ARM:SOUR?`

Description Use this command to select the triggering mode of the instrument by selecting the source of the arming signal (use `:ARM:SENSe EDGE | LEVel` to choose between triggered and gated):

Table 6-5
:ARM:SOUR source selections

Triggering source	ARM:SOURce	Mode
Internal osc.	IMMediate|INTernal[1]	CONTINUOUS
PLL	INTernal2	TRIGGERED|GATED by PLL
EXT INPUT	EXTernal1	TRIGGERED|GATED by :EXT IN
ManTrg key	MANual	TRIGGERED|GATED by :MANKey

Example `:ARM:SOUR EXT` Select external arm source

CHANnel subsystem

:CHAN:MATH

:CHANnel:MATH

Parameters OFF | PLUS

Default OFF

Query :CHAN:MATH?

Description Use this command to enable or disable channel addition in an instrument with two output channels installed (Model 3402). With :CHAN:MATH PLUS the signals from both channels are added at output 1. Output 2 is not used. This allows you to, for example:

- generate 3 and 4 level waveforms
- simulate single or repeated glitches
- generate pulse transitions with a step-change in slew-rate
- simulate overshoot and undershoot.

For levels and amplitude values that can be added in the channel addition mode, refer to specifications.

With Channel Add enabled (Model 3402 only), changing the source and/or load impedance of either Channel 1 or Channel 2 will change the source and/or load impedance of the output.

Example :CHAN:MATH PLUS Enable channel addition

CALibration subsystem

:CAL

:CALibration[:ALL]

Parameters none

Default none

Query :CAL?

Description Use this command to perform a timing calibration of the instrument. The timing circuitries for VCO-period, delay and width are calibrated in reference to the internal PLL reference. The return values for the query command :CALibration[:ALL]? are as follows:

- 0 calibration passed
- >0 calibration failed

When the instrument is switched off and on again, the factory calibration data are activated again.

DIGital subsystem

:DIG:PATT:DATA[1|2|3]

:DIGital[:STIMulus]:PATTern:DATA[1|2|3]

Parameters [<start>,] <data>

Default

Table 6-6
:DIG:PATT:DATA[1|2|3]

Channel		Default		
[1|2|3]	**Description**	**Bit 1**	**Bit 2**	**Bits 3 to 16384**
1	CH1 (OUTPUT 1)	1	1	1
2	CH2 (OUTPUT 2)	0	1	0
3	STRB (STROBE OUT)	1	0	0

Query `:DIG:PATT:DATA[1|2|3]?`

Description Use this command to set or read the pattern data of one or all channels starting from Bit 1. The <data> is an arbitrary block of program data as defined in IEEE 488.2 (7.7.6.2, for example. Note: The optional <start> parameter is ignored by the instrument if you use it):

#1541213

#	Start of block
1	Length of the data
5	Length of the data
41213	5 bytes of data

#2161000100010001000

#	Start of block
2	Length of the data
16	Length of the data
10...00	16 bytes of data

Examples `:DIG:PATT:DATA #1541213`

The instrument uses each byte of data set one bit in the pattern memory. If you don't specify a particular channel, the lowest three bits of each byte are used to set all three channels, and the top five bits are ignored. Note that you can therefore use the ASCII characters .0.,.1.,.2., and .3. to program Outputs 1 and 2 in binary with STROBE=0 (or .4.,.5.,.6., and .7. for STROBE=1):

`:DIG:PATT:DATA2 #1501011`

If you specify a particular channel, the least significant bit of each byte is used to set the selected channel, and the top seven bits are ignored. Note that you can therefore use the ASCII characters "1" and "0" to set individual bits to 1 and 0:

`:ARM:SOUR IMM`	Set continuous mode
`:DIG:PATT:DATA3 #1501011`	Set up pattern data for STROBE channel
`:TRIG:COUN 5`	Set pattern length (last bit) to
`:DIG:PATT ON`	Switch on PATTERN mode

:DIG:PATT:PRBS[1|2|3]

`:DIGital[:STIMulus]:PATTern:PRBS[1|2|3]`

Parameters <n>,<length>

Limits
<n> 5 to 14 (integer)
<length> 2 to 16384 (integer)

Default Not applicable

Query None

Description Use this command to set up PRBS data starting from bit 1. The parameter <n> is used as the basis to generate a 2^n-1 PRBS. The parameter <length> determines how many bits of the PRBS sequence are used. If <length> is longer than the PRBS, the PRBS is repeated as necessary to achieve the required length.

Example To set up a repeating 2^{10}-1 PRBS on output 1:

```
:ARM:SOUR IMM              Set continuous mode
:TRIG:COUN 1023            Set pattern length (last bit) to 1023
:DIG:PATT:PRBS1 10,1023    Set up PRBS on OUTPUT 1
:DIG:PATT ON               Switch on PATTERN mode
```

:DIG:PATT

`:DIGital[:STIMulus]:PATTern[:STATe]`

Parameters ON | OFF | 1 | 0 |

Default 0

Query `:DIG:PATT?`

Description Use this command to enable and disable Pattern mode. Use `:TRIG:COUN` to program the length of the pattern.

Example `:DIG:PATT ON` Enable Pattern mode

:DIG:PATT:UPD

`:DIGital[:STIMulus]:PATTern:UPDate`

Parameters ON | OFF | 1 | 0 | ONCE

Default 1

Query `:DIG:PATT:UPD?`

Description Use this command to enable and disable the automatic updating of the pattern generating hardware following a `:DIG:PATT:DATA` command. Disable the automatic updating if you want to set up new pattern data in the instrument without affecting the pattern which is currently being generated. You can then update the hardware with the new pattern data by sending a `:DIG:PATT:UPD ONCE` command.

Example `:DIG:PATT:UPD ONCE` Update hardware with pattern

:DIG:SIGN[1|2]:FORM

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

Parameters RZ | NRZ
Range Coupling: Period, Frequency

Default RZ

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

Description Use this command to set and read the data format 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.

An RZ pulse is generated for each 1 in the data. You can vary the width, edges and levels of the pulse.

NRZ Non Return to Zero.

A pulse of 100% duty cycle is generated for each 1 in the data. You can vary the edges and levels of the pulse.

Example `:DIG:SIGN:FORM NRZ` Set channel 1 data format to NRZ

DISPlay subsystem

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

:DISP:TIM

:DISPlay:TIMeout[:STATe]

Parameters ON | OFF | 1 | 0

Default 1

Query :DISP:TIM?

Description Use this command to enable or disable the LCD display backlight-saver timer.

Example :DISP:TIM ON Enable display timer

:DISP:TIM:DEL

:DISPlay:TIMeout:DELay

Parameters Numeric (seconds)

Limits 1 to 100

Default 30

Query :DISP:TIM:DEL?

Description Use this command to set the LCD display backlight-saver timer duration.

Example :DISP:TIM:DEL 50 Set timer duration to 50 seconds

OUTPut subsystem

:OUTP[1|2]

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

Parameters ON | OFF | 1 | 0

Default 0

Query :OUTP[1|2]?

Description Use this command to switch the normal outputs on or off.

Examples
:OUTP1 ON Switch on output 1
:OUTP2 OFF Switch off output 2

:OUTP[1|2]:IMP

`:OUTPut[1|2]:IMPedance[:INTernal]`

Parameters Numeric

Suffix OHM with engineering prefixes, e.g.: MOHM is Megaohms

Limits 50Ω or 1kΩ

Default 50Ω

Query `:OUTP[1|2]:IMP?`

Description Use this command to program the source impedance of the output connectors. Note that only two settings are available. If you try to program any other value, it will be rounded to one of the specified values.

With Channel Add enabled (Model 3402 only), changing the source impedance of either Channel 1 or Channel 2 will change the source impedance of the output.

Description

Examples

`:OUTP1:IMP 50OHM`	Set output 1 impedance to 50Ω
`:OUTP2:IMP 1000OHM`	Set output 2 impedance to 1kΩ

:OUTP[1|2]:IMP:EXT

`:OUTPut[1|2]:IMPedance:EXTernal`

Parameters Numeric

Suffix OHM with engineering prefixes, e.g.: MOHM is Megaohms

Limits 0.1Ω to 1MΩ

Default 50.0Ω

Query `:OUTP[1|2]:IMP:EXT?`

Description Use this command to set the expected load impedance of the device-under-test at the output connectors. If you have a non-50Ω load, the output levels at the device-under-test will not be the levels you program or set via the front panel unless you set the expected load using this command.

With Channel Add enabled (Model 3402 only), changing the load impedance of either Channel 1 or Channel 2 will change the load impedance of the output.

Examples

`:OUTP1:IMP:EXT 47.6 OHM`	Set load impedance at OUTPUT 1 to 47.6Ω
`:OUTP2:IMP:EXT 1M OHM`	Set load impedance at OUTPUT 2 to 1MΩ

:OUTP[1|2]:POL

:OUTPut[1|2]:POLarity

Parameters NORMal | INVerted

Default NORM

Query :OUTP[1|2]:POL?

Description Use this command to invert the signal at the outputs.

Examples

:OUTP1:POL INV	Inverted signal at output 1
:OUTP2:POL NORM	Normal signal at output 2

SOURce subsystem

:CURR[1|2]

[:SOURce]:CURRent[1|2][:LEVel][:IMMediate][:AMPLitude]

Parameters Numeric

Value coupling:	Amplitude = High - Low Offset = (High - Low)/2
Range coupling:	Offset

Suffix A with engineering prefixes

Limits 2mApp to 200mApp, 50Ω into 50Ω
4mApp to 400mApp, 1kΩ into 50Ω

Default 20mA (50Ω into 50Ω)

Query :CURR[1|2]?

Description This command programs the amplitude current of the output signal. Note that to set the output levels in terms of current, you first have to execute the [:SOURce]:HOLD CURRent command to enable the [:SOURce]:CURRent subsystem.

The available current range is limited by the combination of:

- Specified voltage limits
- Actual output impedance setting :OUTPut:IMPedance
- Expected load impedance setting: :OUTPut:IMPedance:EXTernal

Example

:HOLD CURR	Enable CURRENT subsystem
:CURR1 75MA	Set output 1 amplitude to 75 mA

:CURR[1|2]:OFFSet

`[:SOURce]:CURRent[1|2][:LEVel][:IMMediate]:OFFSet`

Parameters Numeric

Value coupling:	Amplitude = High - Low Offset = (High + Low)/2
Range coupling:	Amplitude

Suffix A with engineering prefixes

Default 0.0mA (50Ω into 50Ω)

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

Description This command programs the offset current of the output signal. Note that to set the output levels in terms of current, you first have to execute the `[:SOURce]:HOLD CURRent` command to enable the `[:SOURce]:CURRent` subsystem.

The available current range is limited by the combination of:

- Specified voltage limits
- Actual output impedance setting `:OUTPut:IMPedance`
- Expected load impedance setting

Example

`:HOLD CURR`	Enable CURRENT subsystem
`:CURR1:OFF 50MA`	Set output 1 offset to 50mA

:CURR[1|2]:HIGH

`[:SOURce]:CURRent[1|2][:LEVel][:IMMediate]:HIGH`

Parameters Numeric

Value coupling:	Amplitude = High - Low Offset = (High + Low)/2
Range coupling:	Low-level

Suffix A with engineering prefixes

Limits 0 to ±200mA, 50Ω into 50Ω
0 to ±400mA, 1kΩ into 50Ω

Default +10mA (50Ω into 50Ω)

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

Description This command programs the high-level current of the output signal. Note that to set the output levels in terms of current, you first have to execute `[:SOURCE]:HOLD CURRent` command to enable the `[:SOURCE]:CURRent` subsystem.

The available current range is limited by the combination of:

- Specified voltage limits
- Actual output impedance setting `:OUTPut:IMPedance`
- Expected load impedance setting `:OUTPut:IMPedance:EXTernal`

Example

`:HOLD CURR`	Enable CURRENT subsystem
`:CURR1:HIGH 150MA`	Set output 1 high-level to 150mA

:CURR[1|2]:LOW

`[:SOURce]:CURRent[1|2][:LEVel][:IMMediate]:LOW`

Parameters Numeric

Value coupling:	Amplitude = High - Low Offset = (High + Low)/2
Range coupling:	High-level

Suffix A with engineering prefixes

Limits 0 to ±200mA, 50Ω into 50Ω
0 to ±400mA, 1kΩ into 50Ω

Default -10mA (50Ω into 50Ω)

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

Description This command programs the low-level current of the output signal. Note that to set the output levels in terms of current, you first have to execute the `[:SOURce]:HOLD CURRent` command to enable the `[:SOURce]:CURRent` subsystem.

The available current range is limited by the combination of:

- Specified voltage limits
- Actual output Impedance setting `:OUTPut:IMPedance`
- Expected load impedance setting `:OUTPUT:IMPedance:EXTernal`

Example

`:HOLD CURR`	Enable CURRENT subsystem
`:CURR1:LOW 50 MA`	Set output 1 low-level to 50mA

:CURR[1|2]:LIM

`[:SOURce]:CURRent[1|2]:LIMit[:HIGH]`

Parameters Numeric

Suffix A with engineering prefixes

Default +10.0mA

Query `:CURR[1|2]:LIM?`

Description Use this command to set/read the high-level current limit. If you switch on current limiting, the high-level current cannot be set above the programmed limit.

Note: The current is NOT limited by the OUTPUT hardware. This is a software limit and is dependent on amplitude, load impedance and source impedance settings.

Example

`:HOLD CURR`	Enable CURRENT subsystem
`:CURR1:LIM 50MA`	Set output 1 high-level current limit to 50mA
`:CURR1:LIM:STAT ON`	Switch on output 1 limits

:CURR[1|2]:LIM:LOW

`[:SOURce]:CURRent[1|2]:LIMit:LOW`

Parameters Numeric

Suffix A with engineering prefixes

Default -10.0mA

Query `:CURR[1|2]:LIM:LOW?`

Description Use this command to set/read the low-level current limit. If you switch on current limiting, the low-level current cannot be set below the programmed limit.

Note: The current is NOT limited by the OUTPUT hardware. This is a software limit and is dependent on amplitude, load impedance and source impedance settings.

Example

`:HOLD CURR`	Enable CURRENT subsystem
`:CURR1:LIM:LOW -50MA`	Set output 1 low-level current limit to -50mA
`:CURR1:LIM:STAT ON`	Switch on output 1 limits

:CURR[1|2]:LIM:STAT

[:SOURce]:CURRent[1|2]:LIMit:STATe

Parameters ON | OFF | 1 | 0

Default 0

Query `:CURR[1|2]:LIM:STAT?`

Description This command switches the output limits on or off. When you switch on the output limits, you cannot program the output-levels beyond the programmed limits until you switch off the output limits. The limits apply whether you program high/low levels or amplitude/offset levels. Note: You can switch the limits on and off in both the `[:SOURce]:CURRent` and the `[:SOURce]:VOLTage` subsystems but the current and voltage limits are not enabled/disabled independently. The voltage and current limits are always enabled/disabled together.

Example

`:HOLD CURR`	Enable CURRENT subsystem
`:CURR1:LIM 50MA`	Set output 1 high-level current limit to 50mA
`:CURR1:LIM:LOW -50MA`	Set output 1 low-level current limit to -50mA
`:CURR1:LIM:STAT ON`	Switch on output 1 limits

:FREQ

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

Parameters Numeric
Value coupling: Period = 1/Frequency

Suffix Hz with engineering prefixes, or MHZ for Megahertz

Limits 1mHz to 165MHz

Default 1.00MHz

Query `:FREQ?`

Description Use this command to set/read the pulse frequency. Select the frequency source for the pulse frequency using `:TRIGger:SOURce`. The currently selected source is programmed by this command. Note that the specified limits and available resolution depend on the selected source. You cannot set the pulse frequency if you have selected the CLK IN connector as the frequency source (`:TRIG:SOUR EXT2`).

Example

:TRIG:SOUR INT	Select internal osc. as pulse trigger
:FREQ 75MHz	Set pulse frequency to 75MHz

:FREQ:AUTO

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

Parameters ONCE

Default Not applicable

Description Use this command to measure the frequency at the CLK IN connector. If the CLK IN connector is the selected pulse frequency source, you can then read the measured value with `:FREQ?`.

Example

`:TRIG:SOUR EXT2`	Select ext CLK IN as pulse trigger
`:FREQ:AUTO ONCE`	Measure frequency at CLK IN
`:FREQ?`	Query pulse frequency

:HOLD

`[:SOURce]:HOLD`

Parameters VOLTage | CURRent

Default VOLT

Query `:HOLD?`

Description Use this command to enable either of the `[:SOURce]:VOLTage` or `[:SOURce]:CURRent` subsystems. You can control the signal levels of the instrument outputs in terms of voltage or current.

Example

`:HOLD CURR`	Enable CURRent subsystem

:PHAS[1|2]

`[:SOURce]:PHASe[1|2][:ADJust]`

Parameters Numeric

Functional coupling:	Programming the pulse phase also executes `[:SOURce]:PULSe:HOLD PHASe` so that the pulse phase is held constant when the signal frequency is changed.
Value coupling:	Delay = (Phase/360) x Period

Suffix DEG or RAD A parameter without a suffix is interpreted as RAD

Limits 0 to 360° constrained by delay and period limits

Default 0.0

Query `:PHAS[1|2]?`

Description Use this command to set/read the relative phase delay of the output signal. This is equivalent to setting an absolute or percentage pulse delay with `[:SOURce]:PULSe:DELay`. If you want the phase delay to remain constant when the pulse period is varied (rather than the absolute pulse delay) use [:SOURce]:PULSe:DELay[1|2]:HOLD PRATio.

Examples

`:PULS:DEL1 500NS`	Set output 1 delay to 500ns
`:PHAS2 180 DEG`	Set output 2 phase to 180°
`:PULS:DEL1:HOLD TIM`	Hold output 1 delay constant with varying period
`:PULS:DEL2:HOLD PRAT`	Hold output 2 phase constant with varying period

:PULS:DCYC[1|2]

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

Parameters Numeric

Value coupling:	Width = (Duty cycle/100)xPeriod

Limits 0.001% - 99.9%, depends on width, transition, and period

Default 10.0% (derived from Width and Period)

Query `:PULS:DCYC[1|2]?`

Description Use this command to program the duty cycle of the pulse signal. If you want to set an absolute pulse width use `[:SOURce]:PULSe:WIDTh[1|2]`. If you want the pulse duty cycle to remain constant when the pulse period is varied (rather than the absolute pulse width), use `:SOURce]:PULSe:HOLD[1|2] DCYCle.`

Examples

`:PULS:DCYC1 25PCT`	Set output 1 duty cycle to 25%
`:PULS:HOLD1 DCYC`	Hold duty cycle constant with varying period

:PULS:DEL[1|2]

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

Parameters Numeric

Value coupling: Phase = (Delay/Period)x360
Delay% = (Delay/Period)x100

Suffix S with engineering prefixes. You can change the default unit using `:PULSe:DELay[1|2]:UNIT`

Limits 0.00ns to (Period – 3.02ns)

Default 0.0

Query `:PULS:DEL[1|2]?`

Description Use this command to set/read the pulse delay. Delay is the time between the start of the pulse period and the start of the leading edge of the pulse. If you want the pulse delay to remain constant when the pulse period is varied (rather than the phase delay) use `[:SOURce]:PULSe:DELay[1|2]:HOLD TIME.`

Examples

`:PULS:DEL1 500NS`	Set output1 delay to 500ns
`:PHAS2 180 DEG`	Set output 2 phase to180°
`:PULS:DEL1:HOLD TIME`	Hold output 1 delay constant with varying period
`:PULS:DEL2:HOLD PRAT`	Hold OUTPUT 2 phase constant with varying period

:PULS:DEL[1|2]:HOLD

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

Parameters TIME | PRATio

Default TIME

Query `:PULS:DEL[1|2]:HOLD?`

Description Use this command to set/read the coupling between the pulse period and the pulse delay:

TIME - The absolute pulse delay is held fixed when the pulse period is varied (pulse phase varies).

PRATio - The pulse phase delay (delay as ratio of period) is held fixed when the pulse period is varied (pulse delay varies).

Examples

`:PULS:DEL1`	500ns Set output 1 delay to 500ns
`:PHAS2 180DEG`	Set output 2 phase to 180°
`:PULS:DEL1:HOLD TIME`	Hold output 1 delay constant with varying period
`:PULS:DEL2:HOLD PRAT`	Hold output 2 phase constant with varying period

:PULS:DEL[1|2]:UNIT

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

Parameters S | SEC | PCT | DEG | RAD

Default S

Query `:PULS:DEL[1|2]:UNIT?`

Description Use this command to set/read the default units for the pulse-delay parameter. The default unit of a parameter is the unit used when the parameter is programmed to a value without a unit suffix.

Examples

`:PULS:DEL1:UNIT PCT`	Set output 1 delay unit to %
`:PULS:DEL1 50`	Set output 1 delay to 50% of period

:PULS:DOUB[1|2]

`[:SOURce]:PULSe:DOUBle[1|2][:STATe]`

Parameters OFF | ON | 0 | 1

Default 0

Query `:PULS:DOUB[1|2]?`

Description Use this command to switch double-pulse mode on or off. In double pulse mode, two pulses are generated per pulse period and the delay between the leading edges of the first and second pulse can be adjusted.

Example

`:PULS:DOUB1 ON`	Turn on double pulse for output 1

:PULS:DOUB[1|2]:DEL

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

Parameters Numeric

Suffix S with engineering prefixes. You can change the default unit using `[:SOURce]:PULSe:DOUBle:DELay[1|2]:UNIT`.
Value coupling: DblDel% = (DblDel/Period)x100

Limits 6.06ns to 1000s, (period – width – 3.02ns), min period 11.12ns

Default 0.0ps

Query `:PULS:DOUB[1|2]:DEL?`

Description Use this command to set/read the delay between the leading edges of the two pulses in double-pulse mode. The first pulse always begins at the start of the pulse period. If you want the double-delay to remain constant when the pulse period is varied (rather than the double-delay as percentage of period), use `[:SOURce]:PULSe:DOUBle[1|2]:DELay:HOLD TIME`.

Examples

`:PULS:DOUB1 ON`	Switch on Double pulses on output 1
`:PULS:DOUB1:DEL 500NS`	Set inter-pulse delay to 500ns
`:PULS:DOUB1:DEL:HOLD TIME`	Hold inter-pulse delay fixed withvaryi pulse period

:PULS:DOUB[1|2]:DEL:HOLD

`[:SOURce]:PULSe:DOUBle[1|2]:DELay:HOLD`

Parameters TIME|PRATio

Default TIME

Query `:PULS:DOUB[1|2]:DEL:HOLD?`

Description Use this command to set/read the coupling between the pulse period and the double-pulse delay:

TIME - The absolute pulse delay is held fixed when the pulse period is varied (pulse phase varies).

PRATio - The pulse phase delay (delay as ratio of period) is held fixed when the pulse period is varied (pulse delay varies).

Examples

`:PULS:DOUB1 ON`	Enable double pulses on output 1
`:PULS:DOUB1:DEL 50 PCT`	Set inter-pulse delay to 50% of pulse period
`:PULS:DOUB1:DEL:HOLD PRAT`	Hold inter-pulse delay as fixed percentage of pulse period

:PULS:DOUB[1|2]:DEL:UNIT

`[:SOURce]:PULSe:DOUBle[1|2]:DELay:UNIT`

Parameters S | SEC | PCT

Default S

Query `:PULS:DOUB[1|2]DEL:UNIT?`

Description Use this command to set/read the default units for the double-delay parameter. The default unit is the unit used when the parameter is programmed to a value without a unit suffix.

Examples

`:PULS:DOUB1:DEL:UNIT PCT`	Set output 1 double-delay unit to %
`:PULS:DOUB1:DEL 50`	Set output 1 inter-pulse delay to 50% of period

:PULS:HOLD[1|2]

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

Parameters WIDTh | DCYCle | TDELay

Default WIDTh

Query `:PULS:HOLD[1|2]?`

Description Use this command to set whether the pulse width, the pulse duty cycle, or the pulse trailing edge delay is held constant when the pulse period is changed.

Examples

`:PULS:DEL:HOLD1 TIME`	Hold output 1 delay fixed when frequency varies
`:PULS:DEL 20NS`	Set output 1 delay to 20ns
`:PULS:HOLD1 DCYC`	Hold output 1 duty cycle fixed when frequency varies
`:PULS:DCYC 25PCT`	Set output 1 duty cycle to 25%

:PULS:PER

`[:SOURce]:PULSe:PERiod`

Parameters Numeric
Value coupling: Frequency = 1/Period

Suffix S with engineering prefixes

Limits 6.06ns to 1000s

Default 1ms

Query `:PULS:PER?`

Description Use this command to set/read the pulse period. Select the pulse-period source using `:TRIGger:SOURce`. The currently selected source is programmed by this command. Note that the specified limits and available resolution depend on the selected source. You cannot set the pulse period if you have selected the CLK IN connector as the frequency source (`:TRIG:SOUR EXT2`).

Examples

`:TRIG:SOUR INT`	Select internal osc. as pulse trigger
`:PULS:PER 25NS`	Set pulse period to 25ns

:PULS:PER:AUTO

`[:SOURce]:PULSe:PERiod:AUTO`

Parameters ONCE

Default Not applicable

Query `:PULS:PER:AUTO?`

Description Use this command to measure the period at the CLK IN connector. If the CLK IN connector is the selected pulse-period source, you can then read the measured value with `:PULS:PER?`.

Examples

`:TRIG:SOUR EXT2`	Select ext CLK IN as pulse trigger
`:PULS:PER:AUTO ONCE`	Measure period at CLK IN
`:PULS:PER?`	Query pulse period

:PULS:TDEL[1|2]

`[:SOURce]:PULSe:TDELay[1|2]`

Parameters Numeric

Suffix S with engineering prefixes

Limits 3.02ns to (period – 3.02ns)

Default 100ns

Query `:PULS:TDEL[1|2]?`

Description Use this command to program the delay of the trailing edge of the pulse relative to the start of the pulse period. This is an alternative method of programming the pulse width.

Examples

`:PULS:DEL1 500NS`	Set output 1 delay to 500ns
`:PULS:DEL1:HOLD TIME`	Hold output 1 delay constant with varying period
`:PULS:TDEL1 750NS`	Set output 1 trailing delay to 750ns

:PULS:TRAN[1|2]:HOLD

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

Parameters TIME | WRATio

Default TIME

Query `:PULS:TRAN[1|2]:HOLD?`

Description Use this command to set the coupling between transition times and the pulse width:

TIME

The absolute transition times are held when the pulse width is varied.

WRATio

The ratio of transition time to pulse width is held when the pulse width is varied.

Examples

`:PULS:TRAN1:HOLD TIME`	Hold output 1 transitions fixed when pulse width varies
`:PULS:TRAN2:HOLD WRAT`	Hold output 2 transition:width ratio when pulse width varies

:PULS:TRAN[1|2]:UNIT

`[:SOURce]:PULSe:TRANsition[1|2]:UNIT`

Parameters S | SEC | PCT

Default S

Query `:PULS:TRAN[1|2]:UNIT?`

Description Use this command to set the default units for the pulse transition-times. The default unit is used when the parameter is programmed to a value without a unit suffix.

Example `:PULS:TRAN1:UNIT SEC` Set units to SEC

:PULS:TRAN[1|2]

[:SOURce]:PULSe:TRANsition[1|2][:LEADing]

Parameters Numeric

Values coupling: Trailing edge = Leading edge if :PULS:TRAN:TRA:AUTO ON (this is the default condition). Use :PULS:TRAN:TRA:AUTO OFF to enable independent programming of the trailing edge within a 1:20 ratio for the ranges.

Suffix S with engineering prefixes, or PCT

Limits 2ns to 200ms

Default 2.5ns

Query :PULS:TRAN[1|2]?

Description Use this command to set/read the transition time of the pulse-leading edge. Note that the leading and trailing edges of the pulse have to fit within the defined pulse width.

Examples

:PULS:TRAN1 3NS	Set output 1 leading edge to 3 ns
:PULS:TRAN1:TRA:AUTO OFF	Enable independent setting of trailing edge
:PULS:TRAN1:TRA 15 NS	Set output 1 trailing edge to 15ns

:PULS:TRAN[1|2]:TRA

[:SOURce]:PULSe:TRANsition[1|2]:TRAiling

Parameters Numeric

Values coupling: Trailing edge = Leading edge if :PULS:TRAN:TRA:AUTO ON (this is the default condition). Use :PULS:TRAN:TRA:AUTO OFF to enable independent programming of the trailing edge within a 1:20 ratio for the ranges.

Suffix S with engineering prefixes, or PCT

Limits 2ns to 200ms

Default 2.5ns

Query :PULS:TRAN[1|2]:TRA?

Description Use this command to set/read the transition time of the pulse-trailing edge. Note that the leading and trailing edges of the pulse have to fit within the defined pulse width.

Examples

:PULS:TRAN1 3NS	Set output 1 leading edge to 3ns
:PULS:TRAN1:TRA:AUTO OFF	Enable independent setting of trailing edge
:PULS:TRAN1:TRA: 15NS	Set output 1 trailing edge to 15ns

:PULS:TRAN[1|2]:TRA:AUTO

:[SOURce]:PULSe:TRANsition[1|2]:TRAiling:AUTO

Parameters ON | OFF | 1 | 0 | ONCE

Default 1

Query :PULS:TRAN[1|2]:TRA:AUTO?

Description Use this command to set/read the automatic coupling of the pulse trailing-edge transition time to the leading-edge transition time.

ON

The trailing-edge transition time is automatically set to the same value as the leading edge, and is updated automatically each time the leading-edge transition time changes.

OFF

The trailing-edge transition time is independently programmable.

ONCE

The trailing-edge transition time is set ONCE to the same value as the leading edge.

Examples

`:PULS:TRAN1 3NS`	Set output 1 leading edge to 3ns
`:PULS:TRAN1:TRA:AUTO OFF`	Enable independent setting of trailing edge
`:PULS:TRAN1:TRA 15NS`	Set output 1 trailing edge to 15ns

:PULS:WIDT[1|2]

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

Parameters Numeric

Suffix S with engineering prefixes

Limits 3.02ns to (period – 3.02ns)

Default 100ns

Query `:PULS:WIDT[1|2]?`

Description Use this command to program the width of the pulse signal. If you want to set width as duty cycle, use `[:SOURce]:PULSe:DCYCle[1|2]`. If you want the pulse width to remain constant when the pulse period is varied (rather than the duty cycle), use `[:SOURce]:PULSe:HOLD[1|2] WIDTh`.

Examples

`:PULS:WIDT1 50NS`	Set OUTPUT 1 pulse width to 50ns
`:PULS:HOLD1 WIDTH`	Hold pulse width constant with varying period

:ROSC:SOUR

`[:SOURce]:ROSCillator:SOURce`

Parameters INTernal | EXTernal

Default INTernal

Query `:ROSC:SOUR?`

Description Use this command to set/read the reference source for the PLL. With EXTernal selected, the Series 3400 will automatically monitor Ref In for a 10MHz signal. If a signal is found, it will use that signal as the reference source. If no signal is found, it will use its internal reference.

With INTernal selected, the Series 3400 will use its internal reference.

Example

`:ROSC:SOUR EXT`	Use external signal if present at EXT IN

:ROSC:EXT:FREQ

`[:SOURce]:ROSCillator:EXTernal:FREQuency`

Parameters Numeric

Default 10 MHZ

Query `:ROSC:EXT:FREQ?`

Description Use this command to set/read the expected reference frequency for the PLL at the Ref In connector. The external reference must be a 10 MHz signal.

Note that :ROSC:SOUR must be set for the external reference source (EXT).

Example

```
:ROSC:SOUR EXT          Use external signal if present at Ref In
:ROSC:EXT:FREQ 10 MHZ   Set expected frequency for reference to 10MHz
```

:VOLT[1|2]

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

Parameters Numeric

Value coupling:	High = Offset + Amplitude/2 Low = Offset – Amplitude/2
Range coupling:	With Offset

Suffix V with engineering prefixes

Limits 100mVpp to 10Vpp, 50Ω into 50Ω
200mVpp to 20Vpp, 1kΩ into 50Ω

Default 1000mV

Query `:VOLT[1|2]?`

Description This command programs the amplitude voltage of the output signal. Note that to set the output levels in terms of voltage, you first have to execute the `[:SOURce]:HOLD VOLTage` command to enable the `[:SOURce]:VOLTage` subsystem.

The available voltage range is limited by the combination of:

- Specified limits
- Actual output impedance setting `:OUTPut:IMPedance`
- Expected load impedance setting `:OUTput:IMPedance:EXTernal`

Examples

```
:HOLD VOLT      Enable VOLTAGE subsystem
:VOLT1 5V       Set output 1 amplitude to 5V
```

:VOLT[1|2]:OFFSet

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

Parameters Numeric

Value coupling:	High = Offset + Amplitude/2 Low = Offset – Amplitude/2
Range coupling:	With Amplitude

Suffix V with engineering prefixes

Limits -10V+Amplitude/2 to 10V-Amplitude/2, 50Ω into 50Ω
-20V+Amplitude/2 to 20V-Amplitude/2, 1kΩ into 50Ω

Default 0.0mV

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

Description This command programs the offset voltage of the output signal. Note that to set the output levels in terms of voltage, you first have to execute the `[:SOURce]:HOLD VOLTage` command to enable the `[:SOURce]:VOLtage` subsystem. The available voltage range is limited by the combination of:

- Specified limits
- Actual output impedance setting `:OUTPut:IMPedance`
- Expected load impedance setting `:OUTput:IMPedance:EXTernal`

Examples

`:HOLD VOLT`	Enable VOLTAGE subsystem
`:VOLT1:OFF -800MV`	Set output 1 offset to -800mV

:VOLT[1|2]:HIGH

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

Parameters Numeric

Value coupling:	Amplitude = High - Low Offset = (High + Low)/2
Range coupling:	With Low-level

Suffix V with engineering prefixes

Limits 0 to ±10V, 50Ω into 50Ω
0 to ±20V, 1kΩ into 50Ω

Default 500mV

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

Description This command programs the high-level voltage of the output signal. Note that to set the output levels in terms of voltage, you first have to execute the `[:SOURce]:HOLD VOLTage` command to enable the `[:SOURce]:VOLTage` subsystem. The available voltage range is limited by the combination of:

- Specified limits
- Actual output impedance setting `:OUTPut:IMPedance`
- Expected load impedance setting `:OUTPut:IMPedance:EXTernal`

Examples

`:HOLD VOLT`	Enable VOLTAGE subsystem
`:VOLT1:HIGH 4.8V`	Set output 1 high level voltage to 4.8V

:VOLT[1|2]:LOW

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

Parameters Numeric

Value coupling:	Amplitude = High - Low Offset = (High+Low)/2
Range coupling:	With High-level

Suffix V with engineering prefixes

Default -500mV

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

Limits 0 to ±10V, 50Ω into 50Ω
0 to ±20V, 1kΩ into 50Ω

Description This command programs the low-level voltage of the output signal. Note that to set the output levels in terms of voltage, you first have to execute the

`[:SOURce]:HOLD VOLTage` command to enable the `[:SOURce]:VOLTage` subsystem. The available voltage range is limited by the combination of:

- Specified limits
- Actual output impedance setting `:OUTPut:IMPedance`
- Expected load impedance setting `:OUTPut:IMPedance:EXTernal`

Examples

`:HOLD VOLT`	Enable VOLTAGE subsystem
`:VOLT1:LOW 500MV`	Set output 1 low-level to 500mV

:VOLT[1|2]:LIM

`[:SOURce]:VOLTage[1|2]:LIMit[:HIGH]`

Parameters Numeric

Suffix V with engineering prefixes

Default +500mV

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

Description Use this command to set/read the high-level voltage limit. If you switch on voltage limiting, the high-level voltage cannot be set above the programmed limit. Note that the voltage is not limited by the output hardware; this is a software limit.

Limits depend on the programmed source impedance and load impedance settings. Limits may be exceeded if the actual load impedance does not match the programmed load impedance.

With limits enabled, you will not be able to set the output to levels that exceed the limits. With the output on, you will not be able to set a limit that exceeds the output level.

Examples

`:HOLD VOLT`	Enable VOLTAGE subsystem
`:VOLT1:LIM 3V`	Set output 1 high-level limit to 3V
`:VOLT1:LIM:STAT ON`	Switch on output 1 limits

:VOLT[1|2]:LIM:LOW

`[:SOURce]:VOLTage[1|2]:LIMit:LOW`

Parameters Numeric

Suffix V with engineering prefixes

Default -500mV

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

Description Use this command to set/read the low-level voltage limit. If you switch on voltage limiting, the low-level voltage cannot be set below the programmed limit. Note that the voltage is not limited by the output hardware; this is a software limit.

Limits depend on the programmed source impedance and load impedance settings. Limits may be exceeded if the actual load impedance does not match the programmed load impedance.

With limits enabled, you will not be able to set the output to levels that exceed the limits. With the output on, you will not be able to set a limit that exceeds the output level.

Examples

`:HOLD VOLT`	Enable VOLTAGE subsystem
`:VOLT1:LIM:LOW 0V`	Set output 1 low-level voltage
`:VOLT1:LIM:STAT ON`	Switch on output 1 limits

:VOLT[1|2]:LIM:STAT

`[:SOURce]:VOLTage[1|2]:LIMit:STATe`

Parameters ON | OFF | 1 | 0

Default 0

Query `:VOLT[1|2]:LIM:STAT?`

Description This command switches the output limits on or off. When you switch on the output limits, you cannot program the output levels beyond the programmed limits until you switch off the voltage limits. The limits apply whether you program high/low levels or amplitude/offset levels. Note: You can switch the limits on and off in both the `[:SOURce]:CURRent` and the `[:SOURce]:VOLTage` subsystems, but the current and voltage limits are not enabled/disabled independently. The voltage and current limits are always enabled/disabled together.

With the output on, you will not be able to set a limit that exceeds the output level.

Examples

`:HOLD VOLT`	Enable VOLTAGE subsystem
`:VOLT1:LIM 3V`	Set output 1 high level voltage limit to 3V
`:VOLT1:LIM:LOW 0V`	Set output 1 low-level voltage limit to 0V
`:VOLT1:LIM:STAT ON`	Switch on output 1 limits

STATus subsystem

STAT:OPER

`:STATus:OPERation`

Description This command accesses the OPERation status group. The OPERation status group is not used by the Series 3400.

:STAT:PRES

`:STATus:PRESet`

Default Not applicable

Description This command:

- Clears all status group event registers
- Clears the error queue
- Presets the status group enable-, PTR-, and NTR-registers as follows:

Status Group Register Preset value:

OPERation	
ENABle	0000000000000000
PTR	0111111111111111
NTR	0000000000000000
QUEStionable	
ENABle	0000000000000000
PTR	0111111111111111
NTR	0000000000000000

:STAT:QUES

`:STATus:QUEStionable`

Description This command tree accesses the QUEStionable status group. The QUEStionable status group is not used by the Series 3400.

:SYST:CHEC

`:SYSTem:CHECk[:ALL][:STATe]`

Parameters ON | OFF | 1 | 0

Default 1

Description The Series 3400 performs error checking and reporting for invalid parameter or mode settings. Error checking can be disable (OFF) to increase programming speed.

NOTE *Error checking cannot be turned on from the front panel, and is not automatically enabled when you cycle power. Use this command or the *RST command to enable (ON) error checking.*

:SYST:ERR?

`:SYSTem:ERRor?`

Default Not applicable

Description Use this command to read the instrument error queue. The instrument error queue stores error codes on a first-in-first-out basis. When you read the error queue, the error number and associated message are put into the instrument's output buffer. If the queue is empty, the value 0 is returned, meaning "No Error." If the queue overflows at any time, the last error code is discarded and replaced with -350 meaning "Queue overflow."

Example `:SYST:ERR?` Query for errors

:SYST:VERS?

`:SYSTem:VERSion?`

Default 1992.0

Description This command reads the SCPI revision to which the instrument complies.

TRIGger subsystem

:TRIG:COUN

`:TRIGger[:SEQuence[1]]:COUNt`

Parameters Numeric

Limits :DIG:PATT OFF:1 to 65536
:DIG:PATT ON: 2 to 16384

Default 1

Query `:TRIG:COUN?`

Description Use this command to set/read the number of trigger events (pulse periods) to be generated for each arming event. This corresponds to selecting the event mode on the Mode/Trigger screen:

PULSES

Set a trigger count of 1 so that a single pulse period is generated for each arming event; instrument is in pulse (stream) mode. Switch off pattern mode so that a pulse (or double-pulse) is generated in each pulse period (:DIG:PATT OFF).

BURST of

Set a trigger count of 2 to 65536 so that a burst of 2 to 65536 pulse periods is generated for each arming event. Switch off pattern mode so that a pulse (or double-pulse) is generated in each pulse period (:DIG:PATT OFF).

PATTERN of

Set a trigger count of 2 to 16384 so that a burst of 2 to 16384 bit periods is generated for each arming event. Switch on pattern mode so that the bit pattern is generated (`:DIG:PATT ON`); instrument is in pattern mode.

Examples To set up a continuous pattern of NRZ pulses at output 1 with a 512-bit pattern length:

```
:ARM:SOUR IMM          Set continuous arming
:TRIG:COUN 512         Pattern length 512
:TRIG:SOUR INT1        Pulse period trigger from internal osc
:DIG:PATT ON           Enable pattern operating mode
:DIG:SIGN1:FORM NRZ    Set output 1 data to NRZ
```

To set up a triggered burst of 16 single-pulses at output 1 (each burst triggered by a positive edge at the EXT INPUT):

```
:ARM:SOUR EXT1         Set arming from EXT INPUT
:ARM:SENS EDGE         Set arming on edges
:ARM:SLOP POS          Set arming on positive edges
:TRIG:COUN 16          Burst length 16
:TRIG:SOUR INT1        Pulse-period trigger from internal osc.
:DIG:PATT OFF          Disable pattern operating mode
:PULS:DOUB1 OFF        Ensure single pulses at OUTPUT 1
```

To set up a gated pulses single-pulses at output 1 (gated by a positive level at the EXT INPUT):

```
:ARM:SOUR EXT1         Set arming from EXT INPUT
:ARM: SENS LEV         Set arming on levels
:ARM:SLOP POS          Set arming on positive level 1 pulse period
:TRIG:COUN 1           Single pulse output mode
:TRIG:SOUR INT1        Pulse-period trigger from internal osc.
:DIG:PATT OFF          Disable pattern data
:PULS:DOUB1 OFF        Ensure single pulses at OUTPUT 1
```

:TRIG:IMP

`:TRIGger:IMPedance`

Parameters Numeric

Suffix OHM with engineering prefixes, e.g.: MOHM is Megaohms

Limits 50Ω or 10kΩ

Default 50Ω

Query `:TRIG:IMP?`

Description Use this command to program the input impedance of the CLK IN connector. Note that only two settings are available. If you try to program any other value, it will be rounded to one of the specified values.

Examples

`:TRIG:IMP 50OHM`	Set CLK IN impedance to 50Ω
`:TRIG:LEV 2.5V`	Set CLK IN threshold to 2.5V
`:TRIG:SOUR EXT2`	Pulse-period trigger from CLK IN

:TRIG:LEV

`:TRIGger:LEVel`

Parameters Numeric

Suffix V with engineering prefixes

Limits 0.10V to +10V

Default 1.0V

Query `:TRIG:LEV?`

Description Use this command to program the triggering threshold of the CLK IN connector.

Examples

`:TRIG:IMP 50OHM`	Set CLK IN impedance to 50Ω
`:TRIG:LEV 2.5V`	Set CLK IN threshold to 2.5 V

:TRIG:SLOP

`:TRIGger:SLOPe`

Parameters POSitive | NEGative

Default POS

Query :TRIG:SLOP?

Description Use this command to select the trigger slope for the pulse-period triggering signal applied to the CLK IN connector.

Example

`:TRIG:SLOP POS`	Select positive slope

:TRIG:SOUR

`:TRIGger:SOURce`

Parameters IMMediate | INTernal[1] | INTernal2 | EXTernal2

Default IMM

Query `:TRIG:SOUR?`

Description Use this command to select the source of the pulse-period trigger signal. Pulse-period sources set by the :TRIG:SOUR command:

Table 6-7
:TRIG:SOUR

Pulse-period source	:TRIG:SOUR
internal osc.	IMMediate | INTernal[1]
internal PLL	INTernal2
CLK IN	EXTernal2

Example

`:TRIG:SOUR IMM`	Select immediate trigger source

Appendix A
Specifications

In this appendix:

KEITHLEY

Model 3401/3402

Pulse Pattern Generator Specifications

Keithley Instruments, Inc.
28775 Aurora Road
Cleveland, Ohio 44139
(440) 248-0400
www.keithley.com

1. Basic Modes of Operation

The 340x generator may be set in one of four available modes, Pulse, Pattern, Burst and External Width.

Pulse Mode delivers a single pulse per trigger event to the outputs. The pulse is programmable in delay and duration.

Burst Mode results in a 'burst' of *n* pulses per trigger event, with pulses configured similarly to single pulses in Pulse mode.

Pattern Mode delivers a programmable pattern per trigger event to the outputs. The pattern is programmable, or may be selected from a library of pre-configured patterns. The pattern may be presented in either NRZ or RZ formats. In NRZ mode, the pattern crossing point is programmable. In RZ mode the duration (duty cycle) of the pattern pulse is programmable.

External Width Mode makes the pulse level follow the edges of the Ext In input. A rising edge causes the output to go high, while a falling edge causes the output to go low.

2. Interfaces

The 340x generator may be controlled via the front panel GUI interface, a GPIB interface, or a USB interface. IEEE 488.2, SCPI compliant.

3. General Mechanical Characteristics

Size: 439 mm (17.3 in) wide **x** 87 mm (3.4 in) high **x** 393mm (15.5 in) deep

Weight: 6.80 kg (15.0 lbs)

4. Specifications

Pulse / Level Parameters	Specification
Pulse Amplitude[1]	100mV to +10V 50Ω into 50Ω 200mV to +20V 1kΩ into 50Ω
Level Window[2]	-10V to +10V 50Ω into 50Ω -20V to +20V 1kΩ into 50Ω
Amplitude Accuracy[3]	±(0.5% Amplitude + 30 mV)
Offset Accuracy[4]	± 100 mV
Output Resolution	10mV, 50Ω into 50Ω 20mV, 1kΩ into 50Ω
Overshoot / pre-shoot / ringing[5]	±5% ± 20 mV
Source Impedance[6]	50Ω or 1 kΩ, selectable
Short Circuit Current[7]	±400mA

[1] Amplitude may be set in either voltage or current units.
[2] Level may be set in either voltage or current units.
[3] 50Ω into 50Ω
[4] 50Ω into 50Ω
[5] ±1% at 10V p-p typical / ±2% at 5V p-p typical
[6] ±1% typical
[7] ±800 mA in Channel Add Mode

Pulse Pattern Generator Specifications

Keithley Instruments, Inc.
28775 Aurora Road
Cleveland, Ohio 44139
(440) 248-0400
www.keithley.com

Timing and Trigger Parameters	Specification
Frequency Range[8]	1mHz to 165MHz
Period	6.06 ns to 1000 s
Period Accuracy	PLL: ±0.01% VCO: ±0.5% typical with self-cal ±3% without self-calibration
Period Resolution	PLL: 4 digits, 1 ps best case VCO: 3.5 digits, 10 ps best case
Period Jitter, RMS	VCO: 0.015% + 20ps PLL: 0.001% + 15ps
Pulse Width[9]	3.02 ns to (period – 3.02 ns)
Width Accuracy	±0.5% ± 250ps typical with self-cal ±3% ± 250ps without self-cal
Delay[10]	0 to (period – 3.02 ns)
Delay Accuracy	±0.5% ± 0.5ns typical with self-cal ±3% ± 0.5ns without self-cal
Delay & Width Resolution	3.5 digits, 20 ps best case
Delay & Width Jitter, RMS	0.01% + 15ps
Fixed Delay[11]	22 ns

Rise/Fall Parameters	Specification
Rise / Fall Time	<2.5ns to 200ms, adjustable
Minimum Rise / Fall Time[12]	2.5ns maximum at 10V p-p 2.3ns typical at 5V p-p 2.1ns typical at 2 V p-p
Rise / Fall Time Accuracy	±10% ± 200ps
Rise / Fall Ranges	2ns - 20ns, 10ns - 200ns, 100ns – 2us, 1us – 20us, 10us – 200us, 100us – 2ms, 1ms – 20ms, 10ms – 200ms

Burst Mode Parameters	Specification
Number of pulses	2 – 65,536

[8] Range reduced for 1 kΩ source impedance.
[9] At 50% level. Specified at fastest rise/fall, and for amplitudes < 5 Vpp.
[10] Delay is measured from Trigger Out to Pulse Out, and is the sum of the user defined Delay plus the Fixed Delay.
[11] Nominal.
[12] 10% to 90%, 50 Ω source and load, at 25°C. Higher for 1kΩ source impedance, rising and falling edges independent within selected ranges.

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28775 Aurora Road
Cleveland, Ohio 44139
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www.keithley.com

Pulse Pattern Generator Specifications

Pattern Mode Parameters	Specification
Pattern	
Data Pattern length[13]	2 – 16384 bits
PRBS	2^n-1 with n = 5-14
Data Formats	NRZ, RZ

CLK IN and EXT IN Parameters	Specification
Input Impedance	50 Ω or 10 kΩ
Threshold	-3 V to +3 V
Maximum Input Voltage	± 6 V
Coupling	DC

TRIG OUT and STROBE OUT Parameters	Specification
Output Impedance	50 Ω
Levels	TTL (0V / 2.4V)
Maximum External Voltage	-2V to 5 V
Coupling	DC

REF OSC IN and REF OSC OUT Parameters	Specification
Impedance	50 Ω, AC coupled
Ref Osc In Signal	10 MHz, 0 dBm typical, 20 dBm max
Output Amplitude	10 MHz, 1 V_{pp} typical

General Specifications	
Power	100V to 240V; Single phase; 50 / 60 Hz; universal voltage input; 165 VA max.
Compliance	EMC: Conforms to European Union Directive 89/336/EEC, EN 61326-1. SAFETY: Conforms to European Directive 73/23/EEC, EN 61010-1.
Operating Temperature	0°C to 50°C
Operating Humidity	80% R.H. up to 35°C. De-rate 3% R.H./°C, 35° to 50°C
Storage Temperature	-25°C to 65°C
Altitude	Maximum 2000 meters above sea level.
Environmental	For indoor use only.

[13] Pattern for each channel is independent, must be same length.

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5. Additional Information

Inputs/Outputs

- OUTPUT1- channel 1 signal output, front panel
- OUTPUT2 - channel 2 signal output (optional), front panel
- TRIG OUT - generates trigger pulse on each period, front panel
- STROBE OUT – programmable NRZ in pattern mode, marks burst width in burst mode, front panel
- CLK IN - accepts external clk , front panel
- EXT IN - accepts external signal for arming, front panel
- REF OSC IN - accepts external 10 MHz signal for PLL reference, back panel
- REF OSC OUT - generates 10 MHz signal phase locked to PLL, back panel

Trigger Modes

- Continuous - trigger circuitry is always armed
- Started - trigger arming is edge sensitive, needs selected edge prior to allowing trigger event
- Gated - trigger arming circuitry is level sensitive, always armed when selected level is present

Pulse Period Source (this is period of pulses in continuous mode, or period of pulses within a burst or pattern in burst or pattern modes)

- PLL oscillator
- startable oscillator
- CLK IN

Arming Source (this sets period of entire burst/pattern in burst/pattern mode)

- EXT IN
- PLL oscillator (in started mode, if not used as pulse period source)
- MANUAL (in started mode)

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KEITHLEY

Service Form

Model No. _____ **Serial No.** _____ **Date** _____

Name and Telephone No. _____

Company _____

List all control settings, describe problem and check boxes that apply to problem. _____

_____

_____

❑ Intermittent
❑ Analog output follows display
❑ Particular range or function bad; specify _____
❑ IEEE failure
❑ Obvious problem on power-up
❑ Batteries and fuses are OK
❑ Front panel operational
❑ All ranges or functions are bad
❑ Checked all cables

Display or output (check one)

❑ Drifts
❑ Unable to zero
❑ Unstable
❑ Will not read applied input
❑ Overload

❑ Calibration only
❑ Certificate of calibration required
❑ Data required

(attach any additional sheets as necessary)

Show a block diagram of your measurement system including all instruments connected (whether power is turned on or not). Also, describe signal source.

Where is the measurement being performed? (factory, controlled laboratory, out-of-doors, etc.)

_____

_____

What power line voltage is used? _____ Ambient temperature?°F _____

Relative humidity? _____ Other? _____

Any additional information. (If special modifications have been made by the user, please describe.)

_____

_____

Be sure to include your name and phone number on this service form.

KEITHLEY

A GREATER MEASURE OF CONFIDENCE

Keithley Instruments, Inc.

Corporate Headquarters • 28775 Aurora Road • Cleveland, Ohio 44139 • 440-248-0400 • Fax: 440-248-6168 • 1-888-KEITHLEY • www.keithley.com

12/06