



Model 3390 Arbitrary Waveform Generator

User's Manual

3390-900-01 Rev. C / January 2009

WARRANTY

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

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

During the warranty period, Keithley Instruments will, at its 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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A G R E A T E R M E A S U R E O F C O N F I D E N C E

Keithley Instruments, Inc.

Corporate Headquarters • 28775 Aurora Road • Cleveland, Ohio 44139
440-248-0400 • Fax: 440-248-6168 • 1-888-KEITHLEY (1-888-534-8453) • www.keithley.com

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Model 3390 Arbitrary Waveform Generator User's Manual

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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 user documentation for complete product specifications.

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

The types of product users are:

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

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

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

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

Keithley 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 user documentation.

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 1000V, 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, ensure that 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 the 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 user documentation.

The  symbol on an instrument shows that it can source or measure 1000V 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.

If this  symbol is on a product, it indicates that mercury is present in the display lamp. Please note that the lamp must be properly disposed of according to federal, state, and local laws.

The **WARNING** heading in the user documentation 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 the user documentation 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., a data acquisition board for installation into a computer) should never require cleaning if handled according to instructions. If the board becomes contaminated and operation is affected, the board should be returned to the factory for proper cleaning/servicing.

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Section 1

Introduction

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General information

Contact information

If you have any questions after reviewing this information, please contact your local Keithley Instruments representative or call one of our applications engineers at 1-888-KEITHLEY (1-888-534-8453) within the U.S. and Canada. You can also visit the Keithley Instruments website at www.keithley.com for updated worldwide contact information.

Inspection

Your Keithley Instruments Model 3390 Arbitrary Waveform Generator was carefully inspected electrically and mechanically before shipment. After unpacking all items from the shipping carton, check for any obvious signs of physical damage that may have occurred during transit (there may be a protective film over the display lens, which can be removed). Report damage to the shipping agent immediately. Save the original packing carton for possible future shipment.

The following items are included with every instrument order:

- Arbitrary Waveform Generator with power cord
- One universal serial bus (USB) cable (USB-B-1)
- One pattern generator cable (005-003-00003)
- One Ethernet crossover cable (CA-180-3)
- Accessories as ordered
- Product Information CD-ROM containing the User's Manual and any applicable release notes or addenda

Options and accessories

- Model KPCI-488A GPIB/IEEE-488 interface board for PCI bus
- Model KUSB-488A USB-to-GPIB interface adapter for USB

Model summary

The 50 MHz Model 3390 Arbitrary Waveform Generator gives you the operational flexibility suitable for use in many different applications.

Features

- 50 MHz sine and 25 MHz square waveforms
- Pulse, ramp, noise, and DC waveforms
- 14-bit, 125 MSamples/second, 256K point arbitrary waveforms
- AM, FM, PM, FSK, and PWM modulation types
- Linear and logarithmic sweep and burst operations
- Built-in external time base (10 MHz +/- 500 Hz) synchronization
- 16-bit pattern out with a synchronized clock (up to 50 MHz)
- Universal serial bus (USB) and local area network (LAN) interfaces (general purpose interface bus, GPIB is optional)
- LXI™ Class C compliant
- Save up to four waveforms in nonvolatile memory

Handle adjustment

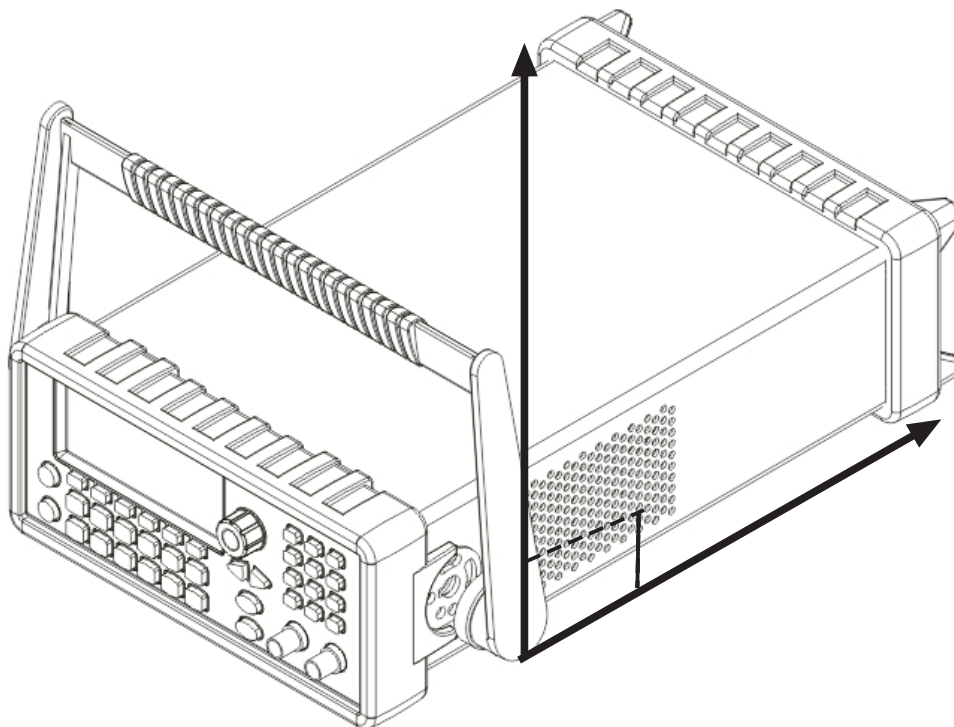
You can adjust the carrying handle to suit your needs. The following text provides detailed information regarding handle adjustment and removal.

Removing the handle

1. Pull slightly outward on both sides of the handle and slowly rotate the handle upright to a 90° angle with the instrument (see [Figure 1-1](#)).

Figure 1-1:

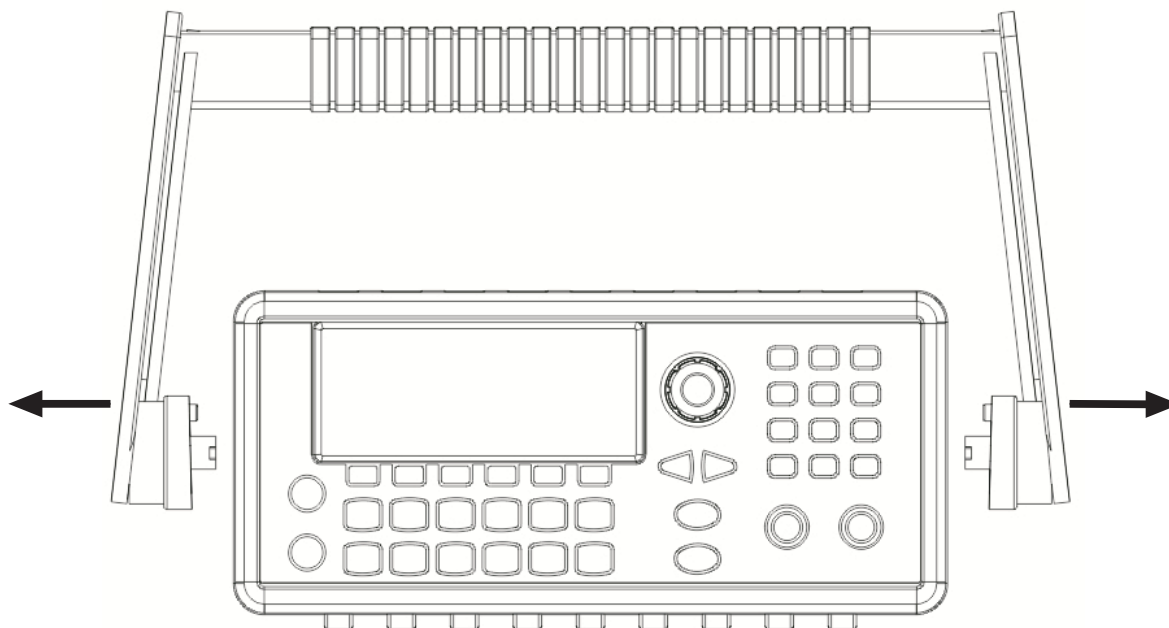
Moving the handle to an upright position



2. After the handle is turned to a 90° angle with the generator, pull the handle sides out from the instrument (see [Figure 1-2](#)).

Figure 1-2:

Removing the handle from the instrument



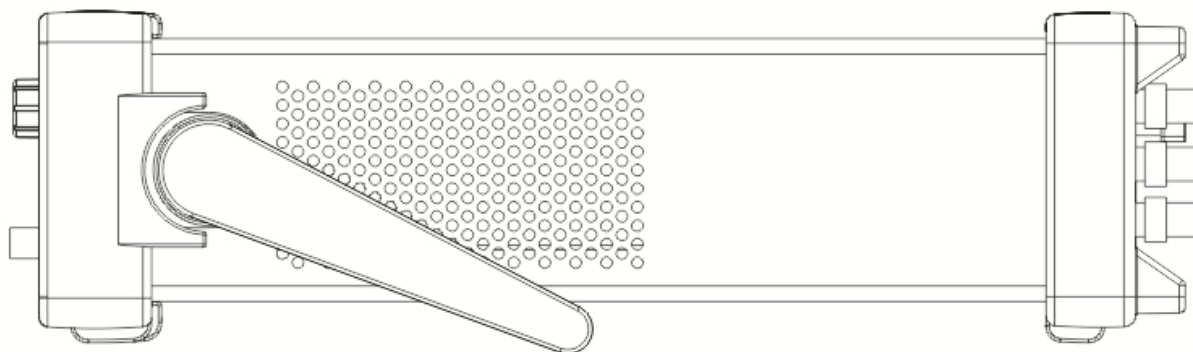
Adjusting the handle position

You can adjust the handle of the Model 3390 for packing ([Figure 1-3](#)), operation ([Figure 1-4](#)), and carrying ([Figure 1-5](#)).

Position 1: Default packing position

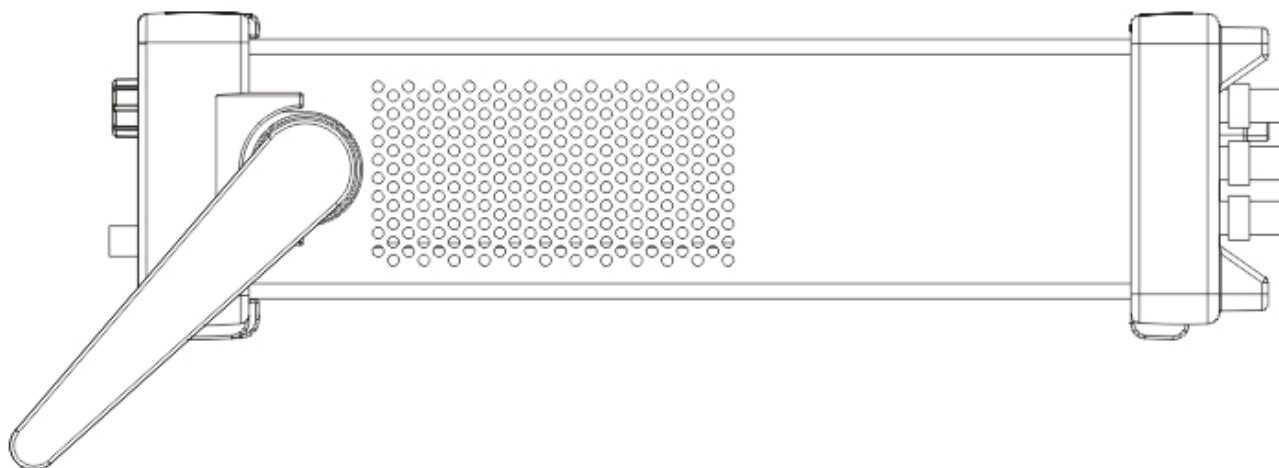
Figure 1-3:

Default handle position for packing



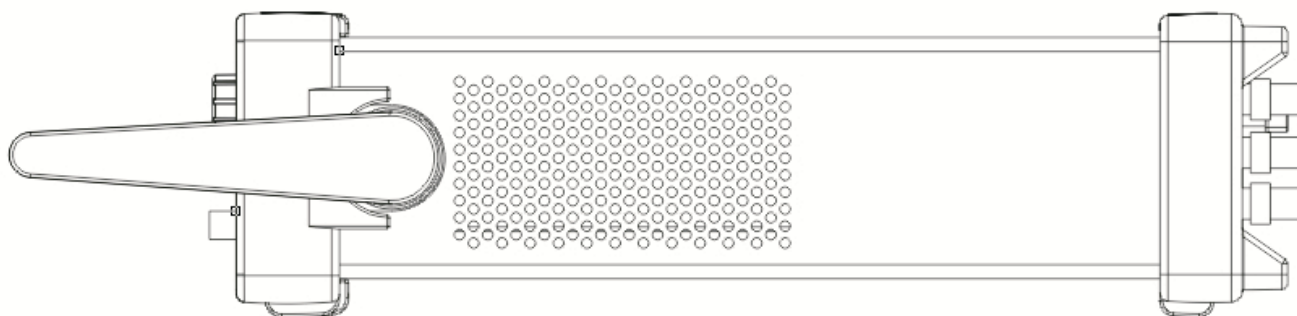
Position 2: Operation position

Figure 1-4:
Operation handle position



Position 3: Carrying position

Figure 1-5:
Carrying handle position



Connect and power the instrument

Line power connection

Follow the procedure below to connect the Model 3390 to line power and turn on the instrument. The Model 3390 operates from a line voltage of 100 V to 240 V at a frequency of 50 Hz or 60 Hz. Line voltage is automatically sensed; there are no switches to set. Ensure the operating voltage in your area is compatible.

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

To connect and power your Model 3390:

1. Connect the female end of the supplied power cord to the power connector (AC receptacle) on the rear panel. Connect the other end of the power cord to a grounded AC outlet.
2. Turn on the instrument by pressing the front-panel power key.

WARNING	<i>The power cord supplied with the Model 3390 contains a separate ground for use with grounded outlets. When proper connections are made, 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.</i>
----------------	---

Ventilation

The Model 3390 has a fan and cooling vents to keep it from overheating.

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

Do not block the cooling vents.

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

Ensure adequate airflow around the instrument rear and sides for proper cooling.

Section 2

Front Panel

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Front panel description

The Keithley Instruments Model 3390 Arbitrary Waveform Generator front panel is described in this section ([Figure 2-1](#)).

Figure 2-1:
Model 3390 front panel

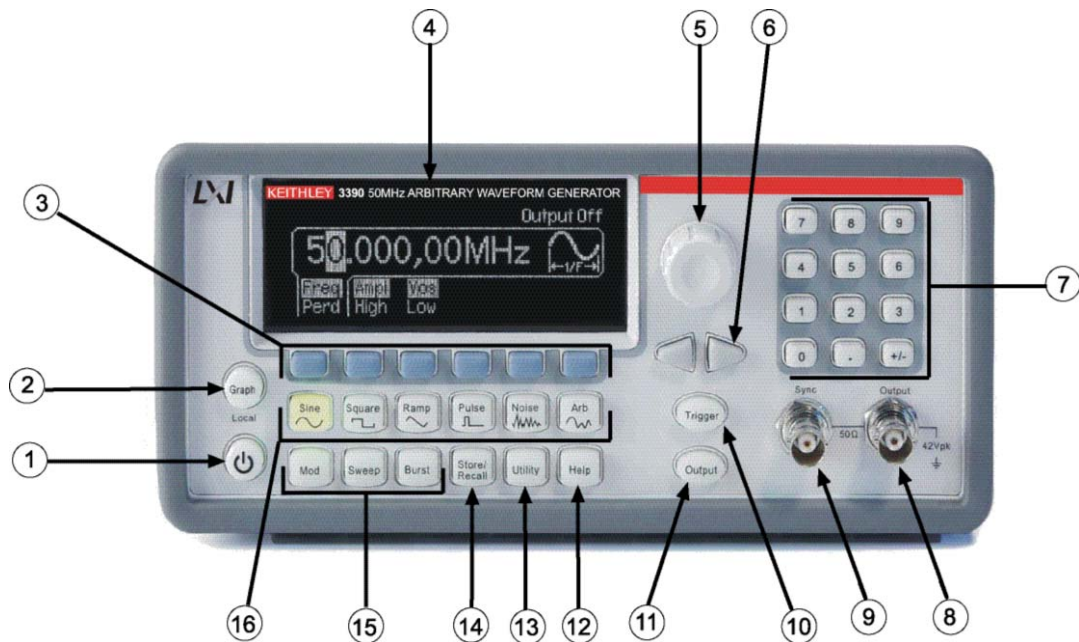


Table 2-1:
Item descriptions

Item	Description
1	Power key
2	Graph/Local key
3	Menu operation soft keys
4	Display
5, 6, 7	Navigation wheel, cursor keys, and numeric keypad
8	Output connector
9	Sync output connector
10	Trigger key
11	Output key
12	Help menu key
13	Utility menu key
14	Store/Recall menu key
15	Modulation, Sweep, and Burst keys
16	Waveform selection keys

Front panel

Power key

Press this key to turn the Model 3390 on. Press it again to turn the Model 3390 off.

Graph/Local key

Pressing the **Graph** key enables the graph mode ([Figure 2-2](#)). You can view the waveform visually in the graph mode and change the waveform parameters by rotating the navigation wheel and pressing the cursor keys. The parameter values that the navigation wheel can reach in the graph mode are limited due to resolution.

To make an exact entry, use the numeric keypad to enter the desired value. Press the **Graph** key again to return to the local mode.

Figure 2-2:
Graph mode



Menu operation soft keys

Press the soft key located directly beneath the desired parameter to select that parameter. Press the soft key again to select the display menu options. When a particular parameter is selected, the indicator will light accordingly.

Display

The Model 3390 display provides visual information on the present active settings. The display will update as you enter changes using the soft keys, navigation wheel, and cursor keys. Figures displaying different modes, operations, and selections are used throughout this publication.

The following figure is an example of the display in local mode ([Figure 2-3](#)). This mode is the default mode for the instrument display. Upon startup, the **Freq**, **Ampl**, and **Vos** indicators are lit. The default waveform output of the Model 3390 is sine waveform.

Figure 2-3:
Default local mode



Navigation wheel, cursor keys, and numeric keypad

Use the numeric keypad, cursor keys, and the navigation wheel to enter numerical and alphabetical parameters. Refer to [Section 4, Editing parameter values and settings](#) for further information.

Output connector

This connector houses the main signal output. Refer to [Section 4, Editing parameter values and settings](#) for details.

Sync output connector

The sync out signal is delivered at this connector. Refer to [Section 4, Front panel connections](#) for details.

Trigger key

Press the **Trigger** key to manually generate an immediate trigger that is independent of the trigger source. This is applicable to sweep, burst, and pattern out operations only.

Output key

Press the **Output** key to manually enable or disable the generation of waveform signals from the front-panel output channel. The default setting is OFF. The **Output** key is lit when enabled.

Help menu key

The **Help** menu key allows access to the following information:

- **View remote command error:** Error messages are issued when an incorrect remote command is sent to the instrument for output. These are stored in a queue and can be retrieved in the first-in-first-out (FIFO) order.
- **Get HELP on any key:** You can view a short description of any front-panel key by pressing and holding the key for a few seconds.
- **Generate a DC voltage level:** Instructions are provided for you to enable the DC-only voltage level option.
- **Generate a modulated waveform:** Follow the instructions provided to produce a modulated waveform.
- **Default state resetting:** Instructions enable you to return the instrument to the factory default state.
- **View a waveform in Graph Mode:** This information details use of the graph mode.
- **Synchronize multiple instruments:** Follow the detailed instructions for connecting multiple instruments.
- **KEITHLEY Technical Support:** Keithley Instruments technical support contact information is located here.

Utility menu key

The **Utility** menu key allows access to the following settings and parameters:

- **DC:** The DC offset voltage setting can be changed from the **Utility** menu. The default DC offset voltage is zero (0) volt for all functions.
- **Sync:** The sync out signal can be turned on and off from the **Utility** menu. All standard output functions (with the exception of DC and noise) can be associated with a sync-out signal. The signal is delivered at the Sync connector on the front panel.
- **Output Setup:** This key contains a number of different parameters. The output termination setting can be changed, voltage auto ranging can be turned on and off, waveform polarity can be specified as normal or inverted, the phase offset of the output waveform can be adjusted, and lastly, the 10 MHz time base output can be turned on and off.

- **I/O:** The general purpose interface bus (GPIB) and local area network (LAN) remote interface configurations can be set up through the **Utility** menu. In addition, you can view the universal serial bus (USB) interface identification here.
- **PATT Mode:** You can set up pattern output through the **Utility** menu. Pattern output provides five built-in patterns and up to four user-defined patterns that are stored in nonvolatile memory.
- **System:** Several system parameters can be accessed through the **Utility** menu. The error beeper and sound can be turned on and off, and the calibration and self-test menus can be entered.

Store/Recall menu key

The Model 3390 has five storage locations in nonvolatile memory to store instrument state. The stored instrument state holds all the parameters for the selected function, including the waveform, frequency, DC offset, amplitude, duty cycle, symmetry, modulation type, and modulation parameters.

The instrument may also be reset to its factory default settings.

Modulation, Sweep, and Burst keys

Modulation, sweep, and burst operations for the Model 3390 can be waveform-specific. The parameters for each operation are found in [Section 5, Waveform Output Operations](#).

Waveform selection keys

The Model 3390 has five types of standard waveforms: Sine, square, ramp, pulse, and noise (refer to [Section 5, Waveform Output Operations](#) for detailed information). In addition, there are five built-in arbitrary waveforms.

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Rear panel description

The Keithley Instruments Model 3390 Arbitrary Waveform Generator rear panel is described in this section ([Figure 3-1](#)).

Figure 3-1:
Model 3390 rear panel

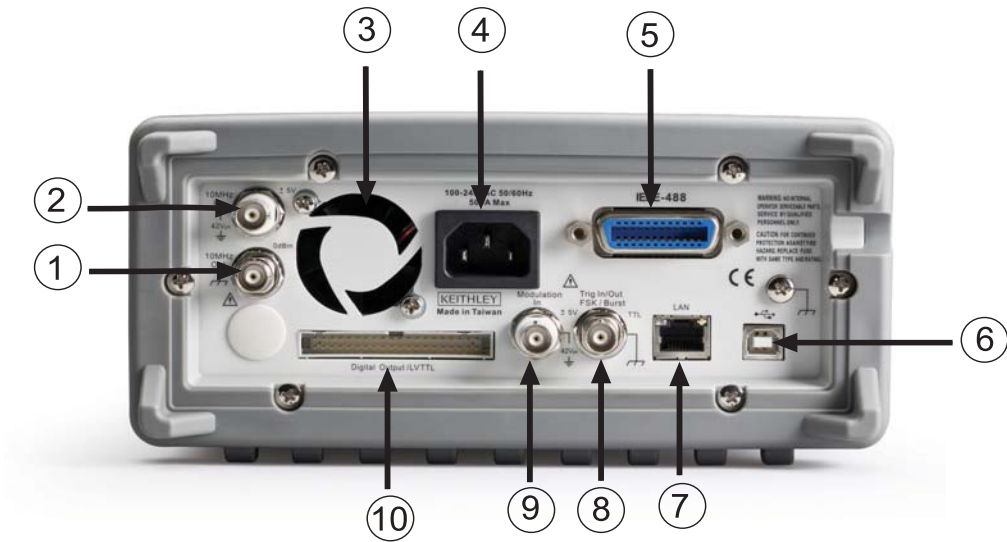


Table 3-1:
Rear panel item descriptions

Item	Description
1, 2	10 MHz Out and In connectors
3	Vent
4	Power connector
5, 6, 7	GPIB, USB, and LAN ports
8	Trig In/Out, FSK / Burst connector
9	Modulation In connector
10	Digital Output/low voltage transistor-transistor logic (LVTTL) port

Rear panel connections

10 MHz Out and In connectors

The 10 MHz Out connector delivers a 10 MHz single-phase signal locked to the internal instrument clock. The 10 MHz In connector accepts an external 10 MHz clock signal. You can use these connections to synchronize multiple instruments and control phase offset.

To set up 10 MHz Out and In from a remote interface:

Use this command to specify degrees or radians:

```
UNIT:ANGLE {DEGREE|RADIAN}
```

Use this command to specify the phase offset of the output waveform. This value can be set in degrees or radians as specified by the `UNIT:ANGL` command:

```
PHASE {<angle>|MINIMUM|MAXIMUM}
```

Use this command to reset to a zero-phase reference point. This command does not affect the output waveform:

```
PHASe:REFeRence
```

Use this command to enable or disable the phase-lock loss error generator. This setting is stored in volatile memory and will be reset to default (OFF) with a power off:

```
PHASe:UNLock:ERRor:STATe {OFF|ON}
```

Power connector

Connect to a grounded AC power outlet using the supplied line cord.

GPIB, USB, and LAN ports

The Model 3390 supports three remote interfaces: Universal serial bus (USB), local area network (LAN) and general purpose interface bus (GPIB or IEEE-488). Instructions for setting up these remote interfaces can be found in [Section 7, Remote Programming](#).

For GPIB communication, connect to the GPIB port using an IEEE-488 cable (Keithley Instruments Model 7007-1 or 7007-2).

Trig In/Out, FSK / Burst connector

This connector routes input and output signals.

Modulation In connector

Modulate the carrier waveform with an external waveform present at the Modulation In connector on the rear panel (external source must be selected).

Digital Output/low voltage transistor-transistor logic (LVTTL) port

This parallel interface includes an edge-selectable clock and 16-bit data (for pattern out operations). The 40-pin cable is used to connect the socket with your board or device.

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Section 4

Setup Basics

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Editing parameter values and settings

Use the keypad, cursor keys, and navigation wheel to adjust the Model 3390 settings. The liquid crystal display (LCD) will update as changes are made.

Numerical entry

Enter a desired value with the numeric keypad, or use the cursor keys to move the cursor on the display and increase or decrease the digit by turning the navigation wheel.

When you use the numeric keypad for an entry, all the available units for that parameter will be shown on the display. Press the soft key under the desired unit to finish the entry, or press **Cancel** to cancel the changes. In some cases, you may need to select the soft key under **DONE** to finish the entry.

Alphabetical entry

For the entry of a string of letters, turn the navigation wheel until the desired letter appears on the display. Use the cursor keys to move the cursor to the next letter or modify the letter previously entered. You can also use the **+/-** key to delete the letter previously entered.

General functions and settings

Selecting output function

Waveforms

The Model 3390 has five standard waveforms: Sine, square, ramp, pulse, and noise. To select a desired output function, press the corresponding front-panel key, and then set related parameters (refer to [Section 5, Waveform Output Operations](#) for detailed information). The default waveform output is sine waveform.

There are also five built-in arbitrary waveforms. You can create a custom waveform with the KiWAVE™ waveform editor software provided with the instrument. Refer to [Section 7, KiWAVE™ software installation](#) for software installation instructions.

Modulation, Sweep, and Burst operations

- **Mod:** The Model 3390 has modulation for sine, square, ramp, and arbitrary waveforms using amplitude modulation (AM), frequency modulation (FM), phase modulation (PM), or frequency-shift keying (FSK). You can also use pulse width modulation (PWM) for a pulse waveform.
- **Sweep:** Linear and logarithmic frequency sweeping modes are included for sine, square, ramp, and arbitrary waveforms.
- **Burst:** Burst waveforms can be generated with any one of the standard or arbitrary waveforms (except DC).

To select the output function from a remote interface:

```
FUNCTION {SINusoid|SQUare|RAMP|PULSe|NOISe|DC|USER|PATtern}
```

You may also use the **APPLY** command to select the function, frequency, amplitude, and offset in one command.

Setting frequency or period

Each waveform function has its own frequency range, but the default frequency is 1 kHz for all functions. Refer to [Table 4-1](#) for a list of the frequency ranges.

Table 4-1:

Waveform function frequency ranges

Function	Frequency range
Sine	1 μ Hz to 50 MHz
Square	1 μ Hz to 25 MHz
Ramp	1 μ Hz to 200 kHz
Pulse	500 μ Hz to 10 MHz
Arbitrary	1 μ Hz to 10 MHz

You may choose to set a frequency or period value. Press the Freq / Perd soft key to toggle between frequency ([Figure 4-1](#)) and period ([Figure 4-2](#)).

Figure 4-1:

Setting instrument frequency



Figure 4-2:

Setting instrument period



To set frequency or period:

1. Press the function key of your selection.
2. Press the soft key under **Freq / Perd** to select frequency or period. Ensure your selection is highlighted.
3. Use the navigation wheel with the cursor keys, or the numeric keypad to change the value. You can change the units by using the numeric keypad in combination with the soft keys.

To set frequency or period from a remote interface:

```
FREQUENCY {<frequency>|MINimum|MAXimum}
```

Setting amplitude

The default amplitude for all functions is 100 mV peak-to-peak (into 50 Ω).

To set amplitude:

1. Press the function key for your selection.
2. Press the soft key under **Ampl / High**. Ensure **Ampl** is highlighted ([Figure 4-3](#)).
3. Use the navigation wheel with the cursor keys, or the numeric keypad to change the value. You can change the units by using the numeric keypad in combination with the soft keys.

Figure 4-3:
Setting instrument amplitude



NOTE A momentary disruption in the output waveform may occur while changing amplitude. You can disable the voltage auto ranging function (refer to [Setting voltage auto ranging](#)) to prevent output disruption.

To set output amplitude from a remote interface:

VOLTage {<amplitude>|MINimum|MAXimum}

Use this command to set units:

VOLTage:UNIT {VPP|VRMS|DBM}

Setting DC offset voltage

The default DC offset voltage for all functions is zero (0) V.

To set DC offset voltage, use one of these two methods:

Method A

1. Press the function key of your selection.
2. Press the soft key under **Vos / Low**. Ensure **Vos** is highlighted ([Figure 4-4](#)).
3. Use the navigation wheel with the cursor keys, or the numeric keypad to change the value. You can change the units by using the numeric keypad in combination with the soft keys.

Figure 4-4:
Setting DC offset voltage



Method B

NOTE Method B can be used to specify a DC voltage line out only. Also, if you use it to set the DC offset voltage; it will hold the setting when you enter the function key of your selection.

1. Press the **Utility** key.
2. Press the soft key under **DC** to choose **DC / ON**. Ensure **ON** is highlighted.
3. Use the navigation wheel with the cursor keys, or the numeric keypad to change the value. You can change the units by using the numeric keypad in combination with the soft keys.

To set DC offset voltage from a remote interface:

VOLTage:OFFSet {<offset>|MINimum|MAXimum}

Setting pulse high and low levels

You can set a high and low level versus specifying amplitude and DC offset. Parameters are calculated as follows:

$$\text{Amplitude} = |\text{High Level}| + |\text{Low Level}|$$

$$\text{Offset} = (\text{High Level} + \text{Low Level}) / 2$$

To set pulse high and low levels:

1. Press the function key for your selection.
2. Press the soft key under **Ampl / High**. Ensure **High** is highlighted.
3. Use the navigation wheel with the cursor keys, or the numeric keypad to change the value. You can change the units by using the numeric keypad in combination with the soft keys.
4. Press the soft key under **Vos / Low**. Ensure **Low** is highlighted.
5. Use the navigation wheel with the cursor keys, or the numeric keypad to change the value. You can change the units by using the numeric keypad in combination with the soft keys.

To set pulse high and low levels from a remote interface:

```
VOLTage:HIGH {<voltage>|MINimum|MAXimum}
```

```
VOLTage:LOW {<voltage>|MINimum|MAXimum}
```

Setting waveform polarity

Waveform polarity can be specified as normal or inverted. When a non-zero offset is specified, the waveform is inverted relative to the offset voltage, and the offset remains the same in the inverted waveform. An inverted waveform does not affect the associated sync signal.

To set waveform polarity:

1. Press the **Utility** key, and then press the soft key under **Output Setup**.
2. Press the soft key under **Norm / Invt** to choose between normal and inverted ([Figure 4-5](#)). Ensure your selection is highlighted.
3. Press the soft key under **DONE** to finish your selection.

Figure 4-5:

Setting waveform polarity



To set waveform polarity from a remote interface:

```
OUTPut:POLarity {NORMal|INVerted}
```

Setting output termination

The default output impedance to the front-panel Output connector is 50 Ω. The termination setting is stored in nonvolatile memory and remains after a remote interface reset, or the instrument power is turned off.

NOTE

If the actual load impedance does not match the value specified, the output amplitude and offset levels will be incorrect. Invalid results may occur.

To set output termination:

1. Press the **Utility** key, and then press the soft key under **Output Setup**.
2. To set a load value: Press the soft key under **Load / Hi-Z** ([Figure 4-5](#)). Ensure **Load** is highlighted. Use the navigation wheel with the cursor keys, or the numeric keypad to change the value. You can change the units by using the numeric keypad in combination with the soft keys.

To select high impedance: Press the **Load / Hi-Z** soft key again to highlight **Hi-Z**.

3. Press the soft key under **DONE** to finish your selection.

To set output termination from a remote interface:

```
OUTPut:LOAD {<ohms>|INFinity|MINimum|MAXimum}
```

Setting voltage auto ranging

Auto ranging is enabled at power up (by default) and finds optimal settings for the output amplifier and attenuators. If auto ranging disabled, the instrument uses the current amplifier and attenuator settings.

To enable/disable voltage auto ranging:

1. Press the **Utility** key, and then press the soft key under **Output Setup**.
2. Press the soft key under **Rang** to select Auto ([Figure 4-6](#)) or Hold ([Figure 4-7](#)). Ensure your selection is highlighted.
3. Press the soft key under **DONE** to finish your selection.

Figure 4-6:

Setting voltage auto ranging to Auto

Figure 4-7:

Setting voltage auto ranging to Hold**To set voltage auto ranging from a remote interface:**

```
VOLTage:RANGe:AUTO {OFF|ON|ONCE}
```

Front panel connections

The Sync and Output connectors are both located on the front panel of the Model 3390.

Controlling the output signal

Signal from the Output connector is controlled by the **Output** key. The output is disabled by default at power up; this protects equipment connected to the instrument.

Press the **Output** key to enable the Output connector. The key is lit when output is enabled.

To enable or disable the output signal from a remote interface:

```
OUTPut {OFF|ON}
```

Controlling the sync signal

All Model 3390 output functions (except DC and noise) can be associated with a sync-out signal ([Table 4-2](#)). The sync-out signal is delivered at the Sync connector. The output signal is at a logic "low" level when the sync signal is disabled. The sync setting is stored in nonvolatile memory and remains after a remote interface reset, or the instrument power is turned off.

The sync signal has three settings, ON, OFF and AUTO. The AUTO setting enables the instrument to vary the signal with the associated function.

Table 4-2:
Sync signal and function relationships

Function	Relationship
Sine, ramp, and pulse waveforms	Sync signal is a square waveform with a 50% duty cycle. Relative to 0 volts, the signal is transistor-transistor logic (TTL) "high" when waveform output is positive and TTL "low" when the waveform output is negative.
Square waveform	Sync signal is a square waveform with the same duty cycle.
Arbitrary waveform	Sync signal is a square waveform with a 50% duty cycle. The signal is TTL "high" when the first waveform point is delivered.
Internally-modulated AM, FM, PM, and PWM	Sync signal is a square waveform with a 50% duty cycle that is aligned with the modulating waveform. The signal is TTL "high" during the first half of the waveform.
Externally-modulated AM, FM, PM, and PWM	Sync signal is a square waveform with a 50% duty cycle that is aligned with the carrier waveform.
FSK	Sync signal is aligned with shifts in frequency. The signal is TTL "high" during output of the hop frequency and TTL "low" during output of the carrier frequency.
Triggered burst	The sync signal becomes TTL "high" when the burst is triggered and transitions to TTL "low" at the end of the specified number of cycles.
Externally-gated burst	The sync signal starts at TTL "high" with the external gate signal and transitions to TTL "low" at the end of the last cycle.

To set the sync output:

1. Press the **Utility** key.
2. Press the soft key under **Sync**. Press the soft key corresponding with your selection (**ON**, **OFF** or **AUTO**).

To enable or disable the sync signal from a remote interface:

```
OUTPut:SYNC {OFF|ON}
```

Default settings

[Table 4-3](#) shows the factory default settings for the Model 3390. These settings will be recalled at power up unless you set the instrument to enable a stored state.

Table 4-3:
Factory default settings

Output configuration	Default setting
Function	Sine waveform
Frequency	1 kHz
Amplitude/offset	100 mV peak-to-peak/0.000 V DC
Output units	V peak-to-peak
Output termination	50 Ω
Auto range	On
Modulation settings	
Carrier	1 kHz Sine (AM, FM, PM, FSK)
	1 kHz Pulse (PWM)
Modulation waveform (AM)	100 Hz Sine
Modulation waveform (PM, FM, PWM)	10 Hz Sine
AM depth	100%
FM deviation	100 Hz
PM deviation	180°
FSK hop frequency	100 Hz
FSK rate	10 Hz
PWM width deviation	10 μ s
Modulation state	Off
Sweep settings	
Start/stop frequency	100 Hz/1 kHz
Sweep time	1 s
Sweep mode	Linear
Sweep state	Off
Burst settings	
Burst count	1 cycle
Burst period	10 ms
Burst start phase	0°
Burst state	Off
System-based operations	
Power-down recall	Disabled
Display mode	On
Error queue	0 errors
Output state	Off
Triggering operations	
Trigger source	Internal (immediate)
Remote interface configuration	
GPIO address	16
DHCP	On

Restoring factory default settings

You can choose to reset the Model 3390 to its original factory default settings.

To restore factory default settings:

1. Press the **Store / Recall** key.
2. Press the soft key under **Set to Def** ([Figure 4-8](#)).
3. Press the soft key under **YES** to finish your selection ([Figure 4-9](#)).

Figure 4-8:

Setting the instrument to default

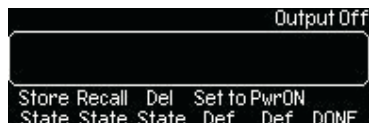
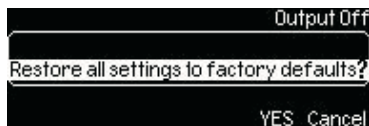


Figure 4-9:

Accept default setting change



To restore factory default settings from a remote interface:

*RST

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Waveform Output Operations

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Introduction

This section describes each of the Model 3390 waveform types, associated front-panel menu options, and remote interface operations for each.

General parameters:

- Frequency and amplitude limits exist: The instrument will automatically adjust frequency or amplitude as necessary each time a new function is selected.
- You can specify a high and low voltage level, or the amplitude and DC offset. For example, if you set the high level to **+2 volts** (Figure 5-1) and the low level to **-3 volts** (Figure 5-2), the resulting amplitude will be 5 V peak-to-peak, with an offset voltage of -0.5 V.

The default output unit is volts peak-to-peak (Vpp), but you can also select V RMS or dBm. The output unit cannot be set to dBm if the output termination is set to high impedance (Hi-Z). Output amplitude limits can be affected by the output units selected.

The unit setting is stored in volatile memory during operation. The default unit (Vpp) will be restored after a power up or a remote interface reset.

Figure 5-1:
Setting the high-voltage level



Figure 5-2:
Setting the low-voltage level



- The output amplitude and DC offset values are constrained by the equation below:

$$V_{\text{peak-to-peak}} \leq 2 \times (V_{\text{max}} - |V_{\text{offset}}|)$$

Where: V_{max} is the maximum allowed peak voltage for the selected output termination (5 V for a 50 Ω load, or 10 V for a high-impedance load). When the output termination setting is changed, the output amplitude automatically adjusts.

Output operations

Sine waveform

A sine waveform is a uniform waveform with a constant frequency and amplitude.

To generate a sine waveform:

1. The default waveform output of the Model 3390 is the sine waveform. If the current output function is not sine, press the **Sine** key.

2. Refer to [Section 4, Setup Basics](#) for configuring common parameters including frequency/period, amplitude, and DC offset voltage ([Figure 5-3](#)).
3. Press the **Graph** key to view the waveform parameters in the graph mode.

Figure 5-3

Setting up a sine waveform**To generate a sine waveform from a remote interface:**

```
APPLY:SINusoid [<frequency>[,<amplitude>[,<offset>]]]
```

or

```
FUNCTION {SINusoid}
FREQUENCY {<frequency>|MINimum|MAXimum}
VOLTage {<amplitude>|MINimum|MAXimum }
VOLTage:OFFSet {<offset>|MINimum|MAXimum }
```

Square waveform

A square waveform has instantaneous transitions between two voltage levels. The duty cycle of a square waveform represents the amount of time in each cycle that the wave is at the high level (the waveform is not inverted):

$$\text{Duty Cycle} = (\text{Time Interval at High Level}) / \text{Period} \times 100\%$$

The default value for duty cycle is 50%. The setting is stored in volatile memory and it will be restored after power off or a remote interface reset. During operation, if the square waveform duty cycle value is changed, it is stored and will be resumed when square waveform is re-selected (until instrument power off). For square waves with frequency set above 10 MHz, the range of the duty cycle is 40% to 60%. For lower frequency, the range is 20% to 80%. If you change frequency to a value that is out of scope for the current duty cycle, the Model 3390 will automatically adjust the duty cycle to the closest possible value for the new frequency. If square waveform is selected as the modulating waveform, the duty cycle is fixed at 50%. The duty cycle setting applies to square wave carrier waveform for AM, FM, PM, or PWM.

To generate a square waveform:

1. Press the **Square** key.
2. Refer to [Section 4, Setup Basics](#) for configuring common parameters including frequency/period, amplitude, and DC offset voltage ([Figure 5-4](#)).
3. Press the soft key under **Duty / Cycle**. Use the navigation wheel with the cursor keys to change the value, and then press another soft key to finish the entry and exit. Or use the numeric keypad to enter a desired value and then press the soft key under % to finish the entry or the soft key under **Cancel** to cancel the changes.
4. Press the **Graph** key to view the waveform parameters in the graph mode.

Figure 5-4:
Setting up a square waveform



To generate a square waveform from a remote interface:

```
APPLY:SQUare [<frequency>[,<amplitude>[,<offset>]]]
```

or

```
FUNCTION {SQUare}
FREQUENCY {<frequency>|MINimum|MAXimum}
VOLTage {<amplitude>|MINimum|MAXimum }
VOLTage:OFFSet {<offset>|MINimum|MAXimum }
FUNCTION:SQUare:DCYCLE {<percent>|MINimum|MAXimum }
```

Ramp waveform

A ramp waveform is a triangle waveform with adjustable symmetry. Symmetry represents the percentage of time in a cycle when the ramp waveform is rising (waveform polarity is not inverted).

The default symmetry is 100%. The symmetry value is stored in volatile memory and it will be restored after power-off or a remote interface reset. During operation, if the output function is changed from ramp waveform, the symmetry is stored in memory and will be resumed when ramp waveform is re-selected (until instrument power off). The symmetry setting is not applicable when ramp waveform is used as the modulating waveform for AM, FM, PM, or PWM.

To generate a ramp waveform:

1. Press the **Ramp** key.
2. Refer to [Section 4, Setup Basics](#) for configuring common parameters including frequency/period, amplitude, and DC offset voltage ([Figure 5-5](#)).
3. Press the soft key under **Symmetry**. Use the navigation wheel with the cursor keys to change the value, and then press another soft key to finish the entry and exit. Or use the numeric keypad to enter a desired value and then press the soft key under % to finish the entry or the soft key under **Cancel** to cancel the changes.
4. Press the **Graph** key to view the waveform parameters in the graph mode.

Figure 5-5:
Setting up a ramp waveform



To generate a ramp waveform from a remote interface:

```
APPLY:RAMP [<frequency>[,<amplitude>[,<offset>]]]
```

(The command generates a ramp waveform with 100% symmetry.)

or

```
FUNCTION {RAMP}
FREQUENCY {<frequency>|MINimum|MAXimum}
VOLTage {<amplitude>|MINimum|MAXimum }
```

```
VOLTage:OFFSet {<offset>|MINimum|MAXimum }
FUNCTion:RAMP:SYMMetry {<percent>|MINimum|MAXimum}
```

Noise waveform

A Gaussian noise waveform with a 20 MHz bandwidth can be generated.

To generate a noise waveform:

1. Press the **Noise** key.
2. Refer to [Section 4, Setup Basics](#) for configuring common parameters including amplitude and DC offset voltage ([Figure 5-6](#)).
3. Press the **Graph** key to view the waveform parameters in the graph mode.

Figure 5-6:

Setting up a noise waveform



To generate a noise waveform from a remote interface:

```
APPLY:NOISE [<frequency>|DEF>[,<amplitude>[,<offset>]]]
FUNCTion {NOISE}
VOLTage {<amplitude>|MINimum|MAXimum }
VOLTage:OFFSet {<offset>|MINimum|MAXimum }
```

NOTE

In the APPL:NOIS command, the frequency parameter has no effect, but you still must specify a value or DEFault for it.

Pulse waveform

A pulse waveform has a pulse period, a pulse width or pulse duty cycle, an ascending edge, and a descending edge.

Pulse period / frequency

The default pulse period is 1 ms (or 1 kHz in frequency), and the allowable value ranges from 100 ns to 2000 s (or 10 MHz down to 0.5 mHz in frequency). Pulse period constrains the other parameters according to the following equation:

$$\text{Pulse Period} \geq \text{Pulse Width} + 1.6 \times \text{Edge Time}$$

NOTE

The waveform generator adjusts the other parameters when necessary to accommodate the given pulse period.

Pulse width

The pulse width represents the time from the 50% point of the ascending edge to the 50% point of the following descending edge. The default pulse width is 100 μ s, and the possible value ranges from 20 ns to 2000 s. The actual allowable range is determined as follows:

$$1.6 \times \text{Edge Time} \leq \text{Pulse Width} \leq \text{Pulse Period} - 1.6 \times \text{Edge Time}$$

$$W_{min} \leq \text{Pulse Width} \leq \text{Pulse Period} - W_{min}$$

Where: W_{min} is the minimum allowable value determined by the following conditions on pulse period:

$$\begin{aligned}
 W_{min} &= 20 \text{ ns, if pulse period is } \leq 10 \text{ s} \\
 &200 \text{ ns, if } 10 \text{ s} < \text{pulse period} \leq 100 \text{ s} \\
 &2 \text{ } \mu\text{s, if } 100 \text{ s} < \text{pulse period} \leq 1000 \text{ s} \\
 &20 \text{ } \mu\text{s, if } 1000 \text{ s} < \text{pulse period}
 \end{aligned}$$

Pulse duty cycle

Specifying pulse duty cycle is another way to define a pulse waveform (versus specifying pulse width). Pulse duty cycle is defined as follows:

$$\text{Duty Cycle} = \text{Pulse Width} / \text{Pulse Period} \times 100\%$$

If the specified pulse duty cycle conflicts with the specified pulse width, or pulse width conflicts with the duty cycle, the most recently specified parameter will be accepted. The default duty cycle is 10%, and the acceptable range is from 0% to 100% with the following constraints:

$$\text{DutyCycle} \geq W_{min} / \text{PulsePeriod} \times 100\%$$

$$\text{DutyCycle} \leq (1.0 - W_{min} / \text{PulsePeriod}) \times 100\%$$

Where: W_{min} is the minimum allowable value for pulse width as defined under the [Pulse width](#) topic.

Edge time

The edge time represents the time from the 10% point to the 90% point of an ascending or descending edge. The default edge time is 5 ns, and the possible value ranges from 5 ns to 100 ns, with the following constraint on the maximum allowable value:

$$\text{EdgeTime} \leq 0.625 \times \text{PulseWidth}$$

To generate a pulse waveform:

1. Press the **Pulse** key.
2. Refer to [Section 4, Setup Basics](#) for configuring common parameters including frequency/period, amplitude, and DC offset voltage ([Figure 5-7](#)).
3. Press the soft key under **Width / Duty** to select between setting pulse width or duty cycle. Use the navigation wheel with the cursor keys to change the value, and then press another soft key to finish the entry and exit. Or use the numeric keypad to enter a desired value and then press a unit soft key, or press %, to finish the entry. Press the soft key under **Cancel** to cancel the changes.

NOTE You can choose to hold pulse width or duty cycle constant during changes in frequency. Press the soft key to highlight your selection (**Width** or **Duty**), then enter your frequency value.

4. Press the soft key under **Edge / Time** and use the navigation wheel with cursor keys to change the value, and then press another soft key to finish the entry and exit. Or use the numeric keypad to enter a new value and then press the soft key under **nsec** to finish the entry. Press the soft key under **Cancel** to cancel the changes.
5. Press the **Graph** key to view the waveform parameters in the graph mode.

Figure 5-7:
Setting up a pulse waveform



To generate a pulse waveform from a remote interface:

```
APPLY:PULSe [<frequency>[,<amplitude>[,<offset>] ]]
```

Or

```
FUNCTION {PULSe}
FREQUENCY {<frequency>|MINimum|MAXimum }
VOLTage {<amplitude>|MINimum|MAXimum }
VOLTage:OFFSet {<offset>|MINimum|MAXimum }
PULSe:PERiod {<seconds>|MINimum|MAXimum}
FUNCTION:PULSe:WIDTH {<seconds>|MINimum|MAXimum }
FUNCTION:PULSe:DCYCLE {<percent>|MINimum|MAXimum }
FUNCTION:PULSe:TRANSition {<seconds>|MINimum|MAXimum }
```

Arbitrary waveform

The Model 3390 has five built-in arbitrary waveforms including, exponential-rise, exponential-fall, negative-ramp, sinc, and cardiac. The default arbitrary waveform is an exponential-rise waveform.

In addition, up to four user-defined arbitrary waveforms can be stored in nonvolatile memory. For each user-defined waveform, you may create up to 262,144 (256 K) points from the remote interface. You can use the KiWAVE™ waveform editor software to create waveforms, or import the waveforms captured previously from an oscilloscope. Refer to [Section 7, KiWAVE™ software installation](#) for software installation instructions.

If you choose an arbitrary waveform as the modulating waveform for AM, FM, PM, or PWM, the waveform is automatically limited to 4 K points and extra points will be removed by decimation.

NOTE If the data points do not span the full range of the output digital-to-analog converter (DAC), the maximum amplitude will be limited.

IEEE-488.2 binary block format

Following is an example of binary block format:

```
# 5 32768
```

This data begins with a number symbol (#) and is followed by a single digit that represents the number of characters in the length. The third number represents the number of bytes (32,768 bytes = 16,384 points).

A waveform data point is represented as a 16-bit integer sent in two bytes. The total number of bytes is always an even number that is twice the number of data points in the waveform.

Use the `FORM:BORD` command to select the byte order for binary block transfers. The default command is `FORM:BORD NORM`, in which the most-significant byte (MSB) of each data point is sent first. If you specify `FORM:BORD SWAP`, the least-significant byte (LSB) of each data point is sent first. The `DATA:DAC` command overwrites the waveform in volatile memory without generating an error.

The following commands are point specific:

- `DATA:DAC VOLATILE, {<binary block>|<value>, <value>, ...}`
Enter this command to download binary or decimal integer values from -8191 to +8191 into volatile memory. The values -8191 and +8191 correspond to the peak values of the waveform with the offset set at zero volts.
You can download from 1 to 65,536 (64K) points per waveform in IEEE-488.2 binary block format, or as a list of values. The range of values corresponds to the values available using internal 14-bit DAC codes.
- `DATA VOLATILE, <value>, <value>, ...`
Enter this command to download floating-point values from -1 to +1 into volatile memory. The values -1 and +1 correspond to the peak values of the waveform with the offset set at zero volts. You can download from 1 to 65,536 points per waveform.

NOTE

If the data points do not span the full range of the output digital-to-analog converter (DAC), the maximum amplitude will be limited. Also, the Model 3390 expands the number of points to fill the waveform memory; less than 16,384 (16K) points will automatically generate a waveform with 16,384 points. More than 16,384 points will automatically generate a waveform with 65,536 points.

To generate a built-in arbitrary waveform:

1. Press the **Arb** key.
2. Press the soft key under **Select Wform** (Figure 5-8), and then the soft key under **Built In** (Figure 5-9).

Figure 5-8:

Press the soft key under Select Wform



Figure 5-9:

Press the soft key under Built In



3. Choose the desired waveform from the five built-in choices by pressing the corresponding soft key (Figure 5-10). The instrument will automatically update to the chosen waveform.

Figure 5-10:

Press the soft key corresponding with the desired waveform



4. Refer to [Section 4, Setup Basics](#) for configuring common parameters including frequency/period, amplitude, and DC offset voltage.
5. Press the **Graph** key to view the waveform parameters in the graph mode.

To generate an arbitrary waveform from a remote interface:

```

FUNCTION USER {EXP_RISE | EXP_FALL | NEG_RAMP | SINC | CARDIAC}
DATA:DAC VOLATILE, {<binary block>|<value>, <value>, ...}
DATA VOLATILE, <value>, <value>, ...
FORMAt:BORDer {NORMAl|SWAPped}
DATA:COpy <destination arb name> [,VOLATILE]

```

Amplitude modulation

Amplitude modulation allows the amplitude of the carrier waveform to vary with the modulating waveform. Only one type of modulation can be active at one time; if amplitude modulation is enabled, the previously selected modulation is automatically disabled. In addition, when amplitude modulation is enabled, sweep mode and burst mode are disabled.

Carrier waveform

The default carrier waveform is sine. You can also choose square, ramp, and arbitrary waveforms. The default carrier frequency is 1 kHz for all waveforms. Each carrier waveform has its own acceptable range of frequencies. Refer to [Table 4-1, Waveform function frequency ranges](#) for details.

Modulating waveform

The Model 3390 accepts either an internal or external modulating source.

The default source is internal with a default frequency of 100 Hz (the acceptable range is 2 mHz to 20 kHz). The default internal modulating waveform is a sine waveform, but you can also select any of the following:

- Square waveform with 50% duty cycle
- URamp (up or positive ramp with 100% symmetry)
- DRamp (down or negative ramp with 0% symmetry)
- Triangle waveform (ramp with 50% symmetry)
- Noise waveform
- Arbitrary waveform (limited to 4 K points with automatic decimation)

Select the external modulating source to modulate the carrier waveform with an external signal present at the Modulation In connector on the rear panel.

Modulation depth

The modulation depth controls the magnitude of the amplitude variation of the modulation output. It is defined in the following formula:

$$\text{Modulation Depth} = (\text{Max Amplitude} - \text{Min Amplitude}) / \text{Amplitude} \times 100\%$$

Where: Amplitude is the specified amplitude of the carrier waveform; Max Amplitude and Min Amplitude are the maximum and minimum amplitudes of the resulting modulation waveform.

When Modulation Depth is 0%, the amplitude of the modulation waveform stays at half of the specified amplitude of the carrier waveform. As a result, Min Amplitude may be negative when Modulation Depth is larger than 100%. The default Modulation Depth is 100% and the allowable range is from 0% to 120%.

Choosing the external source means the modulation is controlled by the specified modulation depth and the ± 5 V signal levels of the external waveform. When the external waveform is at +5 V,

the amplitude of the output will reach Max Amplitude. When the external waveform is at -5 V, the amplitude of the output will reach Min Amplitude.

The modulation output of the Model 3390 will not exceed ± 5 V peak (into a 50 Ω load) even if the modulation depth is greater than 100%.

To set up amplitude modulation:

1. Select the carrier waveform (**Sine**, **Square**, **Ramp**, or **Arb**). Follow the instructions for setting up that specific waveform as given in this publication. Refer to [Section 4, Setup Basics](#) for assistance.
2. Press the **Mod** key to access the modulation menu.
3. Press the soft key under **Type**; then press the soft key under **AM** to select amplitude modulation ([Figure 5-11](#)). An amplitude modulation output will be generated with the set parameters.

Figure 5-11:

Press the soft keys corresponding with AM



4. Press the soft key under **Src** to select between internal source (**Int**) and external source (**Ext**) for the modulating waveform ([Figure 5-11](#)). If internal source is selected:
 - a) Press the soft key under **Shape** to select the modulating waveform. If arbitrary waveform (**Arb**) is chosen, the instrument will use the currently selected arbitrary waveform. Press the **Mod** key to see which arbitrary modulating waveform is currently selected.
 - b) Press the soft key under **AM / Freq**. Use the navigation wheel with the cursor keys to change the value, and then press another soft key to finish the entry and exit. Or use the numeric keypad to enter a desired value and then press the soft key under the desired units to finish the entry, or the soft key under **Cancel** to cancel the changes.
5. Press the soft key under **AM / Depth** ([Figure 5-11](#)). Use the navigation wheel with the cursor keys to change the value, and then press another soft key to finish the entry and exit. Or use the numeric keypad to enter a desired value and then press the soft key under % to finish the entry, or the soft key under **Cancel** to cancel the changes.
6. Press the **Graph** key to view the waveform parameters in the graph mode.

To set up amplitude modulation from a remote interface:

```
FUNCTION {SINusoid|SQUare|RAMP|USER}
FREQUENCY {<frequency>|MINimum|MAXimum}
VOLTage {<amplitude>|MINimum|MAXimum}
VOLTage:OFFSet {<offset>|MINimum|MAXimum}
AM:INTERNAL:FUNCTION {SINusoid|SQUare|RAMP|NRAMP|TRIangle|NOISe|USER}
AM:INTERNAL:FREQUENCY {<frequency>|MINimum|MAXimum}
AM:DEPTH {<depth in percent>|MINimum|MAXimum}
AM:SOURce {INTERNAL|EXTERNAL}
AM:STATE {OFF|ON}
```

Frequency modulation

Frequency modulation allows the frequency of the carrier waveform to vary with the modulating waveform. Only one type of modulation can be active at one time. If frequency modulation is

enabled, the previously selected modulation is automatically disabled. In addition, when frequency modulation is enabled, sweep mode and burst mode are disabled.

Carrier waveform

The default carrier waveform is sine. You can also choose square, ramp, and arbitrary waveforms. The default carrier frequency is 1 kHz for all waveforms. Each carrier waveform has its own acceptable range of frequencies. Refer to [Table 4-1: Waveform function frequency ranges](#) for details.

Modulating waveform

The Model 3390 accepts either an internal or external modulating source.

The default source is internal with a default frequency of 100 Hz (the acceptable range is 2 mHz to 20 kHz). The default internal modulating waveform is a sine waveform, but you can also select from the following:

- Square waveform with 50% duty cycle
- URamp (up or positive ramp with 100% symmetry)
- DRamp (down or negative ramp with 0% symmetry)
- Triangle waveform (ramp with 50% symmetry)
- Noise waveform
- Arbitrary waveform (limited to 4 K points with automatic decimation)

Select the external modulating source to modulate the carrier waveform with an external signal present at the Modulation In connector on the rear panel.

Frequency deviation

The frequency deviation represents the peak variation in the frequency of the modulation output, based on that of the carrier waveform. The default value is 100 Hz. If a value is set greater than allowed, the instrument will automatically adjust it to the instrument maximum. Each type of carrier waveform has a different acceptable range:

- Sine: 1 μ Hz to 25.05 MHz (at carrier frequency = 25.05 MHz)
- Square: 1 μ Hz to 12.55 MHz (at carrier frequency = 12.55 MHz)
- Ramp: 1 μ Hz to 150 kHz (at carrier frequency = 150 kHz)
- Arbitrary: 1 μ Hz to 5.05 MHz (at carrier frequency = 5.05 MHz)

The maximum allowable value is also affected by the following:

- The frequency deviation cannot be greater than the carrier frequency.
- The sum of frequency deviation and the carrier frequency cannot be greater than the maximum frequency of the selected carrier waveform plus 100 kHz; (50.1 MHz for sine; 25.1 MHz for square; 300 kHz for ramp; and 10.1 MHz for arbitrary waveforms).

Choosing the external source means the modulation is controlled by the specified frequency deviation and the ± 5 V signal levels of the external waveform. When the external waveform is at +5 V, the output will reach positive maximum frequency deviation. When the external waveform is at -5 V, the output will reach negative maximum frequency deviation.

To set up frequency modulation:

1. Select the carrier waveform (**Sine**, **Square**, **Ramp**, or **Arb**). Follow the instructions for setting up that specific waveform as given in this publication. Refer to [Section 4, Setup Basics](#) for assistance.
2. Press the **Mod** key to access the modulation menu.

3. Press the soft key under **Type**; then press the soft key under **FM** to select frequency modulation ([Figure 5-12](#)). A frequency modulation output will be generated with the set parameters.

Figure 5-12:

Press the soft keys corresponding with FM



4. Press the soft key under **Src** to select between internal source (**Int**) and external source (**Ext**) for the modulating waveform ([Figure 5-12](#)). If internal source is selected:
 - a) Press the soft key under **Shape** to select the modulating waveform. If arbitrary waveform (**Arb**) is chosen, the instrument will use the currently selected arbitrary waveform. Press the **Mod** key to see which arbitrary modulating waveform is currently selected.
 - b) Press the soft key under **FM / Freq**. Use the navigation wheel with the cursor keys to change the value, and then press another soft key to finish the entry and exit. Or use the numeric keypad to enter a desired value and then press the soft key under the desired units to finish the entry, or the soft key under **Cancel** to cancel the changes.
5. Press the soft key under **Freq / Dev** ([Figure 5-12](#)). Use the navigation wheel with the cursor keys to change the value, and then press another soft key to finish the entry and exit. Or use the numeric keypad to enter a desired value and then press the soft key under the desired units to finish the entry, or the soft key under **Cancel** to cancel the changes.
6. Press the **Graph** key to view the waveform parameters in the graph mode.

To set up frequency modulation from a remote interface:

```
FUNCTION {SINusoid|SQUare|RAMP|USER}
FREQUENCY {<frequency>|MINimum|MAXimum}
VOLTage {<amplitude>|MINimum|MAXimum}
VOLTage:OFFSet {<offset>|MINimum|MAXimum}
FM:INTERNAL:FUNCTION {SINusoid|SQUare|RAMP|NRAMP|TRIangle|NOISe|USER}
FM:INTERNAL:FREQUENCY {<frequency>|MINimum|MAXimum}
FM:DEVIation {<peak deviation in Hz>|MINimum|MAXimum}
FM:SOURce {INTERNAL|EXTERNAL}
FM:STATe {OFF|ON}
```

Phase modulation

Phase modulation allows the phase of the carrier waveform to vary with the modulating waveform.

Carrier waveform

The default carrier waveform is sine. You can also choose square, ramp, and arbitrary waveforms. The default carrier frequency is 1 kHz for all waveforms. Each carrier waveform has its own acceptable range of frequencies. Refer to [Table 4-1: Waveform function frequency ranges](#) for details.

Modulating waveform

The Model 3390 accepts either an internal or external modulating source.

The default source is internal with a default frequency of 100 Hz (the acceptable range is 2 mHz to 20 kHz). The default internal modulating waveform is a sine waveform, but you can also select from the following:

- Square waveform with 50% duty cycle
- URamp (up or positive ramp with 100% symmetry)
- DRamp (down or negative ramp with 0% symmetry)
- Triangle waveform (ramp with 50% symmetry)
- Noise waveform
- Arbitrary waveform (limited to 4 K points with automatic decimation)

Select the external modulating source to modulate the carrier waveform with an external signal present at the Modulation In connector on the rear panel.

Phase deviation

The phase deviation represents the peak variation in the phase of the modulation output, based on that of the carrier waveform. The range of the phase deviation is from 0° to 360°, and the default is 180°.

Choosing the external source means the modulation is controlled by the specified phase deviation and the ± 5 V signal levels of the external waveform. When the external waveform is at +5 V, the output will reach maximum positive phase deviation. When the external waveform is at -5 V, the output will reach maximum negative phase deviation.

To set up phase modulation:

1. Select the carrier waveform (**Sine**, **Square**, **Ramp**, or **Arb**). Follow the instructions for setting up that specific waveform as given in this publication. Refer to [Section 4, Setup Basics](#) for assistance.
2. Press the **Mod** key to access the modulation menu.
3. Press the soft key under **Type**; then press the soft key under **PM** to select phase modulation ([Figure 5-13](#)). A phase modulation output will be generated with the set parameters.

Figure 5-13:

Press the soft keys corresponding with PM



4. Press the soft key under **Src** to select between internal source (**Int**) and external source (**Ext**) for the modulating waveform ([Figure 5-13](#)). If internal source is selected:
 - a) Press the soft key under **Shape** to select the modulating waveform. If arbitrary waveform (**Arb**) is chosen, the instrument will use the currently selected arbitrary waveform. Press the **Mod** key to see which arbitrary modulating waveform is currently selected.
 - b) Press the soft key under **PM / Freq**. Use the navigation wheel with the cursor keys to change the value, and then press another soft key to finish the entry and exit. Or use the numeric keypad to enter a desired value and then press the soft key under the desired units to finish the entry, or the soft key under **Cancel** to cancel the changes.
5. Press the soft key under **Phase / Dev** ([Figure 5-13](#)). Use the navigation wheel with the cursor keys to change the value, and then press another soft key to finish the entry and exit. Or use the numeric keypad to enter a desired value and then press the soft key under **deg** to finish the entry, or the soft key under **Cancel** to cancel the changes.

6. Press the **Graph** key to view the waveform parameters in the graph mode.

To set up phase modulation from a remote interface:

```

FUNCTION {SINusoid|SQUare|RAMP|USER}
FREQUENCY {<frequency>|MINimum|MAXimum}
VOLTage {<amplitude>|MINimum|MAXimum}
VOLTage:OFFSet {<offset>|MINimum|MAXimum}
PM:INTERNAL:FUNCTION {SINusoid|SQUare|RAMP|NRAMP|TRIangle|NOISe|USER}
PM:INTERNAL:FREQUENCY {<frequency>|MINimum|MAXimum}
PM:DEVIation {<deviation in degrees>|MINimum|MAXimum}
PM:SOURce {INTERNAL|EXTERNAL}
PM:STATe {OFF|ON}

```

Frequency-shift keying modulation

Frequency-shift keying (FSK) modulation allows the frequency of the carrier waveform to shift between two discrete frequencies (the carrier frequency and the hop frequency). The shifting rate is determined by the modulating signal.

Carrier waveform

The default carrier waveform is sine. You can also choose square, ramp and arbitrary waveforms. The default carrier frequency is 1 kHz for all waveforms. Each carrier waveform has its own acceptable range of frequencies. Refer to [Table 4-1: Waveform function frequency ranges](#) for details.

Modulating waveform

The Model 3390 accepts either an internal or external modulating source.

The default source is internal, and the internal modulating waveform is a square waveform with a 50% duty cycle.

Select the external modulating source to modulate the carrier waveform with an external signal present at the Trig In/Out, FSK / Burst connector on the rear panel.

Hop frequency

The default frequency is 100 Hz. Each waveform has a different acceptable range:

- Sine: 1 μ Hz to 50 MHz (at carrier frequency = 1 μ Hz)
- Square: 1 μ Hz to 25 MHz (at carrier frequency = 1 μ Hz)
- Ramp: 1 μ Hz to 200 kHz (at carrier frequency = 1 μ Hz)
- Arbitrary: 1 μ Hz to 10 MHz (at carrier frequency = 1 μ Hz)

Choosing the external source means the modulation is controlled by the signal levels of the external waveform. When the external waveform is at the logic "low" level, the output is at the carrier frequency. When the external waveform is at the logic "high" level, the output is at the hop frequency.

FSK rate

The FSK rate is the rate at which the output frequency shifts between the carrier frequency and the hop frequency when internal source is selected. The default FSK rate is 10 Hz and the range is from 2 mHz to 100 kHz.

To set up FSK modulation:

1. Select the carrier waveform (**Sine**, **Square**, **Ramp**, or **Arb**). Follow the instructions for setting up that specific waveform as given in this publication. Refer to [Section 4, Setup Basics](#) for assistance.
2. Press the **Mod** key to access the modulation menu.
3. Press the soft key under **Type**; then press the soft key under **FSK** to select FSK modulation ([Figure 5-14](#)). An FSK modulation output will be generated with the set parameters.

Figure 5-14:

Press the soft keys corresponding with FSK

4. Press the soft key under **Src** to select between internal source (**Int**) and external source (**Ext**) for the modulating waveform ([Figure 5-14](#)). If internal source is selected, press the soft key under **FSK / Rate**. Use the navigation wheel with the cursor keys to change the value, and then press another soft key to finish the entry and exit. Or use the numeric keypad to enter a desired value and then press the soft key under the desired units to finish the entry, or the soft key under **Cancel** to cancel the changes.
5. Press the soft key under **Hop / Freq**. Use the navigation wheel with the cursor keys to change the value, and then press another soft key to finish the entry and exit. Or use the numeric keypad to enter a desired value and then press the soft key under the desired units to finish the entry, or the soft key under **Cancel** to cancel the changes.
6. Press the **Graph** key to view the waveform parameters in the graph mode.

To set up FSK modulation from a remote interface:

```

FUNCTION {SINusoid|SQUare|RAMP|USER}
FREQUENCY {<frequency>|MINimum|MAXimum}
VOLTage {<amplitude>|MINimum|MAXimum }
VOLTage:OFFSet {<offset>|MINimum|MAXimum }
FSKey: FREQUENCY {<frequency>|MINimum|MAXimum}
FSKey: INTERNAL:RATE {<rate in Hz>|MINimum|MAXimum }
FSKey: SOURCE {INTERNAL|EXTERNAL}
FSKey: STATE {OFF|ON}

```

Pulse width modulation waveform

Pulse Width Modulation (PWM) allows the pulse width of the carrier waveform to vary with the modulating waveform. The pulse width can be specified in either time units or duty cycle.

Carrier waveform

Pulse is the carrier waveform. The default period for the carrier pulse is 1 ms and the acceptable range is 100 ns to 200 s.

Modulating waveform

The Model 3390 accepts either an internal or external modulating source.

The default source is internal with a default frequency of 10 Hz (the acceptable range is 2 mHz to 20 kHz). The default internal modulating waveform is a sine waveform, but you can also select from the following:

- Square waveform with 50% duty cycle
- URamp (up or positive ramp with 100% symmetry)
- DRamp (down or negative ramp with 0% symmetry)
- Triangle waveform (ramp with 50% symmetry)
- Noise waveform
- Arbitrary waveform (limited to 4 K points with automatic decimation)

Select the external modulating source to modulate the carrier waveform with an external signal present at the Modulation In connector on the rear panel.

Width deviation

The width deviation represents the peak variation in the pulse width of the modulation output based on that of the original carrier waveform. The range of the width deviation is from 0 s to 1000 s, and the default is 10 μ s.

The deviation cannot be greater than the pulse width of the carrier waveform, and has the following constraints:

$$\text{WidthDeviation} \leq \text{PulseWidth} - W_{\min}$$

$$\text{WidthDeviation} \leq \text{Period} - (\text{PulseWidth} + W_{\min})$$

Where: W_{\min} is the minimum pulse width as described in the [Pulse waveform](#) section.

Choosing the external source means the modulation is controlled by the specified width deviation and the ± 5 V signal levels of the external waveform. When the external waveform is at +5 V, the output will reach the maximum pulse width. When the external waveform is at -5 V, the output will reach the minimum pulse width.

To set up PWM:

1. Press the **Pulse** soft key. Follow the instructions for setting up a pulse waveform as given in this publication. Refer to [Section 4, Setup Basics](#) for assistance.
2. Press the **Mod** key to access the modulation menu.
3. Press the soft key under **Src** to select between internal source (**Int**) and external source (**Ext**) for the modulating waveform ([Figure 5-15](#)). If internal source is selected:
 - a) Press the soft key under **Shape** to select the modulating waveform. If arbitrary waveform (**Arb**) is chosen, the instrument will use the currently selected arbitrary waveform. Press the **Mod** key to see which arbitrary modulating waveform is currently selected.
 - b) Press the soft key under **PWM / Freq**. Use the navigation wheel with the cursor keys to change the value, and then press another soft key to finish the entry and exit. Or use the numeric keypad to enter a desired value and then press the soft key under the desired units to finish the entry, or the soft key under **Cancel** to cancel the changes.

Figure 5-15:

Press the soft keys corresponding with PWM



4. Press the soft key under **Width / Dev** ([Figure 5-15](#)). Use the navigation wheel with the cursor keys to change the value, and then press another soft key to finish the entry and exit. Or use the numeric keypad to enter a desired value and then press the soft key under the desired units to finish the entry, or the soft key under **Cancel** to cancel the changes.

5. Press the **Graph** key to view the waveform parameters in the graph mode.

To set up PWM from a remote interface:

```
VOLTage {<amplitude>|MINimum|MAXimum}
VOLTage:OFFSet {<offset>|MINimum|MAXimum}
PULSe:PERiod {<seconds>|MINimum|MAXimum}
FUNCTion:PULSe:WIDTh {<seconds>|MINimum|MAXimum}
FUNCTion:PULSe:TRANSition {<seconds>|MINimum|MAXimum}
FUNCTion:PULSe:DCYClE {<percent>|MINimum|MAXimum}
PWM:INTernal:FUNCTion {SINusoid|SQUare|RAMP|NRAMP|TRIangle|NOISe|USER}
PWM:INTernal:FREQuency {<frequency>|MINimum|MAXimum}
PWM:DEVIation {<deviation in seconds>|MINimum|MAXimum}
PWM:DEVIation:DCYClE {<deviation in percent>| MINimum|MAXimum}
PWM:SOURce {INTernal|EXTernal}
PWM:STATe {OFF|ON}
```

Frequency sweep

Frequency sweep allows a waveform to gradually step from one frequency to another at a specified rate. The waveform can sweep up or down in frequency with logarithmic or linear spacing. Sine, square, ramp, and arbitrary waveforms work with frequency sweep.

Sweep mode

The waveform generator has two sweep modes:

- Linear: The frequency steps with spacing calculated in a linear function.
- Logarithmic: The frequency steps with spacing calculated in a logarithmic function.

The default sweep mode is linear.

Setting frequency sweep range

You may specify start and stop frequency settings, or a center frequency and frequency span.

Start frequency and stop frequency

The waveform generator sweeps from the start frequency to the stop frequency. The instrument will sweep down when the start frequency is greater than the stop frequency. The instrument will sweep up when the stop frequency is greater than the start frequency.

The default start frequency is 100 Hz and the default stop frequency is 1 kHz. The allowable range is 1 μ Hz to 50 MHz for sine; 1 μ Hz to 25 MHz for square; 1 μ Hz to 200 kHz for ramp; and 1 μ Hz to 10 MHz for arbitrary waveforms.

Center frequency and frequency span

The waveform generator sweeps from the center frequency through the distance of the frequency span. Set a positive frequency span for sweeping up and a negative frequency span for sweeping down.

The default center frequency is 550 Hz. The allowable range is 1 μ Hz to 50 MHz for sine; 1 μ Hz to 25 MHz for square; 1 μ Hz to 200 kHz for ramp; and 1 μ Hz to 10 MHz for arbitrary waveforms. The default frequency span is 900 Hz. The allowable range of the frequency span is dependent on center frequency setting and waveform selection.

Sweep time

The sweep time is the period of time (in seconds) required to sweep from the start frequency (or center frequency) to the stop frequency (or the endpoint of the frequency span). The number of

discrete frequency points is calculated by the waveform generator according to the sweep time specified. The default sweep time is 1 second, and the range is from 1 ms to 500 s.

Marker frequency

Marker frequency controls the sync signal that is output from the front panel Sync connector. The default marker frequency is 500 Hz and the range of the marker frequency is dependent on stop frequency setting or frequency span setting. The marker frequency must be less than or equal to the maximum output frequency.

Performing a sweep with an enabled marker frequency (selected in Hz), starts the sync signal at transistor-transistor logic (TTL) "high" at the beginning of the sweep and turns it to "low" at the marker frequency. For sweeps with Marker Off, the Sync signal is a square waveform with a 50% duty cycle. The Sync signal is at TTL "high" at the beginning of a sweep and turns to "low" at the midpoint of the sweep. The frequency of the Sync signal is the reciprocal of the specified sweep time.

Trigger source

The waveform generator outputs a single sweep when it receives a trigger signal, and it continues delivering the same type of waveform with the start frequency before it receives the next trigger and sends another sweep.

Trigger source can be internal, external, or manual. The default is internal.

The trigger sources perform as follows:

- Internal trigger source: The waveform generator continuously delivers sweeps at the specified sweep time.
- External trigger source: The trigger signal is a TTL pulse with specified polarity applied to the Trig In/Out connector on the rear panel. The trigger period cannot be less than 1 ms plus the specified sweep time.
- Manual trigger source: The waveform generator sends out a sweep each time the **Trigger** key on the front panel is pressed.

Trigger out signal

A trigger out signal is delivered at the Trig In/Out, FSK / Burst connector on the rear panel.

Trigger out signals perform as follows:

- Internal trigger source: A square waveform with 50% duty cycle is delivered at the Trig Out connector with the sweep output.
- Manual trigger source: A pulse is delivered (with pulse width > 1 μ s) at the Trig Out connector at the beginning of each sweep.

To set up frequency sweep:

1. Select the carrier waveform (**Sine**, **Square**, **Ramp**, or **Arb**). Follow the instructions for setting up that specific waveform as given in this publication. Refer to [Section 4, Setup Basics](#) for assistance.
2. Press the **Sweep** key to access the sweep menu.
3. Press the soft key under **Linear / Log** to choose between linear or logarithmic mode ([Figure 5-16](#)).

Figure 5-16:

Press the soft keys corresponding with frequency sweep

4. Select a start frequency and a stop frequency, or select a center frequency and a frequency span:
 - Start and stop frequency: Press the soft key under **Start / Cntr** to specify a start frequency (ensure **Start** is highlighted, [Figure 5-16](#)). Use the navigation wheel with the cursor keys to change the value, and then press another soft key to finish the entry and exit. Or use the numeric keypad to enter a desired value and then press the soft key under the desired units to finish the entry, or the soft key under **Cancel** to cancel the changes. Press the soft key under **Stop / Span** to specify a stop frequency. Follow the same value entry procedures.
 - Center frequency and frequency span: Press the soft key under **Start / Cntr** to specify a center frequency (ensure **Cntr** is highlighted). Use the navigation wheel with the cursor keys to change the value, and then press another soft key to finish the entry and exit. Or use the numeric keypad to enter a desired value and then press the soft key under the desired units to finish the entry, or the soft key under **Cancel** to cancel the changes. Press the soft key under **Stop / Span** to specify a span frequency. Follow the same value entry procedures.
5. Press the soft key under **Sweep / Time**. Use the navigation wheel with the cursor keys to change the value, and then press another soft key to finish the entry and exit. Or use the numeric keypad to enter a desired value and then press the soft key under the desired units to finish the entry, or the soft key under **Cancel** to cancel the changes.
6. Press the soft key under **Mkr** to toggle between **Freq** and **OFF**. Use the navigation wheel with the cursor keys to enter a frequency value, and then press another soft key to finish the entry and exit. Or use the numeric keypad to enter a desired value and then press the soft key under the desired units to finish the entry, or the soft key under **Cancel** to cancel the changes.
7. Press the soft key under **Trig / Setup** to configure the trigger setting ([Figure 5-17](#)). Press the soft key under **Src** to select among **Int** (internal), **Ext** (external), or **Man** (manual) for the trigger source.
 - Internal or manual source: Press the **Trig / Out** soft key, then select among OFF, rising edge, or falling edge trigger.
 - External source: Press the **Slope** soft key, then select rising edge or falling edge trigger.

Figure 5-17:

Press the soft keys corresponding with trigger setting

8. Press the **Graph** key to view the waveform parameters in the graph mode.

To set up frequency sweep from a remote interface:

```

SWEep:SPACing {LINear|LOGarithmic}
SWEep:TIME {<seconds>|MINimum|MAXimum}
FREquency:START {<frequency>|MINimum|MAXimum}
FREquency:STOP {<frequency>|MINimum|MAXimum}
FREquency:CENTER {<frequency>|MINimum|MAXimum}

```

```

FREQuency:SPAN {<frequency>|MINimum|MAXimum}
MARKer:FREQuency {<frequency>|MINimum|MAXimum}
MARKer {OFF|ON}
SWEep:STATe {OFF|ON}

```

Use this command to specify the trigger source:

```

TRIGger:SOURce {IMMediate|EXTernal|BUS}

```

Use this command to specify whether the sweep is triggered on the rising or the falling edge:

```

TRIGger:SLOPe {POSitive|NEGative}

```

Use the following commands to configure the Trig Out signal:

```

OUTPut:TRIGger:SLOPe {POSitive|NEGative}
OUTPut:TRIGger {OFF|ON}

```

Burst operation

The burst operation generates a selected waveform with a specified number of cycles (a burst). Bursts can be triggered internally or manually. Bursts can also be triggered (or gated) externally by a signal applied to the Trig In/Out, FSK / Burst connector on the rear panel. Sine, ramp, pulse, square, and arbitrary waveforms can be generated in both triggered and gated burst modes. Noise can be generated only in the gated burst mode.

Burst mode

You can select triggered or gated burst mode. [Table 5-1](#) presents the modes and the parameters affecting each:

- **Triggered burst mode:** This mode generates a waveform with a specified number of cycles (burst count) each time it receives a trigger. When the specified number of cycles is generated, the instrument pauses and waits for next trigger. You can choose to trigger the bursts using internal source, manual press of the trigger key, external signal at the Trig In/Out, FSK / Burst connector on the rear panel, or software trigger through the remote interface (refer to [Section 7, Remote Programming](#) for details). Triggered burst mode is the default burst mode.
- **Gated burst mode:** In gated burst mode, the length of a burst is determined by the voltage level of the external signal applied at the Trig In/Out, FSK / Burst connector on the rear panel. When the external signal is logic true, the waveform generator outputs a continuous waveform. When the gate signal is logic false, the output waveform remains at the same voltage level as the starting burst phase of the selected waveform. The output stops immediately following a noise burst when the gate signal becomes logic false.

Table 5-1:

Parameters for each burst mode

Burst mode		Burst phase	Burst count	Burst period	External trigger signal polarity
Triggered mode	Internal	X	X	X	
	External and Manual	X	X		
Gated mode		X			X

Burst phase

Burst phase defines the starting phase of a burst. The default is 0° and the range is from -360° to +360°. You can set the burst phase in degrees from the front panel; however, degrees and radians are both available through remote interface operation.

For sine, square, and ramp waveforms, 0° is the point at which the waveform crosses zero volt, or the DC offset, when ascending. For arbitrary waveform, it is the first waveform point specified.

In gated burst mode, when the gate signal turns false, the waveform generator will complete the current waveform and then stop. At this point, the output will remain at the same voltage level as the starting burst phase.

Burst count

The burst count represents the number of cycles in each burst and is only applicable in triggered burst mode. The default burst count is 1 cycle, and the range is from 1 to 50,000 cycles in single-cycle increments. You can also set an infinite burst count.

NOTE	If a new burst count is specified when the instrument is in gated mode, the instrument will store the new count and implement it when a triggered mode is selected.
-------------	---

Burst Period

The burst period represents the time interval between the start times of two consecutive bursts. It is only applicable in the internally triggered burst mode. The default burst period is 10 ms and the range is from 1 µs to 500 seconds.

Waveform frequency

The waveform frequency defines the frequency of the output waveform when trigger signal is logic true. In triggered mode, the specified number of cycles is delivered at the waveform frequency. In gated mode, the waveform frequency is delivered when the external gate signal is logic true.

The default waveform frequency is 1 kHz. The range is from 1 µHz to 200 kHz for ramp; 1 µHz to 25 MHz for square; 1 µHz to 10 MHz for pulse and arbitrary; and 1 µHz to 50 MHz for sine waveforms. The minimum frequency is 2.001 mHz for internally triggered burst mode. For sine and square waveforms, frequencies greater than 10 MHz are permitted only when an infinite burst count is set.

Trigger source

Trigger source can be internal, external or manual.

The trigger sources perform as follows:

- **Internal trigger source:** Internal trigger source delivers bursts repeatedly at a rate determined by the specified burst period, which represents the time interval between the start times of two consecutive bursts. The burst count must be less than the product of the burst period and the waveform frequency:

$$\text{Burst Count} < \text{Burst Period} \times \text{Waveform Frequency}$$

If the burst period is set too short, the instrument automatically adjusts it to the shortest value (up to its maximum) that can accommodate the specified burst count and waveform frequency:

$$\text{Burst period} > (\text{Burst Count} \div \text{Waveform Frequency}) + 200 \text{ ns}$$

- **External trigger source:** External trigger source delivers a burst each time a TTL pulse with specified polarity is received at the Trig In/Out connector on the rear panel. The instrument ignores any trigger signals received during the output of a burst. Burst period is not applicable.
- **Manual trigger source:** Manual trigger source delivers a burst with each press of the **Trigger** key. Burst period is not applicable.

Trigger out signal

The instrument can be set to deliver a trigger out signal at the Trig In/Out connector on the rear panel. This signal can be enabled when the instrument is set for internal or manual triggered burst mode, and it is synchronized with the burst output.

Trigger out signals perform as follows:

- **Internal trigger source:** A square waveform with 50% duty cycle is delivered at the Trig Out connector at the beginning of the burst.
- **Manual trigger source:** A pulse is delivered (with pulse width > 1 μ s) at the Trig Out connector at the beginning of each sweep.

To set up burst output:

1. Select the carrier waveform (**Sine**, **Square**, **Ramp**, or **Arb**. **Noise** is permitted in gated burst mode only). Follow the instructions for setting up that specific waveform as given in this publication. Refer to [Section 4, Setup Basics](#) for assistance.
2. Press the **Burst** key to access the burst menu.
3. Press the soft key under **N Cyc / Gated** to choose between the triggered and external gated modes ([Figure 5-18](#)). Ensure your selection is highlighted.

Figure 5-18:

Press the soft keys corresponding with trigger selection (internal triggering shown)

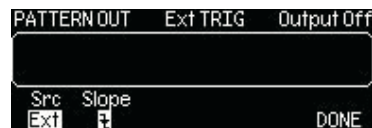


- **Triggered burst mode:**
 - a) Press the soft key under **#Cyc / Inf** to choose between finite and infinite burst count:
 - **Finite burst count:** Ensure that **#Cyc** is highlighted. Use the navigation wheel with the cursor keys to change the value, and then press another soft key to finish the entry and exit. Or use the numeric keypad to enter a desired value and then press the soft key under **Cyc** to finish the entry, or the soft key under **Cancel** to cancel the changes.
 - **Infinite burst count:** Ensure that **Inf** is highlighted. The display will automatically highlight the **Start / Phase** selection. Use the navigation wheel with the cursor keys to change the value, and then press another soft key to finish the entry and exit. Or use the numeric keypad to enter a desired value and then press the soft key under **Deg** to finish the entry, or the soft key under **Cancel** to cancel the changes.

- b) Press the soft key under **Trig / Setup** to configure the trigger setting ([Figure 5-18](#)). Press the soft key under **Src** to select among **Int** (internal), **Ext** (external), or **Man** (manual) for the trigger source.
 - Internal trigger source: Press the **Trig / Out** soft key, then select among OFF, rising-edge, or falling edge trigger. Press the soft key under **Burst / Perd**. Use the navigation wheel with the cursor keys to change the value, and then press another soft key to finish the entry and exit. Or use the numeric keypad to enter a desired value and then press the soft key under the desired units to finish the entry, or the soft key under **Cancel** to cancel the changes.
 - External trigger source: Press the **Slope** soft key, then select rising edge or falling edge trigger ([Figure 5-19](#)).
 - Manual trigger source: Press the **Trig / Out** soft key, then select among OFF, rising-edge, or falling edge trigger.
- c) Press the soft key under **Done** to finish the trigger setting.
- d) Press the **Graph** key to view the waveform parameters in the graph mode.

Figure 5-19:

Press the soft keys corresponding with trigger slope



- **External gated burst mode:**
 - a) Press the soft key under **Polar** to choose between **Neg** and **Pos** for the polarity of the external signal ([Figure 5-20](#)).
 - b) Press the soft key under **Start / Phase**. Use the navigation wheel with the cursor keys to change the value, and then press another soft key to finish the entry and exit. Or use the numeric keypad to enter a desired value and then press the soft key under **Deg** to finish the entry, or the soft key under **Cancel** to cancel the changes.

Figure 5-20:

Press the soft keys corresponding with gated burst



- c) Press the **Graph** key to view the waveform parameters in the graph mode

To set up burst operation from a remote interface:

```

FUNCTION {SINusoid|SQUare|RAMP|PULSe|USER}
FREQUENCY {<frequency>|MINimum|MAXimum}
BURSt:MODE {TRIGgered|GATed}
BURSt:GATE:POLarity { NORMAl|INVerted }
BURSt:NCYCles {<#cycles>|INFinity|MINimum|MAXimum}
BURSt:INTernal:PERiod {<seconds>|MINimum|MAXimum}
BURSt:PHASe {<angle>|MINimum|MAXimum}
UNIT:ANGLE {DEGREE|RADian}
TRIGger:SOURce {IMMediate|EXTernal|BUS}
TRIGger:SLOPe {POSitive|NEGative}
OUTPut:TRIGger:SLOPe {POSitive|NEGative}
OUTPut:TRIGger {OFF|ON}
BURSt:STATe {OFF|ON}
  
```

Pattern output operation

Pattern output allows you to specify a pattern of up to 256k points in 16-bit resolution. Similar to arbitrary waveforms, pattern output provides five built-in patterns and up to four user-defined patterns that are stored in nonvolatile memory. The built-in patterns are exponential-rise, exponential-fall, negative-ramp, sinc, and cardiac. The default pattern output is an exponential-rise waveform.

You can import waveforms captured with an oscilloscope, or create a custom pattern with the KiWAVE™ waveform and pattern editor software provided with the instrument. Refer to [Section 7, KiWAVE™ software installation](#) for software installation instructions.

To set up pattern output:

1. Press the **Utility** key to access the utility menu.
2. Press the soft key under **PATT / Mode** to access the pattern menu.
3. Press the soft key under **Fclk / Perd** ([Figure 5-21](#)) to choose between frequency (**Fclk**) and period (**Perd**). Refer to [Section 4, Setup Basics](#) for assistance.

Figure 5-21:

Setting frequency or period for pattern output



4. Press the soft key under **Start / Addr** to specify a start point for the pattern output ([Figure 5-22](#)). Use the navigation wheel with the cursor keys to change the value, and then press another soft key to finish the entry and exit. Or use the numeric keypad to enter a desired value and then press the soft key under **Enter** to finish the entry, or the soft key under **Cancel** to cancel the changes.

Figure 5-22:

Setting start address for pattern output



5. Press the soft key under **End / Addr** to specify an end point for the pattern output ([Figure 5-23](#)). Use the navigation wheel with the cursor keys to change the value, and then press another soft key to finish the entry and exit. Or use the numeric keypad to enter a desired value and then press the soft key under **Enter** to finish the entry, or the soft key under **Cancel** to cancel the changes.

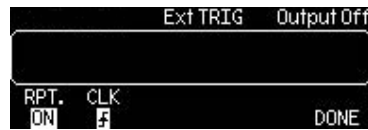
Figure 5-23:

Setting end address for pattern output



6. Press the soft key under **Output / Setup**.
 - a) Press the soft key under **RPT.** to choose between **ON** and **OFF** ([Figure 5-24](#)). Select **ON** to enable the repeat output of the pattern.
 - b) Press the soft key under **CLK** to select rising edge or falling edge.
 - c) Press the soft key under **Done** to finish the selection.

Figure 5-24:
Setting repeat on or off for pattern output



7. Press the soft key under **Select / Wform** to access the waveform menu. Press the soft keys to select among **Built / In**, **Saved / Wform** (saved waveform), or **Delete / Saved** (Figure 5-25).
 - Press the soft key under **Built / In** and choose from the five built-in patterns by pressing the corresponding soft key.
 - Press the soft key under **Saved / Wform** and choose the desired user-defined pattern by pressing the corresponding soft key.
 - Press the soft key under **Delete / Saved** to delete a user-defined pattern. Choose the pattern to be deleted and press the corresponding soft key.

Figure 5-25:
Selecting waveform for pattern output



8. Press the soft key under **Trig / Setup** to configure the trigger setting. Press the soft key under **Src** to select **Ext** (external) or **Man** (manual) for the trigger source.
 - Manual source: Press the **Trig Out** soft key, then select among OFF, rising-edge, or falling edge trigger.
 - External source: Press the **Slope** soft key, then select rising edge or falling edge trigger (Figure 5-26).

Press the soft key under **Done** to finish the trigger setting.

Figure 5-26:
Selecting slope for pattern output



To set up pattern output operation from a remote interface:

```

FUNCTION:Pattern {data name}
FUNCTION:Pattern?
DIGital:Pattern:FREQuency {<frequency>, MINimum, MAXimum}
DIGital:Pattern:FREQuency? {MINimum, MAXimum}
DIGital:Pattern:STARt {<address>, MINimum, MAXimum}
DIGital:Pattern:STARt? {MINimum, MAXimum}
DIGital:Pattern:STOP {<address>, MINimum, MAXimum}
DIGital:Pattern:STOP? {MINimum, MAXimum}
DIGital:Pattern:REPEAT {OFF|ON}
DIGital:Pattern:REPEAT?
DIGital:Pattern:CLOCK {POSitive|NEGative}
DIGital:Pattern:CLOCK?
DIGital:Pattern:TRIGger:SOURce {EXTernal|BUS}
DIGital:Pattern:TRIGger:SOURce?
  
```

Pattern generator cable

Your Model 3390 was shipped with one pattern generator cable (005-003-00003). This cable should be used when generating a pattern output function. Refer to [Figures 5-27](#), [5-28](#) and [5-29](#) for additional information.

Figure 5-27:
Pattern generator cable



Figure 5-28:
Socket pin out structure

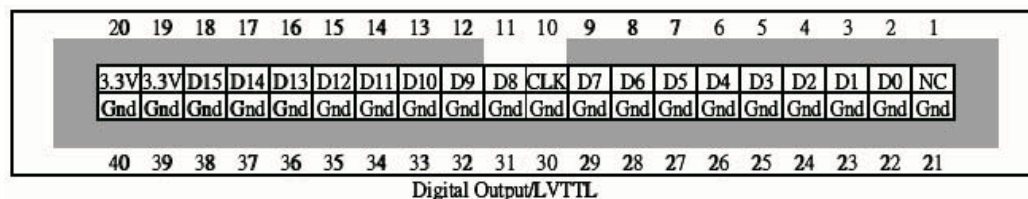
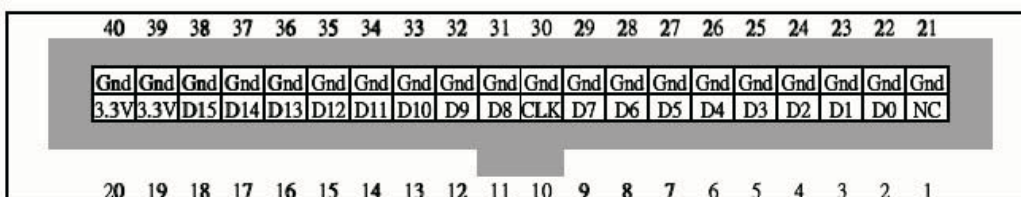


Figure 5-29:
Connector pin out structure



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Introduction

The Model 3390 can store up to five instrument states. You can also control the front display screen, control the sound, and perform test and calibration operations.

Instrument system operations

Storing the instrument state

The Model 3390 has five storage locations in nonvolatile memory for storing instrument state. The stored instrument state holds all the parameters for the selected function, including the waveform, frequency, DC offset, amplitude, duty cycle, symmetry, modulation type, and modulation parameters.

The first location, indexed at "0," is automatically assigned for instrument state at power off and can only be accessed from the remote interface. Any information stored in this location during operation will be overwritten when the instrument is turned off.

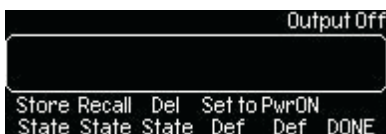
You may assign a custom name to any of these locations from the remote interface. The name can contain up to 12 characters; the first character must be a letter and the rest can be numbers, letters, or the underscore character (_). You cannot assign a name for location "0" from the front panel.

To store or recall the instrument state:

Press the **Store / Recall** key to access the instrument state menu ([Figure 6-1](#)). You can choose to store a state, recall a state, delete a state, or set a power-up state. You can also restore the instrument to the factory default state (refer to [Section 4, Restoring factory default settings](#) for details).

Figure 6-1:

Press the Store / Recall key to access the instrument state menu



To store a state:

1. Press the soft key under **Store / State** to access the store / state menu.
2. Press the soft key under your desired location number (1 through 4 are available from the front panel).
3. Enter a name for the selected memory location. Use the numeric keypad and the navigation wheel with the cursor keys ([Figure 6-2](#)).
4. Press the **Store / State** soft key to store the setting in memory, or press the **Cancel** soft key to cancel the entry.

Figure 6-2:

Enter the name for the selected memory location



To store a state from a remote interface:

```
*SAV {0|1|2|3|4}
MEMory:STATe:NAME {0|1|2|3|4} [ , <name> ]
```

To recall a state:

1. Press the soft key under **Recall / State** to access the recall / state menu.
2. Press the soft key under your desired location number to recall the state from that memory location ([Figure 6-3](#)).
3. Press the **Recall / State** soft key to recall the selected state, or press the **Cancel** soft key to cancel the entry.

Figure 6-3:

Select the desired memory location for recall**To recall a state from a remote interface:**

```
*RCL {0|1|2|3|4}
```

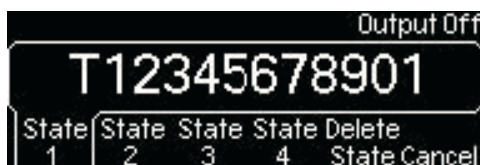
To set a power-up state:

1. Press the soft key under **PwrON / Def** to access the power-up menu.
2. Press the soft key under your desired location number to choose the state from that memory location (1 through 4 are available from the front panel. You can also select **State / Def** to set the power-up state to the default settings.
3. Press the **DONE** soft key to accept the selected state.

To delete the instrument state:

1. Press the soft key under **Del / State** to access the delete state menu.
2. Press the soft key under your desired location number to delete the state from that memory location ([Figure 6-4](#)).
3. Press the **Delete / State** soft key to delete the selected state, or press the **Cancel** soft key to cancel the entry.

Figure 6-4:

Select the desired memory location for deletion**To delete a state from a remote interface:**

```
MEMory:STATe:DELeTe {0|1|2|3|4}
```

Controlling the display

You can choose to turn off the front display screen for security reasons, or to speed up command execution from the remote interface. This option is possible through remote operation only. Error messages will display at all times.

The display is automatically enabled when the instrument is powered up, returned to local front-panel operation, or the `*RST` (reset) command is issued.

The display setting may be saved with the `*SAV` command. When the instrument state is restored using the `*RCL` command, the display setting will return to the saved state.

To control the front display screen from a remote interface:

Use this command to turn off the front panel display:

```
DISP OFF
```

Use this command to display a message and turn the display back on:

```
DISP:TEXT 'message to display'
```

Use this command to clear the current message on display.

```
DISP:TEXT CLear
```

Controlling the error beep

The Model 3390 beeps when an error is detected. This setting is stored in nonvolatile memory and remains after the instrument is turned off, or when the reset command is issued from remote operation.

To control the error beep:

1. Press the **Utility** key, and then press the soft key under **System** to access the system menu.
2. Press the **Beep** soft key to choose between **ON** and **OFF**. Ensure your selection is highlighted.
3. Press the **DONE** soft key to accept the selected state.

Controlling the system sound

The Model 3390 beeps with every keystroke. This setting is stored in nonvolatile memory and remains after the waveform generator is turned off, or when the reset command is issued from the remote operation.

To control the system sound:

1. Press the **Utility** key, and then press the soft key under **System** to access the system menu.
2. Press the **Sound** soft key to choose between **ON** and **OFF**. Ensure your selection is highlighted.
3. Press the **DONE** soft key to accept the selected state.

To control the system sound from a remote interface:

```
SYSTem:BEEPer:STAtE {OFF|ON}
```


Performing self-test

You can perform a self-test on the Model 3390.

To access the self-test function:

1. Press the **Utility** key, and then press the soft key under **System** to access the system menu.
2. Press the **Test / Cal** soft key to enter the test and calibration menu.
3. Press the **Self / Test** soft key to start a self test.
4. Press the **DONE** soft key when finished.

NOTE	Press the Cal / Info soft key to view the most recent instrument calibration date.
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Remote interface operation

The Model 3390 supports universal serial bus (USB), local area network (LAN), and IEEE-488 (general purpose interface bus, GPIB) remote interfaces. This section describes the operations for setting up these remote interfaces.

KiWAVE™ software installation

You can use the Keithley Instruments KiWAVE program to remotely create and configure waveforms for the Model 3390.

To install the software:

NOTE You must have one of the following items installed on your computer: Keithley I/O Layer 7.0 or greater, or NI-VISA™ 3.2 or greater. Keithley I/O Layer 7.0 is included on the CD-ROM that shipped with your instrument.

1. Load the CD-ROM that came with your Model 3390. Double-click the **KiWave_setup.exe** file.
2. Select **Next**.
3. Read the agreement and select **I Agree**.
4. Accept the default settings and select **Next**.
5. Accept the default pathway and select **Install**.
6. When the software installation is complete, select **Finish**.
7. When KiWAVE launches, it will search for Java™ on your system.
 - If Java is found, KiWAVE will start.
 - If Java is not found, your system will ask for permission to download Java from www.java.com. Select **OK** to proceed with the Internet download, or you can install Java from your Model 3390 CD-ROM. To install from the CD-ROM, select **Cancel** to exit KiWAVE. Then open the CD-ROM and double-click the **jre-6u7-windows-i586-p.exe** file to install Java (accept all default settings).

NOTE For LAN and IEEE-488 interfaces, skip to step number 11 to complete this process. For USB interfaces, proceed to step number 8.

8. Connect the USB cable between the Model 3390 and the USB port on your remote computer.
9. The "Found New Hardware Wizard" will launch, and you will see a dialogue box asking, "Can Windows connect to Windows Update to search for software?" Select **No**, then select **Next**.
10. "USB Test and Measurement device" will appear on the computer screen; select **Next**, then select **Finish**.
11. The icon for KiWAVE will appear on your desktop. Double-click this icon to launch the program.

USB interface

Connect the USB cable from the USB connector on the rear panel of the instrument to your computer. The waveform generator sets up the USB interface automatically once the cable is properly connected.

To verify the USB ID:

1. Press the **Utility** key.
2. Press the **I/O** soft key.

3. Press the **Show / USB Id** soft key to verify the USB interface ID.
4. Press the soft key under **DONE** to finish the entry.

IEEE-488 (GPIB) interface

Before setting up the GPIB interface, you must make the proper connections and installations:

1. Insert the GPIB interface card into the interface slot on the waveform generator's rear panel.
2. Install the Model 3390 application onto your PC, and then start the application.
3. Connect the waveform generator to your computer with the GPIB cable.

To set up the IEEE-488 (GPIB) interface:

1. Press the **Utility** key.
2. Press the **I/O** soft key.
3. Press the soft key under **GPIB / Addr** and enter a GPIB address using the numeric keypad or navigation wheel. The factory default GPIB address is 16, however it can be set to any number between 0 and 30. The address is stored in nonvolatile memory, so it is not affected by turning the instrument power off, or by receiving a remote interface reset command. The address you choose must be different than the address for the GPIB interface card in your computer.
4. Press the soft key under **DONE** to finish the entry.

LAN interface

The following parameters must be set before using the LAN interface. Contact your network administrator to obtain the LAN settings for your waveform generator.

IP address

An IP address is a unique identifier assigned to a device in the network. It is expressed in the dot notation: "nnn.nnn.nnn.nnn", where "nnn" is a byte value from 0 to 255. The value is stored in nonvolatile memory, so it is not affected by turning the instrument power off, or by receiving a remote interface reset command.

If dynamic host configuration protocol (DHCP) is used, the device will automatically obtain an IP address from the DHCP server in the network. If the device fails to get an IP address from a DHCP server, it will assign itself an IP address using Auto-IP. The IP address will be randomly chosen in the range from 169.254.0.0 to 169.254.255.255.

Subnet mask

Subnetting is used to divide a network so that the network traffic is evenly distributed and the administration process is simplified. The subnet mask represents the portion of the host address to be used to identify the subnet. For example, the subnet mask 255.255.255.0 for a host IP address 10.10.3.101 indicates that the host belongs to the subnet of hosts addressed from 10.10.3.1 to 10.10.3.254. The subnet mask setting is stored in nonvolatile memory so it is not affected by turning the instrument power off, or by receiving a remote interface reset command.

If DHCP is used, the device will automatically obtain a subnet mask from the DHCP server.

Default gateway

A gateway is a network device that provides connectivity between two networks. The default gateway setting is the IP address of the gateway to which the waveform generator is connected. The value is stored in nonvolatile memory, so it is not affected by turning the instrument power off, or by receiving a remote interface reset command.

If DHCP is used, the instrument will automatically obtain the IP address of the default gateway from the DHCP server.

Host name

Host name is the human-readable identifier for the device. Together with the domain name, the host name represents the device in the networks. Each character in the name can be a number, letter, dash (?), or underscore (_).

Domain name

A domain is an administrator for managing hosts in the networks. The name of a domain is in human-readable format. Each character in the name can be a number, letter, dash (-), or underscore (_).

Domains are structured in a hierarchy. Top domains are typically .edu, .com, and .org. A subdomain under a top domain generally represents an organization. The smallest domain is a host itself. For example, the domain "www.keithley.com" consists of a host name, "www," and two domains "keithley" and "com". The host name and names of its domains are linked with the period (.) in the full domain name of the host.

DNS server

Domain name service (DNS) translates a domain name or a host name into an IP address. The DNS server address is the IP address of the server that provides this service. The setting is stored in nonvolatile memory, so it is not affected by turning the instrument power off, or by receiving a remote interface reset command.

To set up the LAN interface:

1. Press the **Utility** key.
2. Press the **I/O** soft key.
3. Press the soft key under **LAN** to enter the LAN menu.
4. Press the soft key under **Current / Conf** to view the current LAN configuration.
5. Press the **Modify / Set** soft key to enter the Modify / Set menu.

To return the LAN settings to the default values:

- a) Press the **Reset / LAN** soft key.
- b) Press the **YES** soft key to finish the reset.

To configure the IP setup:

- a) Press the **IP / Setup** soft key to enter the IP Setup menu.
- b) Press the **Mode** soft key to choose between **Man** and **Auto**:

NOTE To enable your **Mode** setting changes, you must power off and restart the instrument after setup is complete.

- Automatic (Auto): Enables the instrument to seek DHCP availability.
- Manual (Man): Reveals the IP / Addr, Sub / Mask, and Def / Gate soft keys:
 - i. **IP address:** Use the numeric keys to enter an IP address. Press the soft key under **Enter** to finish the entry, or the soft key under **Cancel** to cancel the changes.
 - ii. **Subnet mask:** Use the numeric keys to enter a subnet mask. Press the soft key under **Enter** to finish the entry, or the soft key under **Cancel** to cancel the changes.

- iii. **Default gateway:** Use the numeric keys to enter a default gateway. Press the soft key under **Enter** to finish the entry, or the soft key under **Cancel** to cancel the changes.

- Press the **DONE** soft key to return to the Modify / Set menu.

To configure the DNS setup (if applicable):

- a) Press the **DNS / Setup** soft key to enter the DNS setup menu.
- b) Press the soft key under **Host / Name** to enter a host name. Use the navigation wheel with the cursor keys, or the numeric keypad to enter the name, and then press the soft key under **DONE** to finish the entry.
- c) Press the soft key under **Domain / Name** to enter a domain name. Use the navigation wheel with the cursor keys, or the numeric keypad to enter the name and then press the soft key under **DONE** to finish the entry.
- d) Press the soft key under **DNS / Serv** to enter a DNS server address. Use the navigation wheel with the cursor keys, or the numeric keypad to enter the address and then press the soft key under **DONE** to finish the entry.

To enter a password:

- a) Press the **Password** soft key to enter a password up to 12 characters long. Use the navigation wheel with the cursor keys, or the numeric keypad to enter the information.
 - b) Press the soft key under **DONE** to finish the entry
6. Press the **DONE** soft key to return to the I/O menu.

LXI™ function

The Model 3390 is designed to LAN extensions for instrumentation (LXI) Class C standards. Using your computer's Ethernet port, the Model 3390 can be connected to your computer directly, or remotely through your LAN.

The LXI setup and online control of the Model 3390 is described in this section.

NOTE	Before attempting the LXI setup, contact your network administrator for your specific network requirements.
-------------	---

LXI setup

Direct connection to a computer

For direct connection of the Model 3390, you need the following:

- Model 3390 Arbitrary Waveform Generator
- Computer with Ethernet interface
- One CAT5E crossover cable (shipped with your instrument)

To set up a connection between your Model 3390 and your computer:

1. Configure the IP address and subnet mask of the instrument. Refer to the [LAN interface](#) topic for details. Set the IP address to **10.1.1.1** and the subnet mask to **255.255.255**.
2. Configure the IP address and subnet mask of your computer's Ethernet interface. Set the IP address to **10.1.1.2** and the subnet mask to **255.255.255.0**.
3. Connect one end of the CAT5E crossover cable to your Model 3390, and then connect the other end to your computer.

4. Launch your web browser and enter the instrument's IP address (<http://10.1.1.1>). The LXI Web Interface – Welcome Page is displayed.

Network connection

For network connection of the Model 3390, you need the following:

- Model 3390 Arbitrary Waveform Generator
- Computer with Ethernet interface
- One standard CAT5E cable
- Ethernet switch or other Ethernet port

To set up a connection between your Model 3390 and a network:

Determine if your network uses a DHCP server to automatically assign an IP address, or if IP addresses are assigned manually (by your network administrator).

To set up using a DHCP server:

- a. Set up the LAN interface. Refer to the [LAN interface](#) topic for details. Ensure the Mode is set to Auto.
- b. Connect one end of the CAT5E cable to your Model 3390. Then connect the other end to the network switch. The instrument will automatically connect to the network and obtain an IP address.
- c. To view the IP address:
 - i. Press the **Utility** key.
 - ii. Press the **I/O** soft key.
 - iii. Press the soft key under **LAN** to enter the LAN menu.
 - iv. Press the soft key under **Current / Conf** to view the current LAN configuration.

To set up using a manual IP address:

- a. Configure the IP address and subnet mask of the instrument. Refer to the [LAN interface](#) topic for details.
- b. Configure the IP address and subnet mask of your computer's Ethernet interface.
- c. Connect one end of the CAT5E cable to your Model 3390, and then connect the other end to the network switch. The instrument will automatically connect to the network.
- d. Launch your web browser and enter the instrument's IP address. The LXI Web Interface – Welcome Page is displayed.

LXI web interface

Welcome Page

The LXI Web Interface – Welcome Page is the default launch page for your Model 3390. This page displays all of the LAN setup and model information for your instrument. IP information displayed on this page can be modified. Refer to the [IP Configuration](#) topic for details.

Click the **ID** button to identify the instrument from the front panel. The front panel of the instrument will display “Web Identify.”

Web Control

The Web Control page allows you to control the device from a virtual interface. All keys and soft keys have the same functionality as during front panel operation ([Figure 7-1](#)). Refer to [Section 2](#),

[Front panel](#) for a review of the front panel keys. Detailed setup and operation instructions for the output functions can be found in [Section 4](#), [Section 5](#), and [Section 6](#) of this manual.

You will be prompted to login from this page. It is only necessary to enter the password, and you can obtain the instrument's password by following these steps:

1. Press the **Utility** key.
2. Press the **I/O** soft key.
3. Press the soft key under **LAN** to enter the LAN menu.
4. Press the **Modify / Set** soft key to enter the Modify / Set menu. The password is displayed.

Click the **Refresh** button to refresh the web page with the instrument's current state.

Figure 7-1:

LXI browser Web Control interface



IP Configuration

The IP Configuration page displays the current configuration of your instrument, and allows you to modify configuration details.

You must log into the web interface to make configuration changes. Refer to the [Web Control](#) topic for login details.

Click the **Modify** button to access the modification page. After you have entered your changes, click the **Submit** button. To enable your changes, you must power the instrument off, and then restart it.

System Status

The System Status page displays various details regarding your system configuration. This page is for information only and cannot be changed.

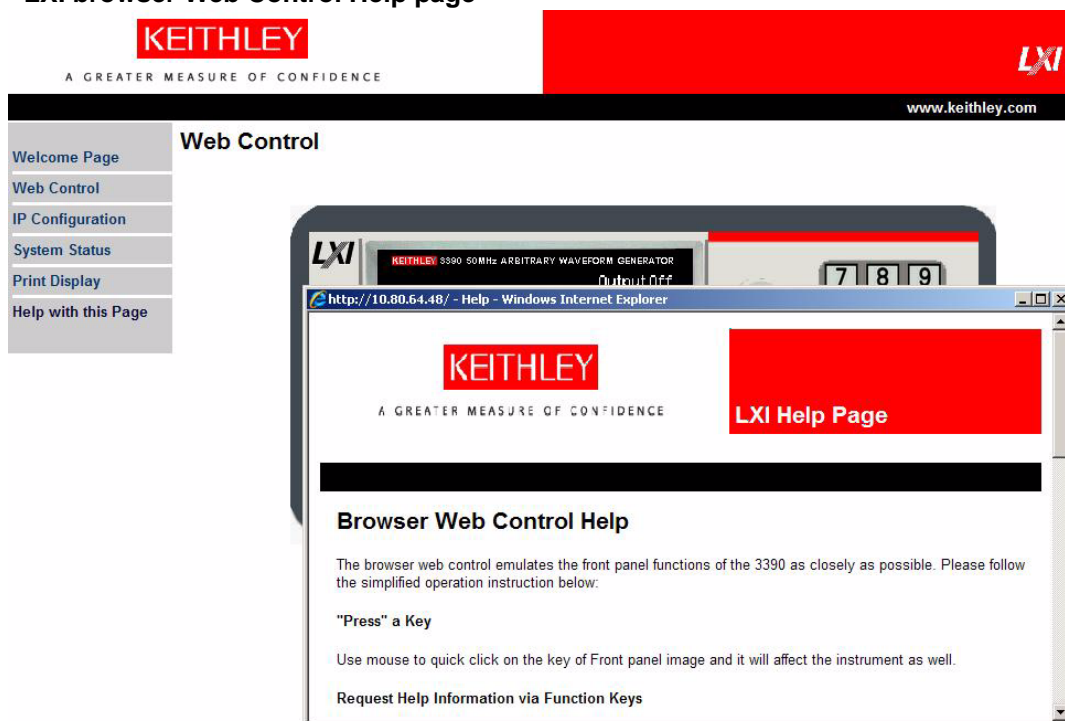
Print Display

The Print Display page allows you to print the information displayed in your web browser window. Print preferences can be selected from the Print dialog box.

Help with this Page

Click Help with this Page to display specific help information for the LXI interface. Select a page, and then click Help with this Page for the associated help file. For example, [Figure 7-2](#) shows the help page associated with the Web Control screen.

Figure 7-2:
LXI browser Web Control Help page



Remote interface commands

After the remote interface is set, you can output waveforms using the standard commands for programmable instruments (SCPI). Refer to [Appendix A, SCPI Command Reference](#) for the commands for this instrument.

Appendix A

SCPI Command Reference

In this section:

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SCPI commands

Standard commands for programmable instruments (SCPI) is an ASCII-based command language designed for testing and measurement instruments. SCPI is based on a hierarchical structure, also known as a tree system. In this system, associated commands are grouped together under a common root, and form subsystems. A portion of the system-related commands is shown as an example:

```
SYSTem:
  ERRor?
  BEEPer
  BEEPer:
    STATe
```

SYSTem is the root keyword of the command; ERRor and BEEPer are second-level keywords; and STATe is a third-level keyword. A colon (:) separates the keyword levels.

Command format

Most commands (and some parameters) are expressed as a combination of upper- and lower-case letters. The upper-case letters indicate the letters that must be specified for the command. For shorter program lines, send the abbreviated form. For better program readability, use the long form. For example, STAR and START are both acceptable forms of the same command. You may also mix upper- or lower-case letters in a command. For example, START, star, and Star are all acceptable forms of the same command. Other forms, such as STA will generate an error.

- Braces ({ }) enclose parameter choices for a command string. The braces are not sent with the command.
- Vertical bars (|) separate multiple parameter choices for a command string.
- Triangle brackets (< >) indicate that you must specify a value for the enclosed parameter. The brackets are not sent with the command string. You must specify a value for the parameter such as STAR 6000.
- Some parameters are enclosed in square brackets ([]). The brackets indicate that the parameter is optional and can be omitted. The brackets are not sent with the command string. If you do not specify a value for an optional parameter, the waveform generator uses the default value.

Command separators

A colon (:) is used to separate a command keyword from a lower-level keyword. You must insert a blank space to separate a parameter from a command keyword. If a command requires more than one parameter, you must use a comma between two parameters:

```
APPL:SIN 5 KHZ, 3.0 VPP, -2.5 V
```

A semicolon (;) is used to separate commands within the same subsystem, and can reduce typing efforts. For example, sending the following command string:

```
BURSt:MODE TRIG; NCYCles 10
```

is the same as sending the following two commands:

```
BURSt:MODE TRIG
```

```
BURSt:NCYCles 10
```

Use a colon and a semicolon to link commands from different subsystems. For example, in the following command string, an error is generated if you do not use both the colon and semicolon:

```
BURSt:STATe ON;:TRIG:SOUR EXT
```

Using the MIN and MAX parameters

You can use MINimum or MAXimum in place of a parameter for some commands. For example, see the following command:

```
FREQuency:STARt {<frequency>|MINimum|MAXimum}
```

Instead of specifying a specific frequency value, use MIN to set the frequency to its minimum value or MAX to set the frequency to its maximum value.

Querying parameter settings

You can query the current value of a parameter by adding a question mark (?) to the command. For example, the following command sets the start frequency to 5000 Hz:

```
FREQ:STAR 5000
```

You can query the start frequency:

```
FREQ:STAR?
```

You can also query the minimum or maximum start frequency allowed for the current waveform function:

```
FREQ:STAR? MIN
```

```
FREQ:STAR? MAX
```

NOTE

If you send two query commands without reading the response from the first, then when you attempt to read the response, you may receive some data from the first response followed by the complete second response. Typically, the unit gives a -410 *Query Interrupted* error. To avoid this error, do not send a query command without reading the response. When you cannot avoid this situation, send a device clear command before sending the second query command.

Command terminators

A command string sent to the Model 3390 must terminate with a "new line" character (<nl>). The IEEE-488 end-or-identify (EOI) message is interpreted as a new line character and can be used to terminate a command string in place of a new line character. A carriage return (<cr>) followed by a <nl> is also accepted. A command string terminator will reset the current SCPI command path to the root level.

IEEE-488.2 common commands

The IEEE Standard 488.2 defines a set of common commands that perform reset, self-test, and status operations. Common commands begin with an asterisk (*), are four to five characters in length, and may include one or more parameters ([Table A-1](#)). The command keyword is separated from the first parameter by a blank space. Use a semicolon (;) to separate multiple commands:

Table A-1:
IEEE-488.2 Common commands

Command	Description
*CLS	Clear the status structure.
*ESE <value>	Set the Standard Event register mask.

Table A-1:
IEEE-488.2 Common commands

Command	Description
*ESE?	Read the Standard Event enable register.
*ESR?	Read the Standard Event event register.
*IDN?	Read the instrument's Identification string.
*LRN?	Read the instrument's Learn string (current settings).
*OPC	Set the Operation Complete Bit when all pending actions are completed.
*OPC?	Read the status of the Operation Complete Bit.
*PSC 0	Save the contents of the Enable Register through power off and on.
*PSC 1	Clear the contents of the Enable Register through power off and on.
*PSC?	Read the Power On status clear setting.
*RCL <value>	Recall the complete instrument setting from memory.
*RST	Reset the instrument to factory default settings.
*SAV <value>	Save the complete instrument setting to memory.
*SRE <value>	Set the Service Request Enable mask.
*SRE?	Read the Service Request Enable mask.
*STB?	Read the Status Byte Register.
*TRG	Trigger the instrument.
*TST?	Start the instrument self-test.
*WAI	Wait until all pending actions are complete.

Parameter types

The SCPI language defines several different data formats to be used in program messages and response messages.

Numeric parameters: Commands that require numeric parameters will accept all commonly used decimal representations of numbers including optional signs, decimal points, and scientific notation. Special values for numeric parameters such as `MINimum`, `MAXimum`, and `DEFault` are also accepted. You can also send engineering unit suffixes with numeric parameters (MHz or kHz). If specific numeric values are necessary, the waveform generator will automatically round the input numeric parameters. The following example has a numeric parameter option:

```
FREQuency:STARt {<frequency>|MINimum|MAXimum}
```

Discrete parameters: Discrete parameters are used in the settings where only a limited number of values (`BUS`, `IMMediate`, `EXTErnal`) are accepted. They have short and long forms and you can mix upper- and lower-case letters. Query responses will return the short form in all upper-case letters. The following example has a discrete parameter:

```
TRIGger:SOURce {BUS|IMMediate|EXTErnal}
```

Boolean parameters: A Boolean parameter represents a condition that is either true or false. For a false condition, the instrument accepts "OFF" or "0" as the parameter value. For a true condition, the instrument accepts "ON" or "1" as the parameter value. When you query a Boolean parameter, the instrument will return "0" or "1." The following example has a Boolean parameter:

```
SWEep:STATe {OFF|ON}
```

String parameters: A string parameter can contain any set of ASCII characters. A string must begin and end with matching angle brackets. You can include the quote delimiter as part of the string by typing it twice without any characters in between. The following example has a string parameter:

```
DISPlay:TEXT <quoted string>
```

Output data formats

Output data will be in one of formats shown ([Table A-2](#)):

Table A-2:

Output data formats

Type of output data	Output data format
Non-reading queries	< 80 ASCII character string
Single reading	(IEEE-488)SD.DDDDDDDDESDD<nl>
Multiple readings	(IEEE-488)SD.DDDDDDDDESDD, . . . , . . . , <nl>

S: Negative sign or positive sign

D: Numeric digits

E: Exponent

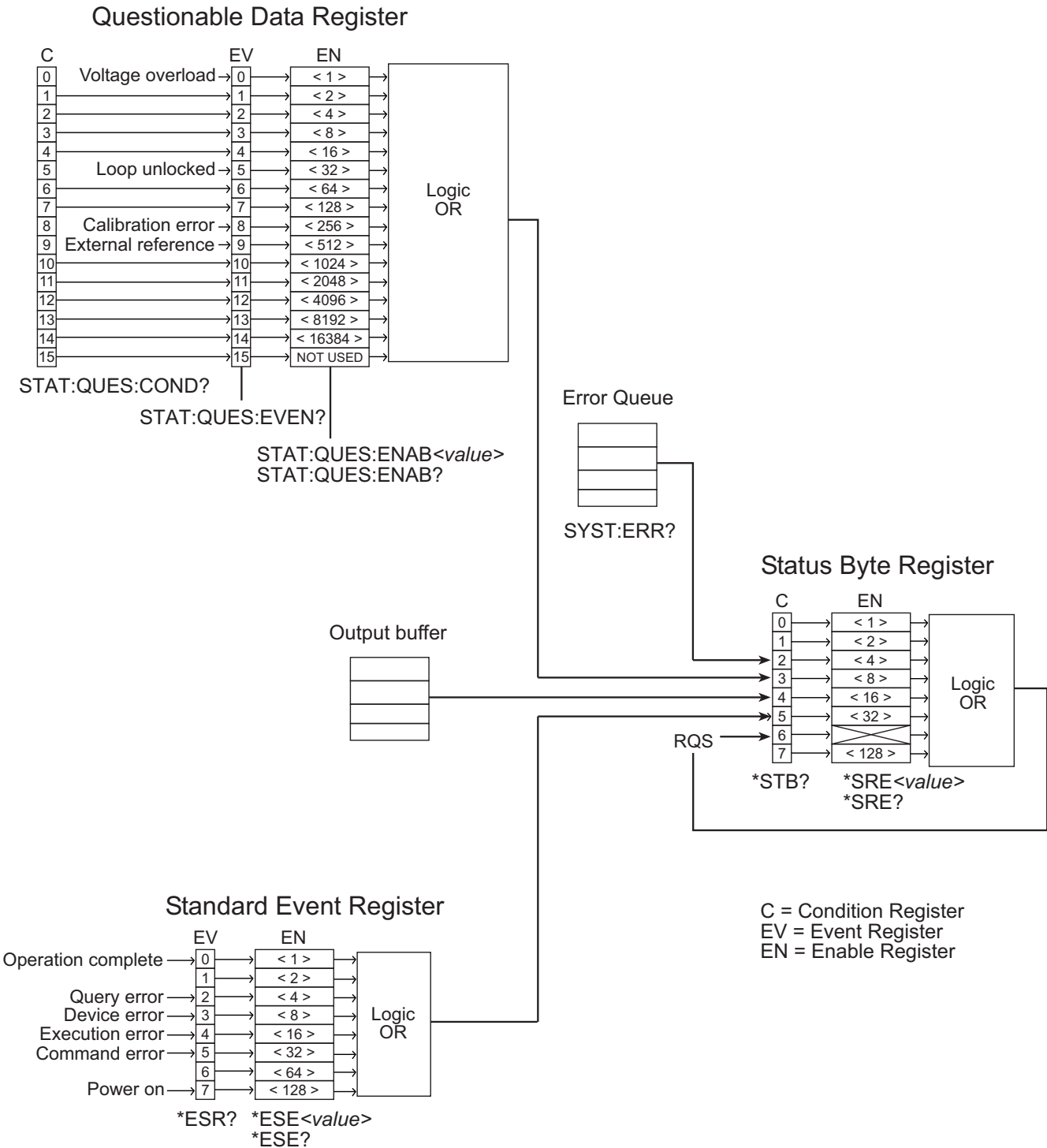
<nl>: New line character

<cr>: Carriage return character

SCPI status model

The SCPI status model shows the structure of the various registers used by the Model 3390 (Figure A-1). These registers record conditions of the instrument and allow you to monitor and manipulate events. The core of the model is the Status Byte Register.

Figure A-1:
Model 3390 status model



Status register sets

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

Event register: Latches transition events from the condition register. Event registers are cleared by reading, by query command, 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 Logic OR, and entered into the summary bit. These bits are then reported to the Status Byte Register. Enable registers are read-write and are not affected by *CLS or querying.

Status Byte Register and service request

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, request for service (RQS). When RQS is set, it generates a service request (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.

Clear the Status Byte condition register by reading an event register from another group, or with a *CLS (clear status) command. Clear the Status Byte enable register with an *SRE 0 command. You can also set the instrument to clear the enable register using the *PSC 1 command; the instrument will clear the enable register at power up.

Bits in the Status Byte Register are summarized in [Table A-3](#).

Table A-3:
Status Byte register

Bit	Decimal value	Description
0	1	Not used (always 0).
1	2	Not used (always 0).
2	4	Error queue stores one or more errors.
3	8	Questionable Data Register contains one or more bits.
4	16	Output buffer contains available message (data).
5	32	Standard Event Register contains one or more bits.
6	64	Status Byte Register contains one or more bits.
7	128	Not used (always 0).

Questionable Data Register

The Questionable Data Register reports information regarding possible instrument problems ([Table A-4](#)). The Questionable Data Register is enabled by using the `STAT:QUES:ENAB <value>` command. Refer to [Figure A-1](#) for condition register, event register, and enable register queries.

Clear the Questionable Data event register by querying the register, or with a `*CLS` (clear status) command. Clear the Questionable Data enable register with the `*STAT:PRES` command or the `*STAT:QUES:ENAB 0` command. The instrument will also clear this enable register at power up.

Table A-4:
Questionable Data register

Bit	Decimal value	Description
0	1	Voltage overload on Output connector. Output is disabled.
1	2	Not used (always 0).
2	4	Not used (always 0).
3	8	Not used (always 0).
4	16	Not used (always 0).
5	32	Loop unlocked. Instrument frequency accuracy is affected.
6	64	Not used (always 0).
7	128	Not used (always 0).
8	256	Calibration error, calibration memory loss, or calibration is unsecured.
9	512	External time base reference is in use.
10	1024	Not used (always 0).
11	2048	Not used (always 0).
12	4096	Not used (always 0).
13	8192	Not used (always 0).
14	16384	Not used (always 0).
15	32768	Not used (always 0).

Standard Event Register

The Standard Event Register reports a number of occurrences including power up, errors, and the `*OPC` command ([Table A-5](#)). The Questionable Data Register is enabled by using the `*ESE <value>` command. Refer to [Figure A-1](#) for event register and enable register queries.

Clear the Standard Event event register by querying the register, or with a `*CLS` (clear status) command. Clear the Standard Event enable register with an `*ESE 0` command. You can also set the instrument to clear the enable register using the `*PSC 1` command; the instrument will clear the enable register at power up.

Table A-5:
Standard Event register

Bit	Decimal value	Description
0	1	Operation complete. All commands have completed including the previous commands, the <code>*OPC</code> command, and the overlapping commands.
1	2	Not used (always 0).
2	4	Query error. Output buffer was empty, or previous query was not read before new command was received, or input and output buffers are full.
3	8	Device error. Device-specific error exists including self test or calibration.
4	16	Execution error exists.

Table A-5:
Standard Event register

Bit	Decimal value	Description
5	32	Command syntax error exists.
6	64	Not used (always 0).
7	128	Power has been turned off and on. Event register is cleared.

SCPI command summary

NOTE The list of IEEE-488.2 Common Commands for the Model 3390 is in the [IEEE-488.2 common commands](#) section.

Table A-6:
SCPI command summary

APPLY commands		
Command	Parameters	Definition
APPLY		
:SINusoid	[<frequency>] [<amplitude>] [<offset>]	See Sine waveform .
:SQUare		See Square waveform .
:RAMP		See Ramp waveform .
:PULSe		See Pulse waveform .
:NOISe	[<frequency DEF>] [<amplitude>] [<offset>]	See Noise waveform .
:DC	[<frequency DEF>] [<amplitude DEF>] [<offset>]	Output a DC voltage at the specified offset level.
:USER	[<frequency>] [<amplitude>] [<offset>]	Output an arbitrary waveform currently specified by the FUNC:USER command with the set frequency, amplitude, and offset.
:APPLY?		Query the current configuration.
Output configuration commands		
Command	Parameters	Definition
FUNCtion	{SINusoid SQUare RAMP PULSe NOISe DC USER}	See Sine waveform , Square waveform , Ramp waveform , Pulse waveform , Noise waveform , Amplitude modulation , Frequency modulation , Phase modulation , Frequency-shift keying modulation , Burst operation .
FUNCtion?		Query the current output function.
FREQuency	{<frequency> MINimum MAXimum}	See Sine waveform , Square waveform , Ramp waveform , Pulse waveform , Noise waveform , Amplitude modulation , Frequency modulation , Phase modulation , Frequency-shift keying modulation , Burst operation .
FREQuency?	[MINimum MAXimum]	Query the frequency setting for the current function.

Table A-6:
SCPI command summary

VOLTage	{<amplitude> MINimum MAXimum}	See Sine waveform , Square waveform , Ramp waveform , Pulse waveform , Noise waveform , Amplitude modulation , Frequency modulation , Phase modulation , Frequency-shift keying modulation , Pulse width modulation waveform .
VOLTage?	[MINimum MAXimum]	Query the output amplitude for the current function.
VOLTage		
:OFFSet	{<offset> MINimum MAXimum}	See Sine waveform , Square waveform , Ramp waveform , Pulse waveform , Noise waveform , Amplitude modulation , Frequency modulation , Phase modulation , Frequency-shift keying modulation , Pulse width modulation waveform .
:OFFSet?	[MINimum MAXimum]	Query the DC offset voltage for the current function.
:HIGH	{<voltage> MINimum MAXimum}	See Setting pulse high and low levels .
:HIGH?	[MINimum MAXimum]	Query the high voltage level.
:LOW	{<voltage> MINimum MAXimum}	See Setting pulse high and low levels .
:LOW?	[MINimum MAXimum]	Query the low voltage level.
:RANGE:AUTO	{OFF ON ONCE}	See Setting voltage auto ranging .
:RANGE:AUTO?		Query the auto-ranging state.
:UNIT	{Vpp Vrms dBm}	See Setting amplitude .
:UNIT?		Query the output amplitude units.
FUNCTion		
:SQUare:DCYCLE	{<percent> MINimum MAXimum}	See Square waveform .
:SQUare:DCYCLE?	[MINimum MAXimum]	Query the current duty cycle percentage.
:RAMP:SYMMetry	{<percent> MINimum MAXimum}	See Ramp waveform .
:RAMP:SYMMetry?	[MINimum MAXimum]	Query the current symmetry setting percentage.
OUTPut	{OFF ON}	See Controlling the output signal .
OUTPut?		Query the on/off state of the Output connector.
OUTPut		
:LOAD	{<ohms> INfinity MINimum MAXimum}	See Setting output termination .
:LOAD?	[MINimum MAXimum]	Query the current load setting in ohms.
:POLarity	{NORMal INVerted}	See Setting waveform polarity .
:POLarity?		Query the waveform polarity.
:SYNC	{OFF ON}	See Controlling the sync signal .
:SYNC?		Query the on/off state of the Sync connector.
Pulse configuration commands		
Command	Parameters	Definition

Table A-6:
SCPI command summary

PULSe		
:PERiod	{<seconds> MINimum MAXimum}	See Pulse waveform , Pulse width modulation waveform .
:PERiod?	[MINimum MAXimum]	Query the period of the pulse waveform.
FUNction		
:PULSe:HOLD	{WIDTH DCYCLe}	See Pulse waveform .
:PULSe:HOLD?	[WIDTH DCYCLe]	Query the value of the pulse width or duty cycle being held.
:PULSe:WIDTh	{<seconds> MINimum MAXimum}	See Pulse waveform , Pulse width modulation waveform .
:PULSe:WIDTh?	[MINimum MAXimum]	Query the pulse width.
:PULSe:DCYCLe	{<percent> MINimum MAXimum}	See Pulse waveform , Pulse width modulation waveform .
:PULSe:DCYCLe?	[MINimum MAXimum]	Query the pulse duty cycle.
:PULSe:TRANSition	{<seconds> MINimum MAXimum}	See Pulse waveform , Pulse width modulation waveform .
:PULSe:TRANSition?	[MINimum MAXimum]	Query the edge time.
Arbitrary waveform commands		
Command	Parameters	Definition
FUNction USER		Output the waveform currently specified by the FUNC:USER command.
FUNction?		Query the current selection of the FUNC:USER command.
DATA VOLATILE,	<value>, <value>...	See Arbitrary waveform .
DATA		
:DAC VOLATILE	{<binary block> <value>, <value>...}	See Arbitrary waveform .
:COPY	<destination arb name>, [VOLATILE]	Copy the currently specified waveform to non-volatile memory.
:CATalog?		Query for a list of all waveforms currently stored.
:NVOLatile:CATalog?		Query for a list of all waveforms currently stored in nonvolatile memory.
:NVOLatile:FREE?		Query for a list of open storage slots in nonvolatile memory.
:ATTRibute:AVERage?	[<arb name>]	Query for the average of all data points for the specified waveform.
:ATTRibute:CFACTOR?	[<arb name>]	Query for the crest factor of all data points for the specified waveform.
:ATTRibute:POINTs?	[<arb name>]	Query for the number of points for the specified waveform.
:ATTRibute:PTPeak?	[<arb name>]	Query for the peak-to-peak value of all data points for the specified waveform.
FORMat		
:BORDER	{NORMAL SWAPPed}	See Arbitrary waveform .
FUNction		
:USER	{<arb name> VOLATILE}	See Arbitrary waveform .
:USER?		Query the currently selected arbitrary waveform.
Amplitude modulation commands		

Table A-6:
SCPI command summary

Command	Parameters	Definition
AM		
:INTERNAL:FUNCTION	{SINusoid SQUARE RAMP NRAMP TRIangle NOISe USER}	See Amplitude modulation .
:INTERNAL:FUNCTION?		Query the modulating function.
:INTERNAL:FREQUENCY	{<frequency> MINimum MAXimum}	See Amplitude modulation .
:INTERNAL:FREQUENCY?	[MINimum MAXimum]	Query the internal modulating frequency.
:DEPTH	{<depth in percent> MINimum MAXimum}	See Amplitude modulation .
:DEPTH?	[MINimum MAXimum]	Query the modulation depth.
:SOURCE	{INTERNAL EXTERNAL}	See Amplitude modulation .
:SOURCE?		Query the modulating source.
:STATE	{OFF ON}	See Amplitude modulation .
:STATE?		Query the on/off state of amplitude modulation.
Frequency modulation commands		
Command	Parameters	Definition
FM		
:INTERNAL:FUNCTION	{SINusoid SQUARE RAMP NRAMP TRIangle NOISe USER}	See Frequency modulation .
:INTERNAL:FUNCTION?		Query the modulating function.
:INTERNAL:FREQUENCY	{<frequency> MINimum MAXimum}	See Frequency modulation .
:INTERNAL:FREQUENCY?	[MINimum MAXimum]	Query the internal modulating frequency.
:DEVIATION	{<peak deviation in Hz> MINimum MAXimum}	See Frequency modulation .
:DEVIATION?	[MINimum MAXimum]	Query the peak frequency deviation.
:SOURCE	{INTERNAL EXTERNAL}	See Frequency modulation .
:SOURCE?		Query the modulating source.
:STATE	{OFF ON}	See Frequency modulation .
:STATE?		Query the on/off state of frequency modulation.
Phase modulation commands		
Command	Parameters	Definition
PM		
:INTERNAL:FUNCTION	{SINusoid SQUARE RAMP NRAMP TRIangle NOISe USER}	See Phase modulation .
:INTERNAL:FUNCTION?		Query the modulating function.
:INTERNAL:FREQUENCY	{<frequency> MINimum MAXimum}	See Phase modulation .
:INTERNAL:FREQUENCY?	[MINimum MAXimum]	Query the internal modulating frequency.
:DEVIATION	{<peak deviation in degrees> MINimum MAXimum}	See Phase modulation .

Table A-6:
SCPI command summary

:DEVIation?	[MINimum MAXimum]	Query the phase deviation.
:SOURce	{INTernal EXTernal}	See Phase modulation .
:SOURce?		Query the modulating source.
:STATe	{OFF ON}	See Phase modulation .
:STATe?		Query the on/off state of phase modulation.
Frequency-shift keying commands		
Command	Parameters	Definition
FSKey		
:FREQuency	{<frequency> MINimum MAXimum}	See Frequency-shift keying modulation .
:FREQuency?	[MINimum MAXimum]	Query the hop frequency.
:INTernal:RATE	{<rate in Hz> MINimum MAXimum}	See Frequency-shift keying modulation .
:INTernal:RATE?	[MINimum MAXimum]	Query the frequency-shift keying rate.
:SOURce	{INTernal EXTernal}	See Frequency-shift keying modulation .
:SOURce?		Query the frequency-shift keying source.
:STATe	{OFF ON}	See Frequency-shift keying modulation .
:STATe?		Query the on/off state of frequency-shift keying.
Pulse width modulation commands		
Command	Parameters	Definition
PWM		
:INTernal:FUNCTion	{SINusoid SQUare RAMP NRAMp TRIangle NOISe USER}	See Pulse width modulation waveform .
:INTernal:FUNCTion?		Query the internal modulating function.
:INTernal:FREQuency	{<frequency> MINimum MAXimum}	See Pulse width modulation waveform .
:INTernal:FREQuency?	[MINimum MAXimum]	Query the internal modulating frequency.
:DEVIation	{< deviation in seconds> MINimum MAXimum}	See Pulse width modulation waveform .
:DEVIation?	[MINimum MAXimum]	Query the pulse width deviation.
:DEVIation:DCYClE	{< deviation in percent> MINimum MAXimum}	See Pulse width modulation waveform .
:DEVIation:DCYClE?	[MINimum MAXimum]	Query the duty cycle deviation.
:SOURce	{INTernal EXTernal}	See Pulse width modulation waveform .
:SOURce?		Query the modulating source.
:STATe	{OFF ON}	See Pulse width modulation waveform .
:STATe?		Query the on/off state of PWM.
Sweep commands		
Command	Parameters	Definition
FREQuency		
:START	{<frequency> MINimum MAXimum}	See Frequency sweep .
:START?	[MINimum MAXimum]	Query the sweep start frequency.

Table A-6:
SCPI command summary

:STOP	{<frequency> MINimum MAXimum}	See Frequency sweep .
:STOP?	[MINimum MAXimum]	Query the sweep stop frequency.
:CENTer	{<frequency> MINimum MAXimum}	See Frequency sweep .
:CENTer?	[MINimum MAXimum]	Query the sweep center frequency.
:SPAN	{<frequency> MINimum MAXimum}	See Frequency sweep .
:SPAN?	[MINimum MAXimum]	Query the sweep span frequency.
SWEep		
:SPACing	{LINear LOGarithmic}	See Frequency sweep .
:SPACing?		Query the sweep spacing.
:TIME	{<seconds> MINimum MAXimum}	See Frequency sweep .
:TIME?	[MINimum MAXimum]	Query the sweep time.
:STATe	{OFF ON}	See Frequency sweep .
:STATe?		Query the on/off state of sweep.
TRIGger		
:SOURce	{IMMediate EXTernal BUS}	See Frequency sweep .
:SOURce?		Query the trigger source.
:SLOPe	{POSitive NEGative}	See Frequency sweep .
:SLOPe?		Query the trigger slope.
OUTPut		
:TRIGger:SLOPe	{POSitive NEGative}	See Frequency sweep .
:TRIGger:SLOPe?		Query the edge for the trigger out signal.
:TRIGger	{OFF ON}	See Frequency sweep .
:TRIGger?		Query the on/off state of trigger out.
MARKer		
:FREQuency	{<frequency> MINimum MAXimum}	See Frequency sweep .
:FREQuency?	[MINimum MAXimum]	Query the marker frequency.
MARKer	{OFF ON}	See Frequency sweep .
MARKer?		Query the on/off state of the frequency marker.
Burst commands		
Command	Parameters	Definition
BURSt		
:MODE	{TRIGgered GATED}	See Burst operation .
:MODE?		Query the burst mode.
:NCYCles	{<# cycles> INFinity MINimum MAXimum}	See Burst operation .
:NCYCles?	[MINimum MAXimum]	Query the burst count.
:INTernal:PERiod	{<seconds> MINimum MAXimum}	See Burst operation .
:INTernal:PERiod?	[MINimum MAXimum]	Query the burst period.
:PHASe	{<angle> MINimum MAXimum}	See Burst operation .
:PHASe?	[MINimum MAXimum]	Query the burst starting phase.

Table A-6:
SCPI command summary

:STATE	{OFF ON}	See Burst operation .
:STATE?		Query the on/off state of the burst mode.
:GATE:POLarity	{NORMal INVerted}	See Burst operation .
:GATE:POLarity?		Query the logic levels at the Ext Trig connector (NORM is true high).
UNIT		
:ANGLE	{DEGREE RADian}	See Burst operation .
:ANGLE?		Query the unit of the starting phase for the burst.
TRIGger		
:SOURce	{IMMediate EXTernal BUS}	See Burst operation .
:SOURce?		Query the trigger source.
:SLOPe	{POSitive NEGative}	See Burst operation .
:SLOPe?		Query the trigger slope.
OUTPut		
:TRIGger:SLOPe	{POSitive NEGative}	See Burst operation .
:TRIGger:SLOPe?		Query the edge for the trigger out signal.
:TRIGger	{OFF ON}	See Burst operation .
:TRIGger?		Query the on/off state of trigger out.
Pattern commands		
Command	Parameters	Definition
FUNction		
:PATtern	{data name}	See Pattern output operation .
:PATtern?		Query the file name of the pattern.
DIGital		
:PATtern:FREQuency	{<frequency> MINimum MAXimum}	See Pattern output operation .
:PATtern:FREQuency?	[MINimum MAXimum]	Query the minimum or maximum frequency of the pattern.
:PATtern:STARt	{<address> MINimum MAXimum}	See Pattern output operation .
:PATtern:STARt?	[MINimum MAXimum]	Query the start address of the pattern.
:PATtern:STOP	{<address> MINimum MAXimum}	See Pattern output operation .
:PATtern:STOP?	[MINimum MAXimum]	Query the end address of the pattern.
:PATtern:REPeat	{OFF ON}	See Pattern output operation .
:PATtern:REPeat?		Query the on/off state of the pattern mode.
:PATtern:CLOCK	{POSitive NEGative}	See Pattern output operation .
:PATtern:CLOCK?		Query the edge for the data clock.
:PATtern:TRIGger:SOURce	{EXTernal BUS}	See Pattern output operation .
:PATtern:TRIGger:SOURce?		Query the trigger source of the pattern.
:PATtern:TRIGger:SLOPe	{POSitive NEGative}	See Pattern output operation .
:PATtern:TRIGger:SLOPe?		Query the edge for the trigger slope.

Table A-6:
SCPI command summary

:PAtTern:OUTPut:TRIGger	{OFF ON}	See Pattern output operation .
:PAtTern:OUTPut:TRIGger?		Query the on/off state of the trigger.
:PAtTern:OUTPut:TRIGger:SLOPe	{POSitive NEGative}	See Pattern output operation .
:PAtTern:OUTPut:TRIGger:SLOPe?		Query the edge for the output trigger slope.
DATA		
:PAtTern VOLATILE	<binary block>	See Pattern output operation .
Trigger commands		
NOTE All other trigger commands are included in the applicable Sweep or Burst section.		
Command	Parameters	Definition
TRIGger		Issue a trigger from the remote interface.
*TRG		Issue a trigger from the remote interface.
State storage commands		
Command	Parameters	Definition
*SAV	{0 1 2 3 4}	See Instrument system operations .
*RCL	{0 1 2 3 4}	See Instrument system operations .
MEMory		
:STATe:NAME	{0 1 2 3 4} [<name>]	See Instrument system operations .
:STATe:NAME?	{0 1 2 3 4}	Query the name of the specified storage location.
:STATe:DELeTe	{0 1 2 3 4}	See Instrument system operations .
:STATe:RECall:AUTO	{OFF ON}	Enable or disable automatic recall of the power-down state from the "0" location when power is turned on. See Default settings .
:STATe:RECall:AUTO?		Query the on/off state of automatic recall of the power-down state.
:STATe:VALId?	{0 1 2 3 4}	See Instrument system operations .
:NSTates?		Query the number of available state storage locations.
System-related commands		
NOTE All other system-related commands are included in the applicable IEEE-488.2 common commands section.		
Command	Parameters	Definition
DISPLay	{OFF ON}	See Instrument system operations .
DISPLay?		Query the on/off state of the display.
DISPLay		
:TEXT	<quoted string>	See Instrument system operations .
:TEXT?		Query the message sent to the front panel display.
:TEXT:CLear		See Instrument system operations .
SYSTem		
:ERRor?		Query and clear one error from the error queue.

Table A-6:
SCPI command summary

:VERSion?		Query the instrument's current SCPI version.
:BEEPer		Issue a single beep tone.
:BEEPer:STATe	{OFF ON}	See Instrument system operations .
:BEEPer:STATe?		Query the on/off state of the system sound.
:KLOCK[:STATe]	{OFF ON}	Disable or enable the front panel key lock.
:KLOCK:EXCLude	{NONE LOCAL}	Choose to include or exclude the Local key when locking the front panel keys.
:KLOCK:EXCLude?		Query if Local key is included or excluded when locking the front panel keys.
:SECurity:IMMediate		Clear all memory except startup parameters and calibration constants. Reset all settings to their *RST values.
Interface configuration commands		
Command	Parameters	Definition
SYSTEM		
:COMMunication:RLSTate	{LOCAL REMote RWLock}	Set the instrument state to local, remote, or remote with lock.
Phase-lock commands		
Command	Parameters	Definition
PHASe	{<angle> MINimum MAXimum}	See 10 MHz Out and In connectors .
PHASe?	[MINimum MAXimum]	Query the phase offset value.
PHASe		
:REFerence		See 10 MHz Out and In connectors .
:UNLock:ERRor:STATe	{OFF ON}	See 10 MHz Out and In connectors .
:UNLock:ERRor:STATe?		Query the on/off state of the unlock error setting.
UNIT		
:ANGLE	{DEGREE RADian}	See 10 MHz Out and In connectors .
:ANGLE?		Query the phase offset value.
Status reporting commands		
NOTE All other status reporting commands are included in the applicable IEEE-488.2 common commands section.		
Command	Parameters	Definition
STATUS		
:PREset		See Questionable Data Register .
:QUEStionable:CONDition?		Query the condition register.
:QUEStionable:ENABle	<enable value>	See Questionable Data Register .
:QUEStionable:ENABle?		Query the enable register.
:QUEStionable[:EVENT]?		Query the event register.

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Appendix B

Error Messages

In this section:

Topic	Page
Introduction	B-2
Error message definitions	B-2

Introduction

Error messages are issued when an incorrect command is sent to the Keithley Instruments Model 3390 Arbitrary Waveform Generator. Error messages are stored in an error queue and can be retrieved in the first-in-first-out (FIFO) order.

If more than 20 errors exist, the last error stored in the queue (the most recent error) is replaced with -350, `Queue Overflow`. Additional errors are not saved until errors are read and cleared from the queue.

The error queue is cleared with power off and on, or a `*CLS` (clear status) command.

Error messages are categorized and listed in this section for your reference (see [Error message definitions](#)). If you cannot find a particular error message in this section, contact your service representative.

To read error messages:

1. Press the **Help** key.
2. Use the up and down soft keys to scroll through the selections until **View remote command error** is highlighted.
3. Press the soft key under **Select** to display the error messages.
4. Press the soft key under **DONE** to exit the error display.

Remote interface operation:

Use this command to read one error from the error queue:

```
SYSTem:ERRor?
```

Use this command to clear all the errors in the error queue:

```
*CLS
```

Error message definitions

Table B-1:
Command errors

Error code	Description
-101 Invalid character	An invalid character was detected in the command string.
-102 Syntax error	Invalid syntax was detected in the command string.
-103 Invalid separator	An invalid separator was detected in the command string.
-105 GET not allowed	GET is not valid in a command string.
-108 Parameter not allowed	Received more parameters than expected.
-109 Missing parameter	Received fewer parameters than expected.
-112 Program mnemonic too long	Received more characters than allowed in the command header.
-113 Undefined header	An invalid command was received.
-123 Exponent too large	Detected a numeric parameter with an exponent larger than 32,759.
-124 Too many digits	Detected a numeric parameter with too many digits.
-128 Numeric data not allowed	A numeric parameter was received when the instrument was expecting a string parameter.
-131 Invalid suffix	A suffix was incorrectly specified for a numeric parameter.
-138 Suffix not allowed	A suffix is not supported for this command.

Table B-1:
Command errors

Error code	Description
-148 Character data not allowed	A discrete parameter was received when it was not expected.
-151 Invalid string data	An invalid character string was received.
-158 String data not allowed	A character string was received when it was not permitted for this command.
-161 Invalid block data	For a definite-length block, the number of bytes of data sent does not match the number of bytes specified in the block header.
-168 Block data not allowed	This command does not accept the data format.
-170 to -178 Expression errors	Mathematical expressions are not acceptable for the instrument.

Table B-2:
Execution errors

Error code	Description
-211 Trigger ignored	A GET or *TRG trigger was received, but the trigger was ignored.
-221 Settings conflict; turned off infinite burst to allow immediate trigger source	An infinite burst count command can only be sent from a remote interface.
-221 Settings conflict; infinite burst changed trigger source to BUS	An infinite burst count command can only be sent from a remote interface.
-221 Settings conflict; burst period increased to fit entire burst	The specified number of cycles in the BURS:NCYC command takes priority over the burst period. The instrument increased the burst period to accommodate the burst count or the waveform frequency.
-221 Settings conflict; burst count reduced to fit entire burst	The burst period is currently at its maximum. The waveform generator adjusted the burst count to accommodate the waveform frequency.
-221 Settings conflict; triggered burst not available for noise	Noise function is not permitted in the triggered burst mode.
-221 Settings conflict; amplitude units changed to Vpp due to high-Z load	dBm is not available as a unit when the output termination is set to high impedance.
-221 Settings conflict; trigger output disabled by trigger external	When accepting an external trigger source, the Trig Out signal is automatically disabled.
-221 Settings conflict; trigger output connector used by burst gate	If you have enabled burst and selected gated burst mode, the Trig Out signal is automatically disabled.
-221 Settings conflict; trigger output connector used by FSK	If you have enabled FSK and are using the external trigger source, the Trig Out signal is automatically disabled.
-221 Settings conflict; trigger output connector used by trigger external	When accepting an external trigger source, the Trig Out signal is automatically disabled.
-221 Settings conflict; frequency reduced for user function	The maximum output frequency for an arbitrary waveform is 10 MHz. When you change function from one allowing higher frequency to arbitrary waveform, the frequency is adjusted to 10 MHz.

Table B-2:
Execution errors

Error code	Description
-221 Settings conflict; frequency changed for pulse function	The maximum output frequency for a pulse waveform is 10 MHz. When you change function from one allowing higher frequency to pulse waveform, the frequency is adjusted to 10 MHz.
-221 Settings conflict; frequency reduced for ramp function	The maximum output frequency for a ramp waveform is 200 kHz. When you change function from one allowing higher frequency to ramp waveform, the frequency is adjusted to 200 kHz.
-221 Settings conflict; frequency made compatible with burst mode	The minimum output frequency for an internally-triggered burst is 2.001 mHz. The waveform generator has adjusted the frequency to be compatible with the current setting.
-221 Settings conflict; burst turned off by selection of other mode or modulation	Only one modulation can be enabled at one time.
-221 Settings conflict; FSK turned off by selection of other mode or modulation	Only one modulation can be enabled at one time.
-221 Settings conflict; FM turned off by selection of other mode or modulation	Only one modulation can be enabled at one time.
-221 Settings conflict; AM turned off by selection of other mode or modulation	Only one modulation can be enabled at one time.
-221 Settings conflict; PM turned off by selection of other mode or modulation	Only one modulation can be enabled at one time.
-221 Settings conflict; PWM turned off by selection of other mode or modulation	Only one modulation can be enabled at one time.
-221 Settings conflict; sweep turned off by selection of other mode or modulation	Only one modulation can be enabled at one time.
-221 Settings conflict; not able to modulate this function	This waveform generator cannot generate an AM, FM, PM, or FSK modulated waveform using the pulse, noise, or DC voltage function.
-221 Settings conflict; PWM only available in pulse function	The waveform generator can only generate a PWM modulated waveform using the pulse function.
-221 Settings conflict; not able to sweep this function	The waveform generator cannot generate a sweep using the pulse, noise, or DC voltage function.
-221 Settings conflict; not able to burst this function	The waveform generator cannot generate a burst using the DC voltage function.
-221 Settings conflict; not able to modulate noise, modulation turned off	The waveform generator cannot generate a modulated waveform using the noise function.
-221 Settings conflict; not able to sweep pulse, sweep turned off	The waveform generator cannot generate a sweep using the pulse function.
-221 Settings conflict; not able to modulate dc, modulation turned off	The waveform generator cannot generate a modulated DC voltage function.
-221 Settings conflict; not able to sweep dc, sweep turned off	The waveform generator cannot generate a sweep using the DC voltage function.

Table B-2:
Execution errors

Error code	Description
-221 Settings conflict; not able to burst dc, burst turned off	The waveform generator cannot generate a burst using the DC voltage function.
-221 Settings conflict; not able to sweep noise, sweep turned off	The waveform generator cannot generate a sweep using the noise function.
-221 Settings conflict; pulse width decreased due to period	With edge time at its minimum, the waveform generator has adjusted the pulse width to accommodate the specified period.
-221 Settings conflict; pulse duty cycle decreased due to period	With edge time at its minimum, the instrument has adjusted pulse duty cycle to accommodate the specified period.
-221 Settings conflict; edge time decreased due to period	The edge time has been decreased to accommodate the period.
-221 Settings conflict; pulse width increased due to large period	The instrument has adjusted the pulse width to accommodate the current period.
-221 Settings conflict; edge time decreased due to pulse width	The waveform generator adjusts the edge time, then the pulse width or duty cycle, then the period (if needed) to accommodate the following: $Edge\ Time \leq 0.625 \times Pulse\ Width$. In this case, the edge time is decreased to accommodate the specified pulse width.
-221 Settings conflict; edge time decreased due to pulse duty cycle	The waveform generator adjusts the edge time, then the pulse width or duty cycle, then the period (if needed) to accommodate the following: $Edge\ Time \leq 0.625 \times Period \times Duty\ Cycle$. In this case, the edge time is decreased to accommodate the pulse duty cycle.
-221 Settings conflict; amplitude changed due to function	When the new function chosen has smaller maximum amplitude, the waveform generator will automatically adjust the amplitude from the old value to the new, smaller maximum value. This may occur when the output units are V RMS or dBm because of the differences in crest factor for the various output functions.
-221 Settings conflict; offset changed on exit from dc function	In the DC voltage function, the voltage level is controlled by adjusting the offset voltage (the current amplitude is ignored). When you select a different function, the instrument will adjust the offset voltage as needed to be compatible with the current amplitude setting.
-221 Settings conflict; FM deviation cannot exceed carrier	The frequency deviation cannot exceed the carrier frequency. The waveform generator will adjust the deviation to a maximum allowed value.
-221 Settings conflict; FM deviation exceeds max frequency	The sum of frequency deviation and the carrier frequency cannot be greater than the maximum frequency of the selected carrier waveform plus 100 kHz; (50.1 MHz for sine; 25.1 MHz for square; 300 kHz for ramp; and 10.1 MHz for arbitrary waveforms). If you set the carrier to a value that is not valid, the instrument will adjust the deviation to the maximum value allowed.

Table B-2:
Execution errors

Error code	Description
-221 Settings conflict; PWM deviation decreased due to pulse parameters	The PWM deviation must follow the limitation concerning the pulse width or duty cycle, edge time, and period (see Pulse width modulation waveform for details). The waveform generator will adjust it automatically.
-221 Settings conflict; frequency forced duty cycle change	In the square wave function, if you change the frequency to a value that cannot produce the current duty cycle, the duty cycle will be automatically adjusted to the maximum value for the new frequency.
-221 Settings conflict; marker forced into sweep span	The marker frequency must be a value between the start and the stop frequency.
-221 Settings conflict; selected arb is missing, changing selection to default	If you delete an arbitrary waveform after storing its instrument state, you will lose the waveform data and cannot generate the waveform. The built-in exponential-rise wave is generated instead.
-221 Settings conflict; offset changed due to amplitude	When the existing offset voltage does not conform to the following limitation: $ V_{offset} + V_{peak-to-peak} / 2 \leq V_{max}$, it is adjusted automatically to the maximum DC voltage allowed with the specified amplitude.
-221 Settings conflict; amplitude changed due to offset	When the existing amplitude does not conform to the following limitation: $ V_{offset} + V_{peak-to-peak} / 2 \leq V_{max}$, it is adjusted automatically to the maximum value allowed with the specified offset voltage.
-221 Settings conflict; low level changed due to high level	The high level must always be greater than the low level. If you specify a high level that is smaller than the low level, the instrument will adjust the low level to be 1 mV less than the high level.
-221 Settings conflict; high level changed due to low level	The high level must always be greater than the low level. If you specify a low level that is greater than the high level, the instrument will adjust the high level to be 1 mV greater than the low level.
-222 Data out of range; value clipped to upper limit	The specified parameter is out of range and is adjusted to the maximum value allowed.
-222 Data out of range; value clipped to lower limit	The specified parameter is out of range and is adjusted to the minimum value allowed.
-222 Data out of range; pulse edge time limited by period; value clipped to upper limit	The specified edge time does not conform within the existing period and is adjusted to the maximum value allowed.
-222 Data out of range; pulse width time limited by period; value clipped to...	The specified pulse width does not conform to the following condition and is adjusted to accommodate the period: $Pulse\ Width \leq Period - (1.6 \times Edge\ Time)$.
-222 Data out of range; pulse duty cycle limited by period; value clipped to...	The specified duty cycle does not conform to the following condition and is adjusted to accommodate the period: $Duty\ Cycle \leq (1 - 1.6 \times Edge\ Time / Period) \times 100\%$.
-222 Data out of range; large period limits minimum pulse width	The minimum pulse width is larger (for pulse waveforms with a period larger than 10 s). Refer to Pulse waveform for details.
-222 Data out of range; pulse edge time limited by width; value clipped to...	The specified pulse edge time does not conform to the following condition, and is adjusted to accommodate the pulse width: $Edge\ Time \leq 0.625 \times Pulse\ Width$.

Table B-2:
Execution errors

Error code	Description
-222 Data out of range; pulse edge time limited by duty cycle; value clipped to...	The specified pulse edge time does not conform to the following condition, and is adjusted to accommodate the duty cycle: $Edge\ Time \leq 0.625 \times Period \times Duty\ Cycle$.
-222 Data out of range; period; value clipped to...	The pulse period is out of range and is adjusted.
-222 Data out of range; frequency; value clipped to...	The frequency is out of range and is adjusted.
-222 Data out of range; user frequency; value clipped to upper limit	The frequency is out of range and is adjusted to the maximum value allowed to accommodate the selected arbitrary waveform.
-222 Data out of range; ramp frequency; value clipped to upper limit	The frequency is out of range and is adjusted to the maximum value allowed to accommodate the selected ramp waveform.
-222 Data out of range; pulse frequency; value clipped to upper limit	The frequency is out of range and is adjusted to the maximum value allowed to accommodate the selected pulse waveform.
-222 Data out of range; burst period; value clipped to...	The burst period is out of range and is adjusted.
-222 Data out of range; burst count; value clipped to...	The burst count is out of range and is adjusted.
-222 Data out of range; burst period limited by length of burst; value clipped to lower limit	The burst period is too short to accommodate the burst count and frequency, and is adjusted to the minimum value allowed.
-222 Data out of range; burst count limited by length of burst; value clipped to upper limit	The burst count is out of range. When the immediate trigger source is selected, the burst count must be less than the product of the burst period and the waveform frequency.
-222 Data out of range; amplitude; value clipped to...	The amplitude is out of range and is adjusted.
-222 Data out of range; offset; value clipped to...	The offset voltage is out of range and is adjusted.
-222 Data out of range; frequency in burst mode; value clipped to...	The frequency is adjusted, as indicated by the burst period.
-222 Data out of range; frequency in FM; value clipped to...	The carrier frequency is adjusted to the lower boundary determined by the FM:DEV command. The carrier frequency must be greater than or equal to the frequency deviation.
-222 Data out of range; marker confined to sweep span; value clipped to...	The specified marker frequency is out of range and is adjusted to the start or stop frequency, whichever is closer.
-222 Data out of range; pulse width; value clipped to...	The desired pulse width is limited to the upper or lower boundary, as indicated by the instrument hardware.
-222 Data out of range; pulse edge time; value clipped to...	The desired edge time is limited to the upper or lower boundary, as indicated by the instrument hardware.
-222 Data out of range; FM deviation; value clipped to...	The desired frequency deviation is limited to the upper or lower boundary set by the carrier frequency.
-222 Data out of range; FM deviation limited by minimum frequency	The frequency deviation is limited to the lower limit.

Table B-2:
Execution errors

Error code	Description
-222 Data out of range; FM deviation limited by maximum frequency; value clipped to upper limit	The frequency deviation cannot exceed the carrier frequency.
-222 Data out of range; PWM deviation	The width deviation is permitted to be in the range of 0, and the width of the underlying pulse waveform. The duty cycle deviation is in the range of 0, and the duty cycle of the underlying pulse waveform. This message indicates that either parameter is further limited by minimum pulse width and edge time parameters.
-222 Data out of range; PWM deviation limited by pulse parameters	The PWM deviation (width or duty cycle) is adjusted to accommodate current pulse parameters such as pulse width/duty cycle, period, and edge time.
-222 Data out of range; duty cycle; value clipped to...	The square wave duty cycle is adjusted to within 20% to 80%.
-222 Data out of range; duty cycle limited by frequency; value clipped to upper limit	The square wave duty cycle is adjusted to within 40% to 60% when the frequency is greater than 25 MHz.
-223 Too much data	An arbitrary waveform specified contains more than 65,536 points. Verify the number of points in the DATA VOLATILE or DATA:DAC VOLATILE command.
-224 Illegal parameter value	An exact parameter value was expected.

Table B-3:
Device-dependent errors

Error code	Description
-313 Calibration memory lost; memory corruption detected	A checksum error was detected in the nonvolatile memory (used to store calibration constant).
-314 Save/recall memory lost; memory corruption detected	A checksum error was detected in the nonvolatile memory (used to store instrument states).
-315 Configuration memory lost; memory corruption detected	A checksum error was detected in the nonvolatile memory (used to store configuration settings).
-350 Queue overflow	More than 20 errors were found and the error queue is full.

Table B-4:
Query errors

Error code	Description
-410 Query INTERRUPTED	A command was received, but the output buffer contained data from a previous command (the previous data is lost).
-420 Query UNTERMINATED	A query command was sent to read the output buffer over the interface, but no such command that generates data to the output buffer was previously sent for execution.
-430 Query DEADLOCKED	An executed command generated too much data for the output buffer and the input buffer is also full. The command continues to execute but the data is lost.

Table B-4:
Query errors

Error code	Description
-440 Query UNTERMINATED after indefinite response	The *IDN? command must be the last query command within a series of commands in a command string.

Table B-5:
Instrument errors

Error code	Description
501 Cross-isolation UART framing error	Internal hardware failure.
502 Cross-isolation UART overrun error	
580 Reference phase-locked loop is unlocked	The PHAS:UNL:ERR:STAT has been turned on and the internal phase-locked loop is currently unlocked.

Table B-6:
Self-test errors

Error code	Description
621 Self-test failed; square-wave threshold DAC	A possible malfunctioning digital-to-analog converter (DAC), failed DAC multiplexer channels, or associated circuitry.
623 Self-test failed; dc offset DAC	A possible malfunctioning DAC, failed DAC multiplexer channels, or associated circuitry.
624 Self-test failed; null DAC	
625 Self-test failed; amplitude DAC	
626 Self-test failed; waveform filter path select relay	The specified relay is not properly switched or the attenuator/amplifier does not provide the expected attenuation or gain. These self-tests use the internal analog-to-digital converter (ADC) to verify whether the output path relays, output amplifier (+20 dB), and output attenuators operate properly.
627 Self-test failed; -10 dB attenuator path	
628 Self-test failed; -20 dB attenuator path	
629 Self-test failed; +20 dB amplifier path	
630 Self-test failed; internal ADC over-range; condition	A probable ADC failure.
631 Self-test failed; internal ADC measurement error	A probable ADC failure.
632 Self-test failed; square/pulse DAC test failure	A probable failure of the square/pulse DAC.

Table B-7:
Arbitrary waveform errors

Error code	Description
770 Nonvolatile arb waveform memory corruption detected	A checksum error was found in the nonvolatile memory (used to store arbitrary waveforms). The arbitrary waveform cannot be retrieved.
781 Not enough memory to store new arb waveform; use DATA:DELETE	All nonvolatile memory locations are occupied. There is no room to store a new waveform.

Table B-7:
Arbitrary waveform errors

Error code	Description
781 Not enough memory to store new arb waveform; bad sectors	Storage hardware failure. New waveforms cannot be saved.
782 Cannot overwrite a built-in waveform	The five built-in waveform names (EXP_RISE, EXP_FALL, NEG_RAMP, SINC, and CARDIAC) are reserved and cannot be used with DATA: COPY command.
784 Name of source arb waveform for copy must be VOLATILE	When using the DATA: COPY command, the chosen data source must be the volatile one.
785 Specified arb waveform does not exist	Before using the DATA: COPY command to copy from the volatile memory, download the waveform to it using the DATA VOLATILE or DATA: DAC VOLATILE command.
786 Not able to delete a built-in arb waveform	Deleting the built-in waveform is not allowed.
787 Not able to delete the currently selected active arb waveform	Deleting the waveform that is currently active is not allowed.
788 Cannot copy to VOLATILE arb waveform	You can only use DATA: COPY command to copy from volatile memory. You cannot copy to volatile memory.
800 Block length must be even	The binary data is represented as 16-bit integers. It is sent in groups of two bytes (DATA: DAC VOLATILE command).
810 State has not been stored	The storage location specified in the *RCL command was never used in previous *SAV commands. You cannot recall instrument state from an empty storage location.

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About application programs

This section provides several remote interface example programs which can be used as reference when creating user programs. Each example includes the list of applicable standard commands for programmable instruments (SCPI) and accompanying comments.

Application examples

To use the `APPLY` commands to configure the instrument for a sine waveform function:

Table C-1:
APPLY example commands

Command	Comment
*RST	Reset Model 3390.
*CLS	Clear 3390 status registers.
APPL:SIN 1000, 1, 0	Set sine to 1 KHz, 1V, 0V offset.

To set up the instrument to generate a service request (SRQ) using the status commands when a command error is received:

Table C-2:
SRQ example commands

Command	Comment
*RST	Reset Model 3390.
*CLS	Clear 3390 status registers.
*ESE 32	Enable SRQ on error.
*SRE 32	Enable SRQ.
APPL:SIN 1000, 1, 0	Set sine to 1 KHz, 1V, 0V offset.
APPL:SAN 1000, 1, 0	Command error, "SAN" vs. "SIN."
*SRE?	Query unit. Should display "+32."

To select amplitude modulation:

Table C-3:
Amplitude modulation example commands

Command	Comment
*RST	Reset Model 3390.
OUTPut:LOAD 50	Set output termination to 50 Ω .
FUNction:SHApe SINusoid	Carrier shape is sine waveform.
FREQuency 6000; VOLTage 3	Carrier frequency is 6 kHz at 3 V peak-to-peak.
AM:INTernal:FUNction	Modulating shape is sine waveform.
AM:INTernal:FREQuency 300	Modulation frequency is 300 Hz.
AM:DEPth 90	Modulation depth is 90 %.
AM:STATe ON	Turn amplitude modulation on.
OUTPut ON	Turn instrument output on.
*SAV 2	Store state in memory location 2.
*RCL 2	Recall the stored state from location (optional).

To select linear sweep:

Table C-4:
Linear sweep example commands

Command	Comment
*RST	Reset Model 3390.
FUNCTION SINusoid	Select sine waveform.
OUTPut:LOAD 50	Set load impedance to 50 Ω .
VOLTage 1	Set the amplitude to 1 V peak-to-peak.
SWEep:SPACing LINear	Set spacing to LINear or LOGarithmic.
SWEep:TIME 1	Set sweep time to 1 s.
FREQuency:START 100	Set start frequency to 100 Hz.
FREQuency:STOP 20e3	Set stop frequency to 20 kHz.
OUTPut ON	Turn instrument output on.
SWEep:STATE ON	Turn sweep function on.

To select pulse waveform:

Table C-5:
Pulse waveform example commands

Command	Comment
*RST	Reset Model 3390.
FUNCTION PULSe	Select pulse waveform.
OUTPut:LOAD 50	Set load impedance to 50 Ω .
VOLTage:LOW 0	Set the low level to 0 V.
VOLTage:HIGH 0.75	Set the high level to 0.75 V.
PULSe:PERiod 1e-3	Set period to 1 ms intervals.
PULSe:WIDTh 100e-6	Set pulse width to 100 μ s intervals.
PULSe:TRANSition 10e-9	Set edge time to 10 ns intervals.
OUTPut ON	Turn instrument output on.

To select pulse width modulation:

Table C-6:
Pulse width modulation example commands

Command	Comment
*RST	Reset 3390.
OUTPut:LOAD 50	Set load impedance to 50 Ω .
FUNCTION:SHAPE PULSe	Carrier shape is pulse waveform.
FREQuency 5000	Carrier frequency is 5 kHz.
VOLTage:LOW 0	Set the low level to 0 V.
VOLTage:HIGH 5	Set the high level to 5 V.
FUNCTION:PULSe:DCYCLE 35	Set beginning duty cycle to 35 %.
PWM:INTernal:FUNCTION TRIangle	Set modulating shape to triangle waveform.
PWM:INTernal:FREQuency 2	Set modulation frequency to 2 Hz.
PWM:DEVIation:DCYCLE 15	Set modulation depth to 15 %.
PWM:SOURce INTernal	Set modulation signal to internal.
PWM:STATE ON	Turn pulse width modulation on.
OUTPut ON	Turn instrument output on.

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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.

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Keithley Instruments, Inc.

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