The HP 33120A is a high-performance 15 MHz synthesized function generator with built-in arbitrary waveform capability. Its combination of bench-top and system features makes this function generator a versatile solution for your testing requirements now and in the future.

Convenient bench-top features

- 10 standard waveforms

- Built-in 12-bit 40 MSa/s arbitrary waveform capability

- Easy-to-use knob input

- Highly visible vacuum-fluorescent display

- Instrument state storage

- Portable, ruggedized case with non-skid feet

Flexible system features

- Four downloadable 16,000-point arbitrary waveform memories

- HP-IB (IEEE-488) interface and RS-232 interface are standard

- SCPI (Standard Commands for Programmable Instruments) compatibility

- Optional *HP 34811A BenchLink/Arb Waveform Generation Software* for Microsoft® Windows™

HP 33120A
Function Generator /
Arbitrary Waveform Generator

The Front Panel at a Glance
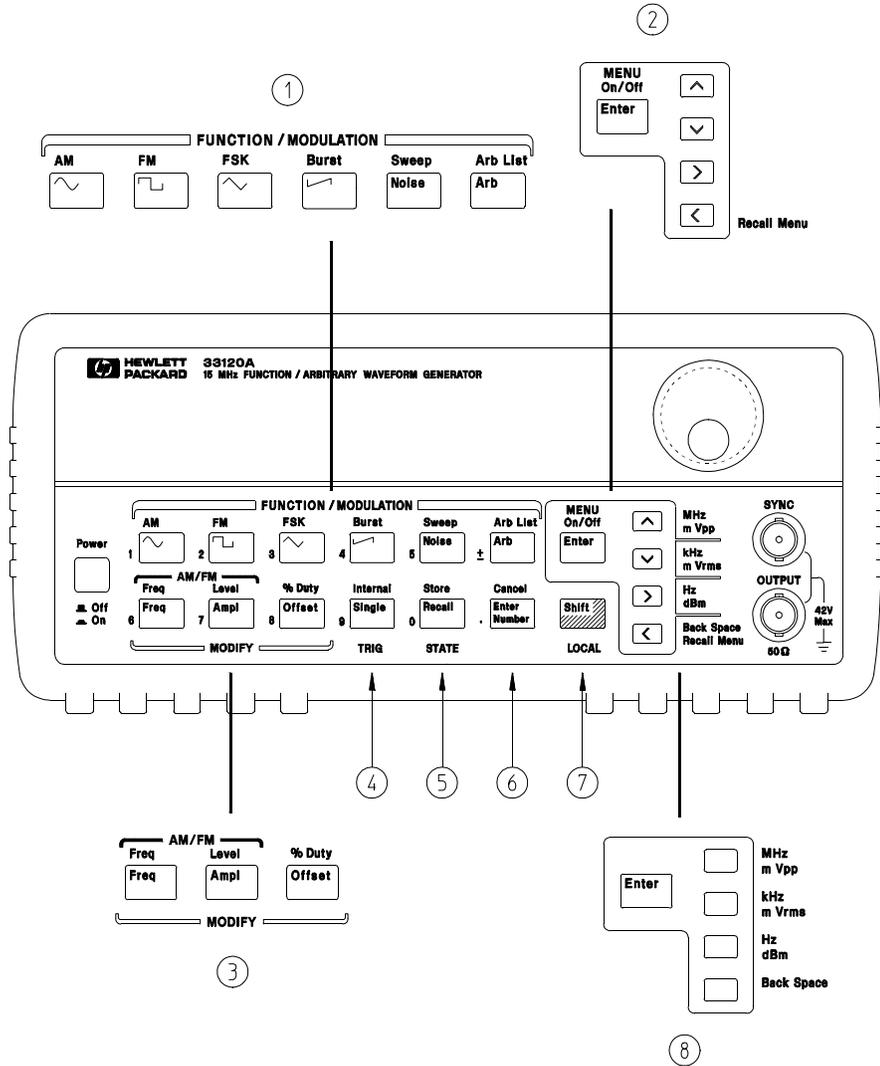
1 Function / Modulation keys
2 Menu operation keys
3 Waveform modify keys
4 Single / Internal Trigger key
   (*Burst and Sweep only)*

5 Recall / Store instrument state key
6 Enter Number key
7 Shift / Local key
8 Enter Number "units" keys

Front-Panel Number Entry

You can enter numbers from the front-panel using one of three methods.

**Use the knob and the arrow keys to modify the displayed number.**

+

$\boxed{>}$
$\boxed{<}$
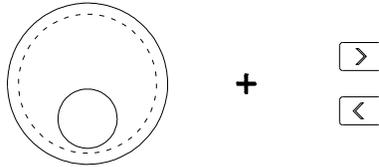
Use the arrow keys to edit individual digits.

$\boxed{\wedge}$ **Increments** the flashing digit.

$\boxed{\vee}$ **Decrements** the flashing digit.

$\boxed{>}$ Moves the flashing digit **to the right**.

$\boxed{<}$ Moves the flashing digit **to the left**.

Use the "Enter Number" mode to enter a number with the appropriate units.

Enter Number ➡

1   2   3   4   5   ±

6   7   8   9   0   .

MHz
m Vpp

kHz
m Vrms
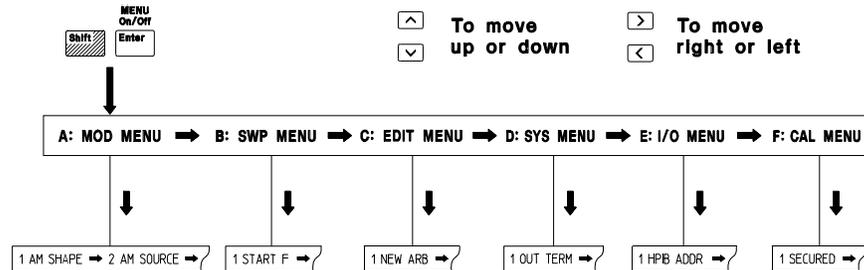
Hz
dBm

Back Space
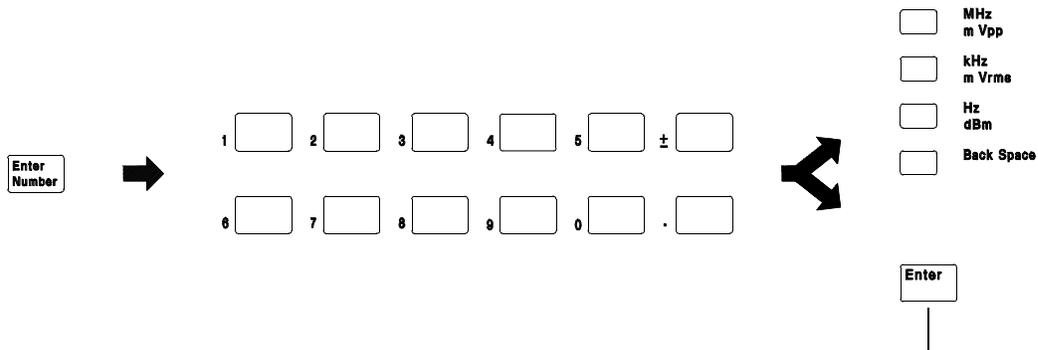
Enter

Use "Enter" for those operations that do not require units to be specified (AM Level, Offset, % Duty, and Store/Recall State).

The Front-Panel Menu at a Glance

The menu is organized in a top-down tree structure with three levels.

To turn on menu press:

MENU On/Off

Shift **Enter**

^ v **To move up or down**

> < **To move right or left**

A: MOD MENU ➡ B: SWP MENU ➡ C: EDIT MENU ➡ D: SYS MENU ➡ E: I/O MENU ➡ F: CAL MENU

1 AM SHAPE ➡ 2 AM SOURCE ➡ | 1 START F ➡ | 1 NEW ARB ➡ | 1 OUT TERM ➡ | 1 HPIB ADDR ➡ | 1 SECURED ➡
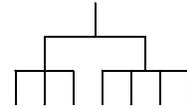
To enter command press:

Enter

A: MODulation MENU

1: AM SHAPE ➜ 2: AM SOURCE ➜ 3: FM SHAPE ➜ 4: BURST CNT ➜ 5: BURST RATE ➜

➜ 6: BURST PHAS ➜ 7: BURST SRC ➜ 8: FSK FREQ ➜ 9: FSK RATE ➜ 10: FSK SRC

B: SWP (Sweep) MENU

1: START F ➜ 2: STOP F ➜ 3: SWP TIME ➜ 4: SWP MODE

C: EDIT MENU∗

1: NEW ARB ➜ [2: POINTS] ➜ [3: LINE EDIT] ➜ [4: POINT EDIT] ➜ [5: INVERT] ➜ [6: SAVE AS] ➜ 7: DELETE

∗ The commands enclosed in square brackets ([ ]) are "hidden" until you make a selection from the
  NEW ARB command to initiate a new edit session.

D: SYStem MENU

1: OUT TERM ➜ 2: POWER ON ➜ 3: ERROR ➜ 4: TEST ➜ 5: COMMA ➜ 6: REVISION
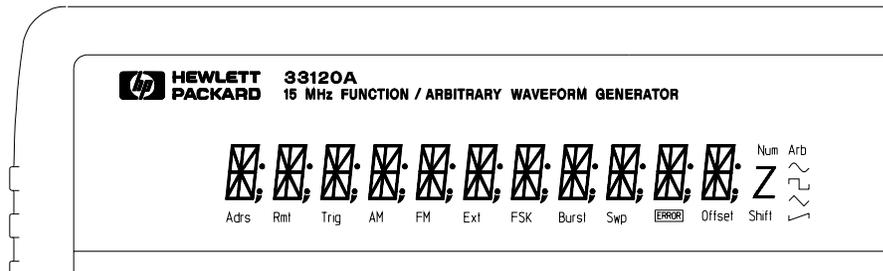
E: Input / Output MENU

1: HPIB ADDR ➜ 2: INTERFACE ➜ 3: BAUD RATE ➜ 4: PARITY ➜ 5: LANGUAGE

F: CALibration MENU∗

1: SECURED ➜ [1: UNSECURED] ➜ [2: CALIBRATE] ➜ 3: CAL COUNT ➜ 4: MESSAGE

∗ The commands enclosed in square brackets ([ ]) are "hidden" unless the function generator
  is UNSECURED for calibration.

Display Annunciators

Adrs	Function generator is addressed to listen or talk over a remote interface.
Rmt	Function generator is in remote mode (remote interface).
Trig	Function generator is waiting for a single trigger or external trigger (Burst, Sweep).
AM	AM modulation is enabled.
FM	FM modulation is enabled.
Ext	Function generator is set for an external modulation source (AM, FSK, Burst).
FSK	FSK (frequency-shift keying) modulation is enabled.
Burst	Burst modulation is enabled.
Swp	Sweep mode is enabled.
ERROR	Hardware or remote interface command errors are detected.
Offset	The waveform is being output with an offset voltage.
Shift	"Shift" key has been pressed. *Press "Shift" again to turn off.*
Num	"Enter Number" mode is enabled. *Press "Shift-Cancel" to disable.*
Arb	Arbitrary waveform function is enabled.
∿	Sine waveform function is enabled.
⊓_	Square waveform function is enabled.
∧∨	Triangle waveform function is enabled.
⌐⌐	Ramp waveform function is enabled.

To review the display annunciators, hold down the ⌐Shift⌐ **key as you turn on the function generator.**

1

Quick Start

Quick Start

One of the first things you will want to do with your function generator is to become acquainted with its front panel. We have written the exercises in this chapter to prepare the function generator for use and help you get familiar with some of the front-panel operations.

The front panel has two rows of keys to select various functions and operations. Most keys have a *shifted* function printed in *blue* above the key. To perform a shifted function, press $\boxed{\text{Shift}}$ (the **Shift** annunciator will turn on). Then, press the key that has the desired label above it. For example, to select the AM (amplitude modulation) function, press $\boxed{\text{Shift}}$ $\boxed{\text{AM}}$ (the shifted version of the $\boxed{\sim}$ key).

If you accidentally press $\boxed{\text{Shift}}$, just press it again to turn off the **Shift** annunciator.

Most keys also have a number printed in *green* next to the key. To enable the number mode, press $\boxed{\text{Enter Number}}$ (the **Num** annunciator will turn on). Then, press the keys that have the desired numbers printed next to them. For example, to select the number "10", press $\boxed{\text{Enter Number}}$ $\boxed{1}$ $\boxed{0}$ (next to the $\boxed{\sim}$ and $\boxed{\text{Recall}}$ keys).

If you accidentally press $\boxed{\text{Enter Number}}$, just press $\boxed{\text{Shift}}$ $\boxed{\text{Cancel}}$ to turn off the **Num** annunciator.

1

To prepare the function generator for use

The following steps help you verify that the function generator is ready for use.

1 Check the list of supplied items.

Verify that you have received the following items with your function generator. If anything is missing, contact your nearest Hewlett-Packard Sales Office.

☐ One power cord.

☐ This *User's Guide*.

☐ One *Service Guide*.

☐ One folded *Quick Reference* card.

☐ Certificate of Calibration.

2 Connect the power cord and turn on the function generator.

The front-panel display will light up while the function generator performs its power-on self-test. The HP-IB bus address is displayed. Notice that the function generator powers up in the *sine wave* function at 1 kHz with an amplitude of 100 mV peak-to-peak (into a 50Ω termination).

To review the power-on display with all annunciators turned on, hold down Shift *as you turn on the function generator.*

3 Perform a *complete* self test.

The *complete* self-test performs a more extensive series of tests than those performed at power-on. Hold down Shift as you press the Power switch to turn on the function generator; *hold down the key for more than 5 seconds*. The self-test will begin when you release the key.

If the self-test is successful, "PASS" is displayed on the front panel. If the self-test is not successful, "FAIL" is displayed and the **ERROR** annunciator turns on. See the *Service Guide* for instructions on returning the function generator to Hewlett-Packard for service.

If the function generator does not turn on

Use the following steps to help solve problems you might experience when turning on the function generator. If you need more help, see the *Service Guide* for instructions on returning the function generator to Hewlett-Packard for service.

1 Verify that there is ac power to the function generator.

First, verify that the function generator's Power switch is in the "On" position. Also, make sure that the power cord is firmly plugged into to the power module on the rear panel. You should also make sure that the power source you plugged the function generator into is energized.

2 Verify the power-line voltage setting.

The line voltage is set to the proper value for your country when the function generator is shipped from the factory. Change the voltage setting if it is not correct. The settings are: 100, 120, 220, or 240 Vac (for 230 Vac operation, use the 220 Vac setting).

*See the next page if you need to change the line-voltage setting.*

3 Verify that the power-line fuse is good.

The function generator is shipped from the factory with a 500 mAT fuse installed. This is the correct fuse for all line voltages.
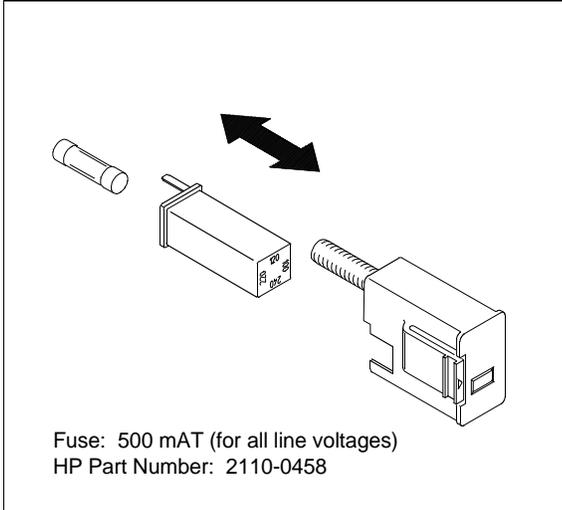
See the next page if you need to change the power-line fuse.

> *To replace the 500 mAT fuse, order HP part number 2110-0458.*

1 *Remove the power cord*. Remove the fuse-holder assembly from the rear panel.
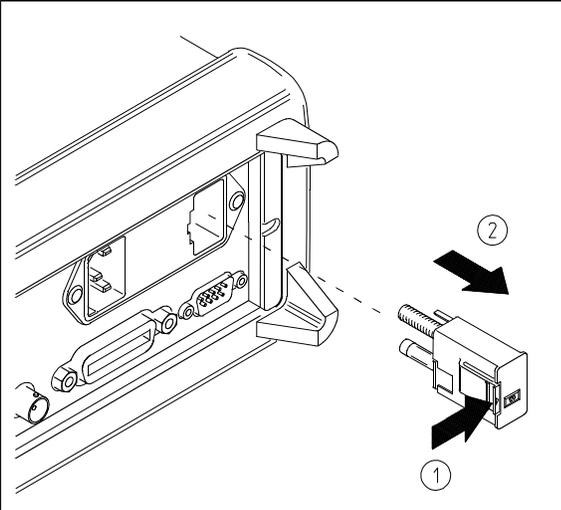
2 Remove the line-voltage selector from the assembly.

Fuse: 500 mAT (for all line voltages)
HP Part Number: 2110-0458

3 Rotate the line-voltage selector until the correct voltage appears in the window.
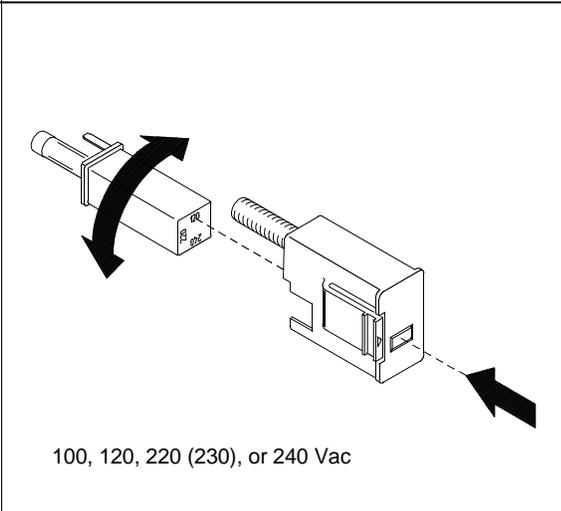
4 Replace the fuse-holder assembly in the rear panel.

100, 120, 220 (230), or 240 Vac
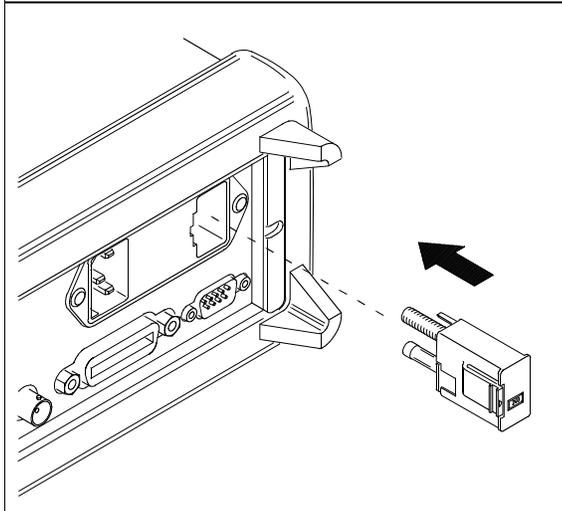
Verify that the correct line voltage is selected and the power-line fuse is good.

To adjust the carrying handle

To adjust the position, grasp the handle by the sides and *pull outward*.
Then, rotate the handle to the desired position.
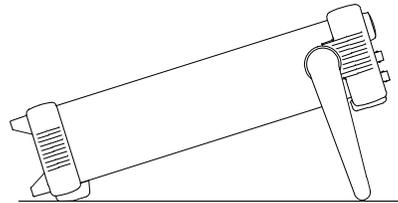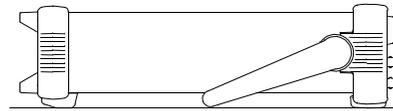
Bench-top viewing positions   **Carrying position**

1

To set the output frequency

At power-on, the function generator outputs a sine wave at 1 kHz with an amplitude of 100 mV peak-to-peak (into a 50Ω termination). *The following steps show you how to change the frequency to 1.2 MHz.*
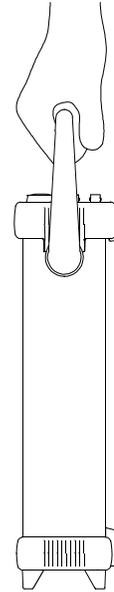
Freq

1 Enable the *frequency modify* mode.

The displayed frequency is either the power-on value or the previous frequency selected. When you change functions, the same frequency is used if the present value is valid for the new function.

```
1.000,000,0 KHz
```

Enter Number

1 . 2

2 Enter the magnitude of the desired frequency. ◎ [1]

Notice that the **Num** annunciator turns on and "ENTER NUM" flashes on the display, indicating that the number mode is enabled.

```
1.2
```

To cancel the number mode, press Shift Cancel *.*

∧   MHz
    m Vpp

3 Set the units to the desired value.

The units are selected using the arrow keys on the right side of the front panel. As soon as you select the units, the function generator outputs the waveform with the displayed frequency. *To turn off the flashing digit, move the cursor to the left of the display using the arrow keys.*

```
1.200,000,0 MHz
```

[1] *You can also use the knob and arrow keys to enter a number. See "Front-Panel Number Entry" on page 3 for more information.*

To set the output amplitude

At power-on, the function generator outputs a sine wave with an amplitude of 100 mV peak-to-peak (into a 50Ω termination).
The following steps show you how to change the amplitude to 50 mVrms.

Ampl

1 Enable the *amplitude modify* mode.

The displayed amplitude is either the power-on value or the previous amplitude selected. When you change functions, the same amplitude is used if the present value is valid for the new function.

```
  100.0    mVPP
```

Enter Number

5   0

2 Enter the magnitude of the desired amplitude. ⊚ [1]

Notice that the **Num** annunciator turns on and "ENTER NUM" flashes on the display, indicating that the number mode is enabled.

```
  50
```

To cancel the number mode, press Shift Cancel .

Shift

∨   kHz
    m Vrms

3 Set the units to the desired value.

The units are selected using the arrow keys on the right side of the front panel. As soon as you select the units, the function generator outputs the waveform with the displayed amplitude. *To turn off the flashing digit, move the cursor to the left of the display using the arrow keys.*

```
  50.00    mVRMS
```

---

[1] *You can also use the knob and arrow keys to enter a number.
See "Front-Panel Number Entry" on page 3 for more information.*

1

To set a dc offset voltage

At power-on, the function generator outputs a sine wave with a dc offset voltage of 0 volts (into a 50Ω termination). *The following steps show you how to change the offset to –1.5 mVdc.*

Offset

1 Enable the *offset modify* mode.

The displayed offset voltage is either the power-on value or the previous offset selected. When you change functions, the same offset is used if the present value is valid for the new function.

> +0.**0**00   VDC

Enter Number

2 Enter the magnitude of the desired offset. ◎ [1]

± 1 . 5

Notice that the **Num** annunciator turns on and "ENTER NUM" flashes on the display, indicating that the number mode is enabled. Notice that ± toggles the displayed value between **+** and **−**.

> –1.5

To cancel the number mode, press Shift Cancel *.*

Shift

∨ kHz
  m Vrms

3 Set the units to the desired value.

At this point, the function generator outputs the waveform with the displayed offset. Notice that the **Offset** annunciator turns on, indicating that the waveform is being output with an offset. The annunciator will turn on when the offset is any value other than 0 volts. *To turn off the flashing digit, move the cursor to the left of the display using the arrow keys.*
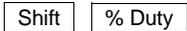
> –0**1**.50   mVDC

[1] *You can also use the knob and arrow keys to enter a number. See "Front-Panel Number Entry" on page 3 for more information.*

To set the duty cycle

Applies only to square waves. At power-on, the duty cycle for square waves is 50%. You can adjust the duty cycle for a square waveform from 20% to 80%, in increments of 1% (for frequencies above 5 MHz, the range is 40% to 60%). *The following steps show you how to change the duty cycle to 45%.*

⌐⌐

1 Select the square wave function.

Notice that the ⌐⌐ annunciator turns on, indicating that the square wave function is enabled.

Shift   % Duty

2 Enable the *duty cycle modify* mode.

The displayed duty cycle is either the power-on value or the previous value selected.

```
50 % DUTY
```

This message appears on the display for approximately 10 seconds. Repeat this step as needed.

Enter Number

4   5
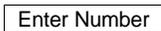
3 Enter the desired duty cycle. [1]

Notice that the **Num** annunciator turns on and "ENTER NUM" flashes on the display, indicating that the number mode is enabled.

```
45
```

To cancel the number mode, press Shift Cancel .

Enter

4 Output the waveform with the displayed duty cycle.

```
45 % DUTY
```

[1] *You can also use the knob and arrow keys to enter a number. See "Front-Panel Number Entry" on page 3 for more information.*

To output a stored arbitrary waveform

There are five built-in arbitrary waveforms stored in non-volatile memory for your use. You can output these waveforms directly from non-volatile memory. *The following steps show you how to output an "exponential rise" waveform from memory.*

Shift   Arb List   **1 Display the list of arbitrary waveforms.**

The list contains the five built-in arbitrary waveforms (sinc, negative ramp, exponential rise, exponential fall, and cardiac). The list may also contain up to four user-defined arbitrary waveform names. The first choice on this level is "SINC".

SINC

This message appears on the display for approximately 10 seconds. Repeat this step as needed.

> >   **2 Move across to the EXP_RISE choice.** [1]

EXP_RISE

Enter   **3 Select and output the displayed arbitrary waveform.**

Notice that the **Arb** annunciator turns on, indicating that the output is an arbitrary waveform. The waveform is output using the present settings for frequency, amplitude, and offset unless you change them.

The selected waveform is now assigned to the Arb *key. Whenever you press this key, the selected arbitrary waveform is output.*

[1] *You can also use the knob to scroll left or right through the choices in the list. See "Front-Panel Number Entry" on page 3 for more information.*

To output a dc voltage

In addition to generating waveforms, you can also output a dc voltage in the range ± 5 Vdc (into a 50Ω termination). *The following steps show you how to output +155 mVdc.*

1 Press the ⌷ Offset ⌷ **key and** *hold it down for more than 2 seconds.*

To enter the dc voltage mode, press the ⌷ Offset ⌷ key or any key in the top row of function keys and *hold it down for more than 2 seconds*. The displayed voltage is either the power-on value or the previous offset voltage selected.

```
      DCV
```

```
 +0.000    VDC
```

Enter Number

1   5   5

2 Enter the magnitude of the desired voltage. ◎ [1]

Notice that the **Num** annunciator turns on and "ENTER NUM" flashes on the display, indicating that the number mode is enabled.

```
    155
```

To cancel the number mode, press ⌷ Shift ⌷ ⌷ Cancel ⌷ .

Shift

∨   kHz
    m Vrms

3 Set the units to the desired value.

At this point, the function generator outputs the displayed dc voltage. Notice that the **Offset** annunciator turns on (all other annunciators are off), indicating that a dc voltage is being output. The annunciator will turn on when the offset is any value other than 0 volts.

```
 +155.0    mVDC
```

[1] *You can also use the knob and arrow keys to enter a number. See "Front-Panel Number Entry" on page 3 for more information.*

1

To store the instrument state

You can store up to three different instrument states in non-volatile memory. This enables you to recall the entire instrument configuration with just a few key presses from the front panel. *The following steps show you how to store and recall a state.*

1 Set up the function generator to the desired configuration.

The state storage feature "remembers" the function, frequency, amplitude, dc offset, duty cycle, as well as any modulation parameters.

| Shift | Store |

2 Turn on the state storage mode.

Three memory locations (numbered 1, 2, and 3) are available to store instrument configurations. The instrument configuration is stored in *non-volatile* memory and is remembered when power has been off.

```
┌──────────────────────────┐
│   STORE    1             │
└──────────────────────────┘
```

This message appears on the display for approximately 10 seconds. Repeat this step as needed.

| ^ |

3 Store the instrument state in memory location "2". [1]

Use the up and down arrow keys to select the memory location.

```
┌──────────────────────────┐
│   STORE    2             │
└──────────────────────────┘
```

To cancel the store operation, press Shift Store *again or let the display time-out after 10 seconds.*

| Enter |

4 Save the instrument state.

The instrument state is now stored. To recall the stored state, turn to the next page.

[1] *You can also use the knob or "enter number" mode to enter a memory location. See "Front-Panel Number Entry" on page 3 for more information.*

25

> *To verify that the state was stored properly, you can turn the power off before recalling the state.*

Recall

5 Recall the stored instrument state.

To recall the stored state, you must use the same memory location used previously to store the state. Use the up and down arrow keys to change the displayed storage location.

```
RECALL   2
```

To cancel the restore operation, press Recall *again.*

This message appears on the display for approximately 10 seconds. Repeat this step as needed.

Enter

6 Restore the instrument state.

The function generator should now be configured in the same state as when you stored the setup on the previous page.

> *When power is turned off, the function generator automatically stores its state in memory location "0". You can recall the power-down state, but you cannot store the state to location "0" from the front panel.*
>
> *Use the POWER ON LAST STATE command in the SYS MENU to automatically recall the power-down state when power is turned on. See chapter 2 for more information on using the front-panel menus.*

2

Front-Panel
Menu Operation

Front-Panel Menu Operation

By now you should be familiar with some of the basic features of the front panel. Chapter 1 shows you how to prepare the function generator for use and describes a few of the front-panel features. If you are not familiar with this information, we recommend that you read chapter 1, "Quick Start," starting on page 13.

Chapter 2 introduces you to the use of the front-panel menu. This chapter *does not* give a detailed description of every front-panel key or menu operation. It does, however, give you a good overview of the front-panel menu and many front-panel operations. See chapter 3 "Features and Functions," starting on page 53, for a complete discussion of the function generator's capabilities and operation.

> *If you purchased the Phase-Lock Option for the HP 33120A, an additional menu* (**G: PHASE MENU**) *is available from the front panel. For information on using the Phase-Lock Option, refer to the User's and Service Guide included with Option 001.*

Front-panel menu reference

A: MODulation MENU

1: AM SHAPE ➙ 2: AM SOURCE ➙ 3: FM SHAPE ➙ 4: BURST CNT ➙ 5: BURST RATE ➙

➙ 6: BURST PHAS ➙ 7: BURST SRC ➙ 8: FSK FREQ ➙ 9: FSK RATE ➙ 10: FSK SRC

1:	**AM SHAPE**	Selects the shape of the AM modulating waveform.
2:	**AM SOURCE**	Enables or disables the internal AM modulating source.
3:	**FM SHAPE**	Selects the shape of the FM modulating waveform.
4:	**BURST CNT**	Sets the number of cycles per burst (1 to 50,000 cycles).
5:	**BURST RATE**	Sets the burst rate in Hz for an internal burst source.
6:	**BURST PHAS**	Sets the starting phase angle of a burst (-360 to +360 degrees).
7:	**BURST SRC**	Selects an internal or external gate source for burst modulation.
8:	**FSK FREQ**	Sets the FSK "hop" frequency.
9:	**FSK RATE**	Selects the internal FSK rate between the carrier and FSK frequency.
10:	**FSK SRC**	Selects an internal or external source for the FSK rate.

B: SWP (Sweep) MENU

1: START F ➙ 2: STOP F ➙ 3: SWP TIME ➙ 4: SWP MODE

1:	**START F**	Sets the start frequency in Hz for sweeping.
2:	**STOP F**	Sets the stop frequency in Hz for sweeping.
3:	**SWP TIME**	Sets the repetition rate in seconds for sweeping.
4:	**SWP MODE**	Selects linear or logarithmic sweeping.

C: EDIT MENU ∗

1: NEW ARB ➙ [2: POINTS] ➙ [3: LINE EDIT] ➙ [4: POINT EDIT] ➙ [5: INVERT] ➙ [6: SAVE AS] ➙ 7: DELETE

1:	**NEW ARB**	Initiates a new arb waveform or loads the selected arb waveform.
2:	**POINTS**	Sets the number of points in a new arb waveform (8 to 16,000 points).
3:	**LINE EDIT**	Performs a linear interpolation between two points in the arb waveform.
4:	**POINT EDIT**	Edits the individual points of the selected arb waveform.
5:	**INVERT**	Inverts the selected arb waveform by changing the sign of each point.
6:	**SAVE AS**	Saves the current arb waveform in non-volatile memory.
7:	**DELETE**	Deletes the selected arb waveform from non-volatile memory.

∗ The commands enclosed in square brackets ([ ]) are "hidden" until you make a selection from the NEW ARB command to initiate a new edit session.

D: SYStem MENU

1: OUT TERM ➜ 2: POWER ON ➜ 3: ERROR ➜ 4: TEST ➜ 5: COMMA ➜ 6: REVISION

1: OUT TERM	Selects the output termination (50Ω or high impedance).
2: POWER ON	Enables or disables automatic recall of the power-down state.
3: ERROR	Retrieves errors from the error queue (up to 20 errors).
4: TEST	Performs a complete self-test.
5: COMMA	Enables or disables a comma separator between digits on the display.
6: REVISION	Displays the function generator's firmware revision codes.

E: Input / Output MENU

1: HPIB ADDR ➜ 2: INTERFACE ➜ 3: BAUD RATE ➜ 4: PARITY ➜ 5: LANGUAGE

1: HPIB ADDR	Sets the HP-IB bus address (0 to 30).
2: INTERFACE	Selects the HP-IB or RS-232 interface.
3: BAUD RATE	Selects the baud rate for RS-232 operation.
4: PARITY	Selects even, odd, or no parity for RS-232 operation.
5: LANGUAGE	Verifies the interface language: SCPI.

F: CALibration MENU ∗

1: SECURED ➜ [1: UNSECURED] ➜ [2: CALIBRATE] ➜ 3: CAL COUNT ➜ 4: MESSAGE

1: SECURED	The function generator is secured against calibration; enter code to unsecure.
1: UNSECURED	The function generator is unsecured for calibration; enter code to secure.
2: CALIBRATE	Performs individual calibrations; must be UNSECURED.
3: CAL COUNT	Reads the total number of times the function generator has been calibrated.
4: MESSAGE	Reads the calibration string (up to 11 characters) entered from remote.

∗ The commands enclosed in square brackets ([ ]) are "hidden" unless the function generator is UNSECURED for calibration.

A front-panel menu tutorial

This section is a step-by-step tutorial which shows you how to use the front-panel menu. We recommend that you spend a few minutes with this tutorial to get comfortable with the structure and operation of the menu.

2

The menu is organized in a top-down tree structure with three levels (*menus*, *commands*, and *parameters*). You move down $\boxed{\vee}$ or up $\boxed{\wedge}$ the menu tree to get from one *level* to the next. Each of the three levels has several horizontal *choices* which you can view by moving left $\boxed{<}$ or right $\boxed{>}$.
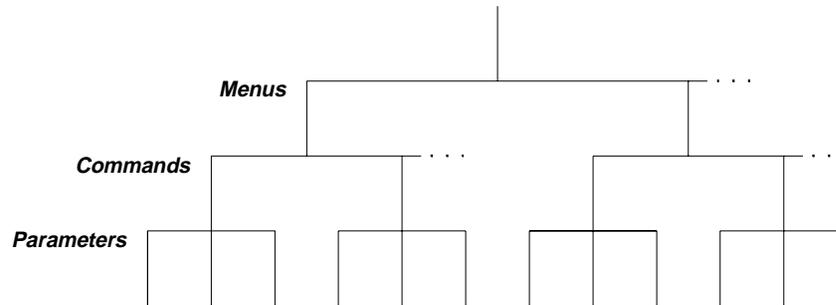
The menu is organized in a top-down tree structure with three levels.

- To *turn on* the menu, press $\boxed{\text{Shift}}$ $\boxed{\text{Menu On/Off}}$.

- To *turn off* the menu, press $\boxed{\text{Shift}}$ $\boxed{\text{Menu On/Off}}$.

- To *execute* a menu command, press $\boxed{\text{Enter}}$.

- To *recall* the last menu command that was executed, press $\boxed{\text{Shift}}$ $\boxed{\text{Recall Menu}}$.

- To *turn off* the menu at any time without saving changes, press $\boxed{\text{Shift}}$ $\boxed{\text{Cancel}}$.

Messages Displayed During Menu Use

TOP OF MENU   You pressed ⌐∧⌐ while on the "MENUS" level; this is the top level of the menu and you cannot go any higher.

To turn off the menu, press ⌐Shift⌐ ⌐Menu On/Off⌐ *. To move across the choices on a level, press* ⌐<⌐ *or* ⌐>⌐ *. To move down a level, press* ⌐∨⌐ *.*

MENUS You are on the "MENUS" level. Press ⌐<⌐ or ⌐>⌐ to view the choices.

COMMANDS You are on the "COMMANDS" level. Press ⌐<⌐ or ⌐>⌐ to view the command choices within the selected menu group.

PARAMETER   You are on the "PARAMETER" level. Press ⌐<⌐ or ⌐>⌐ to view and edit the parameter for the selected command.

MENU BOTTOM   You pressed ⌐∨⌐ while on the "PARAMETER" level; this is the bottom level of the menu and you cannot go any lower.

To turn off the menu, press ⌐Shift⌐ ⌐Menu On/Off⌐ *. To move up a level, press* ⌐∧⌐ *.*

ENTERED   The change made on the "PARAMETER" level is saved. This is displayed after you press ⌐Enter⌐ (Menu Enter) to execute the command.

MIN VALUE   The value you specified on the "PARAMETER" level is too small for the selected command. The minimum value allowed is displayed for you to edit.

MAX VALUE   The value you specified on the "PARAMETER" level is too large for the selected command. The maximum value allowed is displayed for you to edit.

EXITING   You will see this message if you turn off the menu by pressing ⌐Shift⌐ ⌐Menu On/Off⌐ or ⌐Shift⌐ ⌐Cancel⌐ . You did not edit any values on the "PARAMETER" level and changes were NOT saved.

NOT ENTERED   You will see this message if you turn off the menu by pressing ⌐Shift⌐ ⌐Menu On/Off⌐ or ⌐Shift⌐ ⌐Cancel⌐ . You did some editing of parameters but the changes were NOT saved. Press the ⌐Enter⌐ key (Menu Enter) to save changes made on the "PARAMETER" level.

2

Menu Example 1

The following steps show you how to turn on the menu, move up and down between levels, move across the choices on each level, and turn off the menu. *In this example, you will enable the function generator to automatically recall the power-down state when power is turned on.*

Shift

Menu On/Off

1 Turn on the menu.

You enter the menu on the "MENUS" level. The MOD MENU is your first choice on this level.

```
A: MOD MENU
```

> > >

2 Move across to the SYS MENU choice on this level. ◎ [1]

There are six menu group choices available on the "MENUS" level. Each choice has a letter prefix for easy identification (**A:** , **B:** , etc.).

```
D: SYS MENU
```

∨

3 Move down to the "COMMANDS" level within the SYS MENU.

The OUT TERM command is your first choice on this level.

```
1: OUT TERM
```

>

4 Move across to the POWER ON command on this level. ◎ [1]

There are six command choices available in the SYS MENU. Each choice on this level has a number prefix for easy identification (**1:** , **2:** , etc.).

```
2: POWER ON
```

[1] *You can also use the knob to scroll left or right through the choices on each level of the menu.*

| ∨ |

5 Move down a level to the "PARAMETER" choices.

The first parameter choice is "DEFAULT" for the POWER ON command ("DEFAULT" is the factory setting and is stored in non-volatile memory).

```
DEFAULT
```

| > |

6 Move across to the "LAST STATE" choice. ◎ [1]

There are two parameter choices for POWER ON.

```
LAST STATE
```

| Enter |

7 Save the change and turn off the menu.

The function generator beeps and displays a message to show that the change is now in effect. You are then exited from the menu.

```
ENTERED
```

[1] *You can also use the knob to scroll left or right through the choices on each level of the menu.*

2

Menu Example 2

The following example shows how to use the *recall menu* feature as a shortcut to set the POWER ON command back to its original setting. *You must perform the steps in Example 1 before you start this example.*

Shift

< Recall Menu

1 Use recall menu to return to the POWER ON command.

This returns you to the POWER ON command, which was the last command used before you exited the menu in the Example 1.

```
2: POWER ON
```

∨

2 Move down to the "PARAMETER" choices.

The first parameter choice is "LAST STATE" (the current setting from Example 1).

```
LAST STATE
```

>

3 Move across to the "DEFAULT" choice. ◎ [1]

Set the parameter back to its original value.

```
DEFAULT
```

Enter

4 Save the change and turn off the menu.

The function generator beeps and displays a message to show that the change is now in effect. You are then exited from the menu.

```
ENTERED
```

[1] *You can also use the knob to scroll left or right through the choices on each level of the menu.*

Menu Example 3

Some commands in the menu require that you enter a numeric parameter value. The following steps show you how to enter a number in the menu. *For this example, you will set the number of cycles for the burst modulation mode.*

Shift

Menu On/Off

1 Turn on the menu.

You enter the menu on the "MENUS" level. The MOD MENU is your first choice on this level.

```
A: MOD MENU
```

∨

2 Move down to the "COMMANDS" level within the MOD MENU.

The AM SHAPE command is your first choice on this level.

```
1: AM SHAPE
```

> > >

3 Move across to the BURST CNT command on this level. ◎ [1]

There are ten command choices available in the MOD MENU.

```
4: BURST CNT
```

[1] *You can also use the knob to scroll left or right through the choices on each level of the menu.*

⌄

4 Move down a level to edit the BURST CNT parameter.

The number of cycles should be "1" when you come to this point in the menu for the first time. For this example, you will set the number of cycles to "4". Notice that the **Burst** annunciator flashes, indicating that the displayed value is for the burst mode.

```
∧00001  CYC
```

When you see the flashing "∧" on the left side of the display, you can press ∧ *to abort the edit and return to the "COMMANDS" level.*

<

5 Move the flashing cursor over to edit the last digit.

Notice that the rightmost digit is flashing (the digit wraps around).

```
00001  CYC
```

∧   ∧   ∧

6 Increment the last digit until "4" is displayed. ◎ [1]

You decrement or increment each digit independently.

```
00004  CYC
```

Enter

7 Save the change and turn off the menu.

The function generator beeps and displays a message to show that the change is now in effect. You are then exited from the menu.

```
ENTERED
```

---

[1] *You can also use the knob or "enter number" mode to enter a number. See "Front-Panel Number Entry" on page 3 for more information.*

To select the output termination

The function generator has a fixed output impedance of 50 ohms on the *OUTPUT* terminal. You can specify whether **you** are terminating the output into a 50Ω load or an open circuit. Incorrect impedance matching between the source and load will result in an output amplitude or dc offset which does not match the specified value.

Shift

Menu On/Off

1 Turn on the menu.

```
 A: MOD MENU
```

`>` `>` `>`

2 Move across to the SYS MENU choice on this level. ◎ [1]

```
 D: SYS MENU
```

`∨`

3 Move down a level to the OUT TERM command.

```
 1: OUT TERM
```

`∨` `>`

4 Move down a level and then across to the HIGH Z choice. ◎ [1]

With the output termination set to "HIGH Z", the function generator allows you to set the unloaded (open circuit) output voltage.

```
 HIGH Z
```

Enter

5 Save the change and turn off the menu.

The function generator beeps and displays a message to show that the change is now in effect. You are then exited from the menu.

[1] *You can also use the knob to scroll left or right through the choices on each level of the menu.*

To output a modulated waveform

A modulated waveform consists of a *carrier* and a *modulating* waveform. In AM (amplitude modulation), the amplitude of the carrier is varied by the amplitude of the modulating waveform. *For this example, you will output an AM waveform with 80% modulation depth. The carrier will be a 5 kHz sine wave and the modulating waveform will be a 200 Hz sine wave.*
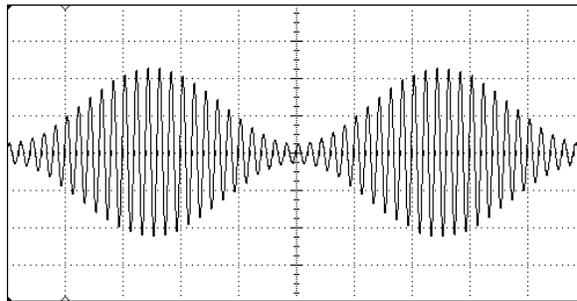
2

⎡∿⎤   **1 Select the function, frequency, and amplitude of the carrier.**

For the carrier waveform, you can select a sine, square, triangle, ramp, or arbitrary waveform. *For this example, select a 5 kHz sine wave with an amplitude of 5 Vpp.*

⎡Shift⎤ ⎡AM⎤   **2 Select AM.**

Notice that the **AM** annunciator turns on.

⎡Shift⎤   **3 Use the menu to select the shape of the modulating waveform.**

⎡<⎤ Recall Menu   After you enable the AM function, the "recall menu" key will automatically take you to the AM SHAPE command in the MOD MENU.

```
1: AM SHAPE
```

∨

4 Move down a level and verify that "SINE" is selected.

For the modulating waveform, you can select a sine, square, triangle, ramp, noise, or arbitrary waveform. For this example, you will modulate the carrier with a sine waveform. Notice that the **AM** annunciator flashes, indicating that the displayed parameter is for AM.

```
SINE
```

Enter

5 Save the change and turn off the menu.

The modulating waveform is now a sine waveform.

```
ENTERED
```

Shift   Freq

6 Set the modulating frequency to 200 Hz.

Notice that the **AM** annunciator flashes, indicating that the displayed frequency is the modulating frequency for AM. Also notice that the modulating frequency is displayed with fewer digits than the carrier frequency. *For more information on editing numbers in the menu, refer to "Menu Example 3" earlier in this chapter.*

```
MOD  200.0  Hz
```

This message appears on the display for approximately 10 seconds. Repeat this step as needed.

Shift   Level

7 Set the modulation depth to 80%.

Notice that the **AM** annunciator flashes, indicating that the displayed percentage is the AM depth (also called *percent modulation*).

```
080  %  DEPTH
```

This message appears on the display for approximately 10 seconds. Repeat this step as needed.

At this point, the function generator outputs the AM waveform with the specified modulation parameters.

2

To output an FSK waveform

You can configure the function generator to "shift" its output frequency between two preset values using FSK (frequency-shift keying) modulation. The rate at which the output shifts between the two frequencies (called the "carrier frequency" and the "hop frequency") is determined by the internal rate generator or the signal level on the rear-panel *FSK* terminal. *For this example, you will set the "carrier" frequency to 3 kHz and the "hop" frequency to 500 Hz, with an FSK rate of 100 Hz.*
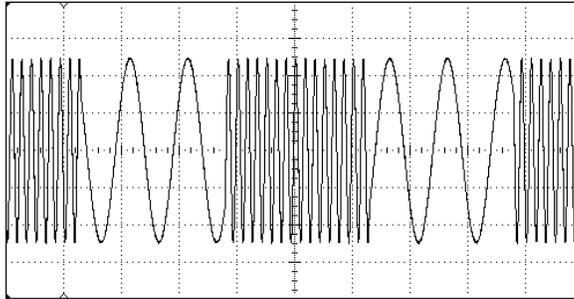
1 Select the function, frequency, and amplitude of the carrier.

For the carrier waveform, you can select a sine, square, triangle, ramp, or arbitrary waveform. *For this example, select a 3 kHz sine wave with an amplitude of 5 Vpp*.

| Shift | | FSK |

2 Enable FSK.

Notice that the **FSK** annunciator turns on.

| Shift |

| < | Recall Menu

3 Use the menu to set the "hop" frequency.

After you enable the FSK mode, the "recall menu" key will automatically take you to the FSK FREQ command in the MOD MENU.

```
8: FSK FREQ
```

2

∨

4 Move down a level and set the "hop" frequency to 500 Hz.

Notice that the **FSK** annunciator flashes, indicating that the displayed parameter is for the FSK mode. Also notice that the hop frequency is displayed with fewer digits than the carrier frequency. *For more information on editing numbers in the menu, refer to "Menu Example 3" earlier in this chapter.*

```
∧500.0   Hz
```

Enter

5 Save the change and turn off the menu.

At this point, the carrier and hop frequencies are set and output.

Now, we will go back into the menu to set the FSK "shift" rate — this is the rate at which the function generator shifts between the carrier frequency and hop frequency.

Shift

< Recall Menu

6 Use the menu to set the FSK "shift" rate.

The "recall menu" key returns you to the FSK FREQ command, which was the last command used before you exited the menu.

```
8: FSK FREQ
```

> `>`

7 Move across to the FSK RATE command.

```
9: FSK RATE
```

> `∨`

8 Move down a level and set the FSK "shift" rate to 100 Hz.

Notice that the **FSK** annunciator flashes, indicating that the displayed parameter is for the FSK mode. *For more information on editing numbers in the menu, refer to "Menu Example 3" earlier in this chapter.*

```
∧100.0   Hz
```

> Enter

9 Save the change and turn off the menu.

The function generator beeps and displays a message to show that the change is now in effect. You are then exited from the menu.

```
ENTERED
```

At this point, the function generator outputs the FSK waveform.

> *You can also use an external signal to shift between the carrier frequency and hop frequency. For more information, see "Frequency-Shift Keying (FSK) Modulation" in chapter 3.*

To output a burst waveform

You can configure the function generator to output a waveform with a
specified number of cycles, called a *burst*. You can output the burst at a
rate determined by the internal rate generator or the signal level on the
rear-panel *Ext Trig* terminal. *For this example, you will output a
three-cycle sine wave. You will not change the other parameters from
their default settings: internal burst source, 0 degree starting phase,
and 100 Hz burst rate.*

2

$\boxed{\sim}$
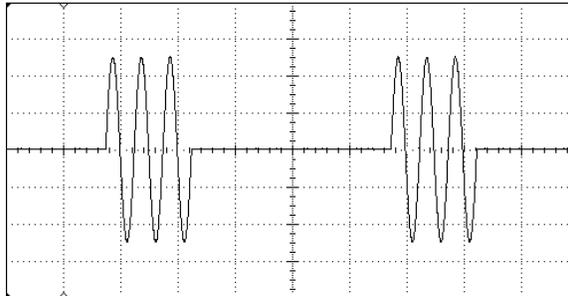
1 Select the function, frequency, and amplitude for the burst.

For bursts, you can select sine, square, triangle, ramp, or arbitrary
waveforms. *For this example, select a **1 kHz** sine wave with an output
amplitude of **5 Vpp**.*

$\boxed{\text{Shift}}$ $\boxed{\text{Burst}}$

2 Enable the burst mode.

Notice that the **Burst** annunciator turns on.

$\boxed{\text{Shift}}$

$\boxed{<}$ Recall Menu

3 Use the menu to set the burst count.

After you enable the burst mode, the "recall menu" key will
automatically take you to the BURST CNT command in the MOD MENU.

```
4: BURST CNT
```

⌄

4 Move down to the parameter level and set the count to "3".

Notice that the **Burst** annunciator flashes, indicating that the displayed parameter is for the burst mode. *For more information on editing numbers in the menu, refer to "Menu Example 3" earlier in this chapter.*

```
∧00003 CYC
```

You can also select an infinite burst count. Press the right or left arrow keys until the "CYC" units are flashing. Then, press the down arrow key to display "INFINITE".

Enter

5 Save the change and turn off the menu.

The function generator beeps and displays a message to show that the change is now in effect. You are then exited from the menu.

```
ENTERED
```

At this point, the function generator outputs a continuous three-cycle burst.

You can generate a single burst (with the specified burst count) by pressing the "Single" key from the front panel or applying a trigger pulse to the rear-panel Ext Trig terminal. For more information, see "To trigger a burst or sweep" on page 51.

You can also use an external gate signal to turn the output signal on and off. For more information, see "Burst Modulation" in chapter 3.

To output a frequency sweep

In the frequency sweep mode, the function generator "steps" from the *start frequency* to the *stop frequency* at a *sweep rate* which you specify. You can sweep up or down in frequency, and with either linear or logarithmic spacing. *For this example, you will output a swept sine wave from 50 Hz to 5 kHz. You will not change the other parameters from their default settings: internal sweep trigger, linear spacing, and 1 second sweep time.*

[∿]
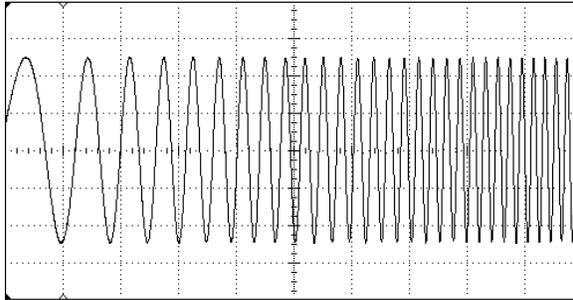
1 Select the function and amplitude for the sweep.

For sweeps, you can select sine, square, triangle, ramp, or arbitrary waveforms. *For this example, select a sine wave with a 5 Vpp amplitude.*

[Shift] [Sweep]

2 Enable the sweep mode.

Notice that the **Swp** annunciator turns on.

[Shift]

3 Use the menu to select the start frequency.

[<] Recall Menu

After you enable the sweep mode, the "recall menu" key will automatically take you to the START F command in the SWP MENU.

```
1: START F
```
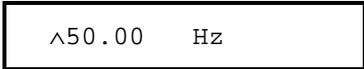
⌄

4 Move down a level and set the start frequency to 50 Hz.

Notice that the **Swp** annunciator flashes, indicating that the displayed
parameter is for the sweep mode. *For more information on editing
numbers in the menu, refer to "Menu Example 3" earlier in this chapter.*

```
∧50.00    Hz
```

Enter

5 Save the change and turn off the menu.

The start frequency is now set to 50 Hz.

Shift

< Recall Menu

6 Use recall menu to return to the START F command.

The "recall menu" key returns you to the START F command, which was
the last command used before you exited the menu.

```
1: START F
```

>

7 Move across to the STOP F command.
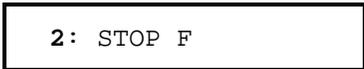
```
2: STOP F
```

⌄

8 Move down a level and set the stop frequency to 5 kHz.

```
∧5.000    KHz
```

Enter

9 Save the change and turn off the menu.

At this point, the function generator outputs a continuous sweep from
50 Hz to 5 kHz.

*You can generate one frequency sweep by pressing the "Single" key or
applying a trigger pulse to the rear-panel Ext Trig terminal. For more
information, see "To trigger a burst or sweep" on the next page.*

2

To trigger a burst or sweep

You can issue triggers from the front-panel for burst modulation and frequency sweeps using *single* trigger or *internal* trigger.

Enables single trigger and triggers the generator.

Enables internal trigger.

Trig annunciator is on when the generator is waiting for single trigger (internal trigger disabled).
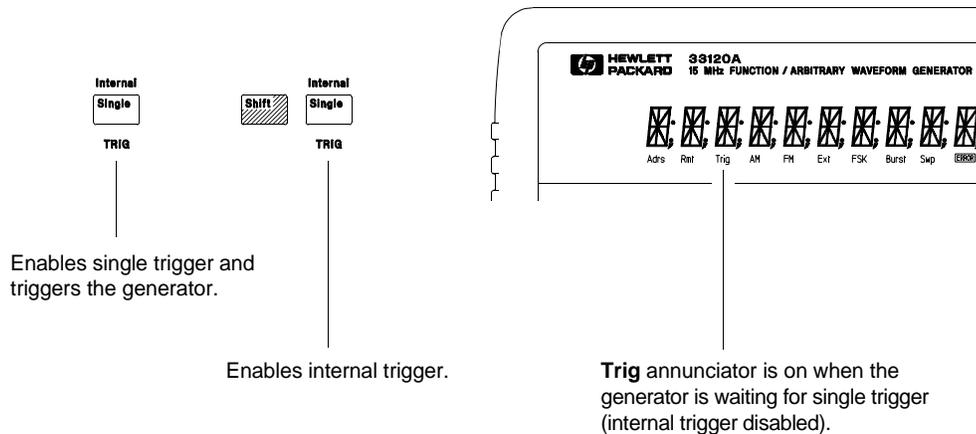
- *Internal* or "automatic" triggering is enabled when you turn on the function generator. In this mode, the function generator outputs continuously when burst modulation or sweep is selected.

- *Single* triggering outputs one burst or initiates one frequency sweep each time you press [Single] . Continue pressing this key to re-trigger the function generator.

- Pressing [Single] to enable the *single* trigger mode also enables the *external* trigger mode. External triggering is like the single trigger mode except that you apply a trigger signal to the rear-panel *Ext Trig* terminal. The function generator is triggered on the rising edge of a TTL pulse.

- The [Single] key is disabled when in remote (the **Rmt** annunciator turns on when in remote) and when a function other than burst modulation or sweep is selected.

To turn off the comma separator

The function generator can display values on the front panel with or without a comma separator. The following steps show how to turn off the comma separator.

```
15.000,000 MHz
```
With comma separator
(factory setting)

```
15.000000 MHz
```
Without comma separator

Shift

Menu On/Off

1 Turn on the menu.

```
A: MOD MENU
```

| > | > | > |
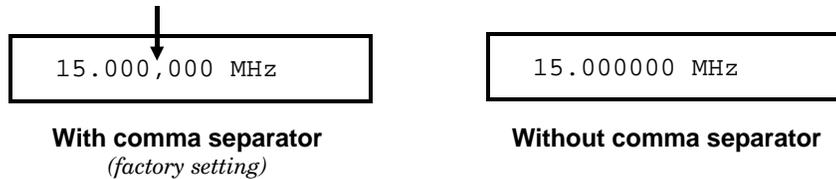
2 Move across to the SYS MENU choice on the "MENUS" level.

```
D: SYS MENU
```

| ∨ | < | < |

3 Move down a level and then across to the COMMA command.

```
5: COMMA
```

| ∨ | > |

4 Move down a level and then across to the "OFF" choice.

```
OFF
```

Enter

5 Save the change and turn off the menu.

The comma separator setting is stored in *non-volatile* memory, and *does not* change when power has been off or after a remote interface reset.

3

3

Features and
Functions

Features and Functions

You will find that this chapter makes it easy to look up all the details about a particular feature of the function generator. Whether you are operating the function generator from the front panel or over the remote interface, this chapter will be useful. This chapter is divided into the following sections:

- Output Configuration, *starting on page 55*
- Amplitude Modulation (AM), *starting on page 71*
- Frequency Modulation (FM), *starting on page 76*
- Burst Modulation, *starting on page 81*
- Frequency-Shift Keying (FSK) Modulation, *starting on page 90*
- Frequency Sweep, *starting on page 94*
- Triggering, *starting on page 98*
- Arbitrary Waveforms, *starting on page 103*
- System-Related Operations, *starting on page 109*
- Remote Interface Configuration, *starting on page 114*
- Calibration Overview, *starting on page 118*
- Power-On and Reset State, *on page 123*

Some knowledge of the front-panel menu will be helpful before you read this chapter. If you have not already read chapter 2, "Front-Panel Menu Operation," starting on page 29, you may want to read it now. Chapter 4, "Remote Interface Reference," starting on page 125, lists the syntax for the SCPI commands available to program the function generator.

Throughout this manual, the following conventions are used for SCPI command syntax for remote interface programming.

- Square brackets (**[ ]**) indicate optional keywords or parameters.
- Braces (**{ }**) enclose parameters within a command string.
- Triangle brackets (**< >**) indicate that you must substitute a value for the enclosed parameter.
- A vertical bar (**|**) separates multiple parameter choices.

Output Configuration

This section contains information to help you configure the function generator for outputting waveforms. You may never have to change some of the parameters discussed here, but they are provided to give you the flexibility you might need.

Output Function

The function generator can output five standard waveforms including sine, square, triangle, ramp, and noise. You can also select one of five predefined arbitrary waveforms or download your own custom waveforms. You can internally modulate any of the standard waveforms (including arbitrary) using AM, FM, FSK, or burst modulation. Linear or logarithmic frequency sweeping is available for any of the standard waveforms (except noise) and arbitrary waveforms. *The default function is sine wave.*

- *Possible Conflict with Output Frequency*:   The output frequency is automatically adjusted if you select a function whose maximum frequency is *less than* that of the currently active function. For example, if you output a 1 MHz sine wave and then change the function to triangle wave, the function generator will adjust the output to 100 kHz (the upper limit for triangle waves).

  From the front panel, "FREQ LIMIT" is displayed and the frequency is adjusted. From the remote interface, a *-221, "Settings conflict"* error is generated and the frequency is adjusted.

- *Possible Conflict with Output Amplitude*:   The output amplitude is automatically adjusted if you select a function whose maximum amplitude is *less than* that of the currently active function. This conflict may arise when the output units are *Vrms* or *dBm* due to the differences in crest factor for the output functions. For example, if you output a 5 Vrms square wave (into 50 ohms) and then change the function to sine wave, the function generator will adjust the output amplitude to 3.535 Vrms (the upper limit for sine waves in Vrms).

  From the front panel, "AMPL LIMIT" is displayed and the amplitude is adjusted. From the remote interface, a *-221, "Settings conflict"* error is generated and the amplitude is adjusted.

3

Output Function
(continued)

- The following matrix shows which output functions are allowed with each modulation mode. Each "X" indicates a valid combination. If you change to a function that is not allowed with the selected modulation, the modulation mode is turned off.

	Sine	**Square**	**Triangle**	**Ramp**	**Noise**	**Arb**
AM Carrier	X	X	X	X		X
AM Modulating Wave	X	X	X	X	X	X
FM Carrier	X	X	X	X		X
FM Modulating Wave	X	X	X	X	X	X
FSK Modulation	X	X	X	X		X
Burst Modulation	X	X	X	X		X
Frequency Sweep	X	X	X	X		X

- *Front-Panel Operation*: To select a function, press any key in the top row of function keys. Press Arb to output the arbitrary waveform currently selected (to scroll through the waveform choices and make a selection, press Arb List).

- To select *dc volts* from the front panel, press Offset and ***hold it down for more than 2 seconds***.

- *Remote Interface Operation*:

  FUNCtion:SHAPe {SINusoid|SQUare|TRIangle|RAMP|NOISe|USER|DC}

  You can also use the APPLy command to select the function, frequency, amplitude, and offset with a single command.

Output Frequency

As shown below, the output frequency range depends on the function currently selected. *The default frequency is 1 kHz for all functions.*

Function	Minimum Frequency	Maximum Frequency
Sine	100 µHz	15 MHz
Square	100 µHz	15 MHz
Triangle	100 µHz	100 kHz
Ramp	100 µHz	100 kHz
Built-In Arbs [1]	100 µHz	5 MHz

1 There are five built-in arbitrary waveforms stored in non-volatile memory: sinc, negative ramp, exponential rise, exponential fall, and cardiac.

For *arbitrary waveforms* that you create and download to memory, the maximum frequency depends on the number of points specified in the waveform. As shown below, the maximum output frequency decreases as you specify more points in the waveform. The five built-in arbitrary waveforms can be output at a maximum of 5 MHz.

Number of Arb Points	Minimum Frequency	Maximum Frequency
8 to 8,192 (8k)	100 µHz	5 MHz
8,193 to 12,287 (12k)	100 µHz	2.5 MHz
12,288 to 16,000	100 µHz	200 kHz

3

Output Frequency
(continued)

- *Possible Conflict with Function Change*: The output frequency is automatically adjusted if you select a function whose maximum frequency is *less than* that of the currently active function. For example, if you output a 1 MHz sine wave and then change the function to triangle wave, the function generator will adjust the output to 100 kHz (the upper limit for triangle waves).

  From the front panel, "FREQ LIMIT" is displayed and the frequency is adjusted. From the remote interface, a *-221, "Settings conflict"* error is generated and the frequency is adjusted.

- *Possible Conflict with Duty Cycle (square wave only)*: For output frequencies above 5 MHz, the duty cycle is limited to values between 40% and 60% (below 5 MHz, the range is 20% to 80%). The duty cycle is automatically adjusted if you select a frequency that is not valid with the present duty cycle. For example, if you set the duty cycle to 70% and then change the frequency to 8 MHz, the function generator will automatically adjust the duty cycle to 60% (the upper limit for this frequency).

  From the front panel, "% DUTY LIMIT" is displayed and the duty cycle is adjusted. From the remote interface, a *-221, "Settings conflict"* error is generated and the duty cycle is adjusted.

- *Front-Panel Operation*: To set the output frequency, press $\boxed{\text{Freq}}$. Then use the knob, arrow keys, or "Enter Number" mode to set the frequency.

- *Remote Interface Operation*:

      FREQuency {<*frequency*>|MINimum|MAXimum}

  You can also use the APPLy command to select the function, frequency, amplitude, and offset with a single command.

Output Amplitude

As shown below, the output amplitude range depends on the function currently selected and the output termination. *The default amplitude is 100 mVpp (into 50 ohms) for all functions.*

Function	Output Termination	Minimum Amplitude	Maximum Amplitude
Sine	50Ω	50 mVpp	10 Vpp
Square	50Ω	50 mVpp	10 Vpp
Triangle	50Ω	50 mVpp	10 Vpp
Ramp	50Ω	50 mVpp	10 Vpp
Noise	50Ω	50 mVpp	10 Vpp
Built-In Arbs [1]	50Ω	50 mVpp	10 Vpp
Sine	Open Circuit	100 mVpp	20 Vpp
Square	Open Circuit	100 mVpp	20 Vpp
Triangle	Open Circuit	100 mVpp	20 Vpp
Ramp	Open Circuit	100 mVpp	20 Vpp
Noise	Open Circuit	100 mVpp	20 Vpp
Built-In Arbs [1]	Open Circuit	100 mVpp	20 Vpp

1 There are five built-in arbitrary waveforms stored in non-volatile memory: sinc, negative ramp, exponential rise, exponential fall, and cardiac.

- For *arbitrary waveforms*, the maximum amplitude will be limited if the data points do not span the full range of the output DAC (Digital-to-Analog Converter). For example, the built-in "SINC" waveform does not use the full range of values between ±1 and therefore its maximum amplitude is 6.084 Vpp (into 50 ohms).

- *Possible Conflict with Function Change*: The output amplitude is automatically adjusted if you select a function whose maximum amplitude is *less than* that of the currently active function. This conflict may arise when the output units are *Vrms* or *dBm* due to the differences in crest factor for the output functions. For example, if you output a 5 Vrms square wave (into 50 ohms) and then change the function to sine wave, the function generator will adjust the output amplitude to 3.535 Vrms (the upper limit for sine waves in Vrms).

  From the front panel, "AMPL LIMIT" is displayed and the amplitude is adjusted. From the remote interface, a *-221, "Settings conflict"* error is generated and the amplitude is adjusted.

Output Amplitude
(continued)

- *Output Amplitude and Output Termination*: The output amplitude is automatically adjusted (and no error is generated) if you change the output termination. For example, if you set the amplitude to 10 Vpp and then change the termination from 50 ohms to "high impedance", the displayed amplitude will *double* to 20 Vpp. If you change from "high impedance" to 50 ohms, the displayed amplitude will drop in half. *See "Output Termination" on page 65 for more information.*

- *Offset Voltage Restrictions*: The output amplitude (in Vpp) and the dc offset voltage must obey the following restrictions. If the specified amplitude is not valid, the function generator will automatically adjust it to the maximum value allowed with the present offset voltage. (V*max* is either 10 volts for a high impedance termination or 5 volts for a 50 ohm termination; V*pp* is the output amplitude in volts peak-to-peak.)

$$| V_{offset} | \; + \; \frac{V_{pp}}{2} \; \leq \; V_{max} \quad and \quad | V_{offset} | \; \leq \; 2 \times V_{pp}$$

  From the front panel, "MAX VALUE" is displayed and the amplitude is adjusted. From the remote interface, a *-221, "Settings conflict"* error is generated and the amplitude is adjusted.

- A momentary glitch occurs in the output waveform at certain voltages due to output attenuator switching. This positive-going glitch occurs when the output voltage crosses the break-point voltage either from a lower voltage or a higher voltage. The voltages are shown below (for a 0 volt dc offset):

  ```
  252 mVpp, 399 mVpp, 502 mVpp, 796 mVpp, 1 Vpp, 1.59 Vpp,
  2.0 Vpp, 3.17 Vpp, 3.99 Vpp, 6.32 Vpp, 7.96 Vpp
  ```

- The output voltage will momentarily drop to 0 volts at certain voltages due to output relay switching. This occurs when the output voltage crosses the break-point voltage either from a lower voltage or a higher voltage. The voltages are shown below (for a 0 volt dc offset):

  ```
  317 mVpp, 632 mVpp, 1.26 Vpp, 2.52 Vpp, 5.02 Vpp
  ```

- You can set the units for output amplitude to Vpp, Vrms, or dBm. *See "Output Units" on page 64 for more information.*

- For *dc volts*, the output level is actually controlled by setting the offset voltage. You can set the dc voltage to any value between ±5 Vdc into 50 ohms or ±10 Vdc into an open circuit. *See "DC Offset Voltage" on page 62 for more information.*

  *To select **dc volts** from the front panel, press* Offset *and **hold it down for more than 2 seconds***.

- *Front-Panel Operation*: To set the output amplitude, press Ampl . Then use the knob, arrow keys, or "Enter Number" mode to set the amplitude.

3

- *Remote Interface Operation*:

  ```
  VOLTage {<amplitude>|MINimum|MAXimum}
  ```

  You can also use the APPLy command to select the function, frequency, amplitude, and offset with a single command.

DC Offset Voltage

At power-on, the dc offset is set to 0 volts. You can set the offset to a positive or negative number with the restrictions shown below. If the specified offset voltage is not valid, the function generator will automatically adjust it to the maximum dc voltage allowed with the present amplitude. (V*max* is either 10 volts for a high impedance termination or 5 volts for a 50 ohm termination; V*pp* is the output amplitude in volts peak-to-peak.)

$$| V_{offset} | \ + \ \frac{V_{pp}}{2} \ \leq \ V_{max} \quad and \quad | V_{offset} | \ \leq \ 2 \times V_{pp}$$

From the front panel, "MAX VALUE" is displayed and the offset is adjusted. From the remote interface, a *-221, "Settings conflict"* error is generated and the offset is adjusted.

* *DC Offset and Output Termination*: The offset voltage is automatically adjusted (and no error is generated) if you change the output termination. For example, if you set the offset to 100 mVdc and then change the termination from 50 ohms to "high impedance", the displayed offset will *double* to 200 mVdc. If you change from "high impedance" to 50 ohms, the displayed offset will drop in half. *See "Output Termination" on page 65 for more information.*

* For *dc volts*, the output level is actually controlled by setting the offset voltage. You can set the dc voltage to any value between ±5 Vdc into 50 ohms or ±10 Vdc into an open circuit.

  *To select **dc volts** from the front panel, press* $\boxed{\text{Offset}}$ *and **hold it down for more than 2 seconds**.*

- For *arbitrary waveforms*, the **Offset** annunciator will turn on if the waveform data has an inherent offset present (if the average is not equal to zero). The function generator calculates the average of the data points and compares the average to zero volts. If the average is not within two DAC (Digital-to-Analog Converter) counts of zero volts, the **Offset** annunciator turns on.

- *Front-Panel Operation*:   To set the dc offset, press ⸢Offset⸥ . Then use the knob, arrow keys, or "Enter Number" mode to set the offset.

- *Remote Interface Operation*:

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

  You can also use the APPLy command to select the function, frequency, amplitude, and offset with a single command.

3

Output Units

Applies only to output amplitude (does not affect offset). At power-on, the units for output amplitude are *volts peak-to-peak*.

- Output units: **Vpp**, Vrms, or dBm. *The default is Vpp*.

- The unit setting is stored in *volatile* memory; the units are set to "Vpp" when power has been off or after a remote interface reset.

- When switching from remote programming over the interface back to front-panel (local) operation, the output units are remembered. For example, if you select "Vrms" from the remote interface, the units are shown as "Vrms" on the front-panel display.

- *Front-Panel Operation*: Use the "Enter Number" units keys (the arrow keys located on the right side of the front panel) to select the output units. You can also convert from one unit to another from the front panel. For example, to convert 2 Vpp to its equivalent value in *Vrms*, press the following keys:

  | Enter Number | | ∨ | kHz
  m Vrms

  The converted value is 707.1 mVrms.

- *Remote Interface Operation*:

  ```
  VOLTage:UNIT {VPP|VRMS|DBM|DEFault}
  ```

Output Termination

Applies only to output amplitude and offset voltage. The function generator has a fixed output impedance of 50 ohms on the *OUTPUT* terminal. You can specify whether **you** are terminating the output into a 50 ohm load or an open circuit. Incorrect impedance matching between the function generator and your load will result in an amplitude or offset which does not match the specified signal level.

- Output termination: **50Ω** or High impedance. *The default is 50Ω.* See the table on page 59 for a list of amplitude limits for all functions.

- The output termination setting is stored in *volatile* memory; 50Ω is selected when power has been off or after a remote interface reset.

- The amplitude (or dc offset) is automatically adjusted (and no error is generated) if you change the output termination. For example, if you set the amplitude to 10 Vpp and then change the termination from 50 ohms to "high impedance", the displayed amplitude will *double* to 20 Vpp. If you change from "high impedance" to 50 ohms, the displayed amplitude will drop in half.

- If you specify a 50 ohm termination but are actually terminating into an open circuit, the displayed output will be *twice* the value specified. For example, if you set the offset to 100 mVdc (and specify a 50 ohm termination) but are actually terminating the output into an open circuit, the actual displayed offset will be 200 mVdc.

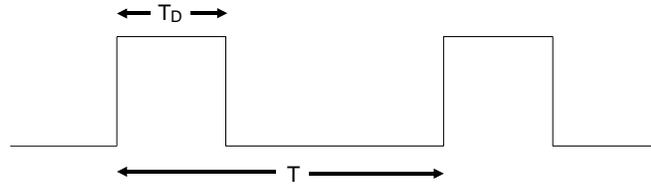- *Front-Panel Operation*: Choose "50 OHM" or "HIGH Z" from the front-panel menu.

      1: OUT TERM **(SYS MENU)**

- *Remote Interface Operation*:

      OUTPut:LOAD {50|INFinity|MINimum|MAXimum}

3

Duty Cycle

Applies only to square waves. Duty cycle is specified as a percentage and represents the amount of time per cycle that the square wave is high.

$$\text{Duty Cycle} = \frac{T_D}{T} \qquad \left(\text{where} \quad T = \frac{1}{\text{frequency}}\right)$$

- Duty cycle: 20% to 80%, in 1% increments (*frequency* $\leq$ 5 MHz).
  40% to 60%, in 1% increments (*frequency* > 5 MHz).
  The default is 50%.

- The duty cycle is stored in *volatile* memory; the duty cycle is set to 50% when power has been off or after a remote interface reset. The APPLy command automatically sets the duty cycle to 50% for square waves.

- Before attempting to set the duty cycle, you must enable the square wave function. From the front panel, "SQUARE ONLY" is displayed if square wave is not currently active. From the remote interface, no error is generated, but the specified duty cycle is remembered when you change to the square wave function.

- The duty cycle setting is remembered when you change from square wave to another function. When you return to the square wave function, the previous duty cycle is used.

- *Possible Conflict with Output Frequency*: The duty cycle is auto-matically adjusted if you select a frequency that is not valid with the present duty cycle. For example, if you set the duty cycle to 70% and then change the frequency to 8 MHz, the function generator will automatically adjust the duty cycle to 60% (the upper limit for this frequency).

   From the front panel, "% DUTY LIMIT" is displayed and the duty cycle is adjusted. From the remote interface, a *-221, "Settings conflict"* error is generated and the duty cycle is adjusted.

- *Front-Panel Operation*: To set the duty cycle, press ⌐Shift⌐ ⌐% Duty⌐ (the value appears on the display for approximately 10 seconds). Then use the knob, arrow keys, or "Enter Number" mode to set the duty cycle.

- *Remote Interface Operation*:

   ```
   PULSe:DCYCle {<percent>|MINimum|MAXimum}
   ```

   The APPLy command automatically sets the duty cycle to 50% for square waves.

3

SYNC Signal

A sync signal output is provided on the front-panel *SYNC* terminal. All of the standard output functions (except dc and noise) have an associated sync signal. For certain applications where you may not want to output the sync signal, you can disable the *SYNC* terminal.

The SYNC terminal can be enabled/disabled from the remote interface only.

- By default, the sync signal is routed to the *SYNC* terminal (enabled).

- When the sync signal is disabled, the output level on the *SYNC* terminal is indeterminate (it might be a TTL "high" or a TTL "low").

- For *sine*, *square*, *triangle*, and *ramp* waveforms, the sync signal is a TTL "high" when the waveform's output is positive, relative to zero volts (or the dc offset value). The signal is a TTL "low" when the output is negative, relative to zero volts (or the dc offset value).

- For *arbitrary* waveforms, a momentary TTL "high" pulse (> 200 ns) is output which corresponds to the first downloaded point in the waveform.

- For *AM* and *FM*, the sync signal is referenced to the modulating signal (not the carrier). A momentary TTL "high" pulse (> 200 ns) is output at each zero-crossing point of the modulating signal.

- For the *triggered burst mode*, a TTL "low" signal is output while the specified number of cycles is output (for the duration of the burst). After the specified number of cycles has been output, the sync signal goes "high" until the next burst.

- For the *external gated burst mode*, the sync signal is a TTL "high" when the output is positive, relative to zero volts (or the dc offset value). The signal is a TTL "low" when the output is negative, relative to zero volts (or the dc offset value).

- For *FSK*, a momentary TTL "high" pulse (> 200 ns) is output on the transition to the "hop" frequency.

- For *frequency sweeps*, the sync signal is a TTL "low" at the start of the sweep (when the start frequency is output) and is a TTL "high" at the end of the sweep (when the stop frequency is output).

- *Remote Interface Operation*:

      OUTPut:SYNC {OFF|ON}   *Setting is stored in volatile memory.*

Instrument State Storage

You can store up to three different instrument states in non-volatile memory. This enables you to recall the entire instrument configuration with a single command from the remote interface or with just a few key presses from the front panel.

- Three memory locations (numbered 1, 2, and 3) are available to store instrument configurations. The state storage feature "remembers" the function (including arbitrary waveforms), frequency, amplitude, dc offset, duty cycle, as well as any modulation parameters. To recall a stored state, you must use the same memory location used previously to store the state.

- You cannot recall the instrument state from a memory location that was not previously specified as a storage location. For example, an error is generated if you attempt to recall from memory location "2" but have never stored to that location.

  From the front panel, "NOT STORED" is displayed if nothing is stored in the specified memory location. From the remote interface, a *+810, "State has not been stored"* error is generated if nothing is stored in the specified memory location.

- Any arbitrary waveforms downloaded to "VOLATILE" memory *are not* remembered. However, if an arbitrary waveform is being output from *non-volatile* memory when the state is stored, the waveform data is stored. The stored waveform is output when the instrument state is recalled.

- If you delete an arbitrary waveform after storing the state, the waveform data is lost and the function generator will not output the waveform when the state is recalled. The "SINC" waveform is output in place of the deleted waveform.

State Storage
(continued)

- When power is turned off, the function generator automatically stores its state in memory location "0". You can configure the function generator to automatically recall the power-down state when power is restored. The recall mode is *disabled* when the function generator is shipped from the factory.

  Select the POWER ON LAST STATE command from the SYS MENU to enable the power-down recall mode. Select POWER ON DEFAULT to disable the power-down recall mode. *See "Power-Down Recall Mode" on page 109 for more information.*

- From the remote interface, you can use memory location "0" to store a fourth instrument configuration (you cannot store to this memory location from the front panel). However, keep in mind that memory location "0" is automatically overwritten when the power is turned off.

- *Front-Panel Operation*:

  To store the state, press $\boxed{\text{Shift}}$ $\boxed{\text{Store}}$. Then use the knob, arrow keys, or "Enter Number" mode to select the memory location.

  To restore the state, press $\boxed{\text{Recall}}$. Then use the knob, arrow keys, or "Enter Number" mode to select the memory location.

- *Remote Interface Operation*:

  ```
  *SAV {0|1|2|3}        State 0 is the instrument state at power down.
  *RCL {0|1|2|3}        States 1, 2, and 3 are user-defined states.
  ```

- From the remote interface, you can delete individual stored states and clear the memory location. If nothing is stored in the specified memory location, a *+810, "State has not been stored"* error is generated.

  ```
  MEMory:STATe:DELete {0|1|2|3}
  ```

Amplitude Modulation (AM)

A modulated waveform consists of a *carrier waveform* and a *modulating waveform*. In AM, the amplitude of the carrier is varied by the amplitude of the modulating waveform. The function generator will accept an internal modulating signal, an external modulating signal, or both.

For more information on the fundamentals of Amplitude Modulation, refer to chapter 7, "Tutorial".

To Select AM Modulation

- The **AM** annunciator turns on when AM is enabled.

- Only one modulation mode can be enabled at a time. When you enable AM, the previous modulation mode is turned off.

- *Front-Panel Operation*: Enable AM *before* setting up the other modulation parameters. Press Shift AM to output an AM waveform using the present settings for the carrier frequency, modulating frequency, output amplitude, and offset voltage.

- *Remote Interface Operation*: To ensure proper operation, you should enable AM *after* you have set up the other modulation parameters.

      AM:STATe {OFF|ON}

Carrier Waveform Shape

- AM carrier shape: **Sine**, Square, Triangle, Ramp, or Arbitrary waveform. *The default is Sine.*

- You *cannot* use the noise function or dc volts as the carrier waveform.

- *Front-Panel Operation*: Press any of the front-panel function keys except Noise . For arbitrary waveforms, the Arb key selects the waveform that is currently downloaded.

- *Remote Interface Operation*:

      FUNCtion:SHAPe {SINusoid|SQUare|TRIangle|RAMP|USER}

  You can also use the APPLy command to select the function, frequency, amplitude, and offset with a single command.

Carrier Frequency

- Carrier frequency: 100 μHz to 15 MHz (100 kHz for triangle and ramp). *The default is 1 kHz.*

- For *arbitrary waveforms*, the maximum carrier frequency depends on the number of points specified in the waveform. The five built-in arbitrary waveforms can be output at a maximum of 5 MHz.

Number of Arb Points	Minimum Frequency	Maximum Frequency
8 to 8,192 (8k) 8,193 to 12,287 (12k) 12,288 to 16,000	100 μHz 100 μHz 100 μHz	5 MHz 2.5 MHz 200 kHz

- *Front-Panel Operation*: Press the Freq key to select any valid frequency for the selected function (the present amplitude and offset voltage are used).

- *Remote Interface Operation*:

      FREQuency {<*frequency*>|MINimum|MAXimum}

Modulating Waveform Shape

The function generator will accept an internal modulating signal,
an external modulating signal, or both.

- Modulating waveform shape (internal source): **Sine**, Square,
  Triangle, Ramp, Noise, or Arbitrary waveform. *The default is Sine.*

- You can use the noise function as the modulating waveform.
  However, you *cannot* use the noise function or dc volts as the
  carrier waveform.

- *Front-Panel Operation*: After enabling AM, press *Recall Menu* to go
  directly to the AM SHAPE command in the menu.

```
   1: AM SHAPE   (MOD MENU)
```

- *Remote Interface Operation*:

```
AM:INTernal:FUNCtion {SINusoid|SQUare|TRIangle|RAMP|NOISe|USER}
```

3

Modulating Waveform Frequency

The function generator will accept an internal modulating signal, an external modulating signal, or both.

- Modulating frequency (internal source):   10 mHz to 20 kHz. *The default is 100 Hz.*

- The sync signal for AM is referenced to the modulating signal (not the carrier). A momentary TTL "high" pulse (> 200 ns) is output at each zero-crossing point of the modulating signal. The signal is output from the front-panel *SYNC* terminal.

- *Front-Panel Operation*:   Press $\boxed{\text{Shift}}$ $\boxed{\text{Freq}}$ to set the modulating frequency (the value is displayed for approximately 10 seconds).

  Before setting the modulating frequency from the front panel, you must have AM enabled. If you attempt to set the frequency when AM is not enabled, "SELECT AM, FM" is displayed.

- *Remote Interface Operation*:

      AM:INTernal:FREQuency {<*frequency*>|MINimum|MAXimum}

Modulation Depth

The *modulation depth* is expressed as a percentage and represents the extent of the amplitude variation. At 0% modulation, the output amplitude is half of the selected value. At 100% modulation, the output amplitude equals the selected value.

- Modulation depth: 0% to 120%. *The default is 100%.*

- *Front-Panel Operation*:   Press $\boxed{\text{Shift}}$ $\boxed{\text{Level}}$ to set the depth in percent (the value is displayed for approximately 10 seconds).

  Before setting the modulation depth from the front panel, you must have AM enabled. If you attempt to set the depth when AM is not enabled, "SELECT AM, FM" is displayed.

- *Remote Interface Operation*:

      AM:DEPTh {<*depth in percent*>|MINimum|MAXimum}

Modulating Source

The function generator will accept an internal modulating signal,
an external modulating signal, or both.

*   Modulating source: Internal-External (both) or External only.
    The default is Both (internal-external).

*   ***The External modulating source is always enabled.***

*   When both sources are enabled (*internal-external*), the function
    generator adds the internal and external modulating signals
    (the carrier waveform is actually modulated with two waveforms).

*   When the internal source is disabled (*external only*), the carrier
    waveform is modulated with the external waveform. The **Ext**
    annunciator turns on to indicate that the function generator is
    expecting a modulating signal on the rear-panel *AM Modulation*
    terminal.

*   You apply the external modulating waveform to the *AM Modulation*
    terminal. The *modulation depth* is controlled by the signal level
    present (5 volts **peak** corresponds to 100% modulation).
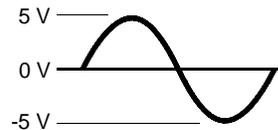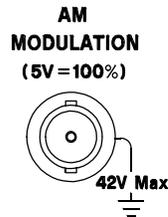
*   *Front-Panel Operation*:

    ```
    2: AM SOURCE   (MOD MENU)
    ```

*   *Remote Interface Operation*:

    ```
    AM:SOURce {BOTH|EXTernal}
    ```

Frequency Modulation (FM)

A modulated waveform consists of a *carrier waveform* and a *modulating waveform*. In FM, the frequency of the carrier is varied by the amplitude of the modulating waveform. The function generator will accept *only* an internal FM modulating signal (no external source is available).

For more information on the fundamentals of Frequency Modulation, refer to chapter 7, "Tutorial".

To Select FM Modulation

- The **FM** annunciator turns on when FM is enabled.

- Only one modulation mode can be enabled at a time. When you enable FM, the previous modulation mode is turned off.

- *Front-Panel Operation*: Enable FM *before* setting up the other modulation parameters. Press Shift FM to output an FM waveform using the present settings for the carrier frequency, modulating frequency, output amplitude, and offset voltage.

- *Remote Interface Operation*: To ensure proper operation, you should enable FM *after* you have set up the other modulation parameters.

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

Carrier Waveform Shape

- FM carrier shape: **Sine**, Square, Triangle, Ramp, or Arbitrary waveform. *The default is Sine.*

- You *cannot* use the noise function or dc volts as the carrier waveform.

- *Front-Panel Operation*: Press any of the front-panel function keys except Noise . For arbitrary waveforms, the Arb key selects the waveform that is currently downloaded.

- *Remote Interface Operation*:

  ```
  FUNCtion:SHAPe {SINusoid|SQUare|TRIangle|RAMP|USER}
  ```

  You can also use the APPLy command to select the function, frequency, amplitude, and offset with a single command.

3

Carrier Frequency

- Carrier frequency: 10 mHz to 15 MHz (100 kHz for triangle and ramp). *The default is 1 kHz.*

- For *arbitrary waveforms*, the maximum carrier frequency depends on the number of points specified in the waveform. The five built-in arbitrary waveforms can be output at a maximum of 5 MHz.

Number of Arb Points	Minimum Frequency	Maximum Frequency
8 to 8,192 (8k)	10 mHz	5 MHz
8,193 to 12,287 (12k)	10 mHz	2.5 MHz
12,288 to 16,000	10 mHz	200 kHz

- The carrier frequency must always be greater than or equal to the *peak frequency deviation*. If you attempt to set the carrier frequency to a value less than the deviation, the function generator will automatically adjust the carrier frequency to equal the present deviation.

  From the front panel, "MIN VALUE" is displayed and the carrier frequency is adjusted. From the remote interface, a *-221, "Settings conflict"* error is generated and the carrier frequency is adjusted.

- The sum of the carrier frequency and *peak frequency deviation* must be less than or equal to the maximum frequency for the selected function **plus 100 kHz** (15.1 MHz for sine and square, 200 kHz for triangle and ramp, and 5.1 MHz for arbitrary waveforms). If you attempt to set the carrier frequency to a value that is not valid, the function generator will automatically adjust the carrier frequency to equal the present deviation.

  From the front panel, "MAX VALUE" is displayed and the deviation is adjusted. From the remote interface, a *-221, "Settings conflict"* error is generated and the deviation is adjusted.

- *Front-Panel Operation*: Press the `Freq` key to select any valid frequency for the selected function (the present amplitude and offset voltage are used).

- *Remote Interface Operation*:

      FREQuency {<*frequency*>|MINimum|MAXimum}

Modulating Waveform Shape

The function generator will accept *only* an internal modulating signal.

- Modulating waveform shape (internal source): **Sine**, Square, Triangle, Ramp, Noise, or Arbitrary waveform. *The default is Sine.*

- You can use the noise function as the modulating waveform. However, you *cannot* use the noise function or dc volts as the carrier waveform.

- *Front-Panel Operation*: After enabling FM, press *Recall Menu* to go directly to the FM SHAPE command in the menu.

      3: FM SHAPE   **(MOD MENU)**

- *Remote Interface Operation*:

  ```
  FM:INTernal:FUNCtion {SINusoid|SQUare|TRIangle|RAMP|NOISe|USER}
  ```

Modulating Waveform Frequency

The function generator will accept *only* an internal modulating signal.

- Modulating frequency (internal source): 10 mHz to 10 kHz. *The default is 10 Hz.*

- The sync signal for FM is referenced to the modulating signal (not the carrier). A momentary TTL "high" pulse (> 200 ns) is output at each zero-crossing point of the modulating signal. The signal is output from the front-panel *SYNC* terminal.

- *Front-Panel Operation*: Press ⌑Shift⌑ ⌑Freq⌑ to set the modulating frequency (the value is displayed for approximately 10 seconds).

  Before setting the modulating frequency from the front panel, you must have FM enabled. If you attempt to set the frequency when FM is not enabled, "SELECT AM, FM" is displayed.

- *Remote Interface Operation*:

  ```
  FM:INTernal:FREQuency {<frequency>|MINimum|MAXimum}
  ```

Peak Frequency Deviation

The *peak frequency deviation* represents the variation in frequency of
the modulating waveform from the carrier frequency.

- Peak frequency deviation: 10 mHz to 7.5 MHz. *The default is 100 Hz.*

- The *carrier frequency* must always be greater than or equal to the
  peak frequency deviation. If you attempt to set the deviation to a
  value greater than the carrier frequency (with FM enabled), the
  function generator will automatically adjust the deviation to equal
  the present carrier frequency.

  From the front panel, "MAX VALUE" is displayed and the deviation is
  adjusted. From the remote interface, a *-221, "Settings conflict"* error
  is generated and the deviation is adjusted.

- The sum of the *carrier frequency* and peak frequency deviation must
  be less than or equal to the maximum frequency for the selected
  function ***plus 100 kHz*** (15.1 MHz for sine and square, 200 kHz for
  triangle and ramp, and 5.1 MHz for arbitrary waveforms). If you
  attempt to set the deviation to a value that is not valid, the function
  generator will automatically adjust the deviation to the maximum
  value allowed with the present carrier frequency.

  From the front panel, "MAX VALUE" is displayed and the deviation is
  adjusted. From the remote interface, a *-221, "Settings conflict"* error
  is generated and the deviation is adjusted.

- *Front-Panel Operation*:   Press ⎡Shift⎤ ⎡Level⎤ to set the peak deviation
  (the value is displayed for approximately 10 seconds).

  Before setting the deviation from the front panel, you must have
  FM enabled. If you attempt to set the deviation when FM is not
  enabled, "SELECT AM, FM" is displayed.

- *Remote Interface Operation*:

  ```
  FM:DEViation {<peak deviation in Hz>|MINimum|MAXimum}
  ```

Burst Modulation

You can configure the function generator to output a waveform with a specified number of cycles, called a *burst*. You can output the burst at a rate determined by the internal rate generator or an external signal applied to the rear-panel connector. *The function generator can produce a burst using sine, square, triangle, ramp, and arbitrary waveforms.*

For more information on the fundamentals of Burst Modulation, refer to chapter 7, "Tutorial".

3

You can use burst modulation in the following two modes. The function generator enables one burst mode at a time based on the *trigger source* and *burst source* that you select (see the table below).

- *Triggered Burst Mode*:   In this mode, the function generator outputs a waveform with a specified number of cycles (*burst count*) each time a trigger is received. After the specified number of cycles has been output, the function generator waits for the next trigger. You can configure the function generator to accept an internal trigger or you can send the trigger externally by pressing the front-panel Single key or by applying a trigger signal to the rear-panel *Ext Trig* terminal.

  At power-on, the internally-triggered burst mode is enabled.

- *External Gated Burst Mode*:   In this mode, the output waveform is either "on" or "off" based on the level of the external signal applied to the rear-panel *Ext Trig* terminal. When the gate signal is true, the function generator outputs a continuous waveform. When the gate signal is false, the output is turned off.

	Trigger Source (TRIG:SOUR)	Burst Source (BM:SOUR)	Burst Count (BM:NCYC)	Burst Rate (BM:INT:RATE)	Burst Phase (BM:PHAS)
External Triggered Mode	External	Internal	Available	Not Used	Available
Internal Triggered Mode	Internal	Internal	Available	Available	Available
External Gated Mode	Internal	External	Not Used	Not Used	Not Used

Burst Trigger Source

In the *triggered burst* mode, the function generator outputs a waveform with the specified number of cycles (*burst count*) each time a trigger is received. After the specified number of cycles has been output, the function generator waits for the next trigger while outputting no signal (zero volts or the dc offset level). *At power-on, the internally-triggered burst mode is enabled.*

- Trigger source: **Internal**, Single, or External. *The default is Internal.*

- In the triggered burst mode, the "burst source" is *Internal*.

- When the *internal* trigger source is selected, the frequency at which the burst is generated is determined by the *burst rate* parameter. The burst rate frequency defines the interval between bursts.

- Pressing ⌐Single¬ to enable the *single* trigger mode also enables the *external* trigger mode. External triggering is like the front-panel single trigger mode except that you apply a trigger signal to the rear-panel *Ext Trig* terminal. The function generator is triggered on the *rising edge* of a TTL pulse.

- The **Trig** annunciator turns on when the function generator is waiting for a single or external trigger.

- When the *single* or *external* trigger source is selected, the *burst count* and *burst phase* remain in effect but the *burst rate* is ignored.

- When the *external gate* source is selected ("gated" burst mode), the specified trigger source is ignored. The external gated mode overrides the triggered mode source.

- *Front-Panel Operation*: Pressing ⌐Single¬ to enable the single trigger mode also enables the external trigger mode.
Press ⌐Shift¬ ⌐Internal¬ to enable the internal trigger mode.

- *Remote Interface Operation*:

      TRIGger:SOURce {IMMediate|EXTernal|BUS}

  See "Triggering" on page 98 for more information.

Burst Source

In the *external gated burst* mode, the output waveform is either
"on" or "off " based on the level of the external signal applied to the
rear-panel *Ext Trig* terminal. When the gate signal is true, the function
generator outputs a continuous waveform. When the gate signal is false,
the output is turned off.

- Burst source: **Internal** or External Gate. *The default is Internal.*

- When the *internal* burst source is selected, the external gated mode
  is disabled.

- When the *external gate* source is selected, the output is enabled or
  disabled based on the logic level of the gate signal applied to the
  Ext Trig terminal. When the gate signal is true (TTL high),
  the function generator outputs a continuous waveform. When the
  gate signal is false (TTL low), the output is turned off (zero volts or
  the dc offset level).

- When the *external gate* source is selected, the burst count, burst rate,
  burst phase, and burst trigger source are ignored (these parameters
  are used for the triggered burst mode only).

- The **Ext** annunciator turns on when the function generator is waiting
  for the external gate signal.

- *Front-Panel Operation*:

```
7: BURST SRC  (MOD MENU)
```

- *Remote Interface Operation*:

```
BM:SOURce {INTernal|EXTernal}
```

3

To Select Burst Modulation

*   The **Burst** annunciator turns on when burst modulation is enabled.

*   Only one modulation mode can be enabled at a time. When you enable the burst mode, the previous modulation mode is turned off.

*   *Front-Panel Operation*:   Enable burst modulation *before* you set up the other modulation parameters. Press Shift Burst to output the burst using the present settings for the carrier frequency, output amplitude, and offset voltage.

*   *Remote Interface Operation*:   To ensure proper operation, you should enable the burst mode *after* you have set up the other modulation parameters.

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

Burst Carrier Frequency

The *carrier frequency* defines the repetition rate of the burst waveform in the triggered and external gated modes. In the triggered mode, the number of cycles specified by the *burst count* are output at the frequency of the carrier signal. In the external gated mode, the carrier frequency is output when the external gate signal is true (TTL high).

Keep in mind that the carrier frequency is different than the "burst rate" which specifies the interval between bursts (triggered mode only).

*   Carrier frequency: 10 mHz to 5 MHz (100 kHz for triangle and ramp). *The default is 1 kHz*. You can use sine, square, ramp, triangle, or arbitrary waveforms for the carrier waveshape.

*   ***Be sure to note the restrictions for carrier frequency and burst count shown on the following pages.***

• For *arbitrary waveforms* used as the carrier waveform, the maximum
frequency depends on the number of points specified in the waveform.
The five built-in arbitrary waveforms can be output at a maximum
of 5 MHz (*be sure to note the restrictions below).*

Number of Arb Points	Minimum Frequency	Maximum Frequency
8 to 8,192 (8k)	10 mHz	5 MHz
8,193 to 12,287 (12k)	10 mHz	2.5 MHz
12,288 to 16,000	10 mHz	200 kHz

3

• For *sine, square,* and *arbitrary* waveforms (does not apply to ramp
and triangle waveforms), the relationship between the carrier
frequency and the minimum burst count is shown below.

Carrier Frequency	Minimum Burst Count
10 mHz to 1 MHz	1
>1 MHz to 2 MHz	2
>2 MHz to 3 MHz	3
>3 MHz to 4 MHz	4
>4 MHz to 5 MHz	5

*For sine, square, and
arbitrary waveforms only.*

• If you attempt to set the carrier frequency to a value that is not valid,
the function generator will automatically adjust the frequency to the
maximum value allowed with the present burst count.

From the front panel, "MAX VALUE" is displayed and the carrier
frequency is adjusted. From the remote interface, a *-221, "Settings
conflict"* error is generated and the carrier frequency is adjusted.

Carrier Frequency
(continued)

- For *all waveforms* used with burst, if the carrier frequency is set less than or equal to *100 Hz*, the following relationship applies.

$$\frac{\text{Burst Count}}{\text{Carrier Frequency}} \leq 500 \text{ seconds} \qquad \textit{For Carrier} \leq \textit{100 Hz}$$

If you attempt to set the carrier frequency to a value that is not valid, the function generator will automatically adjust the frequency to the minimum value allowed with the present burst count.

From the front panel, "MIN VALUE" is displayed and the frequency is adjusted. From the remote interface, a *-221, "Settings conflict"* error is generated and the frequency is adjusted.

- For the *triggered* burst mode, the sync signal is a TTL "low" while the specified number of cycles is output (for the duration of the burst). After the specified number of cycles has been output, the sync signal goes "high" until the next burst. The sync signal is output from the front-panel *SYNC* terminal.

- For the *external gated* burst mode, the sync signal is a TTL "high" when the output is positive, relative to zero volts (or the dc offset value). The signal is a TTL "low" when the output is negative, relative to zero volts (or the dc offset value). The sync signal is output from the front-panel *SYNC* terminal.

- *Front-Panel Operation*: Press the Freq key and select any valid frequency for the selected function (the present amplitude and offset voltage are used).

- *Remote Interface Operation*:

      FREQuency {<*frequency*>|MINimum|MAXimum}

You can also use the APPLy command to select the function, frequency, amplitude, and offset of the carrier with a single command.

Burst Count

The *burst count* defines the number of cycles to be output per burst.
Used only in the triggered burst mode (internal or external source).

---

*Certain combinations of burst count and carrier frequency are not
allowed. If you attempt to specify a burst count that is not valid,
the function generator will automatically adjust the count to
the maximum value allowed with the present carrier frequency.*

*Make sure you note the restrictions in "Burst Carrier Frequency" starting
on page 85 before setting the burst count.*

3

- Burst count: **1** to 50,000 cycles, in 1 cycle increments. You can also
  select an infinite burst count. *The default is 1 cycle.*

- When the *internal* trigger source is selected, the specified number of
  cycles is output continuously at a rate determined by the *burst rate*
  setting. The burst rate frequency defines the interval between bursts.

- When the *single* or *external* trigger source is selected, the *burst count*
  and *burst phase* remain in effect but the *burst rate* is ignored. The
  specified number of cycles is output each time ⌐Single⌐ is pressed or
  when a trigger signal is applied to the *Ext Trig* terminal. The function
  generator is triggered on the *rising edge* of a TTL pulse.

- When the *external gate* burst source is selected, the burst count,
  burst rate, burst phase, and burst trigger source are ignored
  (these parameters are used for the triggered burst mode only).

- *Front-Panel Operation*:

      4: BURST CNT   **(MOD MENU)**

- *Remote Interface Operation*:

      BM:NCYCles {<#*cycles*>|INFinity|MINimum|MAXimum}

Burst Rate

The *burst rate* defines the frequency at which *internally* triggered bursts are generated. The burst rate frequency defines the interval between bursts. *Used only in the internal triggered burst mode.*

Keep in mind that the burst rate is different than the "carrier frequency" which specifies the frequency of the bursted signal.

- Burst rate: 10 mHz to 50 kHz. *The default is 100 Hz.*

- The burst rate setting is used only when *internal* triggering is enabled (triggered mode). The burst rate is ignored when single triggering or external triggering is enabled.

- When the *single* or *external* trigger source is selected (triggered mode), the *burst count* and *burst phase* remain in effect but the *burst rate* is ignored.

- When the *external gate* burst source is selected ("gated" burst mode), the burst count, burst rate, burst phase, and burst trigger source are ignored (these parameters are used for the triggered burst mode only).

- It is possible to specify a burst rate which is too fast for the function generator to output with the specified carrier frequency and burst count. If the burst rate is too high, the function generator will internally adjust it as needed to continuously re-trigger the burst. The adjustment is handled internally by the function generator (the burst rate displayed or queried will be the same as specified).

- *Front-Panel Operation*:

      5: BURST RATE   **(MOD MENU)**

- *Remote Interface Operation*:

      BM:INTernal:RATE {*<frequency>*|MINimum|MAXimum}

Burst Phase

The *burst phase* defines the starting phase of the burst.

- Burst phase: -360 degrees to +360 degrees, in 0.001 degree increments.
  The default is 0 degrees.

- For *sine*, *square*, *triangle*, and *ramp* waveforms, 0 degrees is the point
  at which the waveform crosses zero volts (or the dc offset value), in a
  positive-going direction.

- For *arbitrary* waveforms, 0 degrees is the first data point downloaded
  to memory.

- When the *external gate* source is selected ("gated" burst mode),
  the burst count, burst rate, burst phase, and burst trigger source are
  ignored (these parameters are used for the triggered burst mode only).

- *Front-Panel Operation*:

```
6: BURST PHAS   (MOD MENU)
```

- *Remote Interface Operation*:

```
BM:PHASe {<degrees>|MINimum|MAXimum}
```

3

Frequency-Shift Keying (FSK) Modulation

You can configure the function generator to "shift" its output frequency between two preset values using FSK modulation. The rate at which the output shifts between the two frequencies (called the "carrier frequency" and the "hop frequency") is determined by the internal rate generator or the signal level on the rear-panel *FSK* terminal. *The function generator can produce an FSK waveform using sine, square, triangle, ramp, and arbitrary waveforms.*

For more information on the fundamentals of FSK Modulation, refer to chapter 7, "Tutorial".

To Select FSK Modulation

- The **FSK** annunciator turns on when FSK is enabled.

- Only one modulation mode can be enabled at a time. When you enable FSK, the previous modulation mode is turned off.

- *Front-Panel Operation*: Enable FSK *before* you set up the other modulation parameters. Press Shift FSK to output the waveform using the present settings for frequency, amplitude, and offset voltage.

- *Remote Interface Operation*: To ensure proper operation, you should enable FSK *after* you have set up the other modulation parameters.

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

FSK Carrier Frequency

- Carrier frequency: 10 mHz to 15 MHz (100 kHz for triangle and ramp). *The default is 1 kHz*. You can use sine, square, ramp, triangle, or arbitrary waveforms for the carrier waveform.

- For *arbitrary waveforms*, the maximum carrier frequency depends on the number of points specified in the waveform. The five built-in arbitrary waveforms can be output at a maximum of 5 MHz.

Number of Arb Points	Minimum Frequency	Maximum Frequency
8 to 8,192 (8k)	10 mHz	5 MHz
8,193 to 12,287 (12k)	10 mHz	2.5 MHz
12,288 to 16,000	10 mHz	200 kHz

- For an externally-controlled FSK waveform, the carrier frequency is output when a "low" TTL level is applied to the *FSK* terminal. The hop frequency is output when a "high" TTL level is applied.

- For FSK, the sync signal is referenced to the FSK "hop" signal (not the carrier). A momentary TTL "high" pulse (> 200 ns) is output on the transition to the "hop" frequency. The signal is output from the front-panel *SYNC* terminal.

- *Front-Panel Operation*:   Press the ⌑Freq⌑ key and select any valid frequency for the selected function (the present amplitude and offset voltage are used).

- *Remote Interface Operation*:

      FREQuency {<*frequency*>|MINimum|MAXimum}

  You can also use the APPLy command to select the function, frequency, amplitude, and offset of the carrier with a single command.

FSK "Hop" Frequency

- Hop frequency: 10 mHz to 15 MHz (100 kHz for triangle and ramp). *The default is 100 Hz.* You can use sine, square, ramp, triangle, or arbitrary waveforms for the hop frequency waveshape.

- For *arbitrary waveforms*, the maximum hop frequency depends on the number of points specified in the waveform. The five built-in arbitrary waveforms can be output at a maximum of 5 MHz.

Number of Arb Points	Minimum Frequency	Maximum Frequency
8 to 8,192 (8k)	10 mHz	5 MHz
8,193 to 12,287 (12k)	10 mHz	2.5 MHz
12,288 to 16,000	10 mHz	200 kHz

- For an externally-controlled FSK waveform, the carrier frequency is output when a "low" TTL level is applied to the *FSK* terminal. The hop frequency is output when a "high" TTL level is applied.

- For FSK, the sync signal is referenced to the FSK "hop" signal (not the carrier). A momentary TTL "high" pulse (> 200 ns) is output on the transition to the "hop" frequency. The signal is output from the front-panel *SYNC* terminal.

- *Front-Panel Operation*:   After enabling FSK, press *Recall Menu* to go directly to the FSK FREQ command in the menu.

      8: FSK FREQ   **(MOD MENU)**

- *Remote Interface Operation*:

      FSKey:FREQuency {*<frequency>*|MINimum|MAXimum}

3

FSK Rate

The *FSK rate* is the rate at which the output frequency "shifts" between the carrier frequency and the hop frequency when you select the internal FSK source.

- FSK rate (internal source): 10 mHz to 50 kHz. *The default is 10 Hz*.

- The FSK rate is ignored when the external source is selected.

- *Front-Panel Operation*:

    ```
    9: FSK RATE   (MOD MENU)
    ```

- *Remote Interface Operation*:

    ```
    FSKey:INTernal:RATE {<rate in Hz>|MINimum|MAXimum}
    ```

FSK Source

- FSK source: **Internal** or External. *The default is Internal*.

- When the *internal* source is selected, the rate at which the output frequency "shifts" between the carrier frequency and hop frequency is determined by the *FSK rate* specified.

- When the *external* source is selected, the output frequency is determined by the signal level on the rear-panel *FSK* terminal. When a "low" TTL level is present, the carrier frequency is output. When a "high" TTL level is present, the hop frequency is output.

- The maximum external FSK rate is 1 MHz.

- The **Ext** annunciator turns on when the function generator is waiting for an external trigger signal.

- *Front-Panel Operation*:

    ```
    10: FSK SRC   (MOD MENU)
    ```

- *Remote Interface Operation*:

    ```
    FSKey:SOURce {INTernal|EXTernal}
    ```

Frequency Sweep

In the frequency sweep mode, the function generator "steps" from the *start frequency* to the *stop frequency* at a *sweep rate* which you specify. You can sweep up or down in frequency, and with either linear or logarithmic spacing. You can also configure the function generator to output a single sweep (one pass from start frequency to stop frequency) by applying an external trigger. *The function generator can produce a frequency sweep for sine, square, triangle, ramp, or arbitrary waveforms.*

For more information on the fundamentals of frequency sweeps, refer to chapter 7, "Tutorial".

To Select Sweep Modulation

- The **Swp** annunciator turns on when the sweep mode is enabled.

- Only one modulation mode can be enabled at a time. When you enable the sweep mode, the previous modulation mode is turned off.

- *Front-Panel Operation*:   Enable the sweep mode *before* you set up the other sweep parameters. Press ⎡Shift⎤ ⎡Sweep⎤ to output a sweep using the present settings for amplitude and offset voltage.

- *Remote Interface Operation*:   To ensure proper operation, you should enable the sweep mode *after* you have set up the other modulation parameters.

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

Start Frequency and Stop Frequency

The *start frequency* and *stop frequency* set the upper and lower frequency bounds for the sweep. The function generator begins at the start frequency, sweeps to the stop frequency, and then resets back to the start frequency.

- Start and Stop frequencies: 10 mHz to 15 MHz (100 kHz for triangle and ramp). The sweep is phase continuous over the full frequency range. *The default start frequency is 100 Hz. The default stop frequency is 1 kHz.* The `*RST` command sets the start frequency to 10 mHz (*minimum*) and the stop frequency to 15 MHz (*maximum*).

- For *arbitrary waveforms*, the maximum start or stop frequency depends on the number of points specified in the waveform. The five built-in arbitrary waveforms can be output at a maximum of 5 MHz.

Number of Arb Points	Minimum Frequency	Maximum Frequency
8 to 8,192 (8k)	10 mHz	5 MHz
8,193 to 12,287 (12k)	10 mHz	2.5 MHz
12,288 to 16,000	10 mHz	200 kHz

- To sweep **up** in frequency, set the start frequency **<** stop frequency. To sweep **down** in frequency, set the start frequency **>** stop frequency.

- The sync signal is a TTL "low" at the start of the sweep (when the start frequency is output) and is a TTL "high" at the end of the sweep (when the stop frequency is output). The signal is output from the front-panel *SYNC* terminal.

- *Front-Panel Operation*: After enabling sweeps, press *Recall Menu* to go directly to the START F command in the menu.

```
1: START F   (SWP MENU)
2: STOP F    (SWP MENU)
```

- *Remote Interface Operation*:

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

Sweep Time

The *sweep time* specifies the number of seconds required to sweep from the start frequency to the stop frequency. The number of frequency points in the sweep depends on the sweep time you select and is automatically calculated by the function generator.

- Sweep time: 1 ms to 500 seconds. *The default is 1 second.*

- The function generator computes between 2,048 and 4,096 frequency points from the start frequency to the stop frequency.

- *Front-Panel Operation*:

  ```
  3: SWP TIME   (SWP MENU)
  ```

- *Remote Interface Operation*:

  ```
  SWEep:TIME {<seconds>|MINimum|MAXimum}
  ```

Sweep Mode

You can sweep with either linear or logarithmic spacing. The output frequency of a *linear* sweep changes linearly during the duration of the sweep. For *logarithmic* spacing, the output frequency changes exponentially during the duration of the sweep.

- Sweep mode: **Linear** or Logarithmic. *The default is Linear.*

- *Front-Panel Operation*:

  ```
  4: SWP MODE   (SWP MENU)
  ```

- *Remote Interface Operation*:

  ```
  SWEep:SPACing {LINear|LOGarithmic}
  ```

Sweep Trigger Source

In the *triggered sweep* mode, the function generator outputs a single sweep each time a trigger is received. After one sweep from the start frequency to the stop frequency, the function generator waits for the next trigger while outputting the start frequency.

- Sweep trigger source: **Internal**, Single, or External. *The default is Internal.*

- When the *internal* trigger source is enabled (default), the function generator outputs a continuous sweep at a rate determined by the *sweep rate* specified.

- Pressing ⌷Single⌷ to enable the *single* trigger mode also enables the *external* trigger mode. External triggering is like the front-panel single trigger mode except that you apply a trigger signal to the rear-panel *Ext Trig* terminal. The function generator is triggered on the *rising edge* of a TTL pulse.

- The **Trig** annunciator turns on when the function generator is waiting for a single or external trigger.

- *Front-Panel Operation*: Pressing ⌷Single⌷ to enable the single trigger mode also enables the external trigger mode. Press ⌷Shift⌷ ⌷Internal⌷ to enable the internal trigger mode.

- *Remote Interface Operation*:

      TRIGger:SOURce {IMMediate|EXTernal|BUS}

See "Triggering" on page 98 for more information.

3

Triggering

Applies only to bursts and frequency sweep. You can issue triggers for
bursts and sweeps using *internal* triggering, *single* triggering, or
external triggering.

- Internal or "automatic" triggering is enabled when you turn on the
  function generator. In this mode, the function generator outputs
  continuously when the burst mode or sweep mode is selected.

- Single triggering outputs one burst or initiates one sweep each time
  you press Single from the front-panel. Continue pressing this key to
  re-trigger the function generator.

- Pressing Single to enable the *single* trigger mode also enables the
  external trigger mode. External triggering is like the front-panel
  single trigger mode except that you apply a trigger signal to the
  rear-panel *Ext Trig* terminal. The function generator is triggered on
  the *rising edge* of a TTL pulse.

- The Single key is disabled when in remote (the **Rmt** annunciator
  turns on when in remote) and when a function other than burst or
  sweep is selected.

Trigger Source Choices

Applies only to burst and sweep. You must specify the source from which the function generator will accept a trigger.

- From the *front panel*, the function generator will accept a single trigger, a hardware trigger from the *Ext Trig* terminal, or continuously output bursts or sweeps using the internal trigger. *At power-on, internal trigger is selected.*

- From the *remote interface*, the function generator will accept a software (bus) trigger, a hardware trigger from the *Ext Trig* terminal, or an immediate internal trigger.

- The trigger source setting is stored in *volatile* memory; the source is set to internal trigger (front panel) or immediate (remote interface) when power has been off or after a remote interface reset.

- To select the trigger source from the remote interface, use the following command. The APPLy command automatically sets the trigger source to IMMediate.

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

Internal Triggering In this trigger mode, the function generator continuously outputs the burst or sweep (as specified by the *burst rate* or *sweep time*). This is the power-on trigger source for both front-panel and remote interface use.

To select the internal trigger source from the remote interface, use the following command. The APPLy command automatically sets the trigger source to IMMediate.

```
"TRIGGER:SOURCE IMMEDIATE"
```

Single Triggering In the single trigger mode (front panel only), you can manually trigger the function generator by pressing the front-panel ⌐Single⌐ key. The function generator outputs one burst or initiates one sweep each time you press the key. The **Trig** annunciator turns on when the function generator is waiting for a single trigger.

The front-panel ⌐Single⌐ *key is disabled when in remote.*

External Triggering In this trigger mode, the function generator will accept a hardware trigger applied to the *Ext Trig* terminal. The function generator outputs one burst or initiates one sweep each time *Ext Trig* receives the *rising edge* of a TTL pulse.

See also "Ext Trig/FSK/Burst Input Terminal," on page 102.

- *Front-Panel Operation*: The external trigger mode is like the single trigger mode except that you apply the trigger to the *Ext Trig* terminal. Pressing ⌐Single⌐ to enable the single trigger mode also enables the external trigger mode. The **Trig** annunciator turns on when the function generator is waiting for an external trigger.

  The front-panel ⌐Single⌐ *key is disabled when in remote.*

- *Remote Interface Operation*:

      TRIGger:SOURce EXTernal

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Software (Bus) Triggering The bus trigger mode is available only from the remote interface. This mode is similar to the single trigger mode from the front panel, but you trigger the function generator by sending a bus trigger command. The function generator outputs one burst or initiates one sweep each time the trigger command is received.

- To select the bus trigger source, send the following command.

  ```
  "TRIGGER:SOURCE BUS"
  ```

- To trigger the function generator from the remote interface (HP-IB or RS-232), send the *TRG (trigger) command.

- You can also trigger the function generator from the HP-IB interface by sending the IEEE-488 Group Execute Trigger (GET) message. The following statement shows how to send a GET using *HP BASIC*.
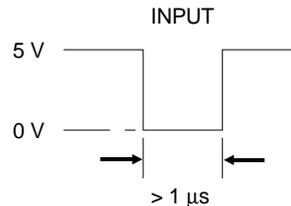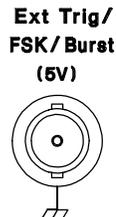
  ```
  TRIGGER 710        Group Execute Trigger
  ```

- The following statement shows how to send a trigger from the HP-IB interface using the HP-IB Command Library for *C* or *QuickBASIC*.

  ```
  IOTRIGGER (710)
  ```

3

Ext Trig / FSK / Burst Input Terminal

This terminal is used in the following modes:

- *Triggered Sweep Mode*: Press `Single` or execute `TRIG:SOUR EXT` from the remote interface to enable the triggered sweep mode (sweeps must be enabled). When the *rising edge* of a TTL pulse is received on the *Ext Trig* terminal, the function generator outputs a single sweep. The **Trig** annunciator turns on when the function generator is waiting for a trigger.

- *Externally-Modulated FSK Mode*: To enable the externally-modulated mode, select "FSK SRC EXT" from the front-panel MOD MENU or execute `FSK:SOUR EXT` from the remote interface when FSK is enabled. When a *low* TTL level is present, the FSK carrier frequency is output. When a *high* TTL level is present, the FSK "hop" frequency is output. The **Ext** annunciator turns on when selected.

- *Triggered Burst Mode*: Press `Single` or execute `TRIG:SOUR EXT` from the remote interface to enable the triggered burst mode (burst must be enabled). When the *rising edge* of a TTL pulse is received, the function generator outputs a burst waveform with the specified number of cycles. The **Trig** annunciator turns on when the function generator is waiting for a trigger.

- *External Gated Burst Mode*: To enable the external gated mode, select "BURST SRC EXT GATED" from the front-panel MOD MENU or execute `BM:SOUR EXT` from the remote interface when burst is enabled. When a *high* TTL level is present, the function generator outputs the carrier waveform. When a *low* TTL level is present, the output is disabled. The **Ext** annunciator turns on when selected.

Arbitrary Waveforms

There are five built-in arbitrary waveforms stored in non-volatile memory. You can also download up to four user-defined waveforms into non-volatile memory. Each waveform can contain between 8 and 16,000 data points.

Refer to chapter 7, "Tutorial", for more information on the internal operation of downloading and outputting an arbitrary waveform.

3

Creating and Storing an Arbitrary Waveform

This section gives an example which shows you how to create and store an arbitrary waveform from the *front panel*. To download an arbitrary waveform from the *remote interface*, see "Arbitrary Waveform Commands" starting on page 174. For this example, you will create and store a pulse waveform containing 400 points.

Shift

Menu On/Off

1 Turn on the menu.

```
A: MOD MENU
```

>		>
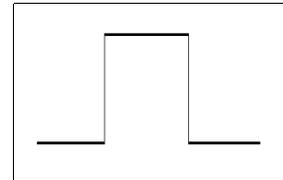
2 Move across to the EDIT MENU choice on this level.

```
C: EDIT MENU
```

∨

3 Move down a level to the NEW ARB command.

There are seven command choices available in the EDIT MENU. However, you can access only two of the choices (NEW ARB and DELETE) until you either clear volatile memory or load an existing user-defined waveform.

```
1: NEW ARB
```

∨

4 Move down a level to the "PARAMETER" choices.

The first parameter choice is "CLEAR MEM" for the NEW ARB command. If you have previously downloaded any user-defined waveforms, you will also see commands like "GET ARB1" on this level (to load the specified waveform into volatile memory).

```
CLEAR MEM
```

Enter

5 Turn on the waveform edit mode.

The function generator beeps and displays a message to show that the waveform edit mode is now enabled. You are then exited from the menu.

```
LOADING
```

Shift

< Recall Menu

6 Use *Recall Menu* to return to the NEW ARB command.

```
1: NEW ARB
```

>

7 Move across to the POINTS command on this level.

```
2: POINTS
```

∨

8 Move down a level and set the number of points to "400".

```
∧00400 PNTS
```

Enter

9 Save the change and turn off the menu.

The function generator beeps and displays a message to show that the change is now in effect. You are then exited from the menu.

```
COMPUTING
```

Shift

< Recall Menu

10 Use *Recall Menu* to return to the POINTS command.

```
2: POINTS
```

3

For this example, the pulse waveform will be "high" for one-half of the cycle (for 200 of the 400 points). From the front panel, each waveform point is a floating-point value between -1 and +1, which correspond to the peak values of the waveform. To define the waveform points, use the LINE EDIT command in the EDIT MENU. The function generator temporarily rescales the waveform amplitude between -1 and +1 at 1 kHz.

>

11 Move across to the LINE EDIT command on this level.

```
3: LINE EDIT
```

∨

12 Move down a level and set point "100" to a value of "1".

Use the left/right arrow keys to move between the point field (left) and the floating-point value (right). The comma (**,**) at the right side of the display indicates that the displayed value is the start point. For this example, the first 99 points in the waveform remain at "0".

```
00100:+1.0000,
```

Enter

13 Press "Enter" to store the start point and move to the end point.

14 Increment to point "299" and set the end point to a value of "1".

Use the left/right arrow keys to move between the point field (left) and the floating-point value (right). As you modify the value, the end point is output. When you press the Enter key, the line between the start point and end point is calculated, output, and stored. If you exit without pressing the Enter key, the start point and stop point are restored.

```
00299:+1.0000
```

Enter

15 Save the start and stop points and output the waveform.

```
COMPUTING
```

Shift

Menu On/Off

16 Save the waveform and turn off the menu.

The function generator beeps and displays a message to show that the waveform is now stored in volatile memory. You are then exited from the menu.

```
EXITING
```

Shift

<   Recall Menu

17 Use *Recall Menu* to return to the LINE EDIT command.

```
3: LINE EDIT
```

>   >   >

18 Move across to the SAVE AS command on this level.

```
6: SAVE AS
```

$\boxed{\lor}$

19 Move down a level to save the waveform in non-volatile memory.

At this point, the pulse waveform is being output from volatile memory. You can store up to four user-defined waveforms in non-volatile memory. From the front panel, you can save the waveform using one of the following names: ARB1, ARB2, ARB3, or ARB4.

```
ARB1 *NEW*
```

$\boxed{\text{Enter}}$

20 Save the waveform and turn off the menu.

The function generator beeps and displays a message to show that the waveform is being saved. You are then exited from the menu.

```
SAVING
```

The waveform is now stored in non-volatile memory and is output from the function generator. The name that you used to store the waveform should appear in the waveform list (press $\boxed{\text{Arb List}}$).

3

Additional Information on Arbitrary Waveforms

- Press the $\boxed{\text{Arb}}$ key to output the arbitrary waveform currently selected (to scroll through the waveform choices and make a selection, press $\boxed{\text{Arb List}}$).

- In addition to creating a new arbitrary waveform from the front panel, you can also edit any existing user-defined waveforms. You can edit waveforms created either from the front panel or from the remote interface. However, you cannot edit any of the five built-in arbitrary waveforms.

  Use the "GET" option under the NEW ARB command in the EDIT MENU to load an existing user-defined waveform. Then, use the LINE EDIT, POINT EDIT, and INVERT commands to edit the waveform.

- The INVERT command in the EDIT MENU takes the inverse of each point in the specified waveform by changing the sign.

- You can use the DELETE command in the EDIT MENU to delete any user-defined waveforms in volatile memory. A list of all user-defined waveforms appears when you move to the DELETE command.

System-Related Operations

This section gives information on topics such as power-down recall, self-test, error conditions, and front-panel display control. This information is not directly related to waveform generation but is an important part of operating the function generator.

Power-Down Recall Mode

When power is turned off, the function generator automatically stores its state in memory location "0". You can configure the function generator to automatically recall the power-down state when power is restored. The recall mode is *disabled* when the function generator is shipped from the factory.

The power-down recall mode can be set from the front-panel only.

- When the recall mode is *disabled* (factory setting), the function generator powers up in its default configuration (see page 123). When the recall mode is *enabled*, the function generator powers up in the power-down configuration.

- The power-down recall setting is stored in *non-volatile* memory, and *does not* change when power has been off or after a remote interface reset.

- The power-down recall mode "remembers" the function (including arbitrary waveforms), frequency, amplitude, dc offset, duty cycle, as well as any modulation parameters.

- Any arbitrary waveforms downloaded to "VOLATILE" memory *are not* remembered. However, if an arbitrary waveform is being output from *non-volatile* memory when the state is stored, the waveform data is stored. The stored waveform is output when the instrument state is recalled.

- *Front-Panel Operation*:

      2: POWER ON   **(SYS MENU)**

  To *enable* the recall mode, select the "LAST STATE" choice.
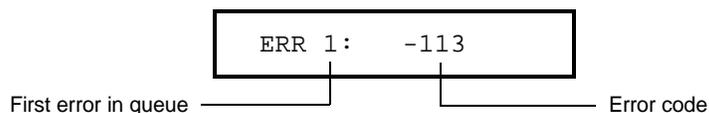 To *disable* the recall mode, select the "DEFAULT" choice.

3

Error Conditions

When the front-panel **ERROR** annunciator turns on, one or more
command syntax or hardware errors have been detected. A record of
up to 20 errors can be stored in the function generator's *error queue*.
See chapter 5, "Error Messages," for a complete listing of the errors.

- Errors are retrieved in first-in-first-out (FIFO) order. The first error
  returned is the first error that was stored. When you have read all
  errors from the queue, the **ERROR** annunciator turns off. The function
  generator beeps once each time an error is generated.

- If more than 20 errors have occurred, the last error stored in the
  queue (the most recent error) is replaced with *-350, "Too many errors"*.
  No additional errors are stored until you remove errors from the
  queue. If no errors have occurred when you read the error queue,
  the function generator responds with *+0, "No error"*.

- The error queue is cleared when power has been off or after a *CLS
  (clear status) command has been executed. The *RST (reset)
  command *does not* clear the error queue.

- *Front-Panel Operation*:

      3: ERROR   **(SYS MENU)**

  If the **ERROR** annunciator is on, press $\boxed{\text{Shift}}$ $\boxed{<}$ (Recall Menu) to read
  the errors stored in the queue. The errors are listed *horizontally* on
  the "PARAMETER" level. All errors are cleared when you go to the
  "PARAMETER" level and then turn off the menu.

      ┌─────────────────────────┐
      │   ERR 1:   -113   │
      └─────────────────────────┘

  First error in queue ──────────┘   └────────── Error code

- *Remote Interface Operation*:

      SYSTem:ERRor?   *Reads one error from the error queue*

  Errors have the following format (the error string may contain
  up to *80 characters*):

      -113,"Undefined header"

3

Self-Test

- A *power-on* self-test occurs automatically when you turn on the function generator. This limited test assures you that the function generator is operational.

- A *complete* self-test runs a series of tests and takes approximately 10 seconds to execute. If all tests pass, you can have a high confidence that the function generator is fully operational.

- If the complete self-test is successful, "PASS" is displayed on the front panel. If the self-test fails, "FAIL" is displayed and the **ERROR** annunciator turns on. See the *Service Guide* for instructions on returning the function generator to Hewlett-Packard for service.

- *Front-Panel Operation*:

  ```
  4: TEST  (SYS MENU)
  ```

  Another way to perform the complete self-test from the front panel is as follows: Hold down ⌐Shift⌐ as you press the Power switch to turn on the function generator; *hold down the key for more than 5 seconds*. The self-test will begin when you release the key.

- *Remote Interface Operation*:

  ```
  *TST?
  ```

  Returns "0" if the self-test passes or "1" if it fails. If the self-test fails, an error message is also generated with additional information on why the test failed.

Display Control

To speed up the rate at which the function generator can make configuration changes, or for security reasons, you may want to turn off the front-panel display. From the remote interface, you can also display a message containing up to 11 characters on the front panel.

The display can be enabled/disabled from the remote interface only.

- When the display is turned off, output parameters are not sent to the display and all annunciators except **ERROR** and **Shift** are disabled. Front-panel operation is otherwise unaffected by turning off the display.

- The display state is stored in *volatile* memory; the display is always enabled when power has been off or after a remote interface reset.

- You can display a message on the front panel by sending a command from the remote interface. The function generator can display up to 11 characters of the message on the front panel; any additional characters are truncated. Commas, periods, and semicolons share a display space with the preceding character, and *are not* considered individual characters. When a message is displayed, information relating to the output waveform (such as frequency and amplitude) is not sent to the display.

- Sending a message to the display from the remote interface overrides the display state; this means that you can display a message even if the display is turned off.

- The display state is automatically turned on when you return to the local (front panel) state. Press the ⎡Shift⎤ key or execute `LOCAL 710` from the remote interface to return to the local state.

- *Remote Interface Operation*:

  ```
  DISPlay {OFF|ON}                  Disable/enable the display
  DISPlay:TEXT <quoted string>      Display the string enclosed in quotes
  DISPlay:TEXT:CLEar                Clear the displayed message
  ```
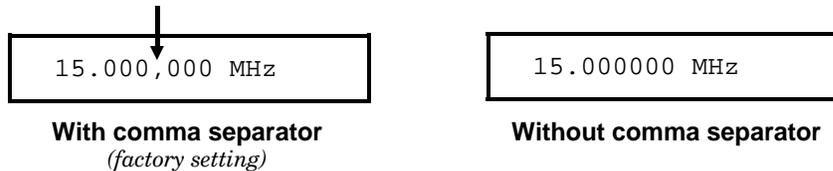
  The following command string shows how to display a message on the front panel.

  ```
  "DISP:TEXT 'HELLO'"
  ```

Comma Separators

The function generator can display values on the front panel with or without a comma separator. *This feature is available only from the front panel.*

```
 15.000,000 MHz
```

With comma separator
(factory setting)

```
 15.000000 MHz
```

Without comma separator

- The display format is stored in *non-volatile* memory, and *does not* change when power has been off or after a remote interface reset. The comma separator is *enabled* when the function generator is shipped from the factory.

- *Front-Panel Operation*:

    5: COMMA **(SYS MENU)**

  See also "To turn off the comma separator," on page 52.

Firmware Revision Query

The function generator has three microprocessors for control of various internal systems. You can query the function generator to determine which revision of firmware is installed for each microprocessor.

- The function generator returns three numbers. The first number is the firmware revision number for the *main generator processor*; the second is for the *input/output processor*; and the third is for the *front-panel processor*.

- *Front-Panel Operation*:

    6: REVISION **(SYS MENU)**   `X.X–X.X–X.X`

- *Remote Interface Operation*:

    *IDN?   *Returns* "HEWLETT-PACKARD,33120A,0,X.X-X.X-X.X"

  Be sure to dimension a string variable with at least 40 characters.

Remote Interface Configuration

This section gives information on configuring the remote interface. For information on programming the function generator over the remote interface, see chapter 4, "Remote Interface Reference," starting on page 125.

HP-IB Address

Each device on the HP-IB (IEEE-488) interface must have a unique address. You can set the function generator's address to any value between 0 and 30. The current address is displayed momentarily on the front panel when you turn on the function generator. *The address is set to "10" when the function generator is shipped from the factory.*

The HP-IB address can be set from the front-panel only.

- The address is stored in *non-volatile* memory, and *does not* change when power has been off or after a remote interface reset.

- Your HP-IB bus controller has its own address. Be sure to avoid using the bus controller's address for any instrument on the interface bus. Hewlett-Packard controllers generally use address "21".

- *Front-Panel Operation*:

      1: HPIB ADDR **(I/O MENU)**

  See also "To set the HP-IB address," on page 217.

Remote Interface Selection

The function generator is shipped with both an HP-IB (IEEE-488) interface and an RS-232 interface. Only one interface can be enabled at a time. The *HP-IB interface* is selected when the function generator is shipped from the factory.

The remote interface can be selected from the front-panel only.

- The interface selection is stored in *non-volatile* memory, and *does not* change when power has been off or after a remote interface reset.

- If you select the HP-IB interface, you must select a unique address for the function generator. The current address is displayed momentarily on the front panel when you turn on the function generator.

- Your HP-IB bus controller has its own address. Be sure to avoid using the bus controller's address for any instrument on the interface bus. Hewlett-Packard controllers generally use address "21".

- If you enable the RS-232 interface, you must select the baud rate and parity to be used. "RS-232" is displayed momentarily on the front panel when you turn on the function generator if you have selected this interface.

- *Front-Panel Operation*:

    2: INTERFACE **(I/O MENU)**

See also "To select the remote interface," on page 218.

Refer to "RS-232 Interface Configuration," starting on page 195 for more information on connecting the function generator to a computer, terminal, or modem over the RS-232 interface.

3

Baud Rate Selection (RS-232)

You can select one of six baud rates for RS-232 operation. The rate is set to *9600 baud* when the function generator is shipped from the factory.

The baud rate can be set from the front-panel only.

- Select one of the following: 300, 600, 1200, 2400, 4800, or **9600** baud. *The factory setting is 9600 baud*.

- The baud rate selection is stored in *non-volatile* memory, and *does not* change when power has been off or after a remote interface reset.

- *Front-Panel Operation*:

    3: BAUD RATE   **(I/O MENU)**

See also "To set the baud rate," on page 219.

Parity Selection (RS-232)

You can select the parity for RS-232 operation. The function generator is configured for *no parity and 8 data bits* when shipped from the factory.

The parity can be set from the front-panel only.

- Select one of the following: **None** (*8 data bits*), Even (*7 data bits*), or Odd (*7 data bits*). When you set the parity, you are indirectly setting the number of data bits.

- The parity selection is stored in *non-volatile* memory, and *does not* change when power has been off or after a remote interface reset.

- To download binary data for arbitrary waveforms over the RS-232 interface, you must select *8 data bits* with *no parity*.

- *Front-Panel Operation*:

    4: PARITY **(I/O MENU)**

See also "To set the parity," on page 220.

Programming Language Query

The function generator complies with the rules and conventions of the present version of SCPI (*Standard Commands for Programmable Instruments*). You can verify from the front-panel that the SCPI language is selected.

The interface language can be queried from the front-panel only.

- *Front-Panel Operation*:

    5: LANGUAGE **(I/O MENU)**

3

SCPI Language Version Query

You can determine the SCPI version with which the function generator is in compliance by sending a query from the remote interface.

The SCPI version can be queried from the remote interface only.

- *Remote Interface Operation*:

    SYSTem:VERSion?

    Returns a string in the form "YYYY.V" where the "Y's" represent the year of the version, and the "V" represents a version number for that year (for example, 1993.0).

Calibration Overview

This section gives an overview of the calibration features of the function generator. For a more detailed discussion of the calibration procedures, see chapter 4 in the *Service Guide*.

Calibration Security

This feature allows you to enter a security code to prevent accidental or unauthorized calibrations of the function generator. When you first receive your function generator, it is secured. Before you can calibrate the function generator, you must unsecure it by entering the correct security code.

- *The security code is set to "HP033120" when the function generator is shipped from the factory*. The security code is stored in *non-volatile* memory, and *does not* change when power has been off or after a remote interface reset.

- To secure the function generator from the remote interface, the security code may contain up to 12 alphanumeric characters as shown below. The first character *must be a letter*, but the remaining characters can be letters or numbers. You do not have to use all 12 characters but the first character must always be a letter.

    A _ _ _ _ _ _ _ _ _ _ _   *(12 characters)*

- To secure the function generator from the remote interface so that it can be unsecured from the front panel, use the eight-character format shown below. The first two characters must be "HP" and the remaining characters must be numbers. Only the last six characters are recognized from the front panel, but all eight characters are required. *To unsecure the function generator from the front panel, omit the "HP" and enter the remaining characters as shown on the following pages.*

    H P _ _ _ _ _ _   *(8 characters)*

To Unsecure for Calibration You can unsecure the function
generator for calibration either from the front panel or over the remote
interface. *The function generator is secured when shipped from the
factory and the security code is set to "HP033120".*

- *Front-Panel Operation*:

      1: SECURED   **(CAL MENU)**

  If the function generator is secured, you will see the above command
  when you go into the CAL MENU. (If you move across the "COMMANDS"
  level in the menu, you will notice that the "CALIBRATE" command is
  hidden when the function generator is secured.) To unsecure the
  function generator, go to the "PARAMETER" level of the SECURED
  command, enter the security code, and then press Enter.

  > ∧000000:CODE

  When you go to the "COMMANDS" level in the CAL MENU again,
  you will notice that the function generator is unsecured. Notice also
  that the "CALIBRATE" command is no longer hidden and you can
  perform a calibration.

  > **1:** UNSECURED

- *Remote Interface Operation*:

      CALibration:SECure:STATe {OFF|ON},*<code>*

  To unsecure the function generator, send the above command with
  the same code used to secure calibration. For example,

      "CAL:SEC:STAT OFF,HP033120"

To Secure Against Calibration You can secure the function
generator against accidental calibration either from the front panel or
over the remote interface. *The function generator is secured when
shipped from the factory and the security code is set to "HP033120".*

*Be sure to read the security code rules on page 118 before attempting to
secure the function generator.*

- *Front-Panel Operation*:

    ```
    1: UNSECURED   (CAL MENU)
    ```

    If the function generator is unsecured, you will see the above
    command when you go into the CAL MENU. To secure the function
    generator, go to the "PARAMETER" level of the UNSECURED
    command, enter the security code, and then press `Enter`.

    ```
    ∧000000:CODE
    ```

    When you go to the "COMMANDS" level in the CAL MENU again,
    you will notice that the function generator is secured. Notice also that
    the "CALIBRATE" command is now hidden and you cannot perform a
    calibration.

    ```
    1: SECURED
    ```

- *Remote Interface Operation*:

    ```
    CALibration:SECure:STATe {OFF|ON},<code>
    ```

    To secure the function generator, send the above command with the
    same code as used to unsecure calibration. For example,

    ```
    "CAL:SEC:STAT ON,HP033120"
    ```

To Change the Security Code To change the security code, you must first unsecure the function generator, and then enter a new code. *Be sure to read the security code rules on page 118 before changing the security code.*

- *Front-Panel Operation*: To change the security code, first make sure that the function generator is unsecured. Select the "PARAMETER" level of the UNSECURED command, enter the new security code, and then press Enter. *Changing the code from the front panel also changes the code required from the remote interface.*

- *Remote Interface Operation*:

  CALibration:SECure:CODE <*new code*>

  To change the security code, first unsecure the function generator using the old security code. Then, enter the new code. For example,

  "CAL:SEC:STAT OFF, HP033120" *Unsecure with old code*
  "CAL:SEC:CODE ZZ002133" *Enter new code*

Calibration Count

You can determine the number of times that your function generator has been calibrated. Your function generator was calibrated before it left the factory. When you receive your function generator, read the count to determine its initial value.

- The calibration count is stored in *non-volatile* memory, and *does not* change when power has been off or after a remote interface reset.

- The calibration count increments up to a maximum of 32,767 after which it wraps-around to 0. Since the value increments by one for each calibration point, a complete calibration will increase the value by many counts.

- *Front-Panel Operation*:

  3: CAL COUNT **(CAL MENU)**

- *Remote Interface Operation*:

  CALibration:COUNt?

Calibration Message

You can use the calibration message feature to record calibration information about your function generator. For example, you can store such information as the last calibration date, the next calibration due date, the instrument serial number, or even the name and phone number of the person to contact for a new calibration.

You can record information in the calibration message only from the remote interface. However, you can read the message from either the front-panel menu or the remote interface.

- The calibration message may contain up to 40 characters. However, the function generator can display only 11 characters of the message on the front panel (additional characters are truncated).

- The calibration message is stored in *non-volatile* memory, and *does not* change when power has been off or after a remote interface reset.

- *Front-Panel Operation*:

    4: MESSAGE **(CAL MENU)**   *Read the cal message*

- *Remote Interface Operation*:

    CALibration:STRing *<quoted string>*   *Store the cal message*

    The following command string shows how to store a calibration message.

    "CAL:STR 'CAL 12-10-93'"

Power-On and Reset State

The parameters marked with a bullet (•) are stored in ***non-volatile*** memory.
The factory settings are shown.

3

Output Configuration	**Power-On/Reset State**
Function	Sine wave
Frequency	1 kHz
Amplitude (into 50 ohms)	100 mV peak-to-peak
Offset	0.00 Vdc
Output Units	Volts peak-to-peak
Output Termination	50 ohms

Modulation	**Power-On/Reset State**
AM Carrier Waveform	1 kHz Sine wave
AM Modulating Waveform	100 Hz Sine wave
AM Depth	100%
FM Carrier Waveform	1 kHz Sine wave
FM Modulating Waveform	10 Hz Sine wave
FM Peak Frequency Deviation	100 Hz
Burst Carrier Frequency	1 kHz Sine wave
Burst Count	1 cycle
Burst Rate	100 Hz
Burst Starting Phase	0 degrees
FSK Carrier Waveform	1 kHz Sine wave
FSK "Hop" Frequency	100 Hz Sine wave
FSK Rate	10 Hz
Modulation State	Off
Sweep Start / Stop Frequency	100 Hz / 1 kHz
Sweep Time	1 second
Sweep Mode	Linear

System-Related Operations	**Power-On/Reset State**
• Power-Down Recall	• Disabled
Display Mode	On
• Comma Separators	• On

Triggering Operations	**Power-On/Reset State**
Trigger Source	Internal

Input/Output Configuration	**Power-On/Reset State**
• HP-IB Address	• 10
• Interface	• HP-IB (IEEE-488)
• Baud Rate	• 9600 baud
• Parity	• None (8 data bits)

Calibration	**Power-On/Reset State**
Calibration State	Secured

*For your convenience,
this table is duplicated
on the rear cover of this
manual and on the
Quick Reference Card.*

8

Specifications

WAVEFORMS

Standard Waveforms: Sine, Square, Triangle,
                            Ramp, Noise, DC volts,
                            Sine(x)/x, Negative Ramp,
                            Exponential Rise,
                            Exponential Fall, Cardiac

Arbitrary Waveforms:
  Waveform Length: 8 to 16,000 points
  Amplitude Resolution: 12 bits (including sign)
  Sample Rate: 40 MSa / sec
  Non-Volatile Memory: Four (4) 16k waveforms

FREQUENCY CHARACTERISTICS

Sine: 100 μHz – 15 MHz
Square: 100 μHz – 15 MHz
Triangle: 100 μHz – 100 kHz
Ramp: 100 μHz – 100 kHz
Noise (Gaussian)**:**   10 MHz bandwidth
Arbitrary Waveforms:
  8 to 8,192 points: 100 μHz – 5 MHz
  8,193 to 12,287 points: 100 μHz – 2.5 MHz
  12,288 to 16,000 points: 100 μHz – 200 kHz

Resolution: 10 μHz or 10 digits

Accuracy: 10 ppm in 90 days,
                            20 ppm in 1 year,
                            18°C – 28°C

Temperature Coefficient: < 2 ppm / °C

Aging: < 10 ppm / yr

SINEWAVE SPECTRAL PURITY (into 50Ω)

Harmonic Distortion
  DC to 20 kHz: -70 dBc
  20 kHz to 100 kHz: -60 dBc
  100 kHz to 1 MHz: -45 dBc
  1 MHz to 15 MHz: -35 dBc

Total Harmonic Distortion
  DC to 20 kHz: < 0.04%

Spurious (non-harmonic)
  Output (DC to 1 MHz):   < -65 dBc
  Output (> 1 MHz):   < -65 dBc + 6 dB/octave

Phase Noise: < -55 dBc in a 30 kHz band

SIGNAL CHARACTERISTICS

Square wave
  Rise/Fall Time: < 20 ns
  Overshoot: < 4%
  Asymmetry: 1% + 5 ns
  Duty Cycle: 20% to 80% *(to 5 MHz)*
                            40% to 60% *(to 15 MHz)*

Triangle, Ramp, Arb
  Rise/Fall Time: 100 ns   *(typical)*
  Linearity: < 0.1% of peak output
  Settling Time: < 250 ns to 0.5% of final value
  Jitter: < 25 ns

OUTPUT CHARACTERISTICS [1]

Amplitude (into 50Ω): [2]   50 mVpp – 10 Vpp
  Accuracy (at 1 kHz):   ± 1% of specified output
  Flatness   (sine wave relative to 1 kHz)
    < 100 kHz: ± 1% (0.1 dB)
    100 kHz to 1 MHz: ± 1.5% (0.15 dB)
    1 MHz to 15 MHz: ± 2% (0.2 dB) Ampl ≥ 3Vrms
    1 MHz to 15 MHz: ± 3.5% (0.3 dB) Ampl < 3Vrms

Offset (into 50Ω): [3]   ± 5 Vpk ac + dc
  Accuracy: [4]   ± 2% of setting + 2 mV

Output Impedance: 50 ohms fixed

Resolution: 3 digits, Amplitude and Offset

Output Units: Vpp, Vrms, dBm

Isolation: 42 Vpk maximum to earth

Protection: Short-circuit protected
                            ± 15 Vpk overdrive < 1 minute

(1) Add 1/10th of output amplitude and offset specification
    per °C for operation outside of 18°C to 28°C range
    (1-year specification).

(2) 100 mVpp – 20 Vpp amplitude into open-circuit load.

(3) Offset ≤ 2 X peak-to-peak amplitude.

(4) For square wave outputs, add 2% of output amplitude
    additional error.

MODULATION CHARACTERISTICS

AM Modulation
Carrier -3 dB Freq:	10 MHz *(typical)*
Modulation:	Any internal waveform plus Arb
Frequency:	10 mHz to 20 kHz ($\pm 0.05\%$ to 2.5 kHz, then decreases linearly to $\pm 0.4\%$ at upper limit)
Depth:	0% to 120%
Source:	Internal / External

FM Modulation
Modulation:	Any internal waveform plus Arb
Frequency:	10 mHz to 10 kHz ($\pm 0.05\%$ to 600 Hz, then decreases linearly to $\pm 0.8\%$ at upper limit)
Peak Deviation:	10 mHz to 15 MHz
Source:	Internal Only

Burst Modulation
Carrier Frequency:	5 MHz max.
Count:	1 to 50,000 cycles, or Infinite
Start Phase:	-360° to +360°
Internal Rate:	10 mHz to 50 kHz $\pm 1\%$
Gate Source:	Internal or External Gate [1]
Trigger Source:	Single, External, or Internal Rate

FSK Modulation
Frequency Range:	10 mHz to 15 MHz ($\pm 0.05\%$ to 600 Hz, then decreases linearly to $\pm 4\%$ at upper limit)
Internal Rate:	10 mHz to 50 kHz
Source:	Internal / External (1 MHz max.)

FREQUENCY SWEEP

Type:	Linear or Logarithmic
Direction:	Up or Down
Start F / Stop F:	10 mHz to 15 MHz
Time:	1 ms to 500 sec $\pm 0.1\%$
Source:	Single, External, or Internal

REAR-PANEL INPUTS

External AM Modulation:	± 5 Vpk = 100% Modulation 5 kΩ Input Resistance

External Trigger/FSK
Burst Gate: [1]	TTL (low true)
Latency:	1.3 μs
Jitter:	25 ns

SYSTEM CHARACTERISTICS

Configuration Times [2]
Function Change: [3]	80 ms
Frequency Change: [3]	30 ms
Amplitude Change:	30 ms
Offset Change:	10 ms
Select User Arb:	100 ms
Modulation Parameter Change:	< 350 ms

Arb Download Times over HP-IB:

Arb Length	*Binary*	*ASCII Integer*	*ASCII Real* [4]
16,000 points	8 sec	81 sec	100 sec
8,192 points	4 sec	42 sec	51 sec
4,096 points	2.5 sec	21 sec	26 sec
2,048 points	1.5 sec	11 sec	13 sec

Arb Download Times over RS-232 at 9600 Baud: [5]

Arb Length	*Binary*	*ASCII Integer*	*ASCII Real* [6]
16,000 points	35 sec	101 sec	134 sec
8,192 points	18 sec	52 sec	69 sec
4,096 points	10 sec	27 sec	35 sec
2,048 points	6 sec	14 sec	18 sec

(1) Trigger source ignored when External Gate is selected.

(2) Time to change parameter and output the new signal.

(3) Modulation or sweep off.

(4) Times for 5-digit and 12-digit numbers.

(5) For 4800 baud, multiply the download times by two;
      For 2400 baud, multiply the download times by four, etc.

(6) Time for 5-digit numbers. For 12-digit numbers,
      multiply the 5-digit numbers by two.

8

GENERAL SPECIFICATIONS

Power Supply: [1]   100V / 120V / 220V / 240V $\pm$10%
(switch selectable)

Power-Line Frequency: 45 Hz to 66 Hz and 360 Hz to 440 Hz. Automatically sensed at power-on.

Power Consumption: 50 VA peak (28 W average)

Operating Environment: 0°C to 55°C
80% Relative Humidity to 40°C

Storage Environment: -40°C to 70°C

State Storage Memory: Power-off state automatically saved. Three (3) User-Configurable Stored States, Arbitrary waveforms stored separately.

Dimensions (W x H x D)
  Bench Top: 254.4 mm x 103.6 mm x 374 mm
  Rack Mount: 212.6 mm x 88.5 mm x 348.3 mm

Weight: 4 kg (8.8 lbs)

Safety Designed to: EN61010, CSA1010, UL-1244

EMC: EN55011, EN50082-1, MIL-461C [2]
(data on file)

Vibration and Shock: MIL-T-28800E, Type III, Class 5
(data on file)

Acoustic Noise: 30 dBa

Warm-Up Time: 1 hour

Warranty: 3 years standard

Remote Interface: IEEE-488 and RS-232 standard

Programming Language: SCPI-1993, IEEE-488.2

Accessories Included: User's Guide, Service Guide, Quick Reference Card, Test Report, and power cord.

(1) For 400 Hz operation at 120 Vac, use the 100 Vac line-voltage setting.

(2) The HP 33120A does not meet the performance requirements of MIL-461C characterization. However, performance test data is available upon request.