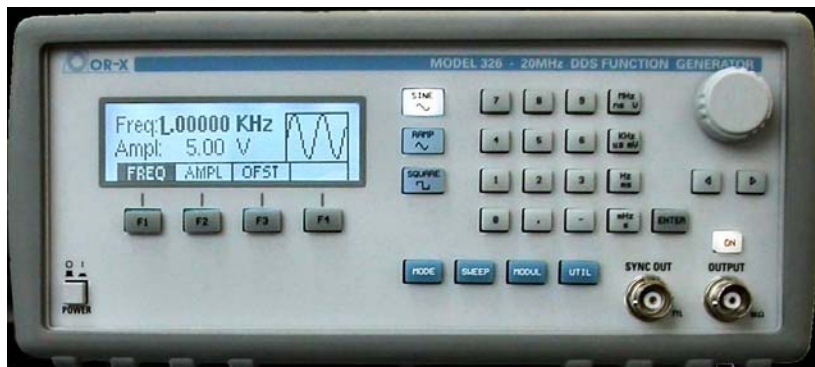




# MODEL 326

## FUNCTION GENERATOR



**OPERATING MANUAL**





# **Model 326**

## **20 MHz Function Generator**

**OPERATING MANUAL**

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# Warranty

OR-X warrants only to the original purchaser that this product, as purchased from OR-X or an OR-X distributor or dealer, will conform to the written specifications for a period of one year from the date of purchase. If the product fails to conform to these warranties, OR-X, as its sole and exclusive liability hereunder, will repair or replace the product and/or its components within a reasonable period of time if the product is returned to OR-X's facility, within the warranty period as expressed above.

These warranties are made upon the express condition that:

- a. The purchaser promptly notify OR-X in writing of any non-conformity with the above warranty including a detailed explanation of the alleged deficiencies.
- b. The product is returned to OR-X at the buyer's expense only after obtaining the proper authorization from OR-X.
- c. When the product is returned for repair, a copy of the original bill of sale or invoice is sent with the product .
- d. OR-X will not be liable for any incidental or consequential damages.
- e. In the opinion of OR-X upon inspection, the product has not been misused, altered, or damaged due to abnormal handling and/or operation.
- f. Repairs to the product and/or its components have not been made by anyone other than OR-X or one of its authorized repair agents.
- g. The product has not been modified, altered, or changed in any manner by anyone other than OR-X or one of its authorized repair agents.

**THIS WARRANTY EXCLUDES ALL OTHER WARRANTIES, WHETHER EXPRESSED OR IMPLIED, ORAL OR WRITTEN, INCLUDING WITHOUT LIMITATION WARRANTIES OF MERCHANTABILITY AND/OR FITNESS FOR A PARTICULAR PURPOSE.**

No term, condition, understanding or agreement purporting to modify the terms of this warranty shall have any legal effect unless made in writing and signed by an authorized officer of OR-X and the purchaser.

---

# Safety Summary

The following safety precautions apply to both operating and maintenance personnel and must be observed during all phases of operation, service, and repair of this instrument. Before applying power, follow the installation instructions and become familiar with the operating instructions for this instrument.

Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. OR-X assumes no liability for a customer's failure to comply with these requirements. This is a Safety Class I instrument.

## **GROUND THE INSTRUMENT**

To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground. This instrument is grounded through the ground conductor of the supplied, three-conductor ac power cable. The power cable must be plugged into an approved three-conductor electrical outlet. Do not alter the ground connection. Without the protective ground connection, all accessible conductive parts (including control knobs) can render an electric shock. The power jack and mating plug of the power cable meet IEC safety standards.

## **DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE**

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

## **KEEP AWAY FROM LIVE CIRCUITS**

Instrument covers must not be removed by operating personnel. Component replacement and internal adjustments must be made by qualified maintenance personnel. Disconnect the power cord before removing the instrument covers and replacing components. Under certain conditions, even with the power cable removed, dangerous voltages may exist. To avoid injuries, always disconnect power and discharge circuits before touching them.

## **DO NOT SERVICE OR ADJUST ALONE**

Do not attempt any internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

## **DO NOT SUBSTITUTE PARTS OR MODIFY THE INSTRUMENT**

Do not install substitute parts or perform any unauthorized modifications to this instrument. Return the instrument to OR-X for service and repair to ensure that safety features are maintained.

## **WARNINGS AND CAUTIONS**

**WARNING** and **CAUTION** statements, such as the following examples, denote a hazard and appear throughout this manual. Follow all instructions contained in these statements.

A **WARNING** statement calls attention to an operating procedure, practice, or condition, which, if not followed correctly, could result in injury or death to personnel.

A **CAUTION** statement calls attention to an operating procedure, practice, or condition, which, if not followed correctly, could result in damage to or destruction of part or all of the product.

---

**WARNING:** *Do not alter the ground connection. Without the protective ground connection, all accessible conductive parts (including control knobs) can render an electric shock. The power jack and mating plug of the power cable meet IEC safety standards.*

---

---

**WARNING:** *To avoid electrical shock hazard, disconnect power cord before removing covers. Refer servicing to qualified personnel.*

---

**CAUTION:** *Before connecting the line cord to the AC mains, check the rear panel AC line voltage indicator. Applying a line voltage other than the indicated voltage can destroy the AC line fuses. For continued fire protection, replace fuses only with those of the specified voltage and current ratings.*

---

**CAUTION:** *This product uses components which can be damaged by electro-static discharge (ESD). To avoid damage, be sure to follow proper procedures for handling, storing and transporting parts and subassemblies which contain ESD-sensitive components.*

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# **Introduction**

## **1.1 Introduction**

This manual contains information required to operate, program and test the MODEL 326 - Function Generator. This section covers the instrument general description, instrument specifications and characteristics.

## **1.2 Description**

The MODEL 326 is a versatile high performance function generator. Waveforms can be output in continuous, triggered, gated or burst mode. AM and FM modulation combined with versatile Sweep capabilities make the unit suitable for a wide range of applications.

Editing is flexible and easy including auto increment, line draw and predefined waveform facilities. The instrument can be remotely operated via the USB interface bus and it is SCPI compatible.

## MODEL 326 - SPECIFICATIONS

### GENERAL DESCRIPTION

The MODEL 326 is a programmable arbitrary waveform generator that can generate Sine, Triangle, Square and Pulse.

### FREQUENCY CHARACTERISTICS

Sine	-	0.01 Hz to 20 MHz
Square	-	0.01 Hz to 20 MHz
Triangle , Ramp	-	0.01 Hz to 1 MHz
Accuracy	-	0.005 % (50 ppm) +/- 6 mHz
Resolution	-	6 digits or 10 mHz

### OUTPUT CHARACTERISTICS

Amplitude Range	-	10mV to 10Vp-p into 50 ohms
Resolution	-	3 digits (1000 counts)
Amplitude Accuracy	-	$\pm 2\% \pm 20\text{mV}$ of the programmed output from 1.01V- 10V
Flatness	-	0.5 dB at 1MHz
	-	1 dB to 20 MHz
Offset Range	-	$\pm 4.5\text{V}$ into 50 ohms, depending on the Amplitude setting
Offset Resolution	-	10 mV with 3 digits resolution
Offset Accuracy	-	$\pm 2\% \pm 10\text{mV}$ into 50 ohms
Output Impedance	-	50 ohms
Output Protection	-	The instrument output is protected against short circuit or accidental voltage practically available in electronic laboratories, applied to the main output connector
Filter	-	9 pole Elliptic

### WAVEFORM CHARACTERISTICS

Harmonic Distortion	-	DC-20 KHz	-55 dBc
	-	20 KHz-100 KHz	-50 dBc
	-	100 KHz-1 MHz	-40 dBc
	-	1 MHz-20 MHz	-30 dBc
Spurious	-	DC-1MHz	<-60 dBc
Square Rise/Fall Time	-	< 18 ns (10% to 90%) at full amplitude into 50 ohms	
Variable Duty Cycle	-	20% to 80% to 2 MHz for Square and 10%-90% for Triangle	
Symmetry at 50%	-	< 1 %	

### OPERATING MODES

Continuous	-	Output continuous at programmed parameters.
Triggered	-	Output quiescent until triggered by an internal or external trigger, then one waveform cycle is generated to programmed parameters. Up to 1MHz trig rate.

---

Gate	-	Same as triggered mode, except waveform is executed for the duration of the gate signal. The last cycle started is completed.
Burst	-	2- 65,535 cycles
Trigger Source	-	Trigger source may be internal, external or manual. Internal trigger rate 0.1Hz-1MHz (1us – 10 s)

### MODULATION CHARACTERISTICS

Amplitude Modulation		
- Internal:		0.1Hz-20KHz sine , square or triangle waveform Variable modulation from 0% to 100%.
- External:		5 Vp-p for 100% modulation, 10 Kohms input impedance.
Frequency Modulation		
- Internal:		0.1Hz-20KHz sine wave, square or triangle
- External:		5 Vp-p for 100% deviation, 10 Kohms input impedance.

### SWEEP CHARACTERISTICS

Sweep Shape:	Linear and Logarithmic, up or down
Sweep Time:	10 ms to 100 s.
Sweep trigger	internal, external, continuous or burst

### INPUTS AND OUTPUTS

Trigger In	- TTL compatible. - Max. rate 10MHz. - Minimum width 50ns.
Sync Out	- TTL pulse at programmed frequency, 50 ohms source impedance.
Modulation IN	- 5 Vp-p for 100% modulation . - 10 K $\Omega$ input impedance. - DC to >20 KHz minimum bandwidth.

### GENERAL

Store memory	20 full panel settings at power-off
Dimensions	- 8.4 inch (213 mm) wide - 3.5 inch (88 mm) high - 8.3 inch (210 mm) deep
Weight	- Aprox 2.5 Kg.
Power	- 90V-264V - 30 VA max
Temperature	
Operating	- 0°C to +50°C
Non-operating	- -10°C to +70°C

Humidity	- 95 % RH , 0°C to 30°C
EMC	- According to EN55011 for radiated and conducted emissions.
Electrical Discharge Immunity	- According to EN55082
Safety Specifications	- According to EN61010
<b>CE</b> Labeled	

***NOTE***

Specifications are verified according to the performance check procedures in the technical manual.  
Specifications not verified in the manual are either explanatory notes or general performance characteristics only.

---

## Section 2

# Installation

### **2.1 Introduction**

This section contains installation information, power requirements, initial inspection and signal connections for MODEL 326 - Function Generator.

### **2.2 Mechanical Inspection**

This instrument was carefully inspected before shipment. Upon receipt inspect the instrument for damage that might have occurred in transit. If there is damage due to shipping, file a claim with the carrier who transported the unit. The shipping and packing material should be saved if reshipment is required. If the original container is not to be used, then use a heavy carton box. Wrap the unit with plastic and place cardboard strips across the face for protection. Use packing material around all sides of the container and seal it with tape bands. Mark the box "FRAGILE".

### **2.3 Initial Inspection**

After the mechanical inspection, verify the contents of the shipment (accessories and installed options). If the contents are incomplete, or if the instrument does not pass the specification acceptance tests, notify the local service center.

### **2.4 Instrument Mounting**

The MODEL 326 - Function Generator is intended for bench use. The instrument includes a front feet tilt mechanism for optimum panel viewing angle. The instrument does not require special cooling when operated within conventional temperature limits. The unit can be installed in a closed rack or test station if proper air flow is assured for removing about 15 W of power dissipation.

### **2.5 Power Requirements**

The MODEL 326 can be operated from any source of 90V to 264V AC, frequency from 48Hz to 66Hz. The maximum power consumption is 30 VA. Use a slow blow fuse UL/CSA approved of 1A as indicated on the rear panel of the instrument.

The instrument power fuse is located in the AC input plug. To access the fuse, first disconnect the power cord and then remove the fuse cartridge.

## **2.6 Grounding Requirements**

For the safety of operating personnel, the instrument must be grounded. The central pin on the AC plug grounds the instrument when properly connected to the ground wire and plugged into proper receptacle.

### **WARNING**

TO AVOID PERSONAL INJURY DUE TO SHOCK, THE THIRD WIRE EARTH GROUND MUST BE CONTINUOUS TO THE POWER OUTLET. BEFORE CONNECTION TO THE POWER OUTLET, EXAMINE ALL CABLES AND CONNECTIONS BETWEEN THE UNIT AND THE FACILITY POWER FOR A CONTINUOUS EARTH GROUND PATH. THE POWER CABLE MUST MEET IEC SAFETY STANDARDS.

## **2.7 Signal Connections**

Use RG58U 50 Ohm or equivalent coaxial cables for all input and output signals to and from the instrument.

## **2.8 USB Connection**

The rear panel USB connector is a standard Type B device USB

## **2.9 USB Configuration**

For the USB operation, the driver provided on the CD with the unit must be installed into the computer. After the installation, the computer virtual COM port for the USB must be configured for 115K baud rate, 8 bit data, 1 stop bits and no parity.

## Section 3

# Operating Instructions

### 3.1 General Description

This section describes the displays, controls and connectors of the MODEL 326 - Function Generator. All controls for the instrument local operation are located on the front panel. The connectors are located on both front and rear panels.

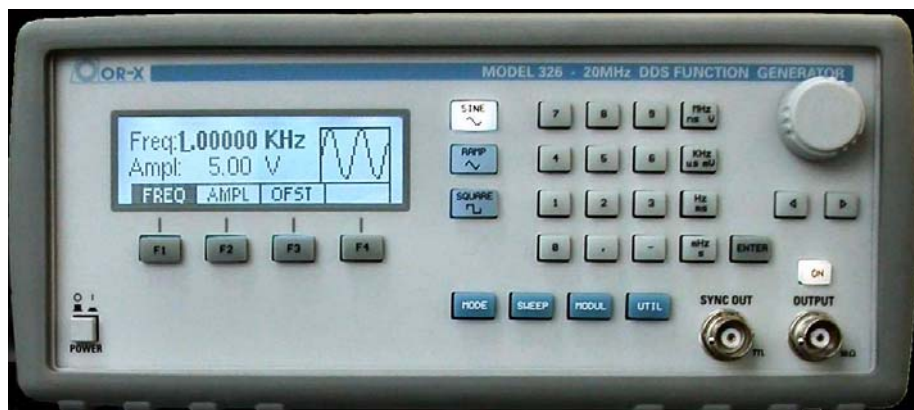


Figure 3.1 - MODEL 326 Front Panel

1. Power ON-OFF -Applies and removes AC power to the unit.
2. Display Window -Displays all instrument data and settings on a LCD.
3. F1-F4 Keys -Select the menu options that appear on the second line of the LCD display. Menus differ depending on the selected parameter, function or mode.
4. Function Keys -Select the output waveform, Sine, Square or Triangle.
5. Rotary Knob -Used to increment/decrement numerical values or to scan through the possible selections.
6. Modify Keys -Used to move the cursor (when visible) to either left or right.
7. Output ON -Controls the main output signal. The output status is displayed on the LCD.

### 3.2 Display Window

The MODEL 326 has a graphic LCD display that can display up to 124 x 32 dots. When you power-on the unit the SINE is selected and its current settings appear in the display. The bottom displays a menu that corresponds to the function, parameter or mode displayed selected.

### 3.3 Front Panel Controls

The front-panel controls select, display, and change parameter, function, and mode settings. They also include the keys you use to program and generate arbitrary waveform output. Use the rotary input knob and the cursor movement keys to enter data into the waveform generator.

To change a setting:

1. Press the key that leads to a required item.
2. Move cursor using cursor keys to the appropriate position in the numeric field (if applicable).
3. Use the rotary input or the numerical keyboard to change the value of the displayed item. Changes take effect immediately.

The following subsections describe the function of each front panel key and connector.

### 3.4 Connectors

The function generator has two BNC connectors on the front panel and two on the rear panel where you can connect coaxial cables. These coaxial cables serve as carrier lines for input and output signals delivered to and from the function generator.

#### Output Connector

Use this connector to transfer the main output signal from the function generator.

#### Trig In Connector

Use this connector to apply an external trigger or gate signal, depending on the waveform generator setting, to the generator.

#### Sync Out Connector

Use this connector to output a positive TTL sync pulse generated at each waveform cycle.

#### Modulation In Connector

5V p-p signal for 100% modulation, 10Kohms input impedance with DC - >20 KHz bandwidth.

### 3.5 Output Connections

The waveform generator output circuits operate as a 50 ohms voltage source working into a 50 ohms load. At higher frequencies, non terminated or improperly terminated output cause aberrations on the output waveform. In addition, loads less than 50 ohms reduce the waveform amplitude, while loads more than 50 ohms increase waveform amplitude.

Excessive distortion or aberrations caused by improper termination are less noticeable at lower frequencies, especially with sine and triangle waveforms. To ensure waveform integrity, follow these precautions:

1. Use good quality 50 ohms coaxial cable and connectors.
2. Make all connections tight and as short as possible.

3. Use good quality attenuators if it is necessary to reduce waveform amplitudes applied to sensitive circuits.
  4. Use termination or impedance-matching devices to avoid reflections.
  5. Ensure that attenuators and terminations have adequate power handling capabilities.
- If there is a DC voltage across the output load, use a coupling capacitor in series with the load. The time constant of the coupling capacitor and load must be long enough to maintain pulse flatness.

### **Impedance Matching**

If the waveform generator is driving a high impedance, such as the 1 Mohm input impedance (paralleled by a stated capacitance) of an oscilloscope vertical input, connect the transmission line to a 50 ohms attenuator, a 50 ohms termination and to the oscilloscope input. The attenuator isolates the input capacitance of the device and terminates the waveform generator properly.

## **3.6 MENU Keys**

These keys select the main menus for displaying or changing a parameter, function or mode.

### **3.6.1 WAVEFORM Keys**

The keys select the waveform output and displays the waveform parameter menu (frequency, amplitude and offset). When the Arbitrary Waveform is selected, the display shows also the waveform rate.



#### *Sine Menu*

- F1: FREQ** - (Frequency) Selects and displays the frequency. Change the frequency setting using the cursor keys, rotary knob or numerical keys.
- F2: AMPL** - Selects the Amplitude parameter.
- F3: OFST** - Selects the Offset parameter. Change the offset by using the cursor keys, rotary dial or numerical keys. If a certain setting cannot be produced, the waveform generator will display a "Setting Conflict" message.

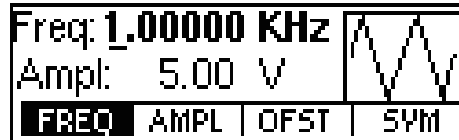
#### **Amplitude and Offset Interaction:**

Amplitude and offset settings interact and are bound by hardware restrictions. In order to obtain the desired waveform the following amplitude and offset hardware limitations must be considered:

The offset voltage has three ranges as follows:

Output Voltage Range	Constraints of Amplitude + Offset
1.01 volt to 10.00 volts	$(V_{p-p})/2 +  \text{offset}  \leq 5$ volts
0.101 volt to 1 volt	$(V_{p-p})/2 +  \text{offset}  \leq 0.5$ volts
0.010 volt to 0.100 volt	$(V_{p-p})/2 +  \text{offset}  \leq 0.05$ volts

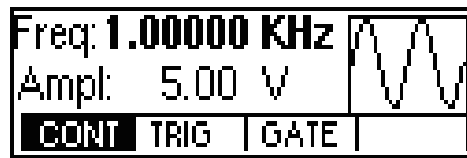
**F4:SYM** - When the Square or Triangle waveforms are selected, the SYMMETRY is available. Change the symmetry by using the cursor keys, rotary dial or numerical keys. If a certain setting cannot be produced, the waveform generator will display a warning message.



*Triangle Menu*

### 3.6.2 MODE Key

Selects the output mode: CONT (Continuous), TRIG (Triggered), GATE (Gated), and BRST (Burst). To select the output mode, press MODE, then press the function key that corresponds to the desired Mode menu option, as shown:



*Mode Menu*

**F1: CONT** - (Continuous) - Selects continuous output.

**F2: TRIG** - (Triggered) - Triggers one output cycle of the selected waveform for each trigger event.

**F3: GATE** - (Gated) - Triggers output cycles as long as the trigger source asserts the gate signal.

**F4: BRST** - (Burst) - Triggers output N output cycles for each trigger event, where N ranges from 2 to 65,535.

After selecting the TRIG, GATE or BURST menu, the trigger source menu is available:



### *Trigger Menu*

- F1: MAN** - Selects manual as the trigger source. To trigger the waveform generator, press this MAN TRIG again.
- F2: INT** - Selects the internal trigger generator as the trigger source. Change the internal trigger rate displayed with the rotary input knob.
- F3: EXT** - Selects the external trigger signal as the trigger source. The trigger source is supplied through the TRIG IN connector.

In BURST mode, the **F4** displays **NBRST**, the number of burst pulses to be output with each trigger. The N can be changed from 2 to 65,535.

### **3.6.3 UTILITY Key**



### *Utility Menu*

- F1: RECALL** - Recalls a previously stored front-panel setup from the selected buffer. Change the buffer number by using the rotary input knob. Valid storage buffer numbers are from 1 to 19. Buffer 0 is the factory default setup.
- F3: STORE** - Stores the current front-panel setup to the specified storage buffer. Change the buffer number by using the data keys or the rotary input knob. Valid storage buffer numbers range from 1 to 19.

### **3.6.4 SWEEP Key**

Selects the Sweep Mode and allows the entering of sweep parameters as Sweep Start, Sweep Stop and Sweep Rate.

To select the sweep mode, press SWEEP, then press the function key that corresponds to the desired Sweep menu option, as shown:



*Sweep Menu*

- F1: ON/OFF** - Operates the sweep function, selecting between Sweep On or Off.
- F2: LIN** - Selects the Linear sweep shape.
- F3: LOG** - Selects the Logarithmic sweep shape.
- F4: SET** - Defines the Sweep Start and Stop frequencies.



*Set Sweep Menu*

**3.6.5 MODULATION Key**

Selects the Modulation mode **AM** or **FM**.

To select the output mode, press **MODUL** key, then press the function key that corresponds to the desired menu option, as shown:



*Modulation Menu*

If the **AM** is selected, the following menu is available:



*AM Menu*

- F1: %** - Defines the modulation depth (from 0 to 100%)
- F2: FREQ** - Selects the modulation frequency, from 0.1Hz to 20.00KHz.
- F4-F5: EXT- INT** - Selects and enables the external modulation by an external signal applied to the Modulation In connector.

If the **FM** is selected, the following menu is available:



#### *FM Menu*

- F1: DEV** - Defines the FM deviation frequency or the modulation shape,
- F2: FREQ** - Selects the modulation frequency, from 0.1Hz to 20.00KHz.
- F3: SHAPE** - Selects the shape of the modulating waveform between Sine, Triangle, Square
- F4: EXT-INT** - Selects and enables the external modulation by an external signal applied to the Modulation In connector.

### **3.7 ON Key**

Use these key to control the main output signal. When the output is active, an internal LED is illuminated.

### **3.8 Cursor Movement Keys**

Use these keys to move the cursor (when visible) either left or right. They are used in conjunction with the rotary input knob to set the step size of the rotary input knob.

### **3.9 Rotary Input Knob**

Use this knob to increase and decrease numeric values or to scroll through a list. The cursor indicates the low-order position of the displayed value which changes when you rotate the knob (for straight numeric entries only). For other types of data, the whole value changes when you rotate the knob.

### **3.10 Power-On Settings**

At power-on, the waveform generator performs a diagnostic self-test procedure to check itself for errors. If it find an error, and error code and text appear in the display window. Other error codes appear when you enter and invalid front-panel setting. For more information on error codes, see the Error Indication section.

When the waveform generator finishes the diagnostic self-test routine, it enters the local state (LOGS) and assumes

power-on default settings. Table 3-2 lists the factory default settings. You can program the waveform generator for any settings you want at power on, as described earlier in this section.

**Table 3-2**  
**Power-on Default Settings**

<b>Key Function</b>		<b>Comments</b>
FREQUENCY	100000 Hz	Wave frequency
AMPLITUDE	5.00V	Peak to peak output amplitude
FUNCTION	SINE	Output waveform
OFFSET	0.00V	Zero offset
REPETITION	10ms	Internal trigger rate
MODE	CONT	Waveform mode
N-BURST	2	Waves per burst
TRIG SOURCE	EXT	External trigger source
OUTPUT	OFF	Output disabled
SWEEP	OFF	Sweep execution
MODULATION	OFF	Modulation execution

### 3.11 Memory

The waveform generator uses a Nonvolatile FLASH for storing the front panel settings. Up to 20 front panel settings are stored.

Because it is impossible to 100% guarantee against loss of stored data, you should maintain a record of the data stored in memory so that you can manually restore such data, if necessary.

### 3.12 Displaying Errors

At power-on, the waveform generator performs a diagnostic routine to check itself for problems. If the diagnostic routine finds an error, an error message is displayed. The waveform generator also displays error messages when front-panel settings are either invalid or may produce unexpected results.

#### *Error messages for MODEL 326*

<b>Message Text</b>	<b>Cause</b>
Out of range	Attempt to set variable out of instrument limits.
Setting conflict	Can't have this parameter set with some other.
Trig rate short	Internal trigger rate too short for wave/burst.
Empty location	Attempt to restore non existent setting.
RAM error	Error in testing RAM.
Save RAM	New firmware installed.

---

### **3.13 Using The MODEL 326**

This section explains how to generate various waveforms and modify the output waveform

- \* Generating a waveform output
- \* Modifying waveform output
- \* Storing and recalling a waveform generator setup

#### **3.13.1 Selecting a Standard Waveform**

You can select several standard waveforms as: sine, triangle and square. Creating a standard waveform requires selecting the waveform type, parameters, modes, etc., and their settings that define the waveform. Generating a standard waveform requires the following:

- \* Selecting the waveform
- \* Setting the output frequency
- \* Setting the output amplitude and offset

#### **3.13.2 Setting the Output Mode**

To set the output mode:

1. Press MODE to display the Mode menu on the display window.
2. Press the function key (F1 to F4) that corresponds to the desired mode.

#### **3.13.3 Setting the Output**

To set the output channel, press the Output ON key. An internal LED is illuminated to indicate that the Output is ON.

#### **3.13.6 Using Voltage Offset**

Through the offset parameter you can add a positive or negative DC level to the output waveform.

To set voltage offset:

1. Press Waveform to display the menu.
2. Press F3 :OFST to display the offset setting.
3. Use the rotary input knob or the numerical keys to set the voltage offset.

To turn the voltage offset OFF, repeat the steps above, but set the offset voltage level to 0.

#### **3.13.7 Storing and Recalling a Waveform Generator Setup**

You can store up to 20 front-panel setups in a part of nonvolatile Flash known as the settings storage memory. When you recall a stored setup, the front-panel settings change to match the settings in the stored setup. These stored and recalled settings include the starting address and length of the arbitrary memory that is loaded in the execution memory.

### **Storing Setups**

To store the front-panel setup:

1. Press UTILITY to display the menu.
2. Press F2:STORE to select the Store mode.
3. Use the rotary input knob to select a buffer number. Valid buffer numbers range from 1 to 19. Buffer 0 is a read-only buffer that contains the power-on settings listed in Table 3-3.

The waveform generator does not warn you when you store a setup into a settings buffer that is already occupied.

**Recalling Setups.** To recall stored front-panel setup:

1. Press UTILITY to display the menu.
2. Press F1:RECALL to select the Recall mode.
3. Use the rotary input knob to select a buffer number. Valid buffers numbers range from 0 to 19. Buffer 0 is a read-only buffer that contains the power-on settings listed in Table 3-3.

# Programming

### 4.1 Overview

This section provides detailed information on programming the MODEL 326 via the USB interface.

### 4.2 Device States

The device may be in one of the two possible states described below.

#### 4.2.1 Local State (LOCS)

In the LOCS the device may be operated from the front panel.

#### 4.2.2 Remote State (REMS)

In the REMS the device may be operated from the USB interface. Actuating any front panel key will cause the device state to revert to the LOCS.

### 4.3 Message Exchange Protocol

The device decodes messages using the Message Exchange Protocol similar to the one defined in IEEE 488.2. The following functions implemented in the MEP must be considered:

#### 4.3.1 The Input Buffer

The device has a 128-byte long cyclic input buffer. Decoding of remote messages is begun as soon as the input buffer is not empty, that is, as soon as the controller has sent at least one byte to the device. Should the input buffer be filled up by the controller faster than the device can remove the bytes and decode them, the bus handshake (CTS/RTS) is used to pause data transfer until room has been made for more bytes in the buffer. This prevents the controller from overrunning the device with data.

#### 4.3.2 The Output Queue

The device has a 100-byte long output queue in which it stores response messages for the controller to read. If at the time a response message is formatted the queue contains previously formatted response messages, such that there is not enough place in the queue for the new message, the device will put off putting the message in the queue until there is place for it.

### 4.3.3 Response Messages

The device sends a Response Message in response to a valid query. All queries return a single Response Message Unit. In only one case is the Response Message generated when the response is read (as opposed to when the response is parsed), and this is when querying Arbitrary Waveform data. All other queries generate the Response Message when they are parsed.

## 4.4 Instrument Identification

The \*IDN? common query is used to read the instrument's identification string. The string returned is as follows:

```
OR-X,MODEL 326,0,V0.1
```

The “V0.1” reflects the firmware version number and will change accordingly.

## 4.5 Instrument Reset

The \*RST common command effects an instrument reset to the factory default power up state.

## 4.6 Command Syntax

### 4.6.1 General Command Structure

A Program Message is defined as a string containing one Program Message Units, which is an instrument command or query. The Program Message is terminated by the Program Message Terminator.

The Program Message Terminator consists of optional white space characters, followed by the Linefeed (LF) character (ASCII 0A);

The Program Message Unit can be divided into three sections as follows:

#### a) Program Header

The Program Header represents the operation to be performed, and consists of ASCII character mnemonics. Two types of Program Headers are used in the MODEL 326: Instrument-control headers and Common Command and Query headers. Common Command and Query Program Headers consist of a single mnemonic prefixed by an asterisk (\*').

The mnemonics consist of upper - or lower-case alpha characters.

Example: The command to set the frequency to 1KHZ may be written in the following ways:

```
FREQ 1KHZ  
FREQ 1000HZ  
FREQ 1000  
FREQ 1E3  
freq 1khz  
freq 1000hz  
freq 1000  
freq 1e3
```

#### b) Program Header Separator

---

The Program Header Separator is used to separate the program header from the program data. It consists of one or more white space characters, denoted as <ws>. Typically, it is a space.

c) Program Data

The Program Data represent the values of the parameters being set, for example, the '1KHZ' in the above examples. Different forms of program data are accepted, depending on the command. The Program Data types used in the instrument are:

i) Character program data

This form of data is comprised of a mnemonic made up of lower - or upper-case alpha characters. As with Program Header mnemonics, some Character Data mnemonics have short and long forms. Only the short or the long form may be used.

ii) Boolean data

Boolean data indicate that the parameter can take one of two states, ON or OFF. The parameter may be character type  
ON or OFF

or numeric. A numeric value is rounded to an integer. A non-zero result is interpreted as 1 (ON), and a zero result as 0 (OFF).

Queries return the values 0 or 1.

iii) NRf

This is a decimal numeric data type, where  
NR1 indicates an integer number,  
NR2 indicates a fixed point real number, and  
NR3 indicates a floating point real number.

iv) Numeric value program data

This data type defines numeric values, as well as special cases of Character Data. Numeric values may be specified in any of Integer, Fixed Point or Floating Point format. All parameters which have associated units accept a suffix, which may be specified using upper or lower-case characters. When the suffix is not specified, the numeric value is accepted in the default units, which are Hertz for frequency, Seconds for time, and Volts for voltage. To set the frequency to 1KHz we can send one of the following commands:

```
FREQ 1000  
FREQ 1E3
```

The special forms of character data accepted as numbers are

```
MAXimum: sets the parameter to its maximum value.  
MINimum: sets the parameter to its minimum value.
```

For example, to set the frequency to it's maximum value we can send the command

```
FREQ MAX
```

### Definite Form

The Definite Form has the structure

-#-Byte Count Length - Byte Count - 8-bit byte

The Byte Count Length consists of a single ASCII digit from 1 to 9. It tells the parser how many digits are in the Byte Count.

The Byte Count is a decimal integer made up of the number of digits specified in the Byte Count Length. It tells the parser how many 8-bit bytes are being sent.

### Indefinite Form

The Indefinite Form has the structure

- # - 0 – 8-bit byte – LF

Some Program Message Units either require, or can accept, more than one data element. Program data elements are separated from each other by the Program Data Separator. It is defined as optional white space characters followed by a comma (','), which in turn is followed by optional white space characters.

There are two types of Program Message Units: Command Message Units and Query Message Units. A Query differs from a Command in that the Program Header is terminated with a question mark ('?'). For example, the frequency might be queried with the following query:

FREQ?

Some Query Message Units accept data, giving the device more specific information about what is being queried. In many cases the Query Message Unit may optionally be supplied with the MIN or MAX mnemonics as data. This tells the device to return the minimum or maximum value to which the parameter may currently be set. For example,

FREQ? MAX

will return the maximum value to which the frequency may currently be set.

Not all Program Message units have query forms ( for example, SAV), and some Program Message Units might have only the query form (for example IDN?).

The instrument puts the response to the query into the output queue, from where it may be read by the controller.

## 4.7 Status Reporting

The instrument is capable of reporting status events and errors to the controller.

### 4.7.1 The Error Queue

The error queue is used to store codes of errors detected in the device. It is implemented as a cyclic buffer of length 10. The error queue is read with the following query:

ERR?

The first error in the queue is returned, and the queue is advanced.

---

### 4.7.2 Error Codes

The negative error codes are defined by SCPI. Positive codes are specific to the instrument.

The error message is returned in the form

<error number>,"<error description>"

A table of error numbers and their descriptions is presented here.

No error reported

0 - No error

#### Command Errors

A command error is in the range -199 to -100, and indicates that a syntax error was detected. This includes the case of an unrecognized header.

-100	Command Error
-101	Invalid character
-102	Syntax error
-103	Invalid separator
-104	Data type error
-108	Parameter not allowed
	More parameters than allowed were received
-109	Missing parameter
	Fewer parameters than necessary were received
-110	Command header error
-111	Header separator error
-112	Program mnemonic too long
	The mnemonic must contain no more than 12 characters.
-113	Undefined header
-120	Numeric data error
-121	Invalid character in number
-123	Exponent too large
-124	Too many digits
-128	Numeric data not allowed
	A different data type was expected
-131	Invalid suffix
-134	Suffix too long
-138	Suffix not allowed
-140	Character data error.
-141	Invalid character data.
	Incorrect character data were received.
-144	Character data too long
	Character data may contain no more than 12 characters.
-148	Character data not allowed
-158	String data not allowed
-161	Invalid block data
	An error was found in the block data
-168	Block data not allowed
-178	Expression data not allowed

## Execution Errors

An execution error indicates that the device could not execute a syntactically correct command, either since the data were out of the instrument's range, or due to a device condition.

-200	Execution error An attempt was made to RECALL the contents of an uninitialized stored setting buffer.
-211	Trigger ignored. The *TRG common command was ignored due to the device not being in the correct state to execute the trigger.
-220	Parameter error. A parameter is in the correct range, but conflicts with other parameters.
-221	Settings conflict. The parameter is out of range due to the current instrument state.
-222	Data out of range.
-223	Too much data. The arbitrary waveform memory limit has been exceeded.
-224	Illegal parameter value. The parameter value must be selected from a finite list of possibilities.

## Device-Specific Errors

An error specific to the device occurred.

-315	Configuration memory lost. Device memory has been lost.
-330	Self-test failed.
-326	Queue overflow. Error codes have been lost due to more than 10 errors being reported without being read.

## Query Errors

A query error indicates that the output queue control has detected a problem. This could occur if either an attempt was made to read data from the instrument if none was available, or when data were lost. Data could be lost when a query causes data to be formatted for the controller to be read, and the controller sends more commands without reading the data.

-410	Query INTERRUPTED. Data were sent before the entire response of a previous query was read.
-420	Query UNTERMINATED. An attempt was made to read a response before the complete program message meant to generate that response was sent.

## Warnings

The execution of some commands might cause an undesirable instrument state. The commands are executed, but a warning is issued.

500	Trigger rate short
510	Output overload

"Trigger rate short" means that the period of the waveform is larger than the value of the internal trigger rate. Thus not every trigger will generate a cycle (or burst) of the waveform.

---

## 4.8 COMMON COMMANDS

### 4.8.1 System Data Commands

a) **\*IDN?** - Identification query

The identification query enables unique identification of the device over the GPIB. This query should always be the last in a program message. It returns a string with four fields:

Manufacturer name  
Model name  
Serial number (0 if not relevant)  
Version number

Command

Type: Common Query  
Syntax: \*IDN?  
Response: OR-X, MODEL 326,0,V1.1

### 4.8.2 Internal Operation Commands

a) **\*RST** - Reset command

The Reset command performs a device reset. It causes the device to return to the factory default power up state.

Type: Common Command  
Syntax: \*RST

### 4.8.3 Device Trigger Commands

a) **\*TRG** - Trigger command

This command is analogous to the IEEE 488.1 Group Execute Trigger interface message, and has the same effect. It is used to trigger the device to output a wave, and is accepted only when the trigger mode is set to Trigger, Gate or Burst, and the trigger source is set to BUS.

Type: Common Command  
Syntax: \*TRG

### 4.8.4 Stored Settings Commands

a) **\*RCL** - Recall instrument state

This command is used to restore the state of the device to that stored in the specified memory location.

Arguments

Type <NRf>  
Range 0 to 49. Non integer values are rounded before execution

Type: Common Command  
Syntax: \*RCL<ws><NRf>

Example: \*RCL 0 (Recall default state)  
\*RCL 49

Stored setting location 50 stores the last instrument setting before power down.

### b) \*SAV - Save instrument state

This command is used to store the current instrument state in the specified memory location.

#### Arguments

Type: <NRf>  
Range: 1 to 49. Non integer values are rounded before execution  
Type: Common Command  
Syntax: \*SAV<ws><NRf>  
Example: \*SAV 25

Stored setting location 0 stores the factory defaults, and is a read-only location. Location 50 stores a copy of the current instrument setting, and it, too, is read-only.

## 4.9 INSTRUMENT CONTROL COMMANDS

Instrument control commands are grouped into logical subsystems according to the SCPI instrument model. The commands are comprised of mnemonics indicating the subsystem to which the command belongs, and the hierarchy within that subsystem. When the command is to be referred to the Root node, it should be prefixed with a colon (:). Mnemonics appearing in square brackets [...] are optional. The '|' character is used to denote a choice of specifications. The '<ws>' is used to denote a white space character.

### 4.9.1 Default Subsystem

The Source Subsystem controls the frequency, voltage, amplitude modulation and clock source. The command structure is as follows:

<b>FUNCTION</b>	SINusoid SQUare TRIangle
<b>FREQuency</b>	<numeric value>
<b>AMPLitude</b>	<numeric value>
<b>OFFSet</b>	<numeric value>
<b>DCYCLE</b>	<numeric value>
<b>MODE</b>	CONT/ TRIG / GATE / BRST
<b>TRIG</b>	INT / EXT
<b>TRAtE</b>	<numeric value>
<b>BURSt</b>	<numeric value>
<b>MODULation</b>	OFF/AM/FM/INT/EXT
<b>MODFREquency</b>	<numeric value>
<b>MODSHape</b>	SIN/TRI/ SQU
<b>DEViation</b>	<numeric value>
<b>DEPTH</b>	<numeric value>
<b>SWSTArt</b>	<numeric value>
<b>SWSTOp</b>	<numeric value>
<b>SWRAtE</b>	<numeric value>

#### **4.9.1.1 Frequency**

FREQuency <frequency>

The frequency command controls the frequency of the output waveform.

##### Arguments

Type:        Numeric.  
Units:        MHz, KHz, Hz (default)  
Range:        For SIN and SQU - 10uHz to 31MHz,  
              For TRI – 10uHz to 500KHz,  
              For ARB - Dependent on the Point Rate and Wavelength.  
              Fmax = 1/(20nS \* Wavelength)  
              Fmin = 1/(50S \* Wavelength)

Rounding:    The value is rounded to 10 digits (DDS) or 4 digits (ARB).

Command Type: Setting or Query

##### Setting

Syntax:        FREQuency<ws><frequency>[units]  
              FREQuency<ws>MINimum|MAXimum

Examples:    FREQ 5KHZ  
              FREQ 5E3  
              FREQ MAXIMUM  
              FREQ MIN

##### Query

Syntax:        FREQuency? [<ws>MAXimum|MINimum]

Examples:    FREQ?  
              FREQ? MAX

Response:    NR3

##### Considerations:

- 1) The MIN and MAX arguments refer to currently settable minimum or maximum.
- 2) FIXEd is alias for CW.

#### **4.9.1.2 Amplitude**

AMPLitude <p-p amplitude>

The amplitude command is used to set the peak-to-peak amplitude of the output waveform. Note that the amplitude and the offset are limited by the relation

Peak Amplitude + |Offset| <= 5V

##### Arguments

Type:        Numeric  
Units:        V, mV, VPP, mVPP  
Range:        10mV to 10V  
Rounding:    1mV from 10mV to 999mV. 10mV from 1V to 10V.

Command Type: Setting or Query

##### Setting

Syntax:        AMPLitude<ws><amplitude>[units]  
              AMPLitude<ws>MINimum|MAXimum

Examples:    AMPL 2.5  
              AMPL 2.5V

AMPL MAX  
Query  
Syntax:                  AMPLitude? <ws>MINimum|MAXimum]  
Examples:              AMPL?  
                                  AMPL? MAX  
Response:              NR2  
Considerations:

- 1) The MAXimum amplitude is dependent on the offset.
- 2) The MAX and MIN arguments should not be used in a program message containing an OFFSet command, since these values are evaluated during parsing, based on the current value of the offset.

#### 4.9.1.3 Offset

OFFSet <offset>

The offset command is used to set the DC offset of the output waveform. Note that the amplitude and the offset are limited by the relation

$$\text{Peak Amplitude} + |\text{Offset}| \leq 5\text{V}$$

Arguments

Type:                  Numeric  
Units:                  V, mV  
Range:                  10mV to 4.5V  
Rounding:              to 10mV  
Command Type: Setting or Query

Setting

Syntax:              OFFSet<ws><offset>[units]  
                          OFFSet<ws>MINimum|MAXimum  
Examples:              OFFS 2.5  
                          OFFS 2.5V  
                          OFFS MAX

Query

Syntax:              OFFSet? [<ws>MINimum|MAXimum]  
Examples:              OFFS?  
                          OFFS? MAX  
Response:              NR2  
Considerations:

- 1) The MAXimum offset is dependent on the amplitude.
- 2) The MAX and MIN arguments should not be used in a program message containing an AMPLitude command, since these values are evaluated during parsing, based on the current value of the amplitude.

#### 4.9.1.4 Function

FUNcTion

The function command is used to set the type of waveform to be generated by the instrument.

Command Type: Setting or Query  
Setting Syntax: FUNcTion<WS><OPTION>  
Examples:              FUNC SIN  
                          FUNC TRI  
Query Syntax: FUNcTion?  
Examples:              FUNC?

---

Response: SIN|TRI|SQU  
Considerations:

The following functions are available:

SINusoid, SQUare, TRIangle

#### **4.9.1.5 Modulation**

The following commands control the modulation:

##### **MODULation**

This command activates or deactivates modulation:

Command Type: Setting or Query

Setting

Syntax: MODULation OFF|AM|FM|INT|EXT

Examples: MODULation FM  
MODULation OFF

Query

Syntax: MODULation?

Response: OFF |  
AM INT |  
AM EXT |  
FM INT |  
FM EXT

##### **DEPTh**

This command sets the AM modulation depth in %

Arguments

Type: Numeric

Units: none (implied %)

Range: 0 to 100

Rounding: To integer

Command Type: Setting or Query

Setting

Syntax: DEPTh<ws><percent depth>  
DEPTh<ws>MINimum|MAXimum

Examples: DEPTh 50

Query

Syntax: DEPTh? [<ws>MINimum|MAXimum]

Response: NR3

##### **MODFRequency**

This command sets the AM and FM modulating waveform frequency

Arguments

Type: Numeric.

Units: MHz, KHz, Hz (default)

Range: Fmax = 20 KHz  
Fmin = 0.01 Hz

Rounding: The value is rounded to 4 digits.

Command Type: Setting or Query

Setting

Syntax: MODFR<ws><frequency>[units]  
MODFR<ws>MINimum|MAXimum

Examples: MODFR 5KHZ  
MODFR 5E3  
MODFR MAXIMUM  
MODFR MIN

Query  
Syntax: MODFR? [<ws>MAXimum|MINimum]  
Examples: MODFR?  
MODFR? MAX  
Response: NR3

### MODSHape

This command selects the modulating waveform shape

Arguments

Type: Character  
Options: SINusoid, TRIangle, SQUare  
Command Type: Setting or Query

Setting

Syntax: MODSHape<ws><SIN|TRI|SQU>  
Examples: MODSHape SIN  
MODSHape TRI

Query

Syntax: MODSHape?  
Response: SIN|TRI|SQU

### DEViation

This command sets the FM modulation deviation

Arguments

Type: Numeric.  
Units: MHz, KHz, Hz (default)  
Range: Dependent on the carrier frequency, up to 1.56MHz.  
Fmax = carrier frequency  
Fmin = 10 uHz

Rounding: The value is rounded to 4 digits.

Command Type: Setting or Query

Setting

Syntax: DEViation<ws><frequency>[units]  
DEViation<ws>MINimum|MAXimum

Examples: DEV 5KHZ  
DEV 5E3  
DEV MAXIMUM  
DEV MIN

Query

Syntax: DEViation? [<ws>MAXimum|MINimum]  
Examples: DEV?  
DEV? MAX  
Response: NR3

#### 4.9.1.6 Sweep control

The following commands control the sweep functionality:

### SWEep

This command activates or deactivates sweep:

Arguments

Type: Boolean

---

Command Type: Setting or Query

Setting

Syntax: SWE<ws>ON|OFF|LIN|LOG

Examples: SWE ON  
SWE LIN

Query

Syntax: SWE?

Response: OFF|LIN|LOG

Note: Sweep cannot be activated in ARB or if FM is active.

## **SWRAte**

This command sets the time for one complete sweep:

Arguments

Type: Numeric

Units: S, mS, uS, nS

Range: 10mS to 500S

Rounding: to 4 digits

Command Type: Setting or Query

Setting

Syntax: SWRAte<ws><time>[units]  
SWRAte<ws>MINimum|MAXimum

Examples: **SWRAte** 50MS

Query

Syntax: SWRAte? [<ws>MINimum|MAXimum]

Response: NR3

## **SWSTArt**

This command sets the start frequency of the sweep:

Arguments

Type: Numeric.

Units: MHz, KHz, Hz (default)

Range: Dependent on the frequency range of the current function.

Rounding: The value is rounded to 4 digits.

Command Type: Setting or Query

Setting

Syntax: SWSTArt<ws><frequency>[units]  
SWSTArt<ws>MINimum|MAXimum

Examples: SWSTArt 5KHZ  
SWSTArt 5E3  
SWSTArt MAXIMUM  
SWSTArt MIN

Query

Syntax: SWSTArt? [<ws>MAXimum|MINimum]

Examples: SWSTArt ?  
SWSTArt ? MAX

Response: NR3

## **SWSTOp**

This command sets the stop frequency of the sweep:

Arguments

Type: Numeric.

Units: MHz, KHz, Hz (default)

Range: Dependent on the frequency range of the current function.

Rounding: The value is rounded to 4 digits.  
Command Type: Setting or Query  
Setting  
Syntax: SWSTOp<ws><frequency>[units]  
SWSTOp<ws>MINimum|MAXimum  
Examples: SWSTOp 5KHZ  
SWSTOp 5E3  
SWSTOp MAXIMUM  
SWSTOp MIN  
Query  
Syntax: SWSTOp? [<ws>MAXimum|MINimum]  
Examples: SWSTOp ?  
SWSTOp ? MAX  
Response: NR3

### 4.9.1.7 Duty Cycle

DCYCl e <duty cycle value>

This command is used to set the duty-cycle of the square wave or the symmetry of triangular wave. The value is given in percent .

Arguments Type: Numeric  
Units: None (percent implied)  
Range: 20 to 80  
Rounding: To integer  
Command Type: Setting or Query  
Syntax: DCYCl e <ws><duty cycle value>  
DCYCl e <ws>MINimum|MAXimum  
Query Syntax: DCYCl e? [<ws>MINimum|MAXimum]  
Response: NR3

### 4.9.1.8 Output State

:OUT <state 0,1>

This command controls whether the output is ON or OFF.

Arguments  
Type: Boolean  
Command Type: Setting or Query  
Setting  
Syntax: :OUT<ws>ON|1|OFF|0  
Examples: :OUT ON  
:OUT OFF  
Query  
Syntax: :OUT?  
Response: 0|1

### 4.9.1.9 Trigger Mode

MODE <trigger mode>

This command is used to set the trigger mode.

Arguments

---

Type: Character  
Options: CONTInuous  
          TRIGger  
          GATE  
          BURSt  
Command Type: Setting or Query  
Setting  
Syntax: MODE<ws><option>  
Examples: MODE CONT  
          MODE BURS  
Query  
Syntax: MODE?  
Response: CONT|TRIG|GATE|BURS

#### **4.9.1.10 Trigger Source**

TRIGger<trigger source>

This command is used to select the trigger source, for use in the Trigger, Gate and Burst trigger modes.

Arguments  
Type: Character  
Options: INTernal - Internal trigger  
          EXTernal - External trigger  
Command Type: Setting or Query  
Setting  
Syntax: TRIGger<ws><option>  
Examples: TRIG EXT  
          TRIG INT  
Query  
Syntax: TRIGger?  
Response: INT|EXT

#### **4.9.1.11 Burst Count**

BURSt <burst count>

Used to set the number of cycles to be output in the BURST mode. It is not a standard SCPI command.

Arguments  
Type: Numeric  
Range: 2 to 65535  
Rounding: To integer value  
Command Type: Setting or Query  
Setting  
Syntax BURSt<ws><value>  
Examples BURS 100  
          BURS MAXIMUM  
Query  
Syntax: BURSt? [<ws>MAXimum|MINimum]  
Response: NR1  
Examples: BURST?  
          BURS? MAX

#### **4.9.1.12 Internal Trigger Rate**

TRAtE <trigger rate>

Sets the rate of the internal trigger.

Arguments

Type: Numeric  
Units: S, mS, uS, nS  
Range: 1E-6S to 100S  
Rounding: to 4 digits  
Command Type: Setting or Query

Setting

Syntax: TRAtE<ws><value>[units]  
TRAtE<ws>MINimum|MAXimum

Examples: TRAtE 10E-6  
TRAtE MIN

Query

Syntax: TRAtE?[<ws>MINimum|MAXimum]

Response: NR3

Examples: TRAtE?  
TRAtE? MIN

**4.9.2 Error Queue Reading**

ERRor?

This query returns the first entry in the error queue, and removes that entry from the queue.

Command Type: Query only

Query

Syntax: ERRor?

Response: <Error number>, "<error description>"

# ASCII & GPIB CODE CHART

B7 B6 B5 BITS	B4 B3 B2 B1	B7 B6 B5 BITS	B4 B3 B2 B1	B7 B6 B5 BITS	B4 B3 B2 B1	B7 B6 B5 BITS	B4 B3 B2 B1	B7 B6 B5 BITS	B4 B3 B2 B1	B7 B6 B5 BITS	B4 B3 B2 B1
CONTROL		NUMBERS SYMBOLS		UPPER CASE		LOWER CASE					
0	20	40	60	100	120	140	160	180	200	220	240
NUL	DLE	SP	0	@	P	'	p				
1	21	41	61	101	121	141	161	181	201	221	241
SOH	DC1	!	1	A	Q	a	q				
2	22	42	62	102	122	142	162	182	202	222	242
STX	DC2	"	2	B	R	b	r				
3	23	43	63	103	123	143	163	183	203	223	243
ETX	DC3	#	3	C	S	c	s				
4	24	44	64	104	124	144	164	184	204	224	244
EOT	DC4	\$	4	D	T	d	t				
5	25	45	65	105	125	145	165	185	205	225	245
ENQ	NAK	%	5	E	U	e	u				
6	26	46	66	106	126	146	166	186	206	226	246
ACK	SYN	&	6	F	V	f	v				
7	27	47	67	107	127	147	167	187	207	227	247
BEL	ETB	'	7	G	W	g	w				
8	28	48	68	108	128	148	168	188	208	228	248
BS	CAN	(	8	H	X	h	x				
9	29	49	69	109	129	149	169	189	209	229	249
HT	EM	)	9	I	Y	i	y				
10	30	50	70	110	130	150	170	190	210	230	250
LF	SUB	*	10	J	Z	j	z				
11	31	51	71	111	131	151	171	191	211	231	251
VT	ESC	+	11	K	[	k	{				
12	32	52	72	112	132	152	172	192	212	232	252
FF	FS	,	12	L	\	l					
13	33	53	73	113	133	153	173	193	213	233	253
CR	GS	-	13	M	]	m	}				
14	34	54	74	114	134	154	174	194	214	234	254
SO	RS	.	14	N	^	n	~				
15	35	55	75	115	135	155	175	195	215	235	255
SI	US	/	15	O	_	o	DEL (RUBOUT)				
16	36	56	76	116	136	156	176	196	216	236	256
17	37	57	77	117	137	157	177	197	217	237	257
18	38	58	78	118	138	158	178	198	218	238	258
19	39	59	79	119	139	159	179	199	219	239	259
20	40	60	80	120	140	160	180	200	220	240	260
21	41	61	81	121	141	161	181	201	221	241	261
22	42	62	82	122	142	162	182	202	222	242	262
23	43	63	83	123	143	163	183	203	223	243	263
24	44	64	84	124	144	164	184	204	224	244	264
25	45	65	85	125	145	165	185	205	225	245	265
26	46	66	86	126	146	166	186	206	226	246	266
27	47	67	87	127	147	167	187	207	227	247	267
28	48	68	88	128	148	168	188	208	228	248	268
29	49	69	89	129	149	169	189	209	229	249	269
30	50	70	90	130	150	170	190	210	230	250	270
31	51	71	91	131	151	171	191	211	231	251	271
32	52	72	92	132	152	172	192	212	232	252	272
33	53	73	93	133	153	173	193	213	233	253	273
34	54	74	94	134	154	174	194	214	234	254	274
35	55	75	95	135	155	175	195	215	235	255	275
36	56	76	96	136	156	176	196	216	236	256	276
37	57	77	97	137	157	177	197	217	237	257	277
38	58	78	98	138	158	178	198	218	238	258	278
39	59	79	99	139	159	179	199	219	239	259	279
40	60	80	100	140	160	180	200	220	240	260	280
41	61	81	101	141	161	181	201	221	241	261	281
42	62	82	102	142	162	182	202	222	242	262	282
43	63	83	103	143	163	183	203	223	243	263	283
44	64	84	104	144	164	184	204	224	244	264	284
45	65	85	105	145	165	185	205	225	245	265	285
46	66	86	106	146	166	186	206	226	246	266	286
47	67	87	107	147	167	187	207	227	247	267	287
48	68	88	108	148	168	188	208	228	248	268	288
49	69	89	109	149	169	189	209	229	249	269	289
50	70	90	110	150	170	190	210	230	250	270	290
51	71	91	111	151	171	191	211	231	251	271	291
52	72	92	112	152	172	192	212	232	252	272	292
53	73	93	113	153	173	193	213	233	253	273	293
54	74	94	114	154	174	194	214	234	254	274	294
55	75	95	115	155	175	195	215	235	255	275	295
56	76	96	116	156	176	196	216	236	256	276	296
57	77	97	117	157	177	197	217	237	257	277	297
58	78	98	118	158	178	198	218	238	258	278	298
59	79	99	119	159	179	199	219	239	259	279	299
60	80	100	120	160	180	200	220	240	260	280	300
61	81	101	121	161	181	201	221	241	261	281	301
62	82	102	122	162	182	202	222	242	262	282	302
63	83	103	123	163	183	203	223	243	263	283	303
64	84	104	124	164	184	204	224	244	264	284	304
65	85	105	125	165	185	205	225	245	265	285	305
66	86	106	126	166	186	206	226	246	266	286	306
67	87	107	127	167	187	207	227	247	267	287	307
68	88	108	128	168	188	208	228	248	268	288	308
69	89	109	129	169	189	209	229	249	269	289	309
70	90	110	130	170	190	210	230	250	270	290	310
71	91	111	131	171	191	211	231	251	271	291	311
72	92	112	132	172	192	212	232	252	272	292	312
73	93	113	133	173	193	213	233	253	273	293	313
74	94	114	134	174	194	214	234	254	274	294	314
75	95	115	135	175	195	215	235	255	275	295	315
76	96	116	136	176	196	216	236	256	276	296	316
77	97	117	137	177	197	217	237	257	277	297	317
78	98	118	138	178	198	218	238	258	278	298	318
79	99	119	139	179	199	219	239	259	279	299	319
80	100	120	140	180	200	220	240	260	280	300	320
81	101	121	141	181	201	221	241	261	281	301	321
82	102	122	142	182	202	222	242	262	282	302	322
83	103	123	143	183	203	223	243	263	283	303	323
84	104	124	144	184	204	224	244	264	284	304	324
85	105	125	145	185	205	225	245	265	285	305	325
86	106	126	146	186	206	226	246	266	286	306	326
87	107	127	147	187	207	227	247	267	287	307	327
88	108	128	148	188	208	228	248	268	288	308	328
89	109	129	149	189	209	229	249	269	289	309	329
90	110	130	150	190	210	230	250	270	290	310	330
91	111	131	151	191	211	231	251	271	291	311	331
92	112	132	152	192	212	232	252	272	292	312	332
93	113	133	153	193	213	233	253	273	293	313	333
94	114	134	154	194	214	234	254	274	294	314	334
95	115	135	155	195	215	235	255	275	295	315	335
96	116	136	156	196	216	236	256	276	296	316	336
97	117	137	157	197	217	237	257	277	297	317	337
98	118	138	158	198	218	238	258	278	298	318	338
99	119	139	159	199	219	239	259	279	299	319	339
100	120	140	160	200	220	240	260	280	300	320	340
101	121	141	161	201	221	241	261	281	301	321	341
102	122	142	162	202	222	242	262	282	302	322	342
103	123	143	163	203	223	243	263	283	303	323	343
104	124	144	164	204	224	244	264	284	304	324	344
105	125	145	165	205	225	245	265	285	305	325	345
106	126	146	166	206	226	2					

## **4.10 USB Programming**

### **4.10.1 General**

The INSTALLATION section of this manual describes the USB installation of the instrument.

The baud rate is the bit rate during the transmission of a word in bits per second. Different devices use many baud rates, but the baud rates of the two devices that are connected must be the same. The instrument is set to a fixed baud rates of 115K and uses virtual COM for the USB. The USB driver supplied must be installed into the computer.

### **4.10.2 USB Operation**

The instrument is programmed by sending ASCII coded characters to the instrument. When the instrument is in the remote mode remote command input has priority over any front panel control. Therefore, as long as the serial interface is continuously supplied with data, the keyboard will appear to be inoperative to the user.

The instrument accepts a carriage return (CR) as an end of string (EOS) terminator and sends both a CR and LF as the EOS terminator.