HP 8904A
Multifunction Synthesizer
Basic Operation and Application

HEWLETT PACKARD

HP 8904A Operation Made Easy!

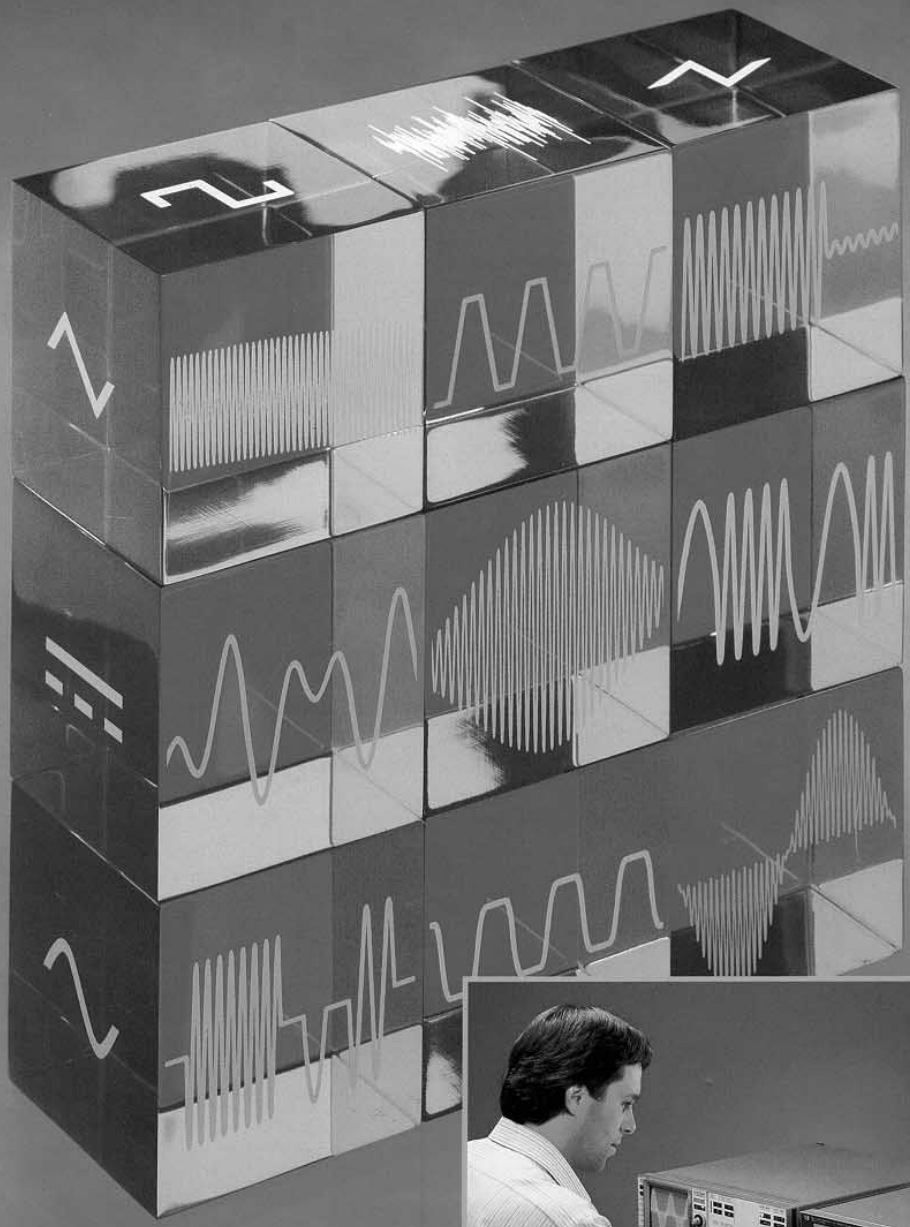
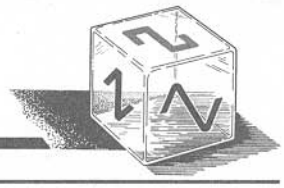


Table of Contents

1 Meet the HP 8904A



What is the HP 8904A?

The HP 8904A Multifunction Synthesizer is a flexible tool designed to meet your low frequency signal source needs by providing:

- **A frequency range of dc to 600 kHz.**
- **Synthesized waveforms (sine, ramp, triangle, square, noise and dc).**
- **Operating modes that meet the needs of a wide range of audio test, modulation source and communication signaling applications.**

Note

If you are unpacking a new HP 8904A, you will want to refer to the installation suggestions provided in Appendix A.

What's in this Guide?

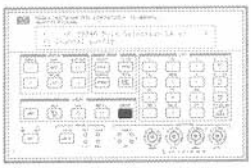
This Operation and Application Guide begins by helping you determine which operating capabilities your HP 8904A has been equipped with.

Note

It is essential that you know which operating capabilities your HP 8904A has been equipped with in order to use this guide effectively.

The guide then helps you quickly learn to use your instrument's capabilities by guiding you through setup examples that demonstrate the HP 8904A's key features.

Has Your HP 8904A Been Equipped with Additional Features?



You can quickly determine if your HP 8904A has been equipped with optional operating capabilities by performing the following steps.

1. **To power-up your HP 8904A, press the white LINE key.**

2. **Now press the blue SHIFT key and then the PRESET key.** (The adjacent HP 8904A diagram shows the **PRESET** key location.) Each time the **SHIFT**, **PRESET** keys are pressed, the HP 8904A briefly displays its Preset display. This display lists the Configuration Options that your HP 8904A has been equipped with.

For example, the Preset display shown below indicates that all three Configuration Options (01, 02 and 03) are present. Note which options (if any) are listed in the Preset display on your instrument.

```
HP 8904A Opts    01/02/03
Firmware Revision 11111A Serial No 00001
```

Once you have determined which options your HP 8904A is equipped with, refer to Table 1–1 for an overview of the capabilities provided by your instrument's configuration.

Table 1-1. The Operating Capabilities Provided by the Configuration Options.

Configuration	Capabilities Provided
Standard (all HP 8904A's)	**One Channel** • A single, internal synthesized signal source capable of generating any one of six waveforms (sine, square, ramp, triangle, noise or dc). **One Output Port** • A single Output Port that can be configured for floating or chassis ground connections.
Option 01	**Four Channels** • Four internal synthesized signal sources each capable of generating any one of six waveforms. **Modulation** • Internal modulation using up to three modulation signals. **Summation** • Internal signal summation of up to four signals. **Three Signal Sequence Modes** • Sequential transmission of analog or digital signals for simulating communications signaling.
Option 02	**Two Channels** • Two internal synthesized signal sources each capable of generating any one of the six waveforms. **Two Output Ports** • Dual Output Ports that can each be configured for floating or chassis ground connections.
Option 03	**Hop Mode** • A synthesized signal source whose frequency, amplitude and phase setting can be changed in a *fast hopping* mode.

As an example, an instrument equipped with all three Configuration Options would have the following capabilities:

- Four Channels (Option 01).
- Signal Sequence Modes (Option 01).
- Two Output Ports (Option 02). [1]
- One Channel (of the four) that could be hopped (Option 03).

[1] Note that each Output Port provides both a High and a Low connection. The operation of these connections will be demonstrated further later in this chapter.

HP 8904A Operation: A Guided Tour

In this chapter, you will learn how to output each of the HP 8904A's six waveforms.

If your HP 8904A is equipped with one of the Configuration Options (01, 02 or 03), you will also want to refer to Chapters 2 through 5 to learn to use the capabilities that they provide.

Table 1–2 provides a quick guide to the chapters you will want to look at to learn to operate your HP 8904A.

Table 1–2. Chapter Guide for the Various Configuration Options

If your HP 8904A has:	Then read through:
No Options	*Chapter 1*
Option 01 Only	*Chapters 1, 2 and 3*
Options 01 and 02	*Chapters 1, 2, 3 and 4*
Options 01, 02 and 03	*Chapters 1, 2, 3, 4 and 5*
Options 01 and 03	*Chapters 1, 2, 3 and 5*
Option 02 Only	*Chapters 1 and 4*
Options 02 and 03	*Chapters 1, 4 and 5*
Option 03 Only	*Chapters 1 and 5*

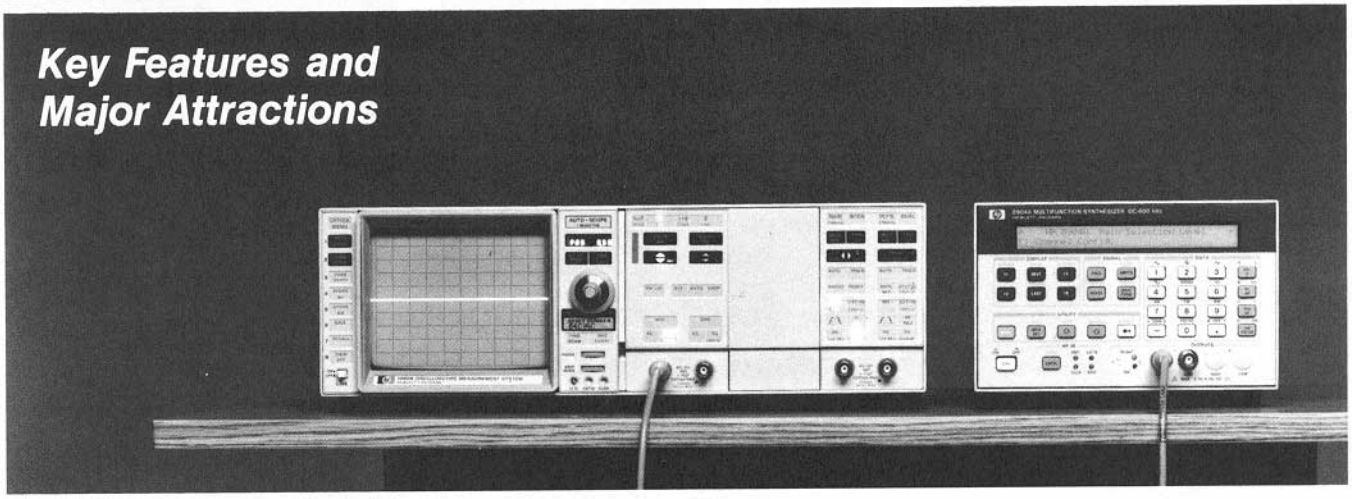
Note

You should complete the operating demonstrations contained in this chapter before referring to the remaining chapters no matter which Configuration Options you have. The operating information provided in this chapter is important to all HP 8904A configurations.

How to Begin

If you are now sitting comfortably in front of your HP 8904A, you are ready to begin. Start on the next page and follow the step-by-step guide to learning to operate your HP 8904A. You will soon discover how the HP 8904A can provide you with both the flexibility and precision needed for many signal source applications.

Key Features and Major Attractions



This chapter contains demonstrations that will help you learn how to:

- **Output a Signal**
- **Control the Output Port**
- **Save and Recall Your HP 8904A Settings**
- **Turn on the HP 8904A's Special Functions**

Set Up Your Equipment

Connect your HP 8904A to an oscilloscope as shown above.

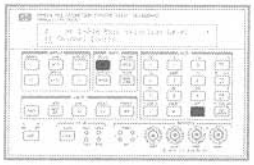
Adjust Your Oscilloscope

Display ..... Channel A
Volts/Division 0.5V
Coupling ..... dc (High Impedance)
Time/Division ..... 2 ms
Trigger ..... Channel A

Note

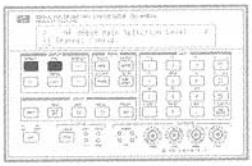
You will find that the back-lighting for the HP 8904A's display is designed to automatically turn off after approximately three minutes if no keys are pressed. The display will light when you press any key.

Select Chassis Ground



1. **Press the blue SHIFT key and then the PRESET key.**
2. **Press the blue SHIFT key and then the FLOAT key.**
3. **Press the 1 key and then the OFF key.** Note that the FLOAT annunciator (LED) for OUTPUT 1 is now off. You have configured the HP 8904A's circuit ground to be referenced to chassis ground at OUTPUT 1. (The chassis-ground output configuration is used in this demonstration to minimize the set up requirements. You will learn more about the HP 8904A's chassis and floating ground configurations later in this demonstration.)
4. **Adjust the oscilloscope's trace to center scale on the display.**

How to Output a Signal



You are now ready to learn how quickly and easily the HP 8904A enables you to set up the output signals you desire.

1. **Press the f1 Channel Config. softkey to enter the HP 8904A's Channel Configuration Mode.** Figure 1–1 shows how to access the Channel Configuration Mode.

2. **Press the NEXT key to advance the display ahead to the Channel A Configuration display.**

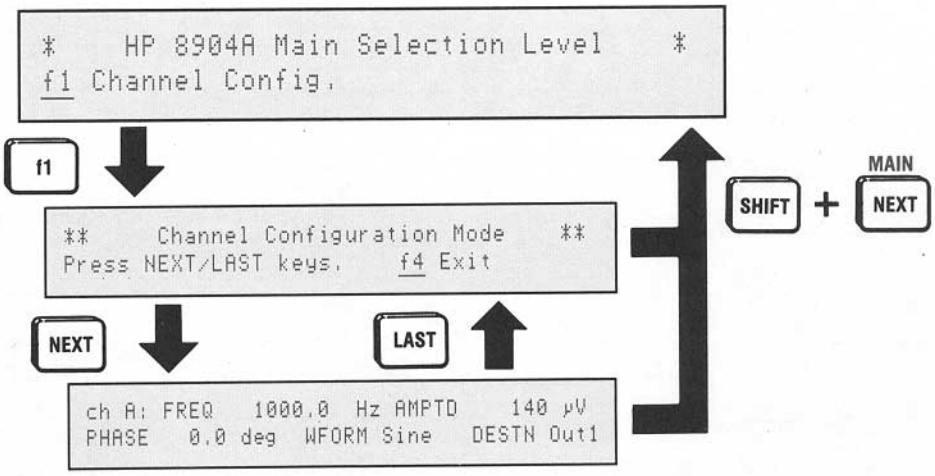
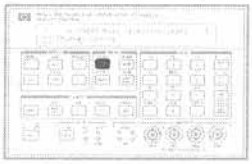


Figure 1–1. Accessing the Channel Configuration Mode is as Simple as Pressing a Key.

Enter a Frequency



3. **Press the FREQ key to select the frequency entry field on the display.** Notice that the parameter entry fields in the display and the four SIGNAL keys below the display have been arranged in the same order to help you quickly find the key you want.

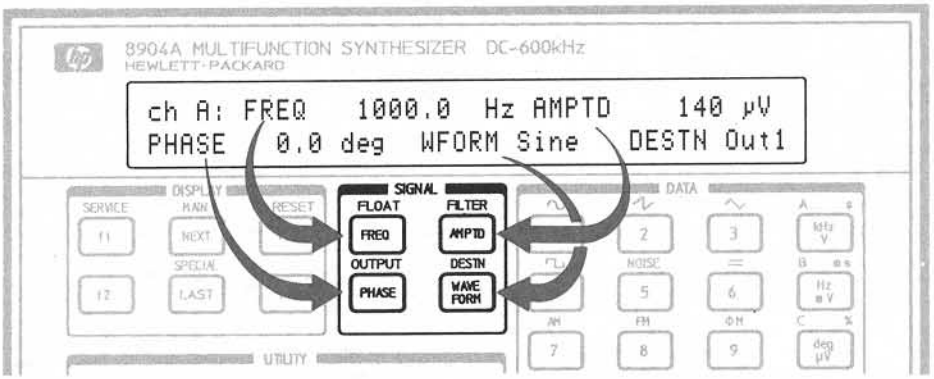


Figure 1-2. The Display Fields and Entry Keys are Similarly Positioned for Quick Access.

Note

If you enter a wrong digit, simply press the ⇐ key to backspace, and then re-enter the correct digit.

4. **Enter 120 Hz.** (If your HP 8904A is operating on a 50 Hz power line rather than 60 Hz, enter 100 Hz for this demonstration.)

That's all you have to do to enter the frequency you desire for your output signal. Table 1-3 shows the frequency ranges provided by your HP 8904A.

Table 1-3. The Output Frequency Ranges of the HP 8904A.

Waveform	Frequency Range
Sine	0.0 Hz to 600 kHz
Square, Triangle, Ramp	0.0 Hz to 50 kHz
Noise	Random to 600 kHz
dc	0.0 Hz

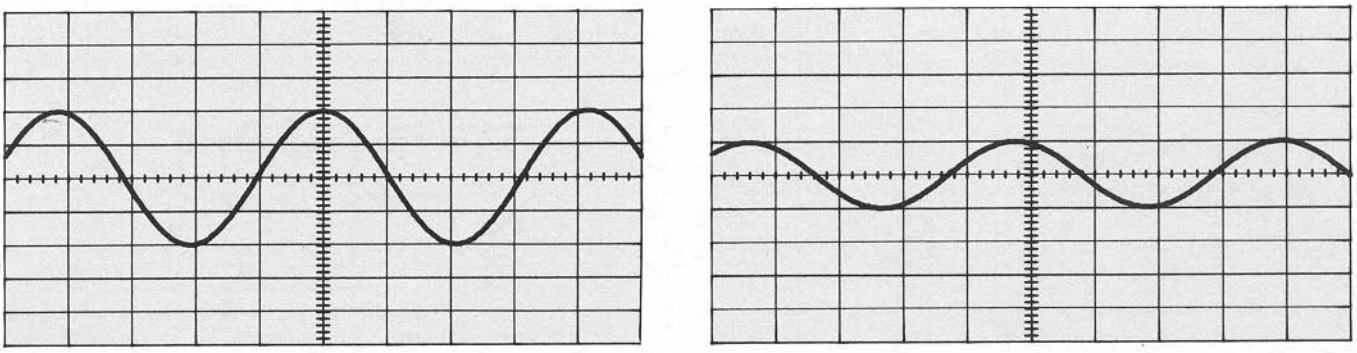
Enter an Amplitude

5. **Press the AMPTD key and enter 1V.** A 1V peak sinewave should now appear on your oscilloscope display. (Adjust the oscilloscope's triggering if needed for a stable display.)

With the HP 8904A, setting up your output amplitude is as easy as pressing the **AMPTD** key and entering the value you desire (0 to 10V).

Note

The amplitude level shown in the HP 8904A's display reflects the output signal level in peak volts when it is terminated by a high impedance input (> 50 kΩ), and peak-to-peak volts when it is terminated by a 50 Ω input. (Throughout this demonstration, the oscilloscope is assumed to have a high impedance input.)



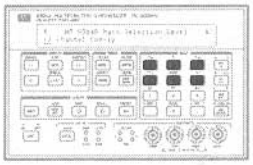
a. High Impedance Termination

b. 50Ω Termination

Figure 1–3. Output Amplitude provided by the HP 8904A when set at 1V.

Select a Waveform

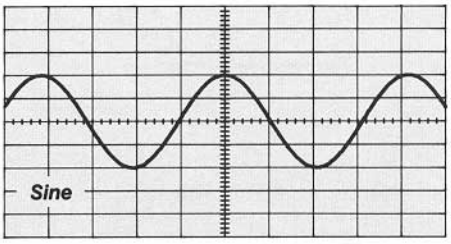
Selecting any one of the HP 8904A's six waveforms is just as easy.

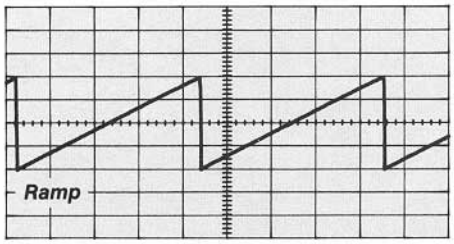


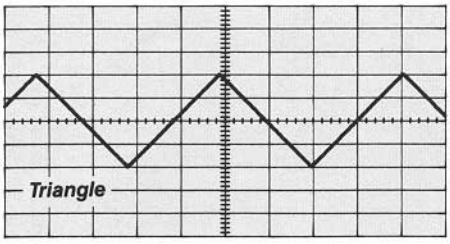
6. **Press the WAVEFORM key.** You can now select any one of the HP 8904A's six waveforms. (Note that the sine waveform is the HP 8904A's default selection.)

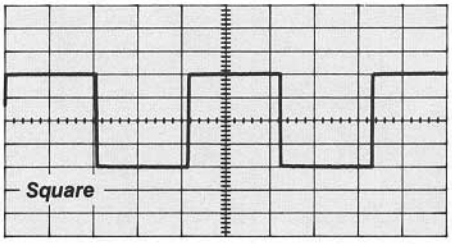
7. **Press the ⩘ (ramp) key, the ∿ (triangle) key, the ⊓⊔ (square) key, the NOISE key and then the ⎓ (dc) key to output each of the five additional waveforms.**

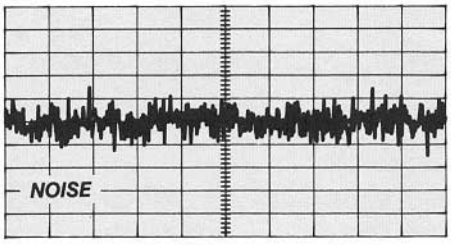
8. **Now press the ⊓⊔ key to select the square wave output.**

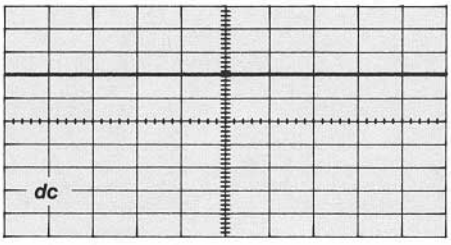








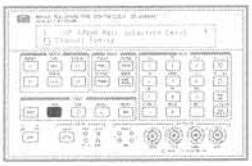




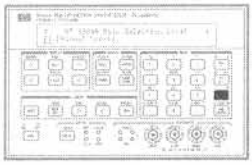
Now Vary the Phase

The HP 8904A allows you to vary the phase of your waveforms from 0 degrees to 359.9 degrees in step sizes specified by you.

9. **Set the oscilloscope to trigger on the line voltage.** (You may need to adjust the oscilloscope's triggering in order to get a stable display.)



10. **Press the PHASE key and the INCR SET key on the HP 8904A.** Notice that the HP 8904A has placed an "is" in its display next to PHASE. This is to let you know that the value now being displayed is the increment set value rather than the current phase setting.



11. **Press 45 and the deg key to enter an increment step size of 45 degrees.**

12. **Now press the ⇧ key.** (Notice that the displayed waveform shifts each time the phase of Channel A is incremented. This is due to the resulting change in Channel A's phase relationship with the line voltage signal that is being used to trigger the oscilloscope.)

13. **Press the 0 key and the deg key to return the HP 8904A's phase setting to 0.0 degrees.**

14. **Set the oscilloscope to trigger on Channel A again rather than the line voltage.**

The HP 8904A allows you to vary the phase of its sine, square, triangle or ramp waveforms from 0 to 359.9 degrees in 0.1 degree steps.

That's how easy the HP 8904A makes it for you to create any of its six waveforms at the frequency, amplitude, and phase setting that you desire.

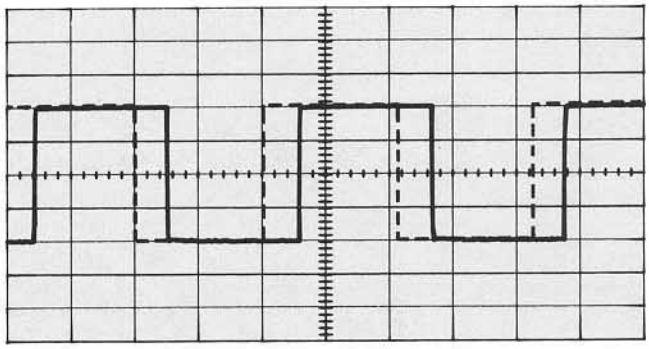


Figure 1–4. Precise 45° Phase Shift of the HP 8904A.

How to Control the Output Port

With the HP 8904A, you can choose either a ***chassis ground*** or a ***floating ground*** circuit configuration. The floating ground configuration allows you to reference the HP 8904A's ground to the ground level of the input device that the HP 8904A is connected to. You can also turn off the HP 8904A's output path to completely remove the output signal from the Output Port.

Figure 1–5 shows the HP 8904A's Output Port LEDs. These LEDs inform you of the current configuration status of each Output Port.

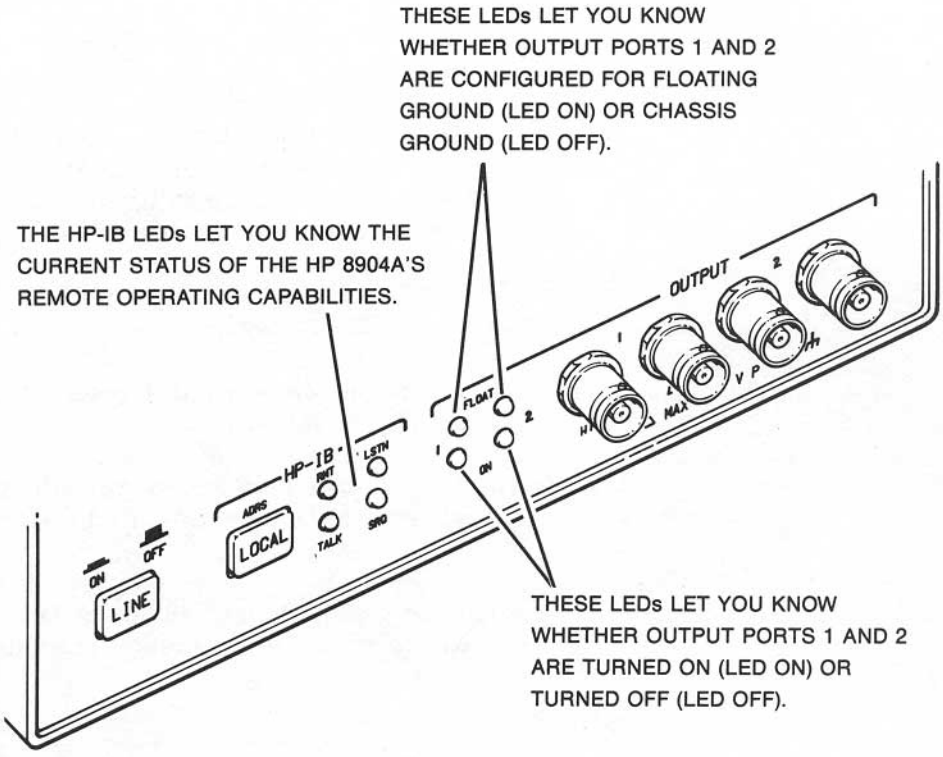
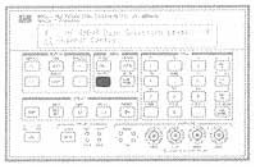


Figure 1–5. The Front Panel LEDs Inform You of the HP 8904A's Current Output and HP-IB Operating Status.

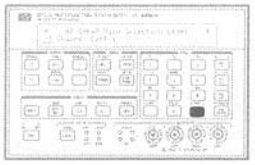
Turn Off the Output



1. **Press the blue SHIFT key and then the OUTPUT key.** The Output Control display should now appear on the HP 8904A.

```
        Output On/Off Control
Enter output number = _ and ON/OFF
```

2. **Press the 1 key.** This designates which Output (1 or 2) you wish to control. (Output 2 can be turned "On" only when the HP 8904A is equipped with Dual Output Ports, Option 02.)



3. **Press the OFF key.** You have turned off Output 1. Note that the ON LED for OUTPUT 1 is no longer lit, and that the output signal no longer appears on the oscilloscope display. You have disconnected the output signal from the Output Port.

Note

The HP 8904A maintains a constant 50 ohm impedance at its output whether the output is on or off.

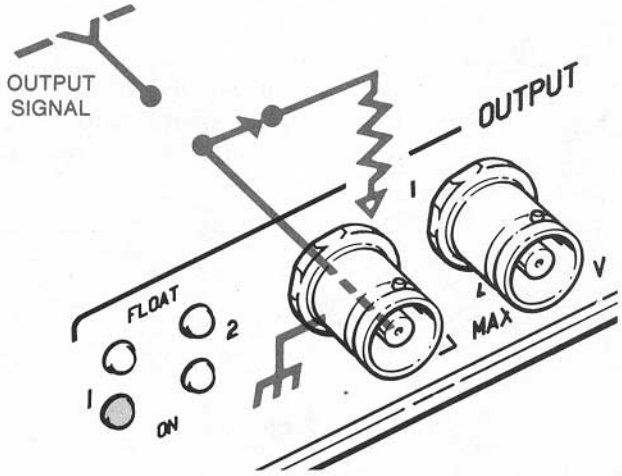


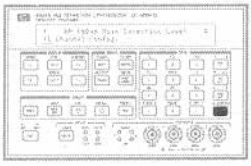
Figure 1–6. The Output Signal is Switched Away from the Output Port when the Output is Turned Off.

4. **Now press the FREQ key and enter 20 kHz.**

5. **Press the AMPTD key and enter 10V.** (Ten volts is the maximum output amplitude provided by the HP 8904A.)

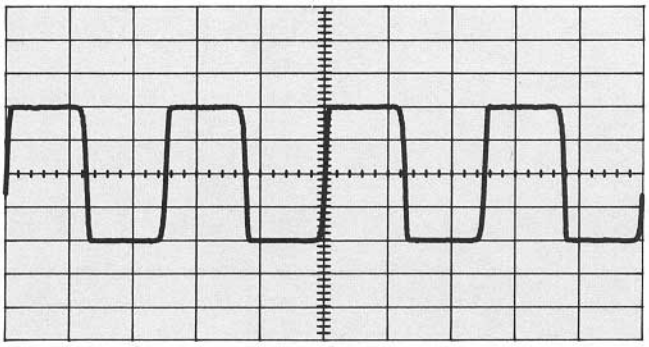
6. **Adjust the volts/division setting for Channel A on the oscilloscope to 5V, and the time/division setting to 20 μs.**

Turn On the Output



7. **Press the blue SHIFT key and then the OUTPUT key to access the Output Control display.**

8. **Enter 1 and then press the ON key.** Note that the ON LED for OUTPUT 1 is now lit.



Turning the HP 8904A's Output Port off can be useful when you wish to make changes to the output signal but you do not want the intermediate transitions present at the output.

Channel versus Output

In the HP 8904A, ***Channel*** refers to an internal synthesized signal source. The standard HP 8904A configuration provides a single channel. Instruments with Option 01 capabilities have four channels and those with Option 02 only have two channels. Each channel provides six waveform choices (sine, ramp, triangle, square, noise and dc).

Output refers to an HP 8904A Output Port. The standard HP 8904A configuration provides 1 Output Port. Option 02 adds a second Output Port.

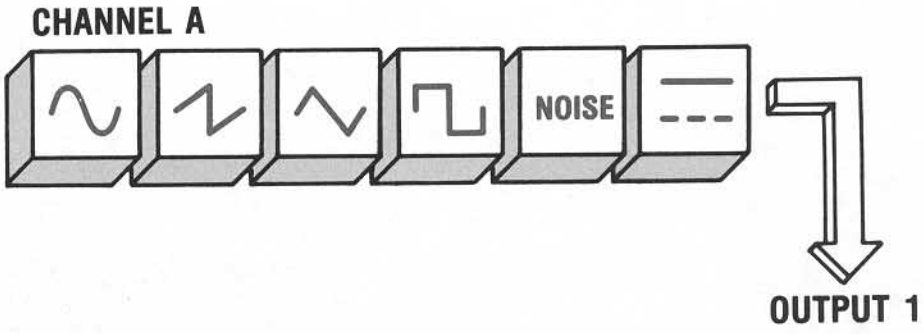


Figure 1–7. The Standard HP 8904A Configuration Provides One Channel and One Output Port.

Table 1–4 lists the channels and output ports provided by the Configuration Options.

Table 1–4. Channel and Output Port Configuration Options.

Options	Configuration
Standard (no options)	Channel A Output 1
01	Channels A, B, C and D Output 1
02	Channels A and B Outputs 1 and 2
01 and 02 (combined)	Channels A, B, C and D Outputs 1 and 2

Choose Between Chassis or Floating Ground

Chassis Ground

At the beginning of this demonstration, you configured the HP 8904A's circuit ground to be referenced to chassis ground. Figure 1–8 shows a simplified block diagram of the chassis ground configuration.

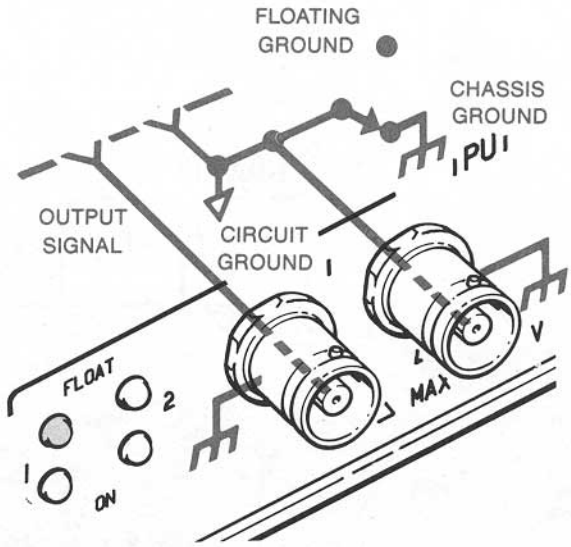


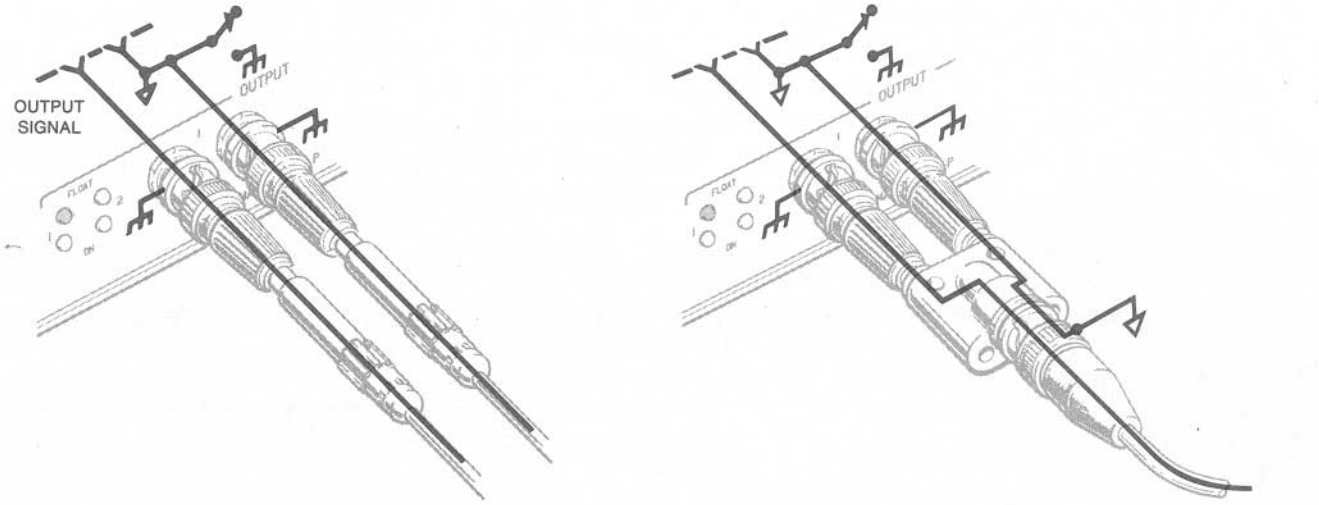
Figure 1–8. Circuit Ground is Connected to Chassis Ground when the FLOAT LED is Off.

Floating Ground

When the FLOAT LED is on for Ouput 1 or 2, the HP 8904A's circuit ground is not referenced to chassis ground at that output. (Floating ground is the HP 8904A's Preset, or default, output configuration.)

The floating ground configuration (LED on) allows the HP 8904A's circuitry to be referenced to an external ground rather than to chassis ground. This configuration eliminates ground loops between the HP 8904A and the input device. Figure 1-9 shows two methods for connecting the floating Output Port to an input device.

Caution *The voltage differential between the HP 8904A's floating ground level and its chassis ground level should not exceed a maximum of 10 Vpk.*



a. Using two BNC cables provides maximum shielding where High and Low inputs are also available.

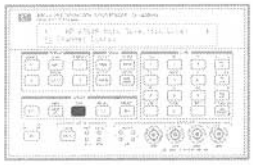
b. Using an adapter allows the High and Low Output Ports to be connected to a single input port.

Figure 1-9. Cable Connections for the Floating Ground Output Configuration.

How to Save and Recall Your Settings

You can easily save all of the operating settings you have entered, and recall them whenever you wish.

Set Up a Save Register

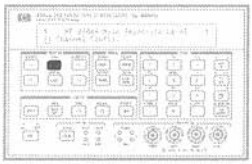


1. **Press the blue SHIFT key and the SAVE key to access the Save Register display.**

```
Save Register   ?   0 - 11 Are Valid
Enter register number and/or  ENTER
```

2. **Press the 1 key and then the ENTER key.** You have stored ***all*** of the HP 8904A's current settings in Save Register 1. The HP 8904A provides 12 Save Registers (0–11).

Now Return to the Main Selection Level



3. **Press the blue SHIFT key and the MAIN key.** The **MAIN** key returns you to the HP 8904A's Main Selection Level display.

```
*    HP 8904A  Main Selection Level    *
f1 Channel Config.
```

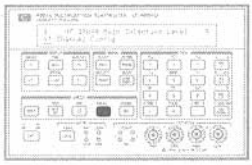
4. **Press the f1 `Channel Config` softkey to return to the Channel Configuration Mode.**

5. **Press the NEXT key to access the Channel A Configuration display.** Note that each of Channel A's parameters were reset to their default settings when you re-entered the Channel Configuration Mode.

Remember

Whenever the HP 8904A exits the Channel Configuration Mode and then re-enters it or any other operating mode, all parameters are reset to their default settings.

Recall Your Settings



6. **Press the blue SHIFT key and then the RECALL key to access the Recall Register display.**

7. **Press the 1 key and then press the ENTER key.** The HP 8904A is now returned to the same operating state it was in when you set up Save Register 1.

```
ch A: FREQ  20.000  kHz AMPTD  10.00  V
PHASE   0.0 deg  WFORM Sq     DESTN Out1
```

Remember

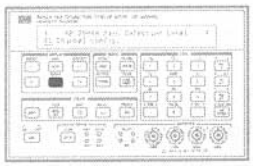
When you Recall a Save Register, the HP 8904A returns all of its parameters (except Special Functions) to the same settings that existed when the Save Register was selected.

How to Turn On the Special Functions

The Special Functions permit you to modify the HP 8904A's operation to best meet your needs. In this demonstration, you will turn on the Special Function that configures the HP 8904A to power up to the state it was in before power was turned off, rather than to the Main Selection Level.

1. **Switch the white LINE key off for a few seconds and then back on.** Notice that the HP 8904A has powered up to the Main Selection Level.

Access the Special Functions



2. **Press the blue SHIFT key and the SPECIAL key to access the HP 8904A's Special Function display.** This display allows you to turn on the HP 8904A's Special Function capabilities.

```
f1 Special #_0  f2 Status = Off  f4 Exit
# 0  Last state recalled on power up
```

Turn On Special Function 0

3. **Press the f2 Status softkey and then press the ON key.** You have turned on Special Function 0. Notice "Status" now equals "On" in the display to let you know that Special Function 0 is now turned on. Special Function 0 enables the HP 8904A to power up to the operating settings that existed when power was turned off.

4. **Press the NEXT key to step through the other Special Functions.** Note that the Special number in the display increments each time you press the **NEXT** key. A brief description is displayed for each Special Function that is provided by your instrument.

5. **Press the f4 Exit softkey to return to the Main Selection Level display.**

Now Try Special Function 0

6. **Press the f1 Channel Config. softkey and the NEXT key to access the Channel A Configuration display again.**

7. **Now switch the white LINE key off for a few seconds and then back on.** Your HP 8904A should power back up to the same state it was in.

Main versus Preset

The HP 8904A always provides you with at least two methods for returning its operation to the Main Selection Level. It is important that you are aware of the effects that each of these methods has on the status of the HP 8904A's settings.

1. **Press the blue SHIFT key and then the PRESET key.** Both the **MAIN** key and the **PRESET** key return you to the Main Selection Level. The **PRESET** key however, resets the HP 8904A's functions to their pre-defined power-up condition, including the Special Function settings and Floating ground.

Save Registers are Retained

2. **Press the blue SHIFT key, the RECALL key, the 1 key and then press the ENTER key.** Note that the HP 8904A's Save Register settings are retained whether you use the **MAIN** key or the **PRESET** key (or even if the instrument is powered down).

Special Functions are Turned Off

3. **Switch the HP 8904A's power OFF for a few seconds and then back ON.** Since Special Function 0 was turned off when you pressed the **PRESET** key, the HP 8904A now powers-up to the Main Selection Level rather than the state it was in.

Table 1–5. Summary of how the PRESET and MAIN keys affect Operation.

Key	Function
PRESET	• Returns operation to the Main Selection Level. • Resets operating functions to their pre-defined power-up condition, including Special Function settings and Floating ground. • Does not reset Save Registers.
MAIN(1)	• Returns operation to the Main Selection Level. • Does not reset Special Function settings, Save Registers or Floating ground.

(1) The **f4** Exit softkey's effect on operation is similar to that of the **MAIN** key.

Things to Remember

Congratulations, you are now familiar with the key operating capabilities that are standard to all HP 8904A's. Table 1–6 shows the final settings that you entered for Channel A in this demonstration. Similar tables are used in the remaining chapters to describe the channel configurations for various application examples.

From now on, when your application requires a function generator, modulation source or stimulus for audio circuit testing you can rely on the HP 8904A to provide the flexibility and accuracy that you need.

Table 1–6. The Channel A Settings from the Chapter 1 Demonstration.

CHANNEL	FLOAT	FREQ	AMPTD	PHASE	WAVE-FORM
A	Off	20 kHz	10V	0.0 deg	Square

Key Points About Operation

Table 1–7 contains operating considerations you should keep in mind as you operate your HP 8904A.

Table 1–7. HP 8904A Operating Considerations.

Operation	Considerations
Control Output Port	• Floating ground (LED on) is the default output setting. • The output impedance is 50Ω whether the Output Port is turned on or off.
Enter Amplitude	• The displayed amplitude value represents peak volts when the HP 8904A is connected to a high impedance input or peak-to-peak volts when it is connected to a 50Ω input.
Output Noise	• The Noise function provides pseudorandom, Gaussian white noise. • The amplitude value you enter sets the peak output level of the noise.
Turn Off Special Functions	• Special Function settings are turned off when the **PRESET** key is pressed, but not when the **MAIN** key is pressed.

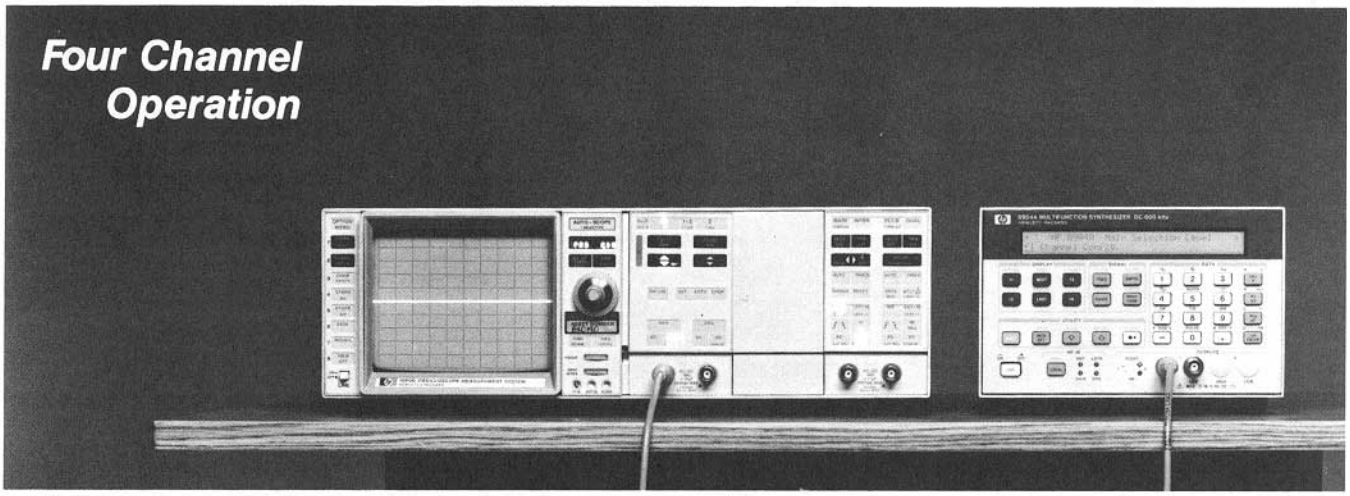
To Learn More

If your HP 8904A is equipped with Option 01, 02 or 03, refer to the remaining chapters to learn more about operating your HP 8904A.

Table 1–8. Chapter Guide for the Various Configuration Options.

If your HP 8904A has:	Then refer to:
Option 01 Only	*Chapters 2 and 3*
Options 01 and 02	*Chapters 2, 3 then 4*
Options 01, 02 and 03	*Chapters 2, 3, 4 then 5*
Options 01 and 03	*Chapters 2, 3 then 5*
Option 02 Only	*Chapter 4*
Options 02 and 03	*Chapters 4 and 5*
Option 03 Only	*Chapter 5*

2 Modulate or Sum the Signals



In This Chapter

This chapter will help you learn to use the four channels provided by Configuration Option 01. If your HP 8904A is equipped with Option 01, simply step through the following demonstrations to learn how to:

- **Modulate Channel A**
- **Set Up Simultaneous Modulation**
- **Sum the Modulation Signals**
- **Sum the Output Signals**
- **Set Up Some Multi-Channel Applications**

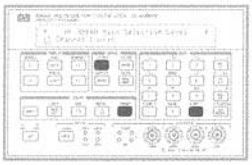
Set Up Your Equipment

Connect your HP 8904A to the oscilloscope as shown above.

Adjust Your Oscilloscope

Display ..... Channel A
Volts/Division 1V
Coupling ..... dc (High Impedance)
Time/Division ..... 0.2 ms
Trigger ..... Channel A

Select Chassis Ground



1. **Press the blue SHIFT key and the PRESET key on your HP 8904A.**
2. **Press the blue SHIFT key and then the FLOAT key.**
3. **Press the 1 key and then the OFF key to reference the HP 8904A's circuit ground to chassis ground at Output 1.** (Note that the FLOAT LED for Output 1 is now off.)
4. **Adjust the oscilloscope's trace position if necessary to center scale.**

Access the Four Channels

5. **Press the f1** `Channel Config` **. softkey.**
6. **Press the NEXT key to access the Channel A Configuration display.**

```
ch A: FREQ   1000.0  Hz AMPTD    140 µV
PHASE   0.0 deg  WFORM Sine   DESTN Out1
```

7. **Continue pressing the NEXT key to step through the Configuration displays for Channels B, C and D.** These are the four channels provided by Option 01. Figure 2–1 shows how to access the four channels.

8. **Continue to press the NEXT key until you have returned to the Channel A Configuration display.** (If you have an instrument that is equiped with Hop Mode (Option 03), the two Hop Mode displays will appear following the Channel D display as you press the **NEXT** key. Chapter 5 contains information to help you learn about Hop Mode operation.)

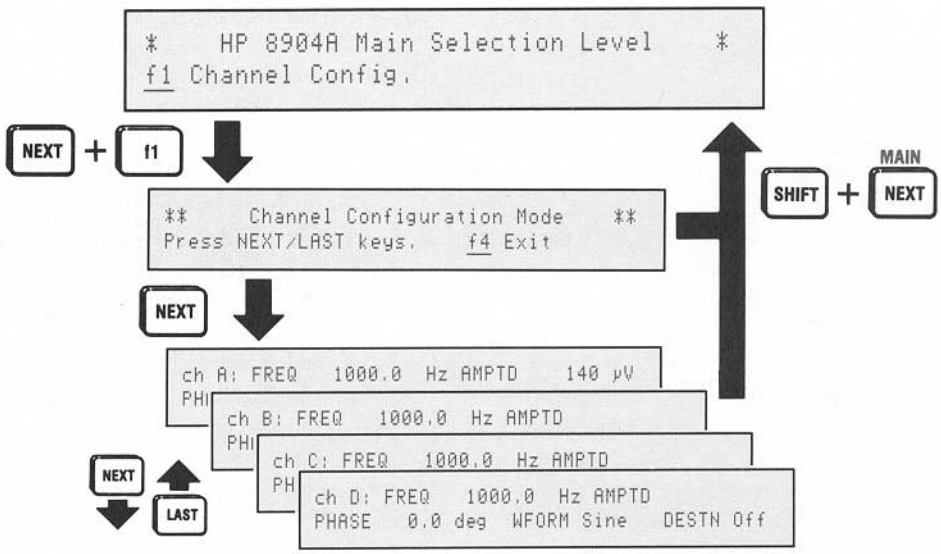


Figure 2–1. All Four Channels Can Be Accessed After You Have Pressed the f1 Channel Config. Softkey.

How to Modulate Channel A

The HP 8904A offers you a wide selection of modulation possibilities. In this demonstration, you will discover that you can create many useful signals by simply modulating Channel A with one other channel.

Set Up the Carrier

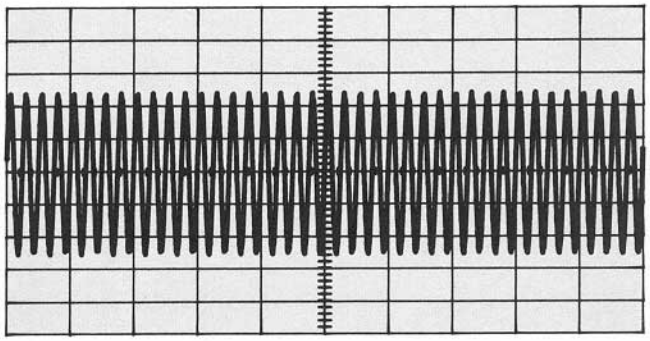
1. **Press the FREQ key and enter 20 kHz as the Channel A frequency.**

Note

If you enter a wrong digit, simply press the ⇐ key to backspace, and then re-enter the correct digit.

---

2. **Press the AMPTD key and enter 2.5V.** The 20 kHz, 2.5 Vpk Channel A signal should now appear on the oscilloscope display.

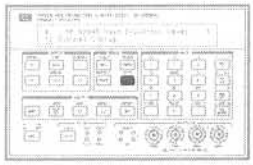


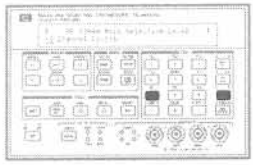
Set Up the Modulation Signal

3. **Press the NEXT key to access the Channel B Configuration display.**

Note

Only Channel A can be modulated. However, any or all of the remaining channels (B, C and D) can be used for modulating Channel A.

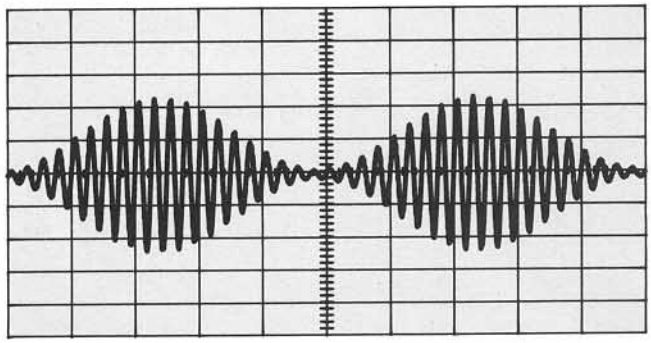




4. **Press the blue SHIFT key and then the DESTN key.** The HP 8904A is now ready for you to specify how you want to use Channel B.

5. **Press the AM key to configure Channel B to amplitude modulate Channel A.** Note that when you specified the destination, the HP 8904A changed the amplitude entry field in the display to the appropriate units (%) for the destination you have chosen (AM).

6. **Press the AMPTD key and enter 90%.** The amplitude modulated sinewave should now appear on your oscilloscope display. (Adjust the oscilloscope's triggering if necessary to get a stable display.)



That's how easy it is to set up a modulated output signal using the HP 8904A.

Note

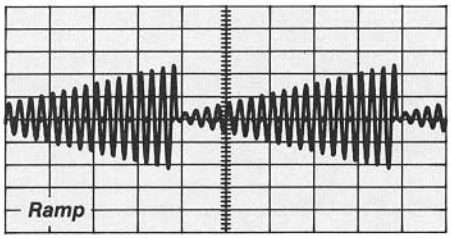
If the output signal no longer appears on the oscilloscope, and you pressed the DSB key, press the LAST key now to return to the Channel A display and re-enter 2.5V for the amplitude. Then press the NEXT key to return to the Channel B display.

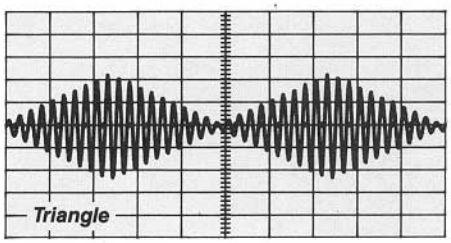
The DSB key selects Dual-Sideband Suppressed-Carrier AM. The operation of this modulation mode and the effect it has on Channel A are described later in this demonstration.

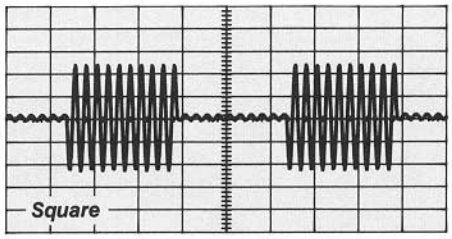
Now Look at the Possibilities

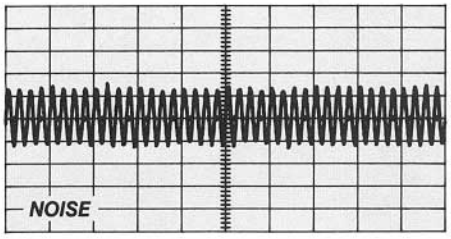
Change the Modulation Waveform

7. **Press the WAVEFORM key and then the ⩘ (ramp), ∿ (triangle), ⊓⊔ (square), and NOISE keys to see each of the other waveforms available for the modulation signal.** (Adjust the oscilloscope's triggering if necessary to get a stable display.)



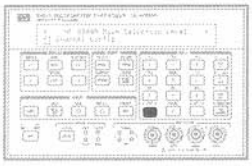






8. **Press the ∿ (sine) key.**

Change the Modulation Mode

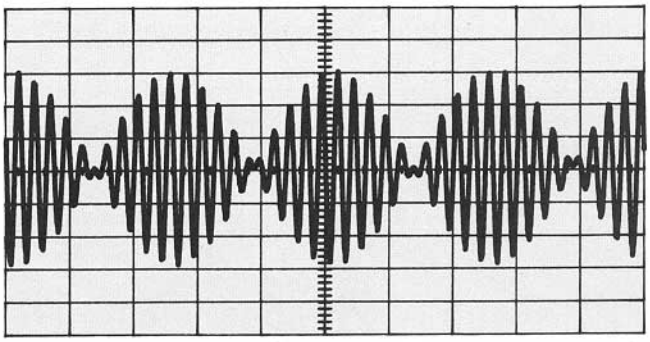


9. **Press the blue SHIFT key, the DESTN key and the DSB key.** You have selected Double-Sideband Suppressed-Carrier AM. The HP 8904A provides you with five modulation modes to choose from (AM, FM, ΦM, DSB and Pulse).

Remember

The HP 8904A always changes the amplitude setting to 140 μV when the destination is changed; so remember to always specify your destination choice first then enter the amplitude setting.

10. **Press the AMPTD key and enter 3V.** Note that DSB modulation suppresses the carrier signal (Channel A).

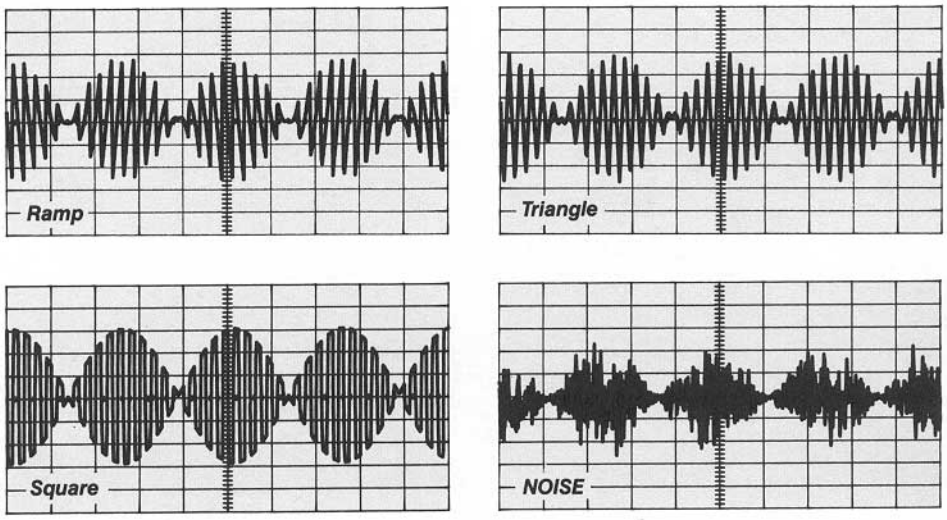


Change the Carrier Waveform

11. **Press the LAST key to return to the Channel A Configuration display.** Notice that "DSB" now appears in the amplitude field in the display to inform you that Channel A's output amplitude has been set (suppressed) by the DSB modulation.

```
ch A: FREQ  20.000  kHz AMPTD        DSB
PHASE   0.0 deg  WFORM Sine   DESTN Out1
```

12. **Press the WAVEFORM key and the ⩘, ∿, ⊓⊔ and NOISE keys.** You can select any of these waveforms for the carrier signal.



13. **Press the ∿ key.**

14. **Press the NEXT key, the blue SHIFT key, the DESTN key and the AM key.**

15. **Press the AMPTD key and enter 90%.**

16. **Press the LAST key.** Notice that Channel A's amplitude setting has now been changed from the 2.5V you originally set to the 3V (DSB) setting.

Remember

When the DSB modulation mode is selected, the amplitude of the carrier (Channel A) is determined by the DSB amplitude setting.

As you can see, the HP 8904A offers you a wide selection of carrier and single source modulation possibilities. Figure 2–2 illustrates these possibilities.

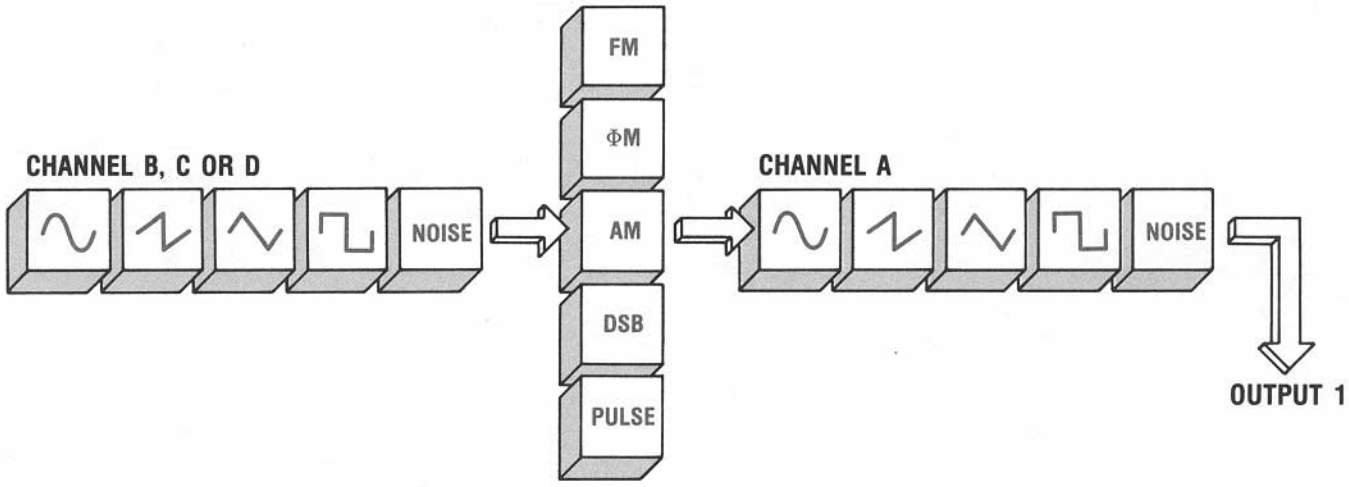


Figure 2–2. The HP 8904A Offers a Wide Selection of Modulation Possibilities.

How to Set Up Simultaneous Modulation

Simultaneous modulation occurs when multiple modulation modes are applied to a single carrier. The HP 8904A makes it easy to simultaneously modulate Channel A using the five modulation modes (AM, FM, ΦM, DSB or Pulse). In the following demonstration, you will configure Channel C to pulse modulate Channel A at the same time that Channel B is amplitude modulating Channel A.

Note

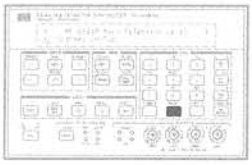
If you have just completed the preceding demonstration, "How to Modulate Channel A," your HP 8904A is correctly configured for beginning this demonstration; proceed to step 1 on the next page.

If your HP 8904A is not configured as shown in Table 2-1, please configure Channels A and B as shown in the table before you begin this demonstration.

Table 2-1. Instrument Settings for Channels A and B.

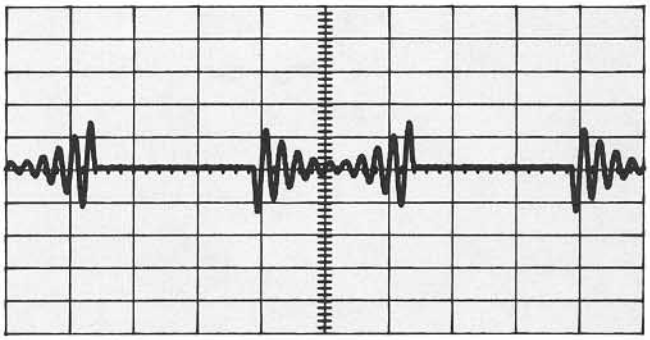
Channel	Destination	Frequency	Amplitude	Phase	Waveform
A	Out 1	20k	3V	0.0 deg	Sine
B	AM	1000 Hz	90%	0.0 deg	Sine

Add Another Modulation Mode



1. **Press the NEXT key as needed to access the Channel C Configuration display.**

2. **Press the blue SHIFT key, the DESTN key and then the PULSE key.** You have now configured Channels B and C to simultaneously AM and pulse modulate Channel A.



You can simultaneously modulate Channel A with up to three different modulation signals by simply configuring Channel D to also modulate Channel A. Figure 2–3 illustrates the simultaneous modulation possibilities provided by your HP 8904A.

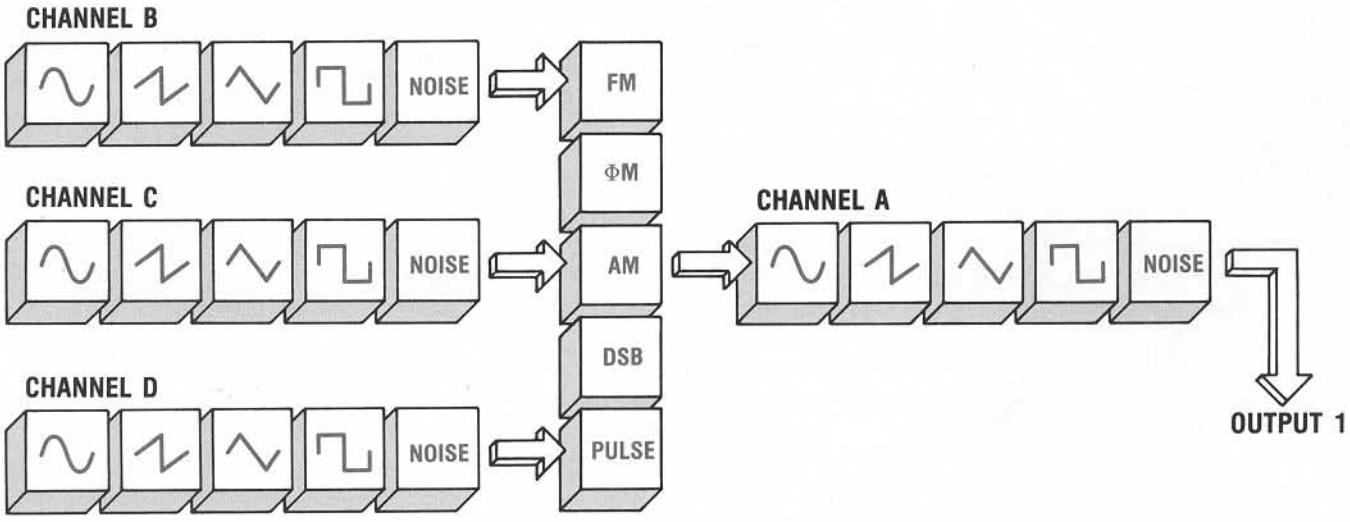
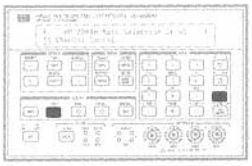


Figure 2–3. The Various Simultaneous Modulation Possibilities.

Now Vary the Phase

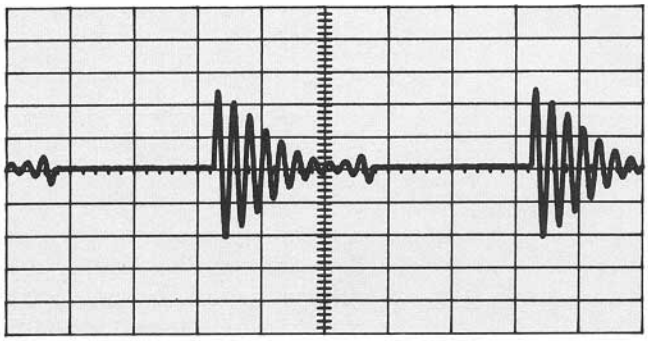
With the HP 8904A you can precisely control the phase of each modulation signal.



3. **Press the PHASE key.**

4. **Press the INCR SET key and enter 45 degrees.** The HP 8904A allows you to advance the phase of the selected channel up to 359.9 degrees.

5. **Press the ⇧ key.** Note on the oscilloscope that the pulse modulation provided by Channel C is advanced 45° each time the ⇧ key is pressed.



Note

If you continue to press the ⇧ key, you will find that the HP 8904A does not respond to your 45 degree increment at 315 degrees. This is because the maximum phase shift allowed by the HP 8904A is 359.9 degrees (315 + 45 = 360).

How to Sum the Modulation Signals

With the HP 8904A, you can even sum the modulation signals first and then use the resulting signal to modulate Channel A in any one of the HP 8904A's modulation modes. In the following steps, you will sum Channels B and C and use the resulting signal to amplitude modulate Channel A.

Note

If you have just completed the preceding demonstration, "How to Set Up Simultaneous Modulation," your HP 8904A is correctly configured for beginning this demonstration; proceed to step 1 on the next page.

If your HP 8904A is not configured as shown in Table 2–2, please configure Channels A, B and C as shown in the table before you begin this demonstration.

Table 2–2. Instrument Settings for Channels A, B and C.

Channel	Destination	Frequency	Amplitude	Phase	Waveform
A	Out 1	20k	3V	0.0 deg	Sine
B	AM	1000 Hz	90%	0.0 deg	Sine
C	Plse	1000 Hz	N/A	45.0 deg	Sine

Sum Channels B and C

1. **Press the blue SHIFT key, the DESTN key and the AM key to configure Channel C to amplitude modulate Channel A.**

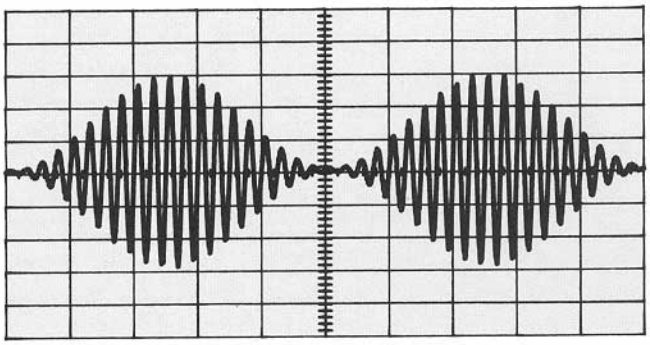
2. **Press the AMPTD key and enter 10%.** Channel A is now being 100% amplitude modulated by Channels B (90%) and C (10%).

Note

The HP 8904A allows a maximum setting of 100% AM between the combined channels. (For example, with Channel B set at 90% AM, Channel C can only be set at ≤ 10% AM.)

---

3. **Press the PHASE key, the 0 key and then the deg key to set the phase to 0.0 degrees.** (Note that your frequency and phase settings did not change when you changed the modulation mode. Only the amplitude setting changes when you change the destination entry.)



4. **Press the WAVEFORM key and the NOISE key.** You have now configured Channel C to add a 10% noise component to the Channel B modulation signal.

Remember

Whenever you select the same modulation modes for two or more channels, these channels are summed and the resulting signal is used to modulate Channel A. Figure 2–4 shows the modulation signal summation capability provided by the HP 8904A.

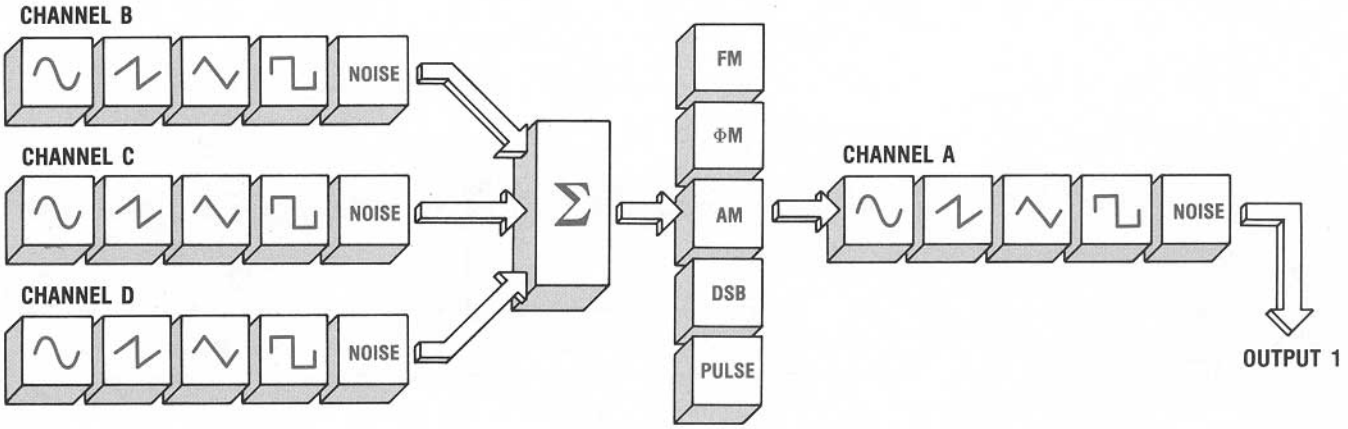


Figure 2–4. The Modulation Signals are first Summed and then used to Modulate Channel A whenever the same Modulation Mode is Selected.

How to Sum the Output Signals

Another possibility offered by the HP 8904A is to sum the output signals. In this demonstration, you will sum the modulated Channel A signal with various other waveforms from Channels C and D.

Note

If you have just completed the preceding demonstration, "How to Sum the Modulation Signals," your HP 8904A is correctly configured for beginning this demonstration; proceed to step 1 on the next page.

If your HP 8904A is not configured as shown in Table 2-3, please configure Channels A, B and C as shown in the table before you begin this demonstration.

Table 2-3. Instrument Settings for Channels A, B and C.

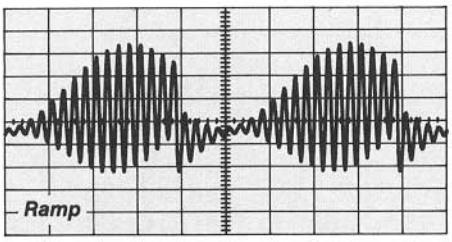
Channel	Destination	Frequency	Amplitude	Phase	Waveform
A	Out 1	20k	3V	0.0 deg	Sine
B	AM	1000 Hz	90%	0.0 deg	Sine
C	AM	N/A	10%	N/A	Noise

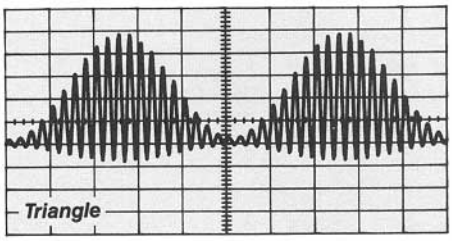
Sum Channels A and C

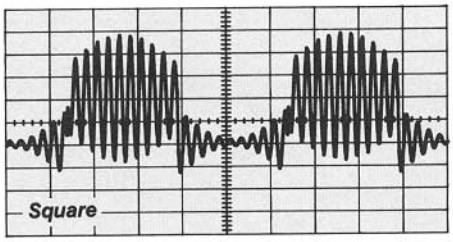
1. **Press the blue SHIFT key, the DESTN key and the 1 key.** You have configured the Channel C signal to be summed with the modulated Channel A signal.

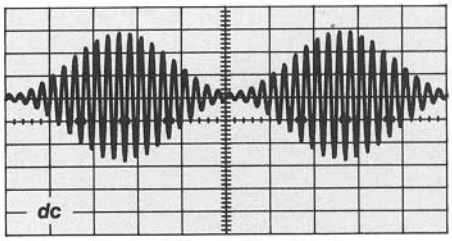
2. **Press the AMPTD key and enter 1V.**

3. **Press the WAVEFORM key and then the ⩘, ∿, ⊓ and ⎓ keys.**

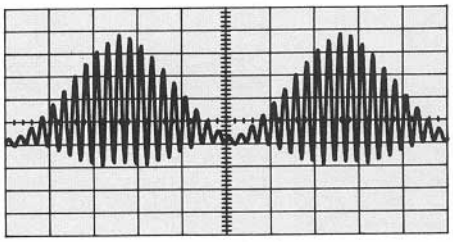








4. **Press the ∿ key.**



Sum Channel D with A and C

5. **Press the NEXT key to access the Channel D Configuration display.**
6. **Press the blue SHIFT key, the DESTN key and the 1 key.**
7. **Press the AMPTD key and enter 300 mV.**
8. **Press the FREQ key and enter 10 kHz.** (Adjust the oscilloscope if necessary to get a stable display.)

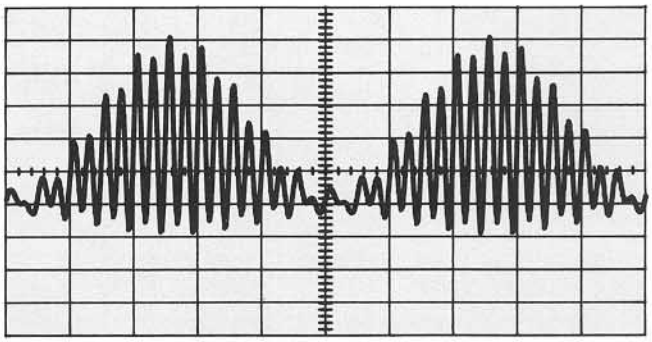


Figure 2–5 shows how channels are summed when you select the same Output Port as the destination for each channel.

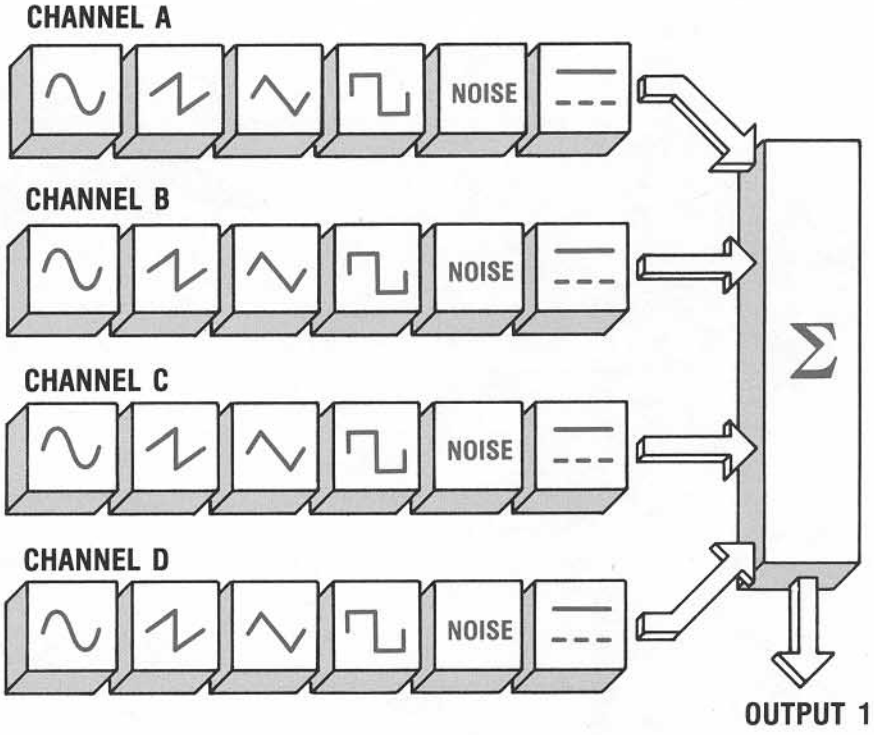


Figure 2–5. The Waveforms from each Channel can be Summed and then Output.

Things to Remember about Four Channel Operation

As you have seen, the HP 8904A's four channels provide you with a wide selection of signal possibilities. Figure 2–6 provides an overview of the HP 8904A's modulation and summation capabilities.

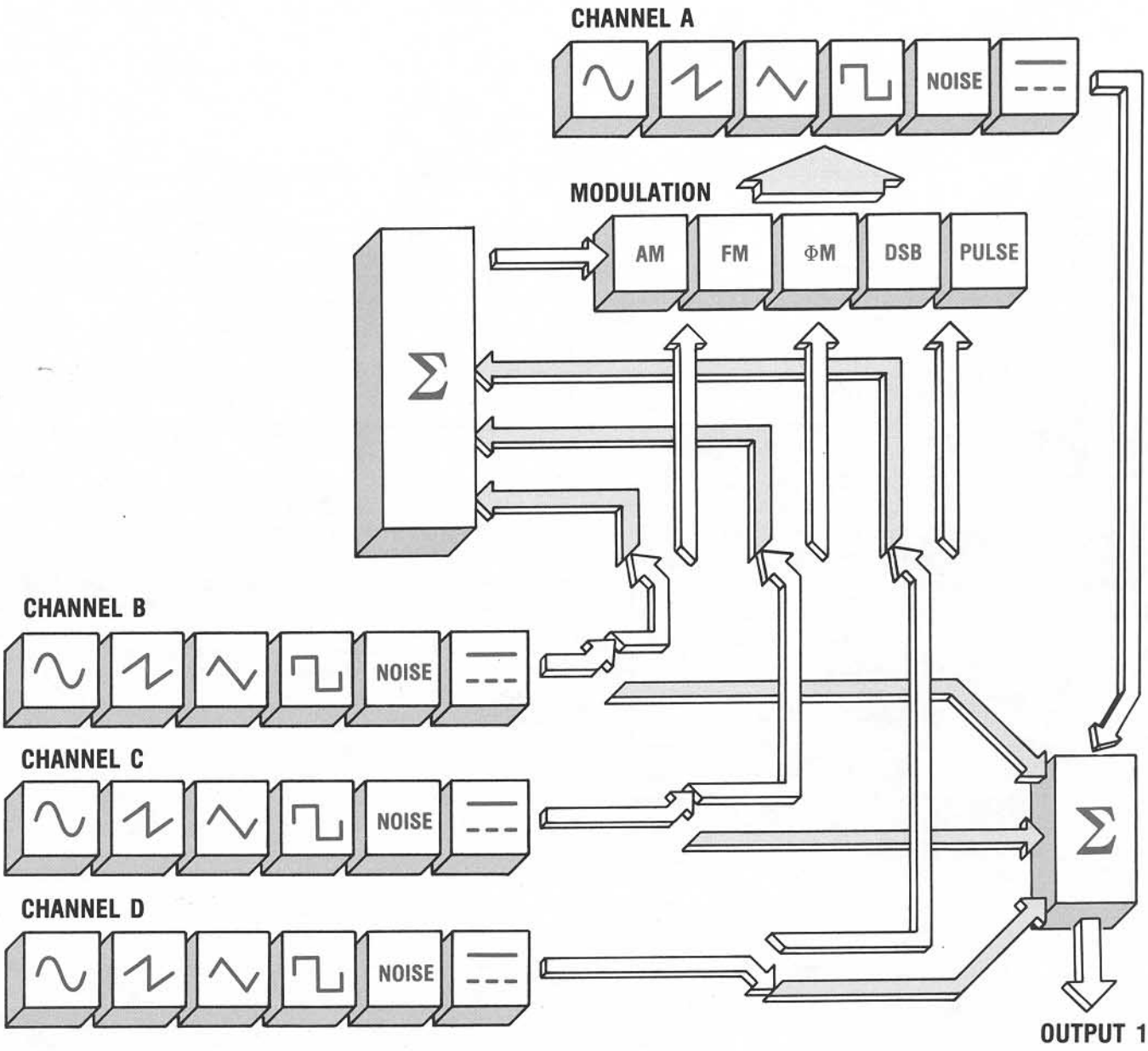


Figure 2–6. The Modulation and Summation Capabilities of the HP 8904A.

Key Points about Operation

Table 2–4 contains operating considerations you should keep in mind as you configure your output signals. Table 2–5 contains the operating ranges for the HP 8904A's modulation capabilities.

Table 2–4. Operating Considerations for Four Channel Operation.

Operation	Considerations
Select Destination	• Select the desired destination before setting the amplitude. • Channels B, C and D can be configured as either modulation sources or output signals, but never both.
Modulate Channel A	• Only Channel A can be modulated. • Channels B, C and/or D can be used to modulate Channel A. • Displayed modulation levels are peak (the overall deviation is twice the amplitude value shown on the display). • The DSB modulation mode sets Channel A's amplitude setting to the DSB amplitude setting. • When frequency or phase modulation is being used, press the ϕ **RESET** key after entering the deviation value (AMPTD) to set a zero phase reference for the angle modulation.
Sum Channels	• Two, three or four channels may be summed into a single output. • Two or three channels may be summed for modulating Channel A (for example, Destn=AM for Channels B, C and D). • All combinations of channels are acceptable **except** for combinations that do not allow the HP 8904A to control the four channels (A, B, C and D) in sequence. (For example, you can not AM Channel A with D and sum Channels B and C. Instead simply AM Channel A with B and sum Channels C and D.)
Save Register	• Saves the current parameter settings for all four channels.

Main versus Preset

The HP 8904A always provides you with at least two methods for returning its operation to the Main Selection Level. It is important that you are aware of the effects that each of these methods has on the status of the HP 8904A's settings.

1. **Press the blue SHIFT key and then the PRESET key.** Both the **MAIN** key and the **PRESET** key return you to the Main Selection Level. The **PRESET** key however, resets the HP 8904A's functions to their pre-defined power-up condition, including the Special Function settings and Floating ground.

Save Registers are Retained

2. **Press the blue SHIFT key, the RECALL key, the 1 key and then press the ENTER key.** Note that the HP 8904A's Save Register settings are retained whether you use the **MAIN** key or the **PRESET** key (or even if the instrument is powered down).

Special Functions are Turned Off

3. **Switch the HP 8904A's power OFF for a few seconds and then back ON.** Since Special Function 0 was turned off when you pressed the **PRESET** key, the HP 8904A now powers-up to the Main Selection Level rather than the state it was in.

Table 1–5. Summary of how the PRESET and MAIN keys affect Operation.

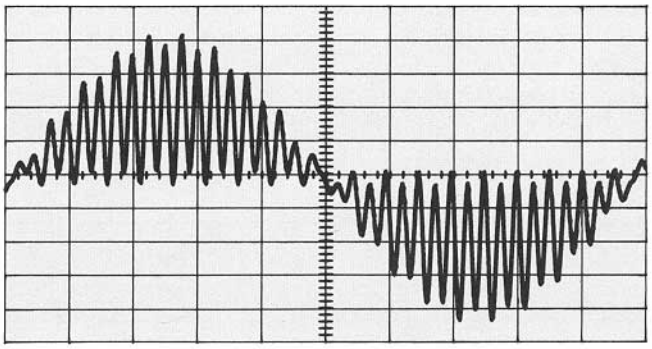
Key	Function
PRESET	• Returns operation to the Main Selection Level. • Resets operating functions to their pre-defined power-up condition, including Special Function settings and Floating ground. • Does not reset Save Registers.
MAIN(1)	• Returns operation to the Main Selection Level. • Does not reset Special Function settings, Save Registers or Floating ground.

(1) The **f4** Exit softkey's effect on operation is similar to that of the **MAIN** key.

How to Set Up Some Applications

The following application examples show some of the waveforms that you can create using the HP 8904A's Four Channel operating capabilities.

FM Stereo Composite Signal



Application:

Testing FM Stereo Receivers

Table 2–6. Instrument Settings for the FM Stereo Composite Signal.

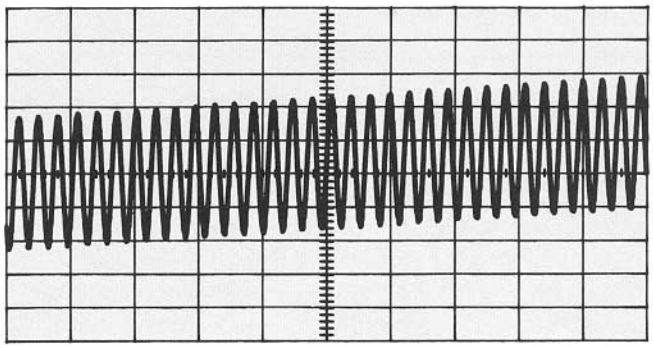
Channel	Destination	Frequency	Amplitude	Phase	Waveform
A	Out 1	38 kHz	140 μV	0.0 deg	Sine
B	DSB	1 kHz	2.5V	0.0 deg	Sine
C	Out 1	1 kHz	2.5V	0.0 deg	Sine
D	Out 1	19 kHz	0.3V	90.0 deg	Sine

Comments:

1. Adjust the amplitude of Channel D to vary the pilot signal level.

2. DSB is Double-Sideband Suppressed-Carrier AM.

VOR Composite Signal



Application:

VOR (VHF Omnidirectional Range) Navigation Radio Testing

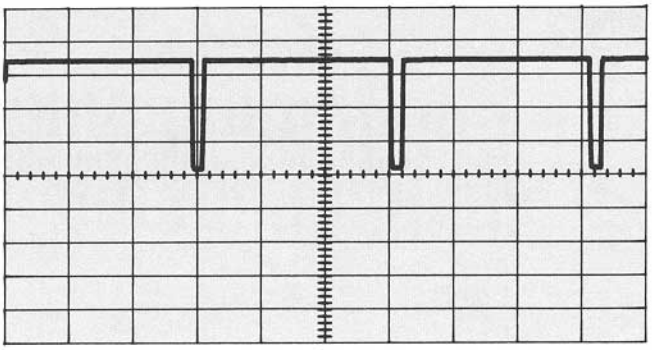
Table 2-7. Instrument Settings for the VOR Composite Signal.

Channel	Destination	Frequency	Amplitude	Phase	Waveform
A	Out 1	9960 Hz	2V	0.0 deg	Sine
B	Out 1	30 Hz	2V	0.0 deg	Sine
C	FM	30 Hz	480 Hz	0.0 deg	Sine
D	Off				

Comments:

1. Adjust the phase of Channel C to vary the bearing. (The phase accuracy of the HP 8904A is typically ±0.05 deg.)

Variable Duty Cycle Pulse Train



Application:

Where required duty cycle is not 50%

Table 2-8. Instrument Settings for a Variable Duty Cycle Pulse Train Signal.

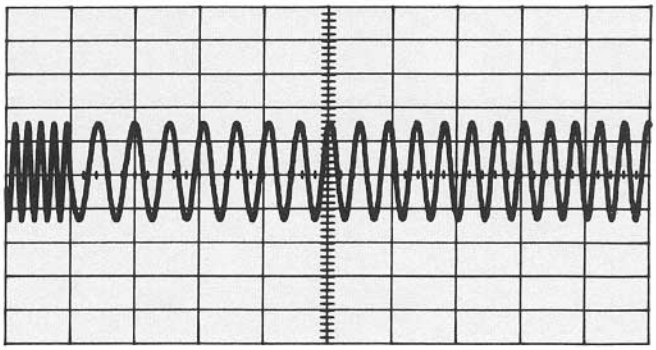
Channel	Destination	Frequency	Amplitude	Phase	Waveform
A	Out 1	1 kHz	140 μV	0.0 deg	Square
B	DSB	1 kHz	2.5V	10 deg	Square
C	Out 1	N/A	2.5 V	N/A	dc
D	Off				

Comments:

1. Adjust the phase of Channel B to vary the duty cycle (for example, 90 deg = 50%).

2. Channel C provides a variable dc reference (optional).

Phase Continuous Sweep



Application:

Frequency Response Testing

Table 2–9. Instrument Settings for a Phase Continuous Sweep Signal.

Channel	Destination	Frequency	Amplitude	Phase	Waveform
A	Out 1	10 kHz	5V	0.0 deg	Sine
B	FM	100 Hz	5 kHz	0.0 deg	Ramp
C	Off				
D	Off				

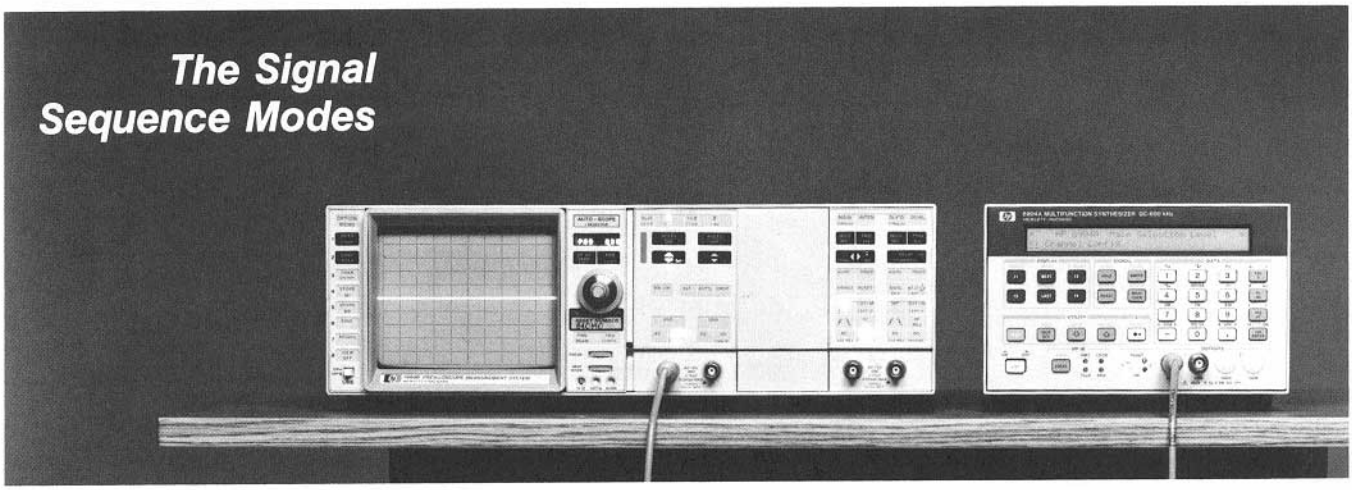
Comments:

1. Adjust the frequency of Channel B to vary the sweep time (for example, 100 Hz = 10 ms sweep).

2. Adjust the amplitude of Channel B to vary the sweep bandwidth (from 5 kHz to 15 kHz in this example).

3 Output a Sequence of Signals

The Signal Sequence Modes



In This Chapter

This chapter contains demonstrations of the Signal Sequencing Modes provided by Configuration Option 01. If your HP 8904A is equipped with Option 01, complete the following demonstrations to learn how to:

- **Output a Tone Sequence**
- **Output a DTMF (Dual-Tone Multi-Frequency) Sequence**
- **Output a Digital Sequence**
- **Set Up a Signal Sequence Application**

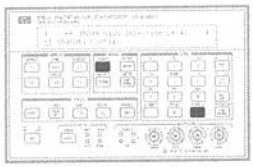
Set Up Your Equipment

Connect your HP 8904A to the oscillocope as shown above.

Adjust Your Oscilloscope

Display ..... Channel A
Volts/Division 2V
Coupling ..... dc (High Impedance)
Time/Division ..... 1.35 ms
Trigger ..... Channel A

Select Chassis Ground



1. **Press the blue SHIFT key and then the PRESET key.**
2. **Press the blue SHIFT key and then the FLOAT key.**
3. **Press the 1 key and then the OFF key to reference the HP 8904A's circuit ground to chassis ground at Output 1.** (Note that the FLOAT LED for Output 1 is now off.)
4. **Adjust the oscilloscope's trace position if necessary to center scale.**

How to Output a Tone Sequence

Tone Sequencing refers to the serial transmission of individual tones in a predetermined order. The HP 8904A's Tone Sequence Mode enables you to configure 16 individual sinewave tones and arrange them in a sequential order that contains up to 250 sequence steps. In this demonstration, you will learn about Tone Sequence operation by configuring a seven-step sequence using four individual tones.

1. **Press the NEXT key and then the f1 Tone Sequence softkey to access the Tone Sequence Mode.**

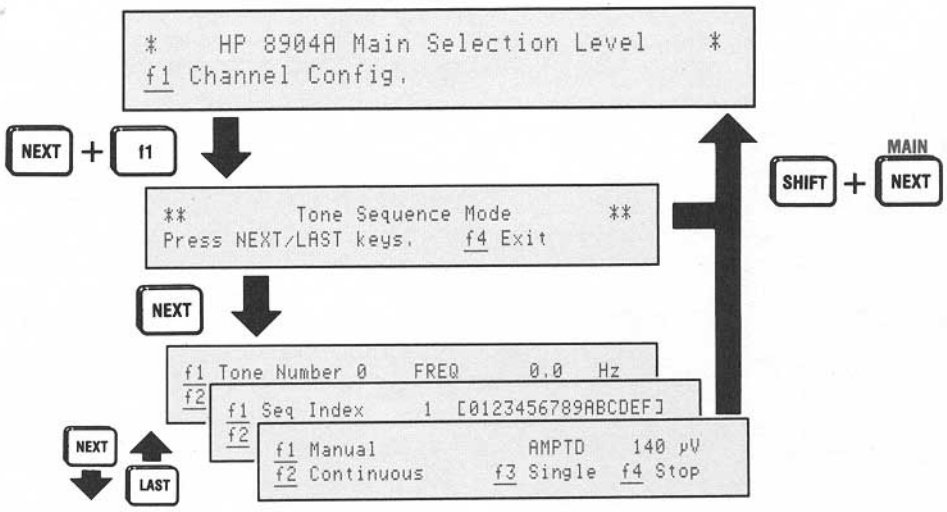


Figure 3–1. How to Access The Tone Sequence Mode.

Enter the Tone Parameters

2. **Press the NEXT key to access the Tone Configuration display.** This display allows you to specify the characteristics of the tones you wish to have in your sequence. You can configure up to 16 different tones using the HP 8904A's 16 Tone Registers (numbered 0 through F).

```
f1 Tone Number 0     FREQ        0.0    Hz
f2 On Time    1.00ms f4 Off Time    1.00ms
```

Configure Tone Register 0

3. **Press the FREQ key and enter 1 kHz.**

4. **Press the f4 Off Time softkey and enter .8 ms.** You have now set Tone 0 to be a 1 kHz signal with a period of 1.8 ms (1 ms on and 0.8 ms off). Note that 1 ms is the default On Time and Off Time setting.

Note

The entered tones will not appear at the output (or on the oscilloscope) until after you have selected a Run Mode as described later in this demonstration.

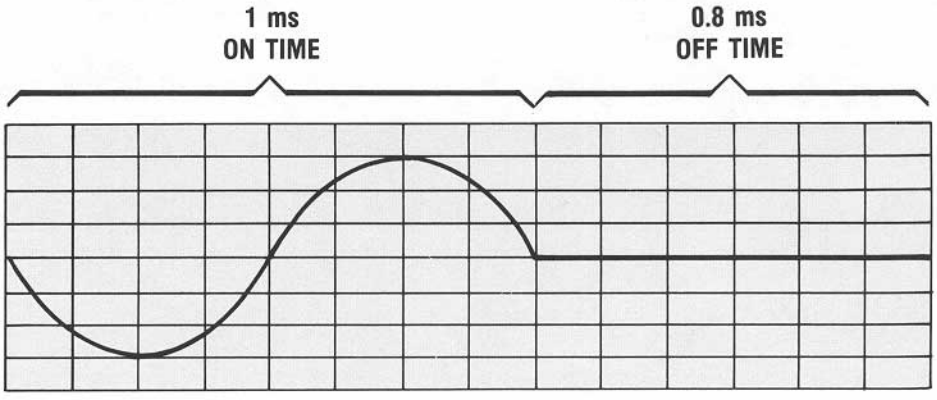


Figure 3–2. Tone 0 Signal

Copy the Off Time

5. **Press the blue SHIFT key and the f4 Off Time softkey.** You have copied the displayed Off Time (0.8 ms) to each of the HP 8904A's 15 other Tone Registers. This function is useful when you wish to have the same Off Time for all of your tones. In this demonstration, the tones you configure will all have the same Off Time but will each have a different On Time. (For your own applications, note that the displayed On Time can also be copied by pressing the blue **SHIFT** key and the **f2** On Time softkey.)

Configure Tone Register 1

6. **Press the f1 Tone Number softkey and then press ⇧ key to access Tone Register 1.** The Tone Number shown in the display indicates which Tone Register is currently being displayed.

7. **Press the FREQ key and enter 2 kHz.**

8. **Press the f2 On Time softkey and enter 1.5 ms.**

Configure Tone Register 2

9. **Press the f1 Tone Number softkey and then the 2 key.** You can access the various Tone Registers by using either the ⇧ or ⇩ keys or by directly entering the number of the register you desire.

10. **Press the FREQ key and enter 3 kHz.**

11. **Press the f2 On Time softkey and enter 2 ms.**

Configure Tone Register 3

12. **Press the f1 Tone Number softkey and then the ⇧ key to access Tone Register 3.**

13. **Press the FREQ key and enter 4 kHz.**

14. **Press the f2 On Time softkey and enter 2.5 ms.**

You have set up four individual tones in Tone Registers 0 through 3. Table 3–1 shows the four tones that you have configured.

Table 3–1. Tone Configuration

Tone Number	Frequency (kHz)	On Time (ms)	Off Time (ms)
0	1.0	1.0	0.8
1	2.0	1.5	0.8
2	3.0	2.0	0.8
3	4.0	2.5	0.8

Specify the Sequence Order

15. **Press the NEXT key to access the Sequence String display.** This display allows you to define the order in which you wish to output the tones you have setup.

```
f1 Seq Index     1  [0123456789ABCDEF]
f2 Seq End     250    f4 Edit Sequence
```

You can arrange your tones in sequence strings that include up to 250 steps. The bracketed field in the upper right corner of the display shows the first 16 tones of the HP 8904A's default sequence string. (The default string is a 250 step sequence that repeatedly cycles through the 16 Tone Registers, 0 through F.)

Step Through the Sequence String

16. **Press the f1 Seq Index key and the ⇧ key to increment the index value.** Notice that the Tone Registers shown within the brackets scroll to the left each time the ⇧ key is pressed allowing you to view the rest of the tones in the sequence string. The Seq Index value helps you keep track of where you are as you step through the sequence string by displaying the position number of the first (left most) tone currently shown in the bracketed field. Figure 3–3 illustrates the windowing effect of the bracketed field and the relationship between the sequence string, position numbers and Sequence Index value.

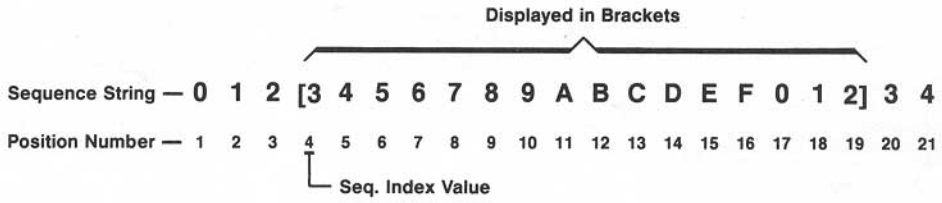


Figure 3–3. Relationship Between the Sequence String, Position Numbers and Seq. Index Value.

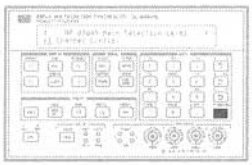
17. **Hold the ⇩ key down to return to the first position in the sequence string (Seq Index 1).**

18. **Press the f4 Edit Sequence softkey.** The Edit function allows you to create the sequence string you desire by deleting and inserting Tone Registers.

19. **Press the ⇧ key to position the cursor underneath the Tone Register 4 entry within the brackets.** (Notice that when you are using the Edit function, the Seq Index value increments when you press the ⇧ key to reflect the cursor's current position in the string.)

20. **Press the f4 Insert softkey and enter 2 1 0.**

21. **Press the f4 Insert softkey again to turn off Insert, and then press the ⇩ key once to position the cursor under the 0 Tone Register that you just entered.**



22. **Press the blue SHIFT key and the END key.** You have now created a seven-step sequence (**0123210**) using the four tones that you configured.

Select the Run Mode

23. **Press the NEXT key to access the Run Mode display.**

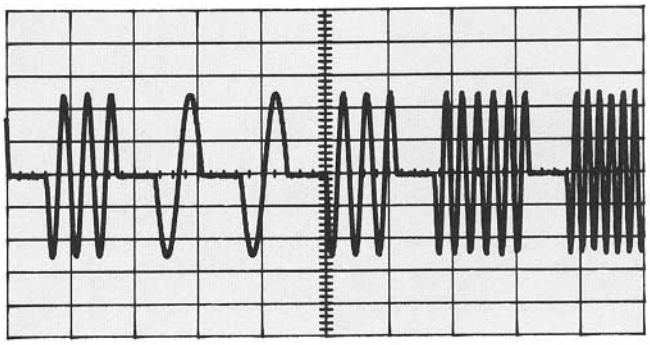
```
f1 Manual                    AMPTD    140 µV
f2 Continuous          f3 Single  f4 Stop
```

24. **Press the AMPTD key and enter 5V.** The output amplitude of each tone in your sequence will be 5 Vpk into a high impedance input (or 5 Vpp into a 50Ω input).

25. **Press the f1 Manual softkey to access the Manual Step mode.**

26. **Press the ⇧ key to step through the Tone Sequence you have set up.** Note that the value shown in brackets in the display is the number of the Tone Register currently being output. The number to the left of the brackets is the sequence position number of that Tone Register.

27. **Press the f2 Continuous softkey.** This causes the HP 8904A to continuously cycle through your Tone Sequence. (Adjust the oscilloscope triggering, if necessary, to get a stable display.)



28. **Press the f4 Stop softkey and then the f3 Single softkey to output a single pass of the Tone Sequence.**

Save and Recall Your Sequence

The HP 8904A will reset the contents of all of its Tone Registers to their default settings when it exits the Tone Sequence Mode to return to the Main Selection Level. When you set up your own signal sequences, you can easily retain all of the parameters you have entered by storing them in a Save Register. When you set up a Save Register (as described in Chapter 1 of this guide), the HP 8904A will store all of the settings for all of its Tone Registers as well as all of its other current operating conditions.

Remember

When you Recall a Save Register, the HP 8904A returns **all** *of its operating modes to the same settings that existed when the Save Register was selected.*

This completes the Tone Sequence demonstration. If you wish to try setting up a different sequence order for the signals you have configured, simply press the **LAST** key to return to the Sequence String display and use the Insert and Delete Editing functions to arrange the Tone Registers in whatever order you desire.

How to Output a DTMF Sequence

In this demonstration, you will learn how to configure your HP 8904A to emulate a telephone keypad for outputting DTMF (Dual-Tone Multi-Frequency) signals.

1. **If you are not currently at the Main Selection Level display, press the blue SHIFT key and the MAIN key.**

2. **Press the NEXT key and then the f3 DTMF Sequence softkey to access the DTMF Sequence Mode.**

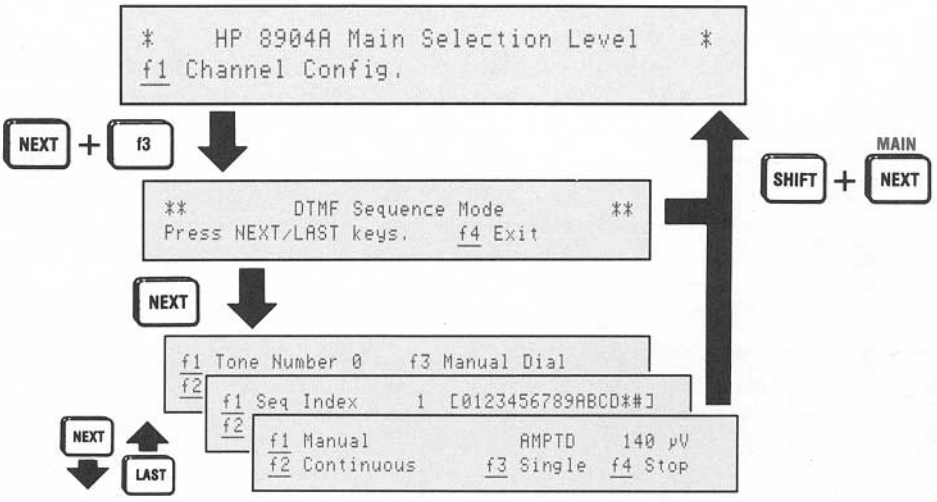


Figure 3–4. How to Access the DTMF Sequence Mode.

Enter the DTMF Parameters

3. **Press the NEXT key to access the DTMF Configuration display.** This display allows you to define the On Time and Off Time for each DTMF signal.

```
f1 Tone Number 0     f3 Manual Dial
f2 On Time   1.00ms  f4 Off Time   1.00ms
```

Configure DTMF Signal 0

4. **Press the f2 On Time softkey and enter 44 ms.**

5. **Press the f4 Off Time softkey and enter 44 ms.** You have now defined the period of the 0 DTMF signal to be 88 ms. (Note that the default period for each DTMF signal is 2 ms, 1 ms on and 1 ms off.)

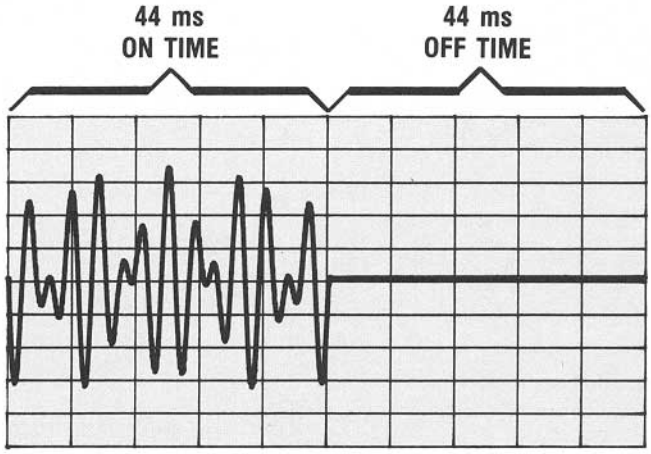
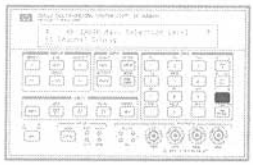


Figure 3–5. 0 DTMF Signal.

Copy the On and Off Times

6. **Press the blue SHIFT key and then the f2 On Time softkey to set the On Time for all of the other DTMF signals to 44 ms as well.**

7. **Press the blue SHIFT key and then the f4 Off Time softkey to also set the Off Time for the other DTMF signals to 44 ms.**



8. **Press the f1 Tone Number softkey and then the C key.** You have accessed the C DTMF signal. (When in the DTMF Sequence Mode, each front-panel DATA key (0 through 9, A through D, and * and #) on the HP 8904A is assigned the appropriate DTMF signal as defined by the Touch-tone® industry standard.) Notice that the On Time and Off Time for the C DTMF signal have each been set to 44 ms.

Specify the Sequence Order

9. **Now press the NEXT key to access the Sequence String display.** This display allows you to define the order in which you wish to sequence through the DTMF signals. (Note that the softkeys shown on this display are the same as those described for the Tone Sequence Mode. Refer to *How to Output a Tone Sequence* if you wish to review the operation of these functions.)

```
f1 Seq Index      1  [0123456789ABCD*#]
f2 Seq End    250    f4 Edit Sequence
```

Select the Run Mode

10. **Press the NEXT key to access the Run Mode display.**

```
f1 Manual                 AMPTD    140 µV
f2 Continuous        f3 Single  f4 Stop
```

11. **Press the AMPTD key and enter 2V.** The output amplitude of each DTMF signal will now be 2 Vpk.

12. **Press the f1 Manual key and then the ⇧ key to step through the DTMF Sequence.**

Manual Dial

You can also output the DTMF signals using the HP 8904A's front-panel keys.

13. **Press the LAST key twice to return to the DTMF Configuration display.**

```
f1 Tone Number C     f3 Manual Dial
f2 On Time  44.00ms  f4 Off Time  44.00ms
```

14. **Press the f3 Manual Dial softkey.** You have configured the HP 8904A's front-panel DATA keys to emulate a telephone key pad.

15. **Press any one of the DATA keys (0 through 9, A through D, or * or #) to output the corresponding DTMF signal for 44 ms at 2 Vpk.** If you wish to hear the DTMF signals, Figure 3–6 shows a connection diagram for connecting an external speaker to Output 1.

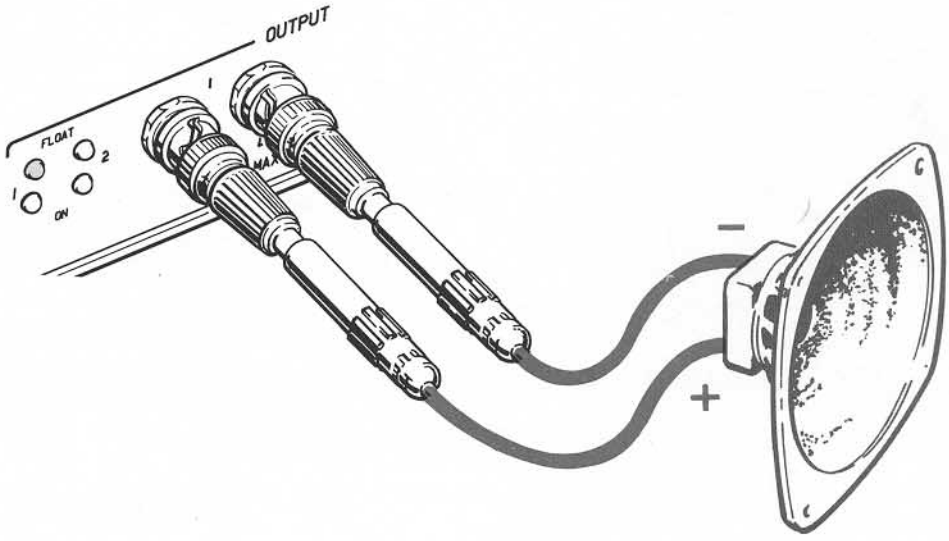


Figure 3–6. Connection Diagram for Connecting an External Speaker to Output 1.

Remember

To use the Manual Dial function, you must first specify an output amplitude in the Run Mode display (as described in this demonstration) in order for the DTMF signals to be > 140 μV at the output.

How to Output a Digital Sequence

In this demonstration, you will output a binary Digital Sequence of TTL compatible bits.

1. **If you are not currently at the Main Selection Level display, press the blue SHIFT key and the MAIN key.**

2. **Press the NEXT key twice and then the f1 Digital Sequence softkey to access the Digital Sequence Mode.**

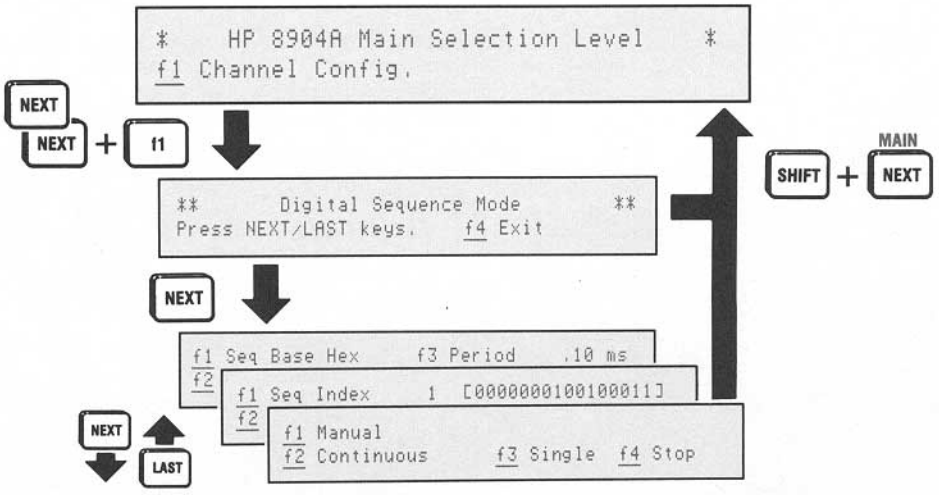
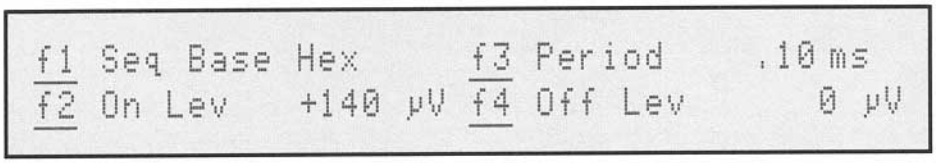


Figure 3-7. How to Access the Digital Sequence Mode.

Enter the Bit Parameters

3. **Press the NEXT key to access the Digital Configuration display.** This display allows you to specify the On Level, Off Level and Period for your digital bits.



Note

In this demonstration, we assume active high logic by setting the On Level to correspond to the desired logic level for the 1 bits (+4V) and the Off Level to correspond to the desired logic level for the 0 bits (+0.5V).

You can also configure a Digital Sequence for active low level logic by entering the desired low level as the On Level and the desired high level as the Off Level. Simply keep in mind that the On Level setting always determines the output level for the 1 bits in your sequence string and the Off Level always determines the level for the 0 bits.

Enter the On Level and the Off Level

4. **Press the f2 `On Lev` softkey and enter 4V.**

5. **Press the f4 `Off Lev` softkey and enter 0.5V.** Note on the oscilloscope display that the HP 8904A's output signal level is now set to the Off Level that you entered (0.5V).

Enter the Period

6. **Press the f3 `Period` softkey and enter 1 ms.** The period of each 1 Bit and each 0 Bit in your sequence will now be 1 ms.

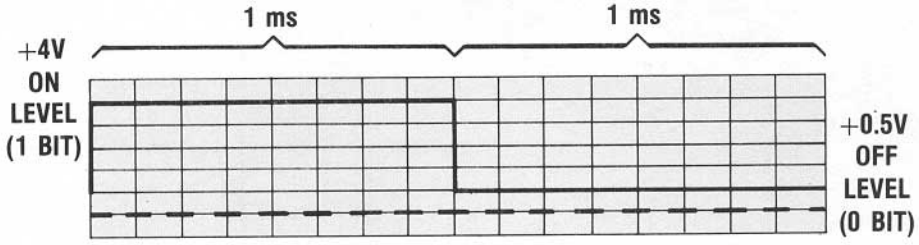


Figure 3–8. 1 and 0 Bit Characteristics.

Select the Base You Desire

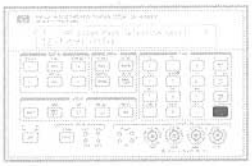
7. **Press the f1 `Seq Base` softkey twice so that `Bin` appears in the display.** The HP 8904A allows you to select between a Hexadecimal, Binary or Octal base numbering system for formatting your Digital Sequence.

Specify the Sequence Order

8. **Press the NEXT key to access the Sequence String display.** This display allows you to define the order of your On and Off bits (where binary 1=On and 0=Off).

```
f1 Seq Index      1  [0000000010010001 1]
f2 Seq End  1000     f4 Edit Sequence
```

9. **Press the f4 Edit Sequence softkey.**



10. **Press the 1 and 0 keys to configure a bit sequence of 101101001.**

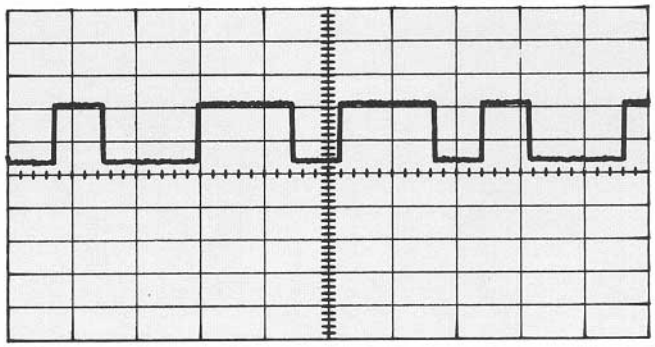
11. **Press the ⇩ key once to position the cursor underneath the last 1 you entered, and press the blue SHIFT key and the END key.**

Select the Run Mode

12. **Press the NEXT key to access the Run Mode display.**

```
f1 Manual
f2 Continuous      f3 Single  f4 Stop
```

13. **Press the f2 Continuous softkey.**



Things to Remember About the Signal Sequence Modes

You have now completed the setup procedures for each of the three Signal Sequence Modes: Tone, DTMF and Digital. The following outline lists the key steps for setting up a signal sequence. Figure 3–9 illustrates the HP 8904A's Signal Sequencing capabilities.

1. ***Enter the parameters*** for each signal you wish to include in your sequence.
2. ***Specify the order*** in which you wish for the signals to be output.
3. ***Select the method*** you desire for outputting the sequence (Manual Step, Single Sequence or Continuous Cycle).

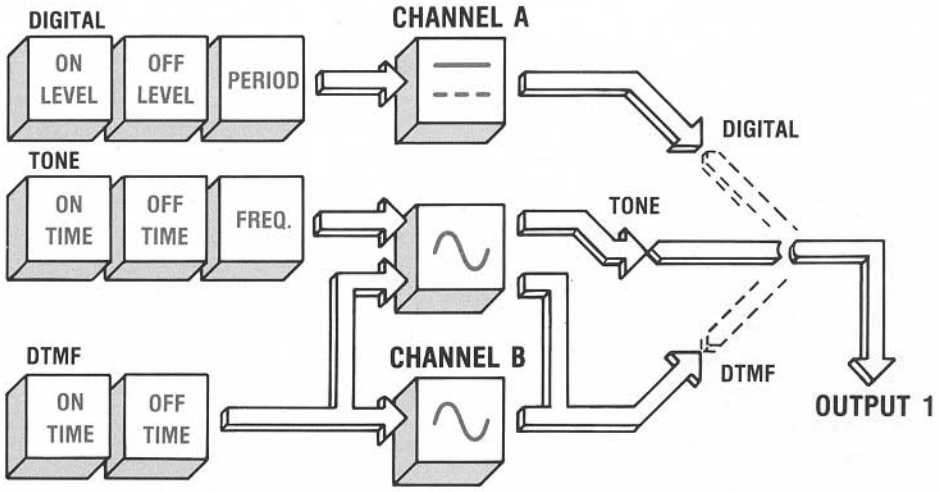


Figure 3–9. The HP 8904A's Signal Sequence Capabilities.

Key Points About Operation

Table 3–2 contains a few operating considerations you should keep in mind as you configure your signal sequences. Table 3–3 contains the specified operating ranges for each the Signal Sequence Modes.

Table 3–2. Operating Considerations for Signal Sequencing.

Operation	Considerations
Copy Paramenters	• Press the blue **SHIFT** key and then **f2** On Time or **f4** Off Time softkeys to copy the displayed time for every tone or DTMF signal.
Output Signal	• The specified Tones or DTMF signals will not appear at the output (> 140 μV) until an amplitude setting has been entered. • The Signal Sequence Modes can only be output at Output Port 1.

Table 3–3. Signal Sequence Specifications.

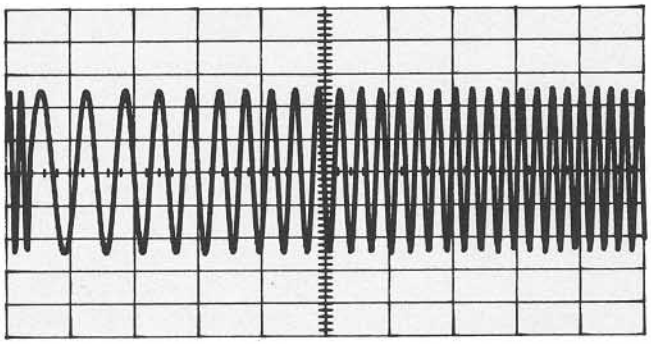
Specifications				
Sequence Mode	**Number of Frequencies**	**On Time(1)**	**Off Time(1)**	**Sequence Length**
Tone	16	0.80 ms to 655.35 ms	0.80 ms to 655.35 ms	1 to 250 Tones
DTMF	16	1.0 ms to 655.35 ms	1.0 ms to 655.35 ms	1 to 250 DTMF signals
Sequence Mode	**On Level**	**Off Level**	**Period**	**Sequence Length**
Digital	−10V to +10V	−10V to +10V	0.1 ms to 655.35 ms	1 to 1000 Bits

(1) Note that either the On Time or the Off Time can be set to 0, but not both.

How to Set Up an Application

Phase Continuous Stepped Sweep

The following setup example demonstrates a Tone Sequence that can be created using an HP 8904A.



Application:

Phase continuous stepped sweeping from 100 Hz to 10 kHz.

Table 3–4. Instrument Settings for Phase Continuous Sweep.

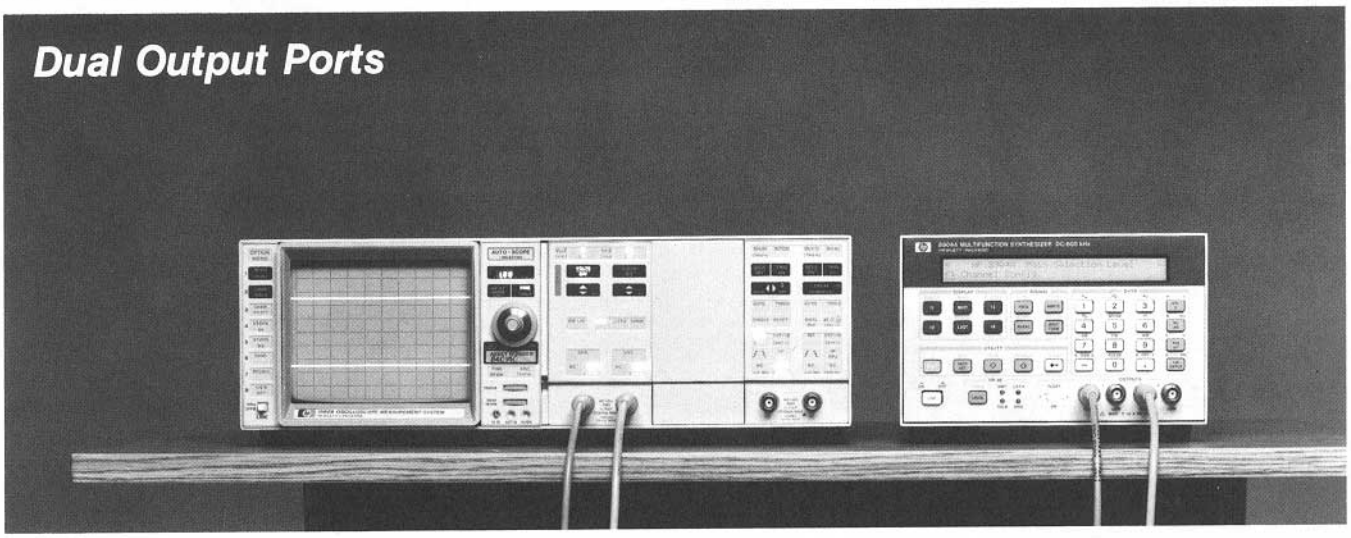
Tone Number	Frequency (kHz)	On Time (ms)	Off Time (ms)
0	100	2.0	0.0
1	200	2.0	0.0
2	300	2.0	0.0
3	500	2.0	0.0
4	700	2.0	0.0
5	900	2.0	0.0
6	1k	2.0	0.0
7	2k	2.0	0.0
8	3k	2.0	0.0
9	4k	2.0	0.0
A	5k	2.0	0.0
B	6k	2.0	0.0
C	7k	2.0	0.0
D	8k	2.0	0.0
E	9k	2.0	0.0
F	10k	2.0	0.0

Comments:

1. The Tone Sequence is: 0 1 2 3 4 5 6 7 8 9 A B C D E F
2. The Run Mode can be: Single or Continuous (5V)

4 Output Two Signals at Once

Dual Output Ports



In this Chapter

In this chapter, you will learn to operate the Dual Output Ports provided by Configuration Option 02. If your HP 8904A is equipped with Option 02, this demonstration will show you how to:

- **Output a Signal at each Output Port**
- **Vary the Phase Relationship of the Signals at each Output Port**
- **Set Up Some Applications that use the Dual Output Ports**
- **Modulate at One Output Port and Sum at the Other (only for instruments that are also equipped with four channels, Option 01)**

Set Up Your Equipment

Connect your HP 8904A to the oscilloscope as shown above.

Note

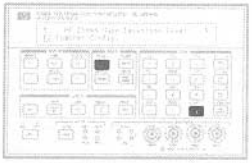
A dual-trace oscilloscope is required to complete the demonstrations in this chapter.

Adjust Your Oscilloscope

Display ..... Alternate
Volts/Division ..... 1V (Channels A and B)
Coupling ..... dc (High Impedance)
Time/Division ..... 0.2 ms
Trigger ..... Channel A

Select Chassis Ground

1. **Press the blue SHIFT key and the PRESET key on the HP 8904A.** Note that all four Output LEDs are lit on HP 8904A's equipped with Dual Output Ports.



2. **Press the blue SHIFT key and then the FLOAT key to access the Output Float Control display.**

3. **Press the 1 key and then the OFF key to reference the HP 8904A's circuit ground to chassis ground at Output 1.**

4. **Press the blue SHIFT key and then the FLOAT key again.**

5. **Press the 2 key and then the OFF key to reference the HP 8904A's circuit ground to chassis ground at Output 2 as well.** (Note that the FLOAT LEDs for Outputs 1 and 2 are now off.)

6. **Adjust the Channel A trace on the oscilloscope to halfway between the top and the middle of the display, and the Channel B trace to halfway between the bottom and the middle of the display.**

How to Output a Signal at each Port

The Dual Output Ports option provides you with two synthesized function generators. (Both a HIGH and a LOW output connection is provided for each function generator.)

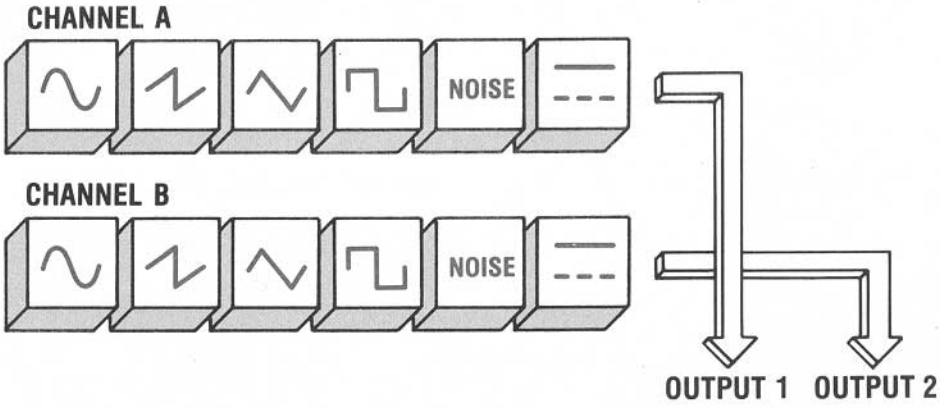


Figure 4–1. Channel and Output Configuration for the Option 02, Dual Output Ports.

1. **Press the f1 Channel Config. softkey to access the Channel Configuration Mode.**

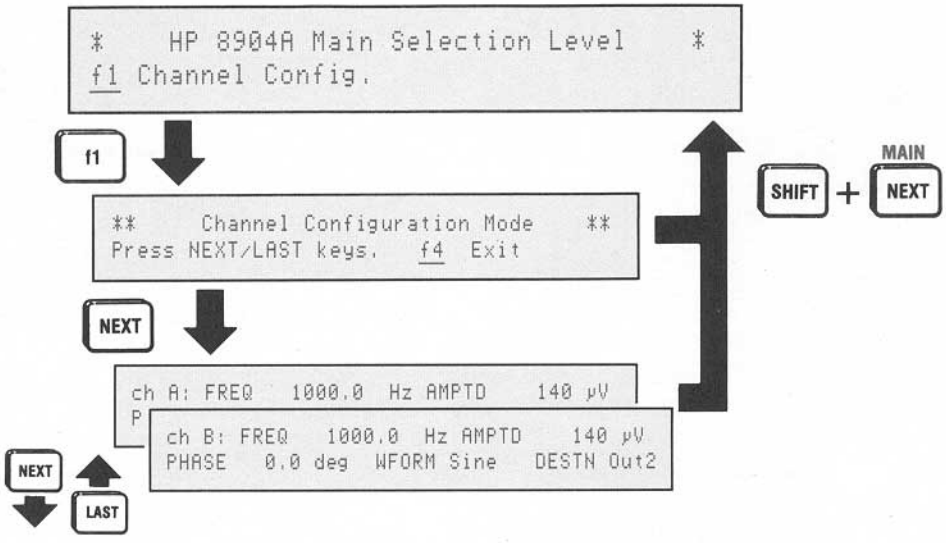


Figure 4–2. How to Access Option 02, Dual Output Ports Operation.

Output Port 1

2. **Press the NEXT key to access the Channel A Configuration display.** Notice that the destination for Channel A is already set to Output 1.

```
ch A: FREQ   1000.0  Hz AMPTD    140 µV
PHASE   0.0 deg  WFORM Sine   DESTN Out1
```

3. **Press the AMPTD key and enter 1V.**

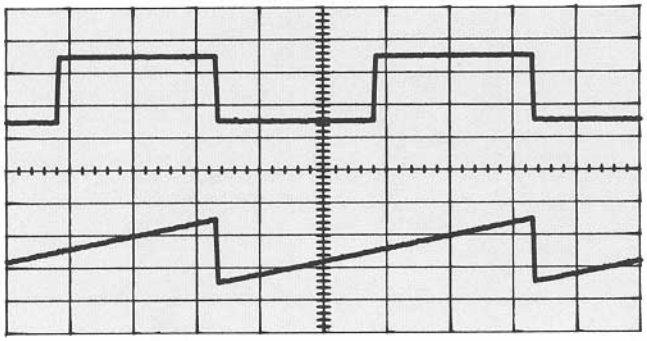
4. **Press the WAVEFORM key and then ⊓⊔ key to output a square wave from Channel A at Output Port 1.**

Output Port 2

5. **Press the NEXT key to access the Channel B Configuration display.** Notice that the destination for Channel B is already set to Output 2.

6. **Press the AMPTD key and enter 1V.**

7. **Press the WAVEFORM key and then the ⩘ key to select a ramp waveform.** Two signals should now appear on the oscilloscope display (a square wave and a ramp wave).



How to Vary the Phase

The HP 8904A gives you precise control of the phase relationship between the two function generators (to 0.1 degrees).

1. **Press the PHASE key, the INCR SET key and enter 45 degrees.**

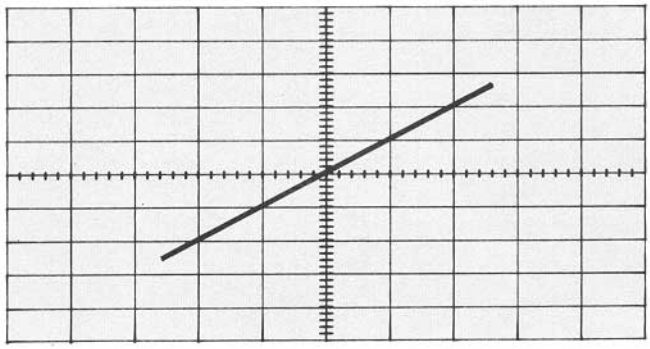
2. **Press the ⇧ key to increment the phase of Channel B up in 45 degree steps.** You should be able to see the phase of the Channel B signal shift on the oscilloscope relative to the Channel A signal each time you press the ⇧ key.

If you continue to press the ⇧ key, you will find that the HP 8904A does not respond to your 45 degree increment at 315 degrees. This is because the maximum phase shift allowed by the HP 8904A is 359.9 degrees.

How to Set Up Some Applications

Stereo Phase Test Signal

The following setup examples demonstrate two test appplications that can be simplified using the Dual Output Ports.



Application:

Used to align stereo audio cassette player (tape deck) heads.

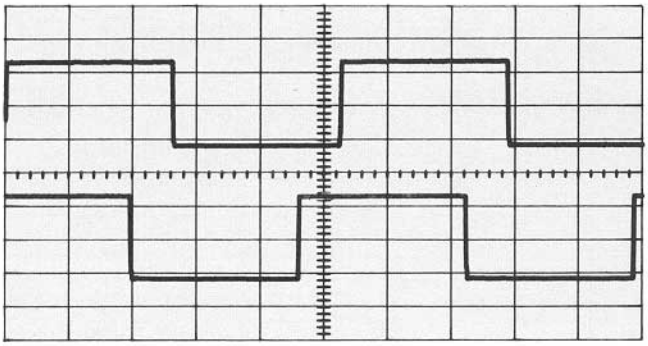
Table 4–1. Instrument Settings for the Stereo Phase Test Signal.

Channel	Destination	Frequency	Amplitude	Phase	Waveform
A	Out 1	1 kHz	2.5V	0.0 deg	Sine
B	Out 2	1 kHz	2.5V	0.0 deg	Sine

Comments:

1. Connect Output Port 1 to the left input on the stereo and Output Port 2 to the right input.
2. Connect the stereo's left and right outputs to the oscilloscope.
3. Set the oscilloscope for A vs. B. (The pattern shown above represents the desired zero phase difference between the stereo's channels.)

Variable Phase Signal



Application:

Testing phase performance on two-channel devices (such as characterizing phase detectors, or testing servo system stability).

Table 4–2. Instrument Settings for a Variable Phase Signal.

Channel	Destination	Frequency	Amplitude	Phase	Waveform
A	Out 1	1 kHz	2.5V	0.0 deg	Square
B	Out 2	1 kHz	2.5V	45 deg	Square

Comments:

1. Adjust Channel B's phase to vary the phase differential. (The HP 8904A provides 0.1 degree phase increments.)

If your HP 8904A is equiped with Option 02 only, you have completed the operating demonstrations provided in this guide for your instrument. The following demonstration (beginning on the next page) is for instruments that are also equiped with four channels (Option 01).

How to Modulate and Sum

If your HP 8904A also has four channels (Option 01), you can use the additional channels (C and D) to modulate or sum with the two output signals. In this demonstration, you will configure the HP 8904A to modulate Channel A using Channel B and output the modulated signal at Output Port 1. You will then sum Channels C and D and output the resulting signal at Output Port 2.

Note

This demonstration assumes that the parameters for Channels A and B are configured as described in the previous demonstration, "How to Output a Signal at Each Port." If they are not, please configure the Channels as shown in Table 4–3 before you begin this demonstration.

Table 4–3. Instrument Settings for Channels A and B.

Channel	Destination	Frequency	Amplitude	Phase	Waveform
A	Out 1	1 kHz	1V	0.0 deg	Square
B	Out 2	1 kHz	1V	315 deg	Ramp
C	Off				
D	Off				

Modulate at Output Port 1

Channel A

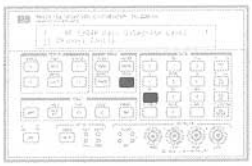
1. **Press the LAST key as needed to access the Channel A Configuration display.**

2. **Enter a frequency of 20 kHz.**

Channel B

3. **Press the NEXT key, the PHASE key and enter 0 degrees for Channel B.**

4. **Press the WAVEFORM key and the ∿ key.**



5. **Press the blue SHIFT key, the DESTN key and then the AM key.**

6. **Press the AMPTD key and enter 100%.** Channel B is now configured to amplitude modulate Channel A. (Adjust the oscilloscope if necessary to get a stable display.)

Sum at Output Port 2

Channel C

7. **Press the NEXT key twice to access the Channel C Configuration display.**

8. **Press the FREQ key and enter 20 kHz.**

9. **Press the WAVEFORM key and the ⊓⊔ key.**

10. **Press the blue SHIFT key, the DESTN key and then the 2 key to route Channel C to Output Port 2.**

11. **Press the AMPTD key and enter 1V.**

Channel D

12. **Press the NEXT key to access the Channel D Configuration display.**

13. **Press the blue SHIFT key, the DESTN key and then the 2 key to route Channel D to Output Port 2.**

14. **Press the AMPTD key and enter 1V.** The HP 8904A is now configured to sum Channels C and D and output the resulting waveform at Output Port 2.

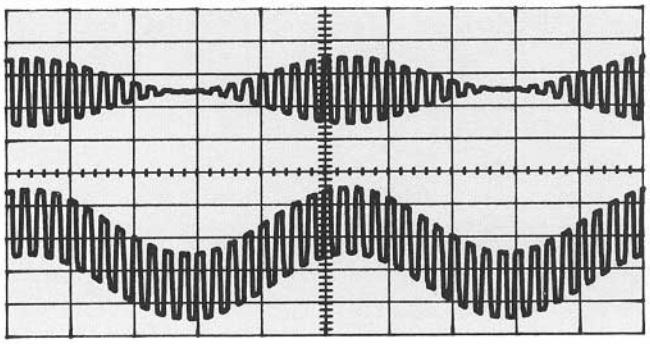


Figure 4–3. Two 20 kHz Square Wave Signals, One Modulated by 1 kHz (top), and the Other Summed with 1 kHz (bottom).

Table 4–4 shows the parameters you have entered for each channel. Instruments that have four channels and Dual Output Ports provide maximum flexibility for meeting the needs of applications that require both modulated and unmodulated signals.

Table 4–4. Instrument Settings for the Four Channel, Dual Output Ports Demonstration.

Channel	Destination	Frequency	Amplitude	Phase	Waveform
A	Out 1	20 kHz	1V	0.0 deg	Square
B	AM	1 kHz	100%	0.0 deg	Sine
C	Out 2	20 kHz	1V	0.0 deg	Square
D	Out 2	1 kHz	1V	0.0 deg	Sine

Remember

Only Channel A can be modulated by the other channels, and each channel can have only one destination at a time (Output Port 1, Output Port 2, or as a modulation source to Channel A.)

Things to Remember About Dual Output Ports Operation

Figure 4–4 provides an overview of the HP 8904A's operation when it is equipped with four channels and Dual Output Ports.

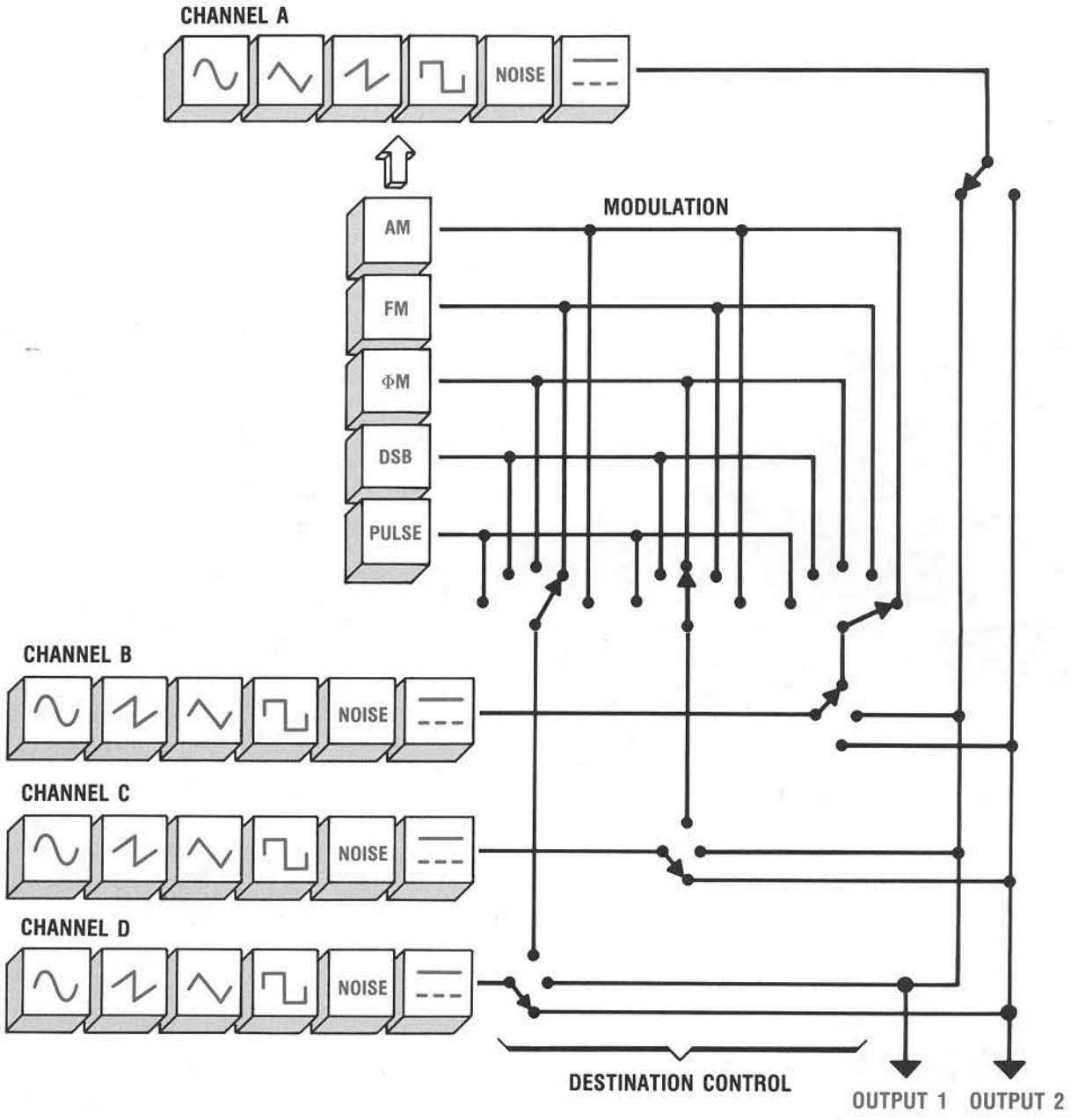


Figure 4–4. Channel and Output Configuration for HP 8904A's Equipped with Four Channels and Dual Output Ports.

Key Points About Operation

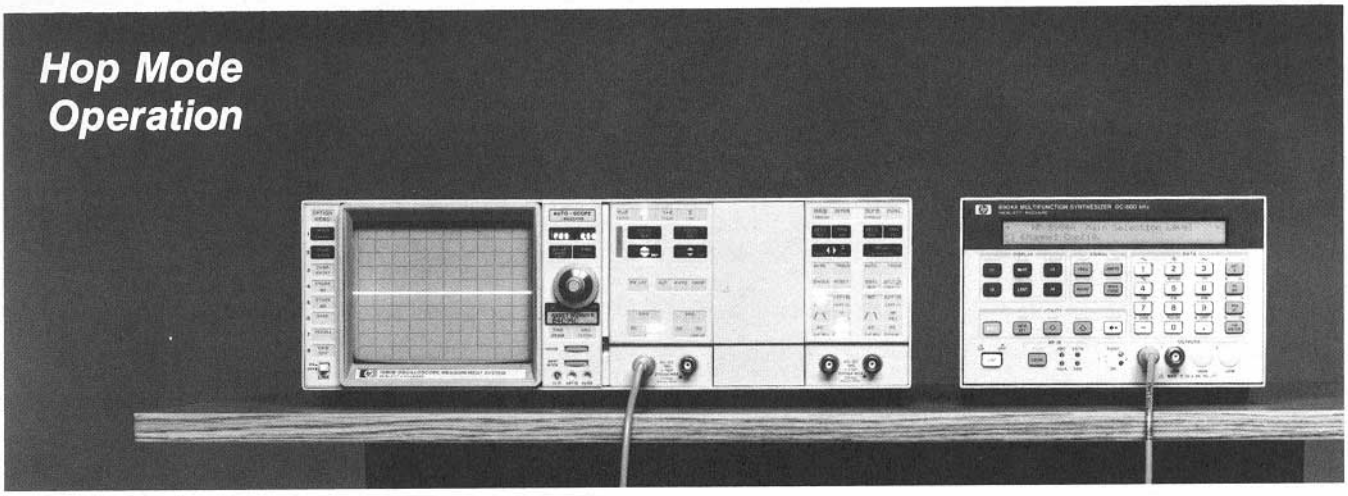
Table 4–5 contains operating considerations you should keep in mind as you configure the HP 8904A's four channels for dual output operation.

Table 4–5. Operating Considerations for Dual Output Port Operation using Four Channels.

Operation	Considerations
Output Signal	• Each Channel can be output at either Output 1 or 2.
Configure Channels	• All considerations shown in Chapter 2 for Four Channel Operation still apply.

5 Hop the Output Signal

Hop Mode Operation



In This chapter

In this chapter, you will learn how to operate the Hop Mode capabilities provided by Configuration Option 03. If your HP 8904A is equipped with Option 03, this Hop Mode demonstration will teach you how to:

- **Access Hop Mode Operation**
- **Configure Channel A for Hopping its Frequency, Amplitude and Phase Settings**
- **Fast Hop Channel A**

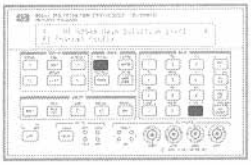
Set Up Your Equipment

Connect your HP 8904A to the oscilloscope as shown above.

Adjust Your Oscilloscope

Display ..... Channel A
Volts/Division 1V
Coupling ..... dc (High Impedance)
Time/Division ..... 0.2 ms
Trigger ..... Channel A

Select Chassis Ground



1. **Press the blue SHIFT key and the PRESET key.**
2. **Press the blue SHIFT key and then the FLOAT key.**
3. **Press the 1 key and then the OFF key to reference the HP 8904A's circuit ground to chassis ground at Output 1.** (Note that the FLOAT LED for Output 1 is now off.)
4. **Adjust the oscilloscope trace if necessary to position the trace at center scale.**

How to Access Hop Mode Operation

1. **Press the f1 Channel Config. softkey to access the Channel Configuration Mode.**

2. **Press the NEXT key to access the Channel A Configuration display.** The HP 8904A will output Channel A when the Hop Mode is turned on. The HP 8904A will allow you to hop the frequency, amplitude and/or phase settings of the Channel A signal.

```
ch A: FREQ   1000.0  Hz AMPTD    140 µV
PHASE   0.0 deg  WFORM Sine   DESTN Out1
```

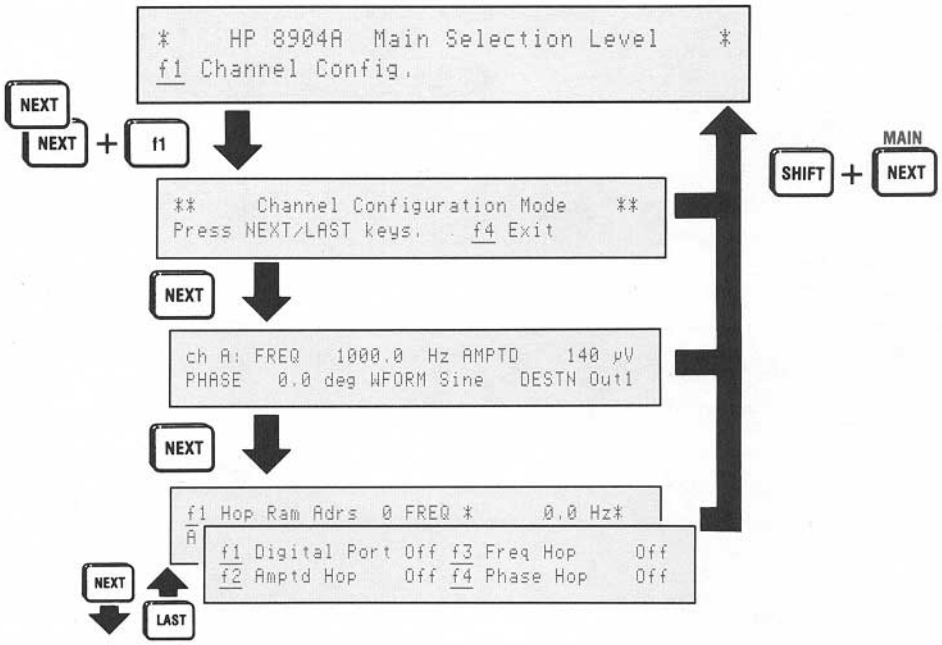


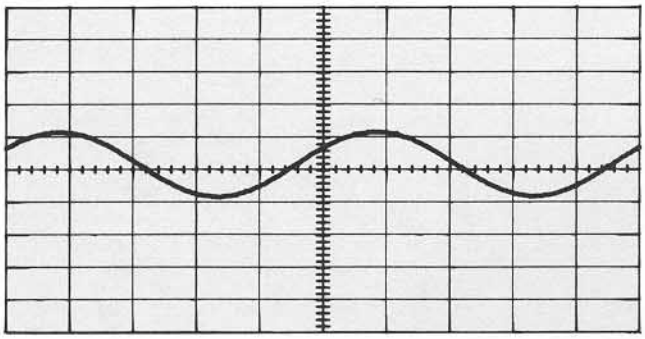
Figure 5–1. How to Access Hop Mode Operation.

How to Configure Channel A for Hopping

The HP 8904A enables you to hop Channel A's frequency, amplitude and/or phase settings. This demonstration will step you through the process of entering the settings you wish to have Channel A hop to.

Note *Only Channel A's settings can be hopped.*

1. **Press the AMPTD key and enter 1V.** The 1 kHz, 1 Vpk Channel A signal should now appear on your oscilloscope.



Enter the Hop Parameters

Note *If your HP 8904A is equipped with four channels, the Parameter Entry displays for Channels B, C and D will precede the Hop Configuration display.*

2. **Press the NEXT key until the Hop Configuration display appears.** This display allows you to enter the settings you wish to have Channel A hop to. The HP 8904A provides 16 Hop Registers (0 through 15).

```
f1 Hop Ram Adrs  0  FREQ *      0.0  Hz*
AMPTD *     0 pV *  PHASE *   0.0 deg *
```

Hop Register 0

3. **Press the FREQ key and enter 5 kHz.**

4. **Press the AMPTD key and enter 2V.** That is all it takes to store parameters in a Hop Register.

Hop Register 1

5. **Press the f1 Hop Ram Adrs softkey and then the ⇧ key.** The HP 8904A is now ready to accept parameters for Hop Register 1.

6. **Press the FREQ key and enter 10 kHz.**

7. **Press the AMPTD key and enter 3V.**

Hop Register 2

8. **Press the f1 Hop Ram Adrs softkey, the 2 key and then the ENTER key.** You can access the various Hop Registers by using either the ⇧ or ⇩ keys or by entering the number of the desired register directly.

9. **Press the FREQ key and enter 15 kHz.**

10. **Press the AMPTD key and enter 4V.**

Hop Register 3

11. **Press the f1 Hop Ram Adrs softkey and the ⇧ key to access Hop Register 3.**

12. **Enter a frequency of 20 kHz and an amplitude of 5V.**

You have now entered frequency and amplitude parameters into four Hop Registers (0 through 3).

Table 5–1. Parameter Entries for Hop Registers 0 through 3.

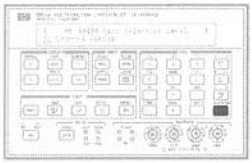
Hop Register	Frequency (kHz)	Amplitude (V)	Phase (deg)
0	5.0	2.0	0.0
1	10.0	3.0	0.0
2	15.0	4.0	0.0
3	20.0	5.0	0.0

Save and Recall Your Hop Parameters

The HP 8904A will reset the contents of all of its Hop Registers to their default values (0) when it exits the Channel Configuration Mode to return to the Main Selection Level. When you set up your own Hop Mode applications, you can easily retain all of the hop parameters that you have entered by storing them in a Save Register. When you set up a Save Register (as described in Chapter 1 of this guide), the HP 8904A will store the current parameter settings for all of its Hop Registers as well as all of the current settings for Channel A.

Remember

When you Recall a Save Register, the HP 8904A returns **all** *of its operating modes to the same settings that existed when the Save Register was selected.*

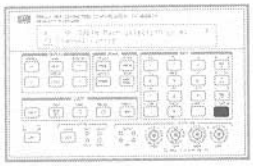


Specify the Hop Parameters

13. **Press the f1 Hop Ram Adrs softkey, the 0 key and then the ENTER key to return to the first Hop Register.**

14. **Press the NEXT key to access the Hop Parameter Selection display.** This display allows you to specify which of Channel A's settings you wish to hop.

```
f1 Digital Port Off  f3 Freq Hop     Off
f2 Amptd Hop    Off  f4 Phase Hop    Off
```



15. **Press the f2 Amptd Hop softkey and then the ON key.** You have configured the HP 8904A to hop Channel A's amplitude setting. The amplitude of the signal on your oscilloscope should increase to 2 Vpk.

The HP 8904A is now outputting its Channel A signal at the amplitude specified in Hop Register 0 (2 Vpk). Note that the frequency of the output signal however, is not 5 kHz as specified in Hop Register 0. The HP 8904A only uses the parameters from the Hop Register that have been turned on (amplitude in this case). Since the frequency parameter has not yet been turned on, the HP 8904A continues to use Channel A's frequency setting.

16. **Now press the f3 Freq Hop softkey and then the ON key.** Now the frequency of Channel A is also being set by Hop Register 0.

Select the Hop Registers

17. **Press the LAST key to return to the Hop Configuration display.** Note that the HP 8904A has removed the asterisk (*) from the frequency and amplitude entry fields on the display to signify that they are currently turned on.

```
f1 Hop Ram Adrs  0  FREQ     5.000  kHz
AMPTD    2.00  V    PHASE *   0.0 deg *
```

18. **Press the f1 Hop Ram Adrs softkey and then the ⇧ key.** Continue to press the ⇧ key until you reach Hop Register 3. Notice the frequency and amplitude of the signal displayed on the oscilloscope hop to the values specified in the selected Hop Register each time the ⇧ or ⇩ keys are pressed.

19. **Now press the 2 key and then the ENTER key.** You can also select the Hop Registers directly in whatever order you wish.

20. **Press the LAST key until the Channel A Configuration display appears.** The HP 8904A display informs you that the frequency and amplitude settings for Channel A are now being set by the Hop Registers.

```
ch A: FREQ *Hop Ram*    AMPTD  *Hop Ram*
PHASE   0.0 deg  WFORM Sine   DESTN Out1
```

Note

Although Channel A's phase setting was not hopped in this demonstration, it can also be configured to hop using the procedures described in this demonstration for hopping the frequency and amplitude settings.

How to Fast Hop Channel A

The HP 8904A allows you to fast hop between the parameters you have entered (at switching speeds of up to 8 μs) using the rear-panel DIGITAL PORT. The DIGITAL PORT provides inputs for the Hop Register address selection lines. The selection address for each register (Hop Ram Adrs) is shown on the Hop Configuration display. The registers can be selected in whatever order you desire. The following steps describe how to use the DIGITAL PORT for fast hopping Channel A.

1. **Press the NEXT key to return to the Hop Parameter Selection display.**

```
f1 Digital Port Off  f3 Freq Hop     On
f2 Amptd Hop    On   f4 Phase Hop    Off
```

Enable the DIGITAL PORT

2. **To enable the DIGITAL PORT, press the f1** `Digital Port` **softkey and then the ON key.** The HP 8904A is now ready to receive Hop Register addresses via its rear-panel DIGITAL PORT.

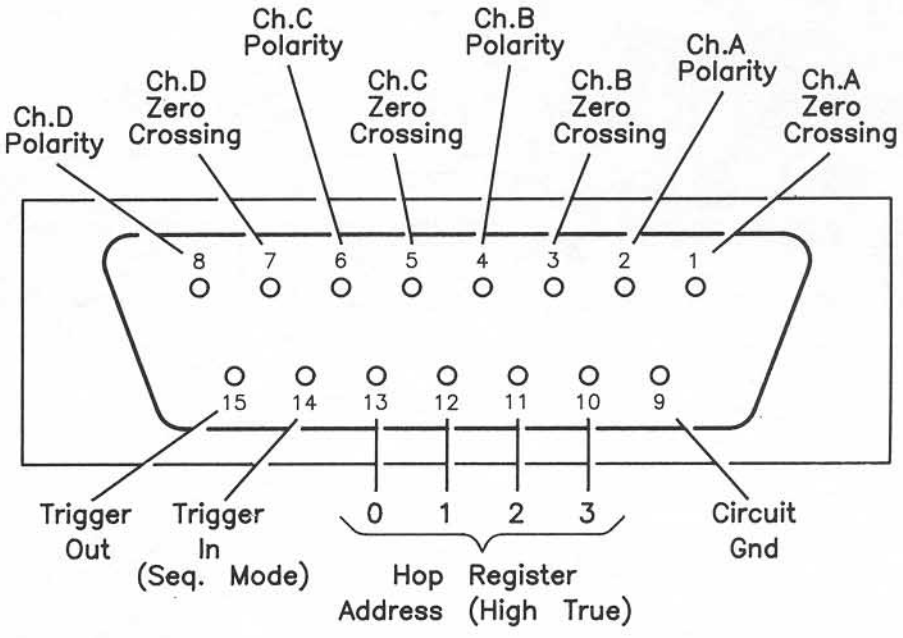


Figure 5–2. Pin Connect Diagram for the Rear-Panel DIGITAL PORT.

Fast Hop Example

Figure 5–3 shows an example of an address selection circuit for fast hopping an HP 8904A (that is equipped with Option 01 and 03) at the rate of the Channel D frequency setting. (An external timing source can be used in place of the Channel D signal to increase the hop rate.)

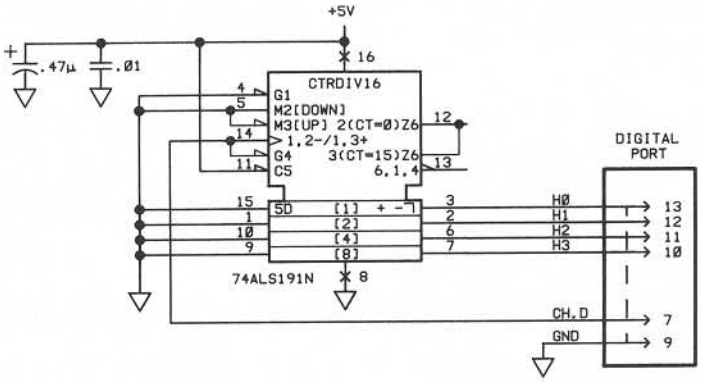


Figure 5–3. Example Address Selection Circuit for Fast Hopping the HP 8904A.

Table 5–2. Instrument Settings for the Fast Hopping Example.

Channel	Destination	Frequency	Amplitude	Phase	Waveform
A	Out 1	1 kHz	140 µV	0.0 deg	Sine
B	Off	62.5 Hz	5V	0.0 deg	Square
C	Off	0 Hz	140 µV	0.0 deg	Sine
D	Off	500 Hz	140 µV	0.0 deg	Sine

The following BASIC program can be used to set up the HP 8904A for this example over its HP-IB.

```
 10 ! EXTHOP 6/25/87
 20 CLEAR
 30 DISP "** EXT  HOP RAM SETUP
      DEMO **"
 40 RESET 7
 50 A=726
 60 OUTPUT A ;"GM0"
 70 OUTPUT A ;"FC10FFC20F"
 80 FOR I=0 TO 15
 90 A$="HRA"&VAL$(I)
100 OUTPUT A ;"HRA";I;"ET"
110 OUTPUT A ;"FRH";I+1;"KZ"
120 OUTPUT A ;"FRD500HZ"
130 OUTPUT A ;"WFBSQ"
140 OUTPUT A ;"APB5VL"
150 OUTPUT A ;"FRB62.5HZ"
160 OUTPUT A ;"FRC0KZ"
170 OUTPUT A ;"APH",(I+1)*.5,"VL
    "
180 NEXT I
190 OUTPUT A ;"DPEONFHRONAHRON".
200 OUTPUT A ;"PR"
210 DISP "LOAD DONE"
220 STOP
```

A Installation

Unpack Your HP 8904A

Inspect the shipping container for damage. If the shipping container is damaged or the cushioning material inside is stressed, keep them until you have checked the shipment for completeness and proper operation.

If components are missing from your shipment, or if there is mechanical damage or defect, notify the nearest Hewlett-Packard office. If the shipping container or cushioning material shows signs of stress, notify the carrier as well as the Hewlett-Packard office. Keep the shipping materials for inspection by the carrier.

Connect Power

The HP 8904A Multifunction Synthesizer requires a power source of 100 to 120 Vac (±10%) at 48 to 440 Hz, or 220 to 240 Vac (±10%) at 48 to 66 Hz. Power consumption is 80 VA maximum. If you need further information about the power requirements for your instrument, refer to the HP 8904A Operation and Calibration Manual.

Warning

This is a Safety Class I product (i.e., provided with a protective earth terminal). An uninterruptible safety earth ground must be provided from the Mains power source to the product input wiring terminals, power cord, or supplied power cord set. Whenever it is likely that the protection has been impaired, the instrument must be made inoperative and be secured against any unintended operation.

Turn On Instrument

If you are operating this instrument in extreme environmental conditions, refer to the HP 8904A Operation and Calibration Manual for specific operating limitations.

B Help Messages

Interpreting the Help Messages

When the HP 8904A detects an inappropriate operating condition (such as when an inactive key is pressed), it beeps to let you know that a message about the condition is available on the Help display.

The HP 8904A's Help display is accessed by pressing the blue **SHIFT** key and then the **HELP** key. Table C-1 lists the Error Number for each Help Message displayed by the HP 8904A along with a brief description of the operating conditions that will cause the HP 8904A to display the message.

```
*  Last reported error was no.    0    *
No Error
```

Table B–1. Error Numbers and Description Listings for the HP 8904A's Help Messages. (1 of 4)

Error Number	Description
0	There is no new message.
1	A key was selected without specifying what the data was related to.
2	The key selected does not correspond to the function selected.
3	Invalid HP-IB address entry. (Only 00-30 (decimal) are valid entries.)
4	The ⇧ or ⇩ key cannot be used with this function.
10	The instrument cannot access the output board that connects to the OUTPUTS 1 connector. Refer to the HP 8904A Service Manual to isolate the problem.
11	A hardware error was detected by the power-up checks. Refer to the HP 8904A Service Manual to isolate the problem.
12	The reference loop of the Digital Synthesis (A2) assembly is out of lock. Refer to the HP 8904A Service Manual to isolate the problem.

Table B–1. Error Numbers and Description Listings for the HP 8904A's Help Messages. (2 of 4)

Error Number	Description
16	The Special Function display can only be accessed from the Main Selection Level.
13	A reverse power error was detected on an output board. (Disconnect the affected output from any external equipment and re-enter the key sequence that originally resulted in the error. If an error is still detected by the instrument, a reverse power problem still exists.)
14	The recalled Save Register does not contain a SAVE setting.
15	The selected function cannot be performed in the present mode. (For example, the FREQ function cannot be executed directly from the Main Selection Level.)
17	An invalid Special Function number was entered. (Only Special Functions 0 - 15 (decimal) may be entered.)
18	The Special Function number input was too large for the instrument to recognize it as data. This condition occurs when the data input is greater than 65535. (Refer to Error Message 17 concerning the range of Special Functions available.)
19	The number entered was too large for the function selected.
20	Increment Set is not available with the function selected.
22	An operation was directed to an output board which does not exist.
24	There are no setable modes or functions at this instrument level. (For example, in Hop Mode Operation the Hop Parameter display lists only four keys that will perform a function in this mode; f1, f2, f3 and f4. Any other key, such as AMPTD, has no meaning in this mode and will result in this error.)
	–Channel Configuration Errors–
31	Instrument is not configured for destination control.
	–Hewlett-Packard Interface Bus (HP-IB) Errors –
41	HP-IB numeric input error. Exponent too large or improper number format.
42	HP-IB numeric input error. The number was too large or too small, or a negative value was received when a positive value was required.
43	A number value was sent via HP-IB when one was not expected.
44	Invalid unique data was input via HP-IB. (Unique data specifies the Waveform, Modulation Type, Modulation On/Off Control, and Filter Selection, when entering a data string via HP-IB.)
45	Unique data was received via HP-IB when none was expected. (Refer to Error 44 for an explanation of unique data.)
46	An invalid terminator for the present data type was received via HP-IB. (A data terminator specifies the units of the data entered; i.e., Hz, Degrees, Volts, Seconds, Percent, etc; the ENTER command is also included in this group.)

Table B–1. Error Numbers and Description Listings for the HP 8904A's Help Messages. (3 of 4)

Error Number	Description
47	A Data Terminator was received via HP-IB when none was expected. (Refer to Error 46 for an expanation of data terminators.)
48	A combination of errors 41 through 47 probably exists. (Confirm that at least one of these errors exists and correct it. Enter the data again and read any error messages that result; an error number other than 48 should be displayed. The second error message should help to further isolate the error until it is eliminated.)
	–Signal Sequence Mode Errors–
50	Time value entered is out of range.
51	On and Off Time values cannot both be zero.
52	Amplitude value entered is out of range.
53	Frequency value entered is out of range.
54	Tone Number entered is out of range. [Only tone numbers 0-F (Hexadecimal) are valid.]
55	Sequence Index value entered is out of range. (Valid Range is 1-250.)
56	Sequence End value entered is out of range. (Valid Range is 1-250.)
57	The number entered is not valid in the Sequence Base selected. (Either the Binary, Octal, or Hexadecimal base numbering system is used to specify the Sequence Index and Sequence End. For example, you may not use the character '9' when you have previously specified the Octal base, since this number does not exist in that numbering system.)
58	Command not permitted in this mode.
59	Command not available in present window.
	–Destination Control Errors–
101	Channel A cannot be used as a source for AM, FM, DSB, Phase or Pulse modulation. (Channel A can be modulated, but it cannot be used as a modulation source.)
102	Channel A has a Waveform of dc and cannot be modulated.
103	A channel which has a Waveform of dc cannot be used as a modulation source.
104	An operation was directed to an output board which does not exist.
105	AM and DSB are mutually exclusive modulations and one is already active.
106	An attempt was made to use a second summer. For this configuration of two summers, only channels A+B with channels C+D is permitted.
107	The Hop Ram is presently enabled as this modulation source.
108	The Frequency set value selected is greater than the permitted maximum for pulse modulation.

Table B–1. Error Numbers and Description Listings for the HP 8904A's Help Messages. (4 of 4)

Error Number	Description
109	The Frequency set value selected is greater than the permitted maximum for this waveform.
110	Either AM or DSB modulation is active so Amplitude Hop Ram cannot be changed.
111	The present value of the Hop Ram amplitude settings will exceed the maximum permitted value and therefore the Amplitude Hop Ram cannot be turned on.
112	The present value of the Hop Ram frequency settings will exceed the maximum permitted value and therefore the Frequency Hop Ram cannot be turned on.
113	The attempted Frequency Hop Ram set value is greater than the permitted maximum for this waveform.
114	Phase modulation is presently active, therefore Phase Hop cannot be changed.
115	The present Channel A waveform cannot be used at the present frequency setting of Channel A if the Frequency Hop Ram is disabled.
	–Miscellaneous Errors–
121	The amplitude value selected is greater than the permitted maximum.
122	The amplitude value selected results in a sum which is greater than the maximum permitted value.
123	The frequency value selected is greater than the maximum permitted value.
124	When the Amplitude Hop Ram was disabled, the last Channel A amplitude setting could not be used with present instrument parameters. (Adjust the the Channel A amplitude to within non-Hop-Ram limits.)
150	The selected Waveform cannot be generated at the present frequency setting.
151	The dc Waveform can only be selected for a channel which has an Output Port or Off as a destination.
152	Channel A Waveform cannot be changed to dc while being modulated.
153	You can sum only one channel with a dc Waveform into an output board, and one is already active.
160	An operation was directed to an output board which does not exist.

C HP-IB Codes

Code Listings for the HP 8904A

This appendix contains listings of the HP-IB programming codes for the HP 8904A. The codes are arranged in four tables. The first table (Table C–1) contains the HP-IB codes for the functions that are standard to all HP 8904A configurations. Tables C–2 through C–4 contain the commands that are unique to each of the Configuration Options (01, 02 and 03). A sample program is presented after each table to demonstrate the use of the codes.

Table C–1. HP-IB Codes for the Standard HP 8904A Functions (1 of 4)

Function	HP-IB Code	Description
Amplitude	AP	**Form:** AP<Channel><Amplitude Value><Terminator> **Example:** "APA1VL" Set amplitude of a channel. Valid terminators for amplitude are VL, MV and UV.
Backlight	BO	Backlight On
	BF	Backlight Off
Beep	BP	Beep
Exit	EM	**Form:** EM Exit Mode. Exit Mode needs no data.
Filter	FS	**Form:** FS<Output Number><Filter> **Example:** "FS1AU" Output Board Filter Select. Designate Output Port 1 (or 2 if the instrument is equipped with Option 02) followed by (no space) the desired filter.
	SH	Eliptic (Sharp Cutoff)
	LO	Gaussian (Low Overshoot)
	AU	Auto (Automatic)
Float Control	FC	**Form:** FC<Output Number><ON or OF> **Example:** "FC1ON" Float Output On/Off Control. Designate Output Port 1 (or 2 if the instrument is equipped with Option 02) followed by (no space) the desired state.
Frequency	FR	**Form:** FR<Channel><Frequency Value><Terminator> **Example:** "FRA20KZ" Set frequency of channel. Valid terminators for frequency are HZ and KZ.

Table C–1. HP-IB Codes for the Standard HP 8904A Functions (2 of 4)

Function	HP-IB Code	Description
Go To	GM	**Form:** GM <Mode Number> **Example:** "GM4" Go to Mode. Go to Mode accepts the values 0–9. 0 = Channel Configuration Mode. 1 = (Reserved for future options.) 2 = Tone Sequence Mode. 3 = DTMF Sequence Mode. 4 = Digital Sequence Mode. 5–9 = (Reserved for future options.)
Help	HP	This function will return a three digit ASCII string representing the Error Number (000 to 255 where 0 means no error reported). Refer to Appendix B for the list of Help Messages.
ID	ID	Read the ID message. A read of the ID string sends 80 characters to the requesting controller in the following format: "HP8904A Opts 01/02/03" "Firmware Revision XXXXXa Serial No XXXXX"
Increment Set	IS	**Form:** <Parameter>IS<Value> **Example:** "APA1VL" Increment set. Used for any parameter that can be modified by the Up and Down commands. UP Increment DN Down **Examples:** "PHAUP", "UPDNDN", "DN" UP and DN can be used for settings which have an associated increment set value. They can be prefixed by a specific function, or used by themselves to modify the presently active function.
Last	<	Use like the **LAST** key to access the previous display.
Next	>	Use like the **NEXT** key to access the next display.
Off	OF	Off
On	ON	On
Output Control	OO	**Form:** OO<Output Number><ON or OF> **Example:** "OO1OF" Output On/Off Control. Designate Output Port 1 (or 2 if the instrument is equipped with Option 02) followed by (no space) the desired state.

Table C–1. HP-IB Codes for the Standard HP 8904A Functions (3 of 4)

Function	HP-IB Code	Description
Phase	PH	**Form:** PH<Channel><Phase Value><Terminator> **Example:** "PHA45DG" Set phase of a channel. Valid terminators are DG and RD.
Phase Reset	PR	Phase reset establishes a common zero reference for the channels.
Preset	PS	Instrument Preset
Query Data	?	**Form:** <Data Setting> **Examples:** "FRA?", "FRAIS?" "?" Query of existing data values is achieved by placing the "?" term after the desired item name. A query terminates any presently running sequence.
Recall	RC	**Form:** RC<Register> **Example:** "RC11" Recall. Valid data values for Recall are 0–11.
Reverse Power	RP	Reset reverse power protection.
Save	SV	**Form:** SV<Register> **Example:** "SV1" Save. Valid data values for Save are 0–11.
Service Request	RM	**Form:** RM Read Service Request Mask. The present value of the SRQ mask is returned, 000–191.
	SM	**Form:** SM<Data Value> **Examples:** "SM128", "SM0" Set Service Request Mask. Valid data = 0–255
Special Functions	SF	**Form:** SF<Data Value> **Examples:** "SF4", "SF12763" Set or Reset Special Functions. The value of the Special Function flag can be read at any time but can only be set at the Main Selection Level. The flag is a composite of bit flags. A Special Function operation configures all 16 bits of the flag (that is, any previously set flags are lost). Do not leave a space between the mnemonic and the data value.

Table C–1. HP-IB Codes for the Standard HP 8904A Functions (4 of 4)

Function	HP-IB Code	Description
Terminators	KZ HZ DG RD VL MV UV ET SC MS % PC	Kilohertz Hertz Degrees Radians Volts Millivolts Microvolts Enter Seconds Milliseconds Percent Percent
Time Base	EO	**Example:** "EO" Read External Reference Status. Ths function allows you to determine whether the Time Base reference is external or internal. If the External reference is on, a 001 is returned, if not a 000 is returned.
Waveform	WF	**Form:** WF<Channel><Waveform> **Example:** "WFATR" Set waveform of a channel. Valid data values for waveform are: SI = Sine RA = Ramp TR = Triangle SQ = Square NS = Noise DC = dc.

```
10    ! ************************************
20    ! * HP SERIES 200/300 BASIC language   *
30    ! * programming example for the        *
40    ! * standard HP 8904A MULTIFUNCTION    *
50    ! * SYNTHESIZER.                       *
60    ! ************************************
70    !
73    OUTPUT 726;"PS"                 ! Preset HP 8904A.
80    OUTPUT 726;"GM0"                ! Goto channel configuration mode.
90    OUTPUT 726;"FC1OF"              ! Turn output 1 float off.
100   OUTPUT 726;"FRA1000.1HZ"        ! Set channel A frequency to 1000.1 Hz.
110   OUTPUT 726;"APA1.25VL"          ! Set channel A amplitude to 1.25 V.
120   OUTPUT 726;"PHA90DG"            ! Set channel A phase to 90 degrees.
130   OUTPUT 726;"WFARA"              ! Set channel A waveform to ramp.
140   END
```

Figure C–1. Sample Program for Configuring Channel A

Table C–2. HP-IB Codes That Can Be Used With Option 01 Instruments (1 of 2).

Function	HP-IB Code	Description
Destination	DE	**– Four Channel Operation –** **Form:** DE<Channel><Destination> **Examples:** "DEAOC1", "DEAAM" Set destination of channel. Valid data values for destination are AM, FM, PM, DS, PU, OC1 (OC2 if the instrument is equipped with Option 02) and OF.
Modulation	AM FM PM DS PU	Amplitude Modulation, valid AM terminators are % or PC. Frequency Modulation Phase Modulation, valid PM terminators are DG or RD. DSB Modulation Pulse Modulation
Amplitude	APH	**– Signal Sequence Modes –** **Form:** APH<Amplitude Value><Terminator> **Example:** "APH1.999VL" Enter Tone or DTMF amplitude. Amplitude terminators are VL, MV and UV.
Digital Level	DAPH DAPL	Digital Sequence On Level Digital Sequence Off Level **Form:** DAPH<Amplitude><Terminator> **Examples:** "DAPH4VL", "DAPL-1VL" Digital Sequence Mode amplitude terminators are VL, MV and UV.
Digital Sequence Base	BSB BSO BSH	Select Binary Base Select Octal Base Select Hexadecimal Base
Off Time	STOF	**Form:** STOF<Time Value><Terminator> **Example:** "STOF1SC" Set Off Time (Tone and DTMF Sequence). Valid terminators are MS and SC.
On Time	STON	**Form:** STON<Time Value><Terminator> **Example:** "STON9.3MS" Set On Time (Tone and DTMF Sequence). Valid terminators are MS and SC.
Period	SBP	**Form:** SBP<Time Value><Terminator> **Example:** "SBP9.3MS" Set Period (Digital Sequence Only). Valid terminitors are MS and SC.

Table C–2. HP-IB Codes That Can Be Used With Option 01 Instruments (2 of 2).

Function	HP-IB Code	Description
Register Number	HRA	**Form:** HRA<1 or 2 Digit Address>ET **Examples:** "HRA2ET" "HRA15ET" Enter Tone or DTMF Register. Addresses 0–15 are valid, Valid terminator is "ET".
Run Mode	RUNC RUNM RUNS STOP	Run Continuously Run Manually Run Single Stop Run
Sequence End	SEQE	**Form:** SEQE<Sequence End Value>ET **Example:** "SEQE115ET" Set Sequence End. Valid terminator is ET.
Sequence Index	SEQP	**Form:** SEQP<Index Value>ET **Example:** "SEQP37ET" Set Sequence Index. Valid terminator is ET.
Sequence String	WSQ	**Form:** WSQ<Data String><Terminator> **Examples:** Tone Sequence = "WSQ01123456789ABCDEF;" DTMF Sequence = "WSQ0123456789ABCD*#;" Digital Sequence Binary Base = "WSQ0101010101010101;" Digital Sequence Octal Base = "WSQ0123456701234567;" Digital Sequence Hex Base = "WSQ0123456789ABCDEF;" Write sequence string. Entry string is terminated with ; , cr/lf, EOI or the etx character.
Tone Frequency	FRH	**Form:** FRH<Frequency Value><Terminator> **Example:** "FRH723.5HZ" Enter tone frequency (Tone Sequence Mode only). Valid terminators are HZ and KZ.

```
10    ! ****************************************
20    ! *   HP SERIES 200/300 BASIC language   *
30    ! *   programming example for the        *
40    ! *   HP 8904A MULTIFUNCTION SYNTHESIZER *
50    ! *   OPTION 001: fm stereo composite.   *
60    ! *               (left channel only)    *
70    ! ****************************************
80    !
90    OUTPUT 726;"PS GM0"                              ! Preset & go to channel
100                                                    ! configuration mode.
110                                                    !
120   OUTPUT 726;"DEA0C1 FRA39KZ APA1VL PHA270DG WFASI" ! Set channel A to
130                                                    ! Destination = Output 1,
140                                                    ! Freq = 39 kHz, Amplitude =
150                                                    ! 1 volt, Phase = 270 degrees
160                                                    ! Waveform = Sine.
170                                                    !
180   OUTPUT 726;"DEB0C1 FRB37KZ APB1VL PHB90DG WFBSI"  ! Set channel B to
190                                                    ! Destination = Output 1,
200                                                    ! Freq = 37 kHz, Amplitude =
210                                                    ! 1 volt, Phase = 90 degrees,
220                                                    ! Waveform = Sine.
230                                                    !
240   OUTPUT 726;"DEC0C1 FRC19KZ APC 100MV WFCSI"      ! Set channel C to
250                                                    ! Destination = Output 1,
260                                                    ! Freq = 19 kHz, Amplitude =
270                                                    ! 0.1 volt, Waveform = Sine.
280                                                    !
290   OUTPUT 726;"DED0C1 FRD1KZ APD2VL WFDSI"          ! Set channel D to
300                                                    ! Destination = Output 1,
310                                                    ! Freq = 1 kHz, Amplitude =
320                                                    ! 2 volts, Waveform = Sine.
330   END
```

Figure C-2. Sample Program for Configuring Channels A, B, C and D.

```
10    ! ****************************************
20    ! *   HP SERIES 200/300 BASIC language   *
30    ! *   programming example for the        *
40    ! *   HP 8904A MULTIFUNCTION SYNTHESIZER *
50    ! *   OPTION 01: digital sequence.       *
60    ! ****************************************
70    !
80    OUTPUT 726;"PS GM4"                              ! Preset & go to digital
90                                                     ! sequence mode.
100                                                    !
110   OUTPUT 726;"BSB SBP0.5MS DAPH5VL DAPL0.2VL"      ! Set sequence base to
120                                                    ! Binary, sequence period =
130                                                    ! 0.5 ms, on level = 5 volts,
140                                                    ! and off level = 0.2 volt.
150                                                    !
160   OUTPUT 726;"SEQP1ET WSQ000100110111; SEQE12ET"   ! Set sequence pointer = 1,
170                                                    ! write sequence =
180                                                    ! "000100110111", and set
200                                                    ! sequence end = 12.
201                                                    !
210   OUTPUT 726;"RUNC"                                ! Run sequence continuously.
300   END
```

Figure C–3. Sample Program for Configuring a Digital Sequence String

Table C-3. HP-IB Codes That Can Be Used with Option 02 Instruments

Function	HP-IB Code	Description
Destination	DE	**Form:** DE<Channel><Destination> **Examples:** "DEAOF" "DEBOC2" Set destination. Valid data values for destination are OC1, OC2 and OF.
Query Port Status	QRE	**Form:** QRE **Example:** "QRE" Query present enable status.

```
10    ! ************************************
20    ! * HP SERIES 200/300 BASIC language   *
30    ! * programming example for the        *
40    ! * HP 8904A MULTIFUNCTION SYNTHESIZER *
50    ! * Option 02.                         *
60    ! ************************************
70    !
80    OUTPUT 726;"PS"                  ! Preset HP 8904A.
90                                     !
100   OUTPUT 726;"GM0"                 ! Goto channel configuration mode.
110                                    !
120   OUTPUT 726;"FRA2KZ APA2VL PHA45DG WFASQ" ! Set channel A frequency =
130                                    ! 2 kHz, amplitude = 2 volts, phase =
140                                    ! 45 degress, and waveform = square.
150                                    !
160   OUTPUT 726;"FRB2KZ APB2VL PHB90DG WFBSQ" ! Set channel B frequency =
170                                    ! 2 kHz, amplitude = 2 volts, phase =
180                                    ! 90 degress, and waveform = square.
190                                    !
200   END
```

Figure C-4. Sample Program for Configuring Output Ports 1 and 2.

Table C–4. HP-IB Codes That Can Be Used with Option 03 Instruments.

Function	HP-IB Code	Description
Amplitude	APH	**Form:** APH<Amplitude Value><Terminator> **Example:** "APH2.123VL" Enter Hop Mode amplitude parameter. Valid terminators are VL, MV and UV.
Hop On/Off	AHR	**Form:** AHR<ON or OF> **Example:** "AHROF" Amplitude Hop On/Off Control.
Digital Port	DPE	**Form:** DPE<ON or OF> **Example:** "DPEOF" Digital Port On/Off Control.
Frequency	FRH	**Form:** FRH<Frequency Value><Terminator> **Example:** "FRH723.5HZ'' Enter Hop Mode frequency parameter. Valid terminators are HZ and KZ.
Hop On/Off	FHR	**Form:** FHR<ON or OF> **Example:** "FHROF" Frequency Hop On/Off Control.
Hop Register	HRA	**Form:** HRA<1 or 2 Digit Address>ET **Example:** "HRA9ET" Enter Hop Register address. Addresses 0–15 are valid, valid terminator is ET.
Phase	PHH	**Form:** PHH<Phase Value><Terminator> **Example:** "PHH59.3DG" Enter Hop Mode phase. Valid terminators are DG and RD.
Hop On/Off	PHR	**Form:** PHR<ON or OF> **Example:** "PHROF" Phase Hop On/Off Control.

```
10    ! ****************************************
20    ! *   HP SERIES 200/300 BASIC language   *
30    ! *   programming example for the        *
40    ! *   HP 8904A MULTIFUNCTION SYNTHESIZER *
50    ! *   OPTION 03: fast hop.               *
60    ! ****************************************
70    !
80    OUTPUT 726;"PS GM0"                          ! Preset & go to channel
90                                                 ! configuration mode.
100                                                !
110   OUTPUT 726;"HRA0ET FRH500HZ APH1VL"          ! Set Hop Ram address = 0,
120                                                ! Hop Freq = 500 Hz, Hop
130                                                ! Amplitude = 1 volt.
140                                                !
150   OUTPUT 726;"HRA1ET FRH1KZ APH2VL"            ! Set Hop Ram address = 1,
160                                                ! Hop Freq = 1 kHz, Hop
170                                                ! Amplitude = 2 volt.
180                                                !
190   OUTPUT 726;"HRA2ET FRH1.5KZ APH3VL"          ! Set Hop Ram address = 2,
200                                                ! Hop Freq = 1.5 kHz, Hop
210                                                ! Amplitude = 3 volt.
220                                                !
230   OUTPUT 726;"HRA3ET FRH2KZ APH4VL"            ! Set Hop Ram address = 3,
240                                                ! Hop Freq = 2 kHz, Hop
250                                                ! Amplitude = 4 volts.
260                                                !
270   OUTPUT 726;"HRA4ET FRH2.5KZ APH5VL"          ! Set Hop Ram address = 4,
280                                                ! Hop Freq = 2.5 kHz, Hop
290                                                ! Amplitude = 5 volt.
300                                                !
310   OUTPUT 726;"HRA5ET FRH3KZ APH6VL"            ! Set Hop Ram address = 5,
320                                                ! Hop Freq = 3 kHz, Hop
330                                                ! Amplitude = 6 volts.
340                                                !
350   OUTPUT 726;"FHRON AHRON"                     ! Turn frequency hop on,
360                                                ! and turn amplitude hop on.
370                                                !
380   FOR I=1 TO 100                               ! Repeat hop seq 100 times.
390      FOR J=0 TO 5                              ! Step from add=0 TO add=5.
400         OUTPUT 726;"HRA",J,"ET"                ! Hop to next address.
410      NEXT J
420   NEXT I
430   END
```

Figure C–5. Sample Program for Hop Mode Operation.

Index

H

I

L

M

N

O

P

R

S

T

V

W

HEWLETT PACKARD

For information about Hewlett-Packard products and services, telephone the local Hewlett-Packard sales and support office listed in your telephone directory. Or write to the appropriate address listed here.

United States
Hewlett-Packard Company
Microwave and
Communications Group
3000 Hanover Street
Palo Alto, CA 94304

Hewlett-Packard Company
4 Choke Cherry Road
Rockville, MD 20850

Hewlett-Packard Company
5201 Tollview Drive
Rolling Meadows, IL 60008

Hewlett-Packard Company
5161 Lankershim Blvd.
North Hollywood, CA 91601

Hewlett-Packard Company
2000 South Park Place
Atlanta, GA 30339

Canada
Hewlett-Packard (Canada) Ltd.
6877 Goreway Drive
Mississauga, Ontario
Canada, L4V1M8

Europe and Africa
Hewlett-Packard S.A.
P.O. Box 529
1180 AM Amstelveen
The Netherlands

Australasia
Hewlett-Packard Australia Ltd.
31-41 Joseph Street
Blackburn, Victoria 3130
Australia

Japan
Yokagawa-Hewlett-Packard Ltd.
29-21, Takaido-Higashi, 3-Chome
Suginami-ku, Tokyo 168
Japan

Far East Area
Hewlett-Packard Asia Headquarters
47th F, China Resources Bldg.
26 Harbour Road, Wanchai
Hong Kong

Latin America
Hewlett-Packard Company
3495 Deer Creek Road
Palo Alto, CA 94304 U.S.A.

Printed in USA 7/87
5953-8491