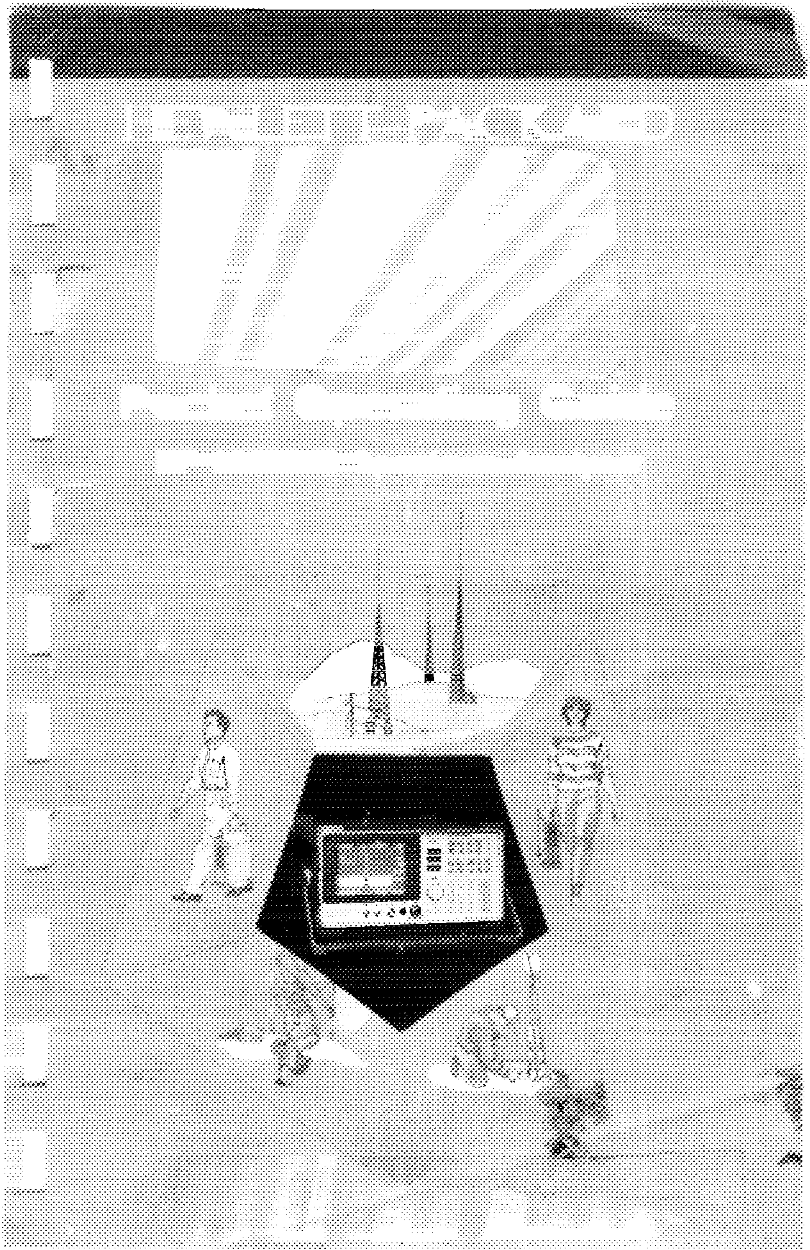


HEWLETT
PACKARD

HP 8562A/B SPECTRUM ANALYZER

1212 Valley House Drive
Rohnert Park, California 94928-4999 U.S.A.

Manual Part Number: 08562-90003
Microfiche Part Number: 08562-90012

Page

Congratulations on your purchase of the Hewlett-Packard 8562A/B Portable Spectrum Analyzer. The HP 8562A/B Spectrum Analyzer is a powerful, general-purpose measurement tool that is easy to use and makes quick, accurate measurements. Basic measurements require only a few steps, and you will find that as you learn more about the instrument, you will be able to make sophisticated measurements almost as easily.

This Pocket Reference Guide explains how to get the most from your spectrum analyzer. Using a "hands on" approach, it introduces the basic spectrum analyzer functions, then leads you through several simple procedures that demonstrate some general-purpose measurement techniques. It also includes programming tips (with examples) for automating your measurements. In addition to describing instrument operation, this booklet also documents softkey menus and HP-IB commands, making it a convenient reference tool for both manual and automated measurements.

Other HP 8562A/B manuals provide additional operating, programming, and service information:

HP 8562A/B Operating and Programming Manual,
part number 08562-90001

HP 8562A/B Quick Reference Guide,
part number 08562-90006

HP 8562A/B Installation and Support Manual,
part number 08562-90007

HP 8562A/B Technical Reference Manual,
part number 08562-90009

This chapter introduces you to basic spectrum analyzer operation. Basic measurements simply involve tuning the instrument to place a signal on the screen, then measuring the frequency and amplitude of the signal.

We can measure an input signal in four steps, using only four functions:

1. Set the center **frequency**
2. Set the frequency **span**
3. Set the **amplitude**
4. Activate the **marker**

As an example, we will measure the 300 MHz calibration signal. First, switch on the spectrum analyzer (for maximum accuracy, if the analyzer has just been plugged into an electrical outlet, allow for a 5-minute warmup). Next, connect the CAL OUT output to the RF INPUT and complete the four steps as described below.

1. Set the Center Frequency:

   Press [ ]. This activates the center frequency function, indicated by CENTER appearing in the **active function block** on the left side of the display (see Figure 1-1). To set the center frequency to 300 MHz, use the keys in the DATA section of the front panel: press [3] [0] [0] [MHz]. These data keys let you select the exact numeric value of the active function, which, in this case, is the center frequency. The step keys and knob also let you select function values.

Active Function Block

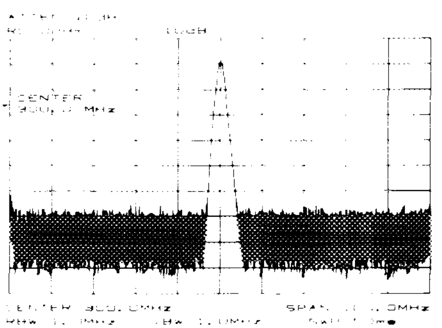


Fig.1.1. Center frequency set to 300 MHz.

2. Set the Frequency Span:
   Press [illegible]. Note that SPAN is now displayed in the active function block, identifying it as the currently active function. To reduce the frequency span — for example, to 20 MHz — either key in [2][0][MHz] or use the STEP [↓] key to "step down" to this value. (Like data keys, step keys can also be used to change the numeric value of the active function.) The resulting display is shown in Figure 1.2. Note that the resolution and video bandwidths are coupled to the span; thus, they automatically adjust to appropriate values for a given span. Sweeptime is also a coupled function.

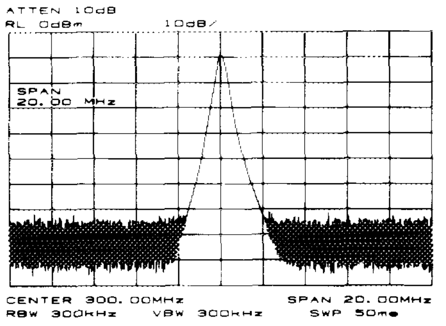


Fig.1.2. Frequency span reduced to 20 MHz.

Note: The low band of the spectrum analyzer ranges from 1 kHz to 2.9 GHz. The upper band ranges from 2.75 GHz to 22 GHz. The frequency span cannot be set to overlap both bands at the same time. For example, to sweep a range from 2.0 GHz to 3.5 GHz, use the low band to sweep from 2.0 GHz to 2.9 GHz and use the upper band to sweep from 2.75 GHz to 3.5 GHz.

3. Set the Amplitude:
   Generally, placing the signal peak at the reference level provides the best measurement accuracy. To adjust the signal peak to the reference level (Figure 1.3), press [illegible], then key in [1][0][−dBm] or use either the step keys or the knob. Using the knob is the easiest way of fine tuning the signal peak to the reference level, which is at the top of the screen.

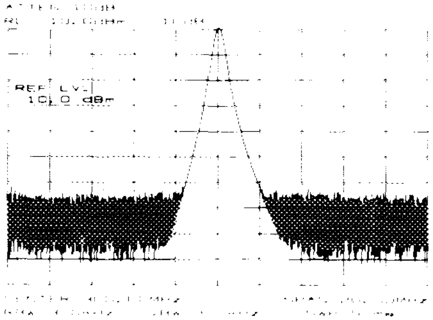


Fig. 1.3. Signal peak set to reference level.

4. Activate the Marker:
   Press [ON], located in the MARKER section of the front panel. This places a marker at the center of the trace (in this case, at the peak of the signal) and completes the measurement. The marker reads both the frequency and the amplitude, and it displays these values in the active function block. In this case, the marker reads 300.00 MHz and −12.67 dBm, as shown in Figure 1.4.

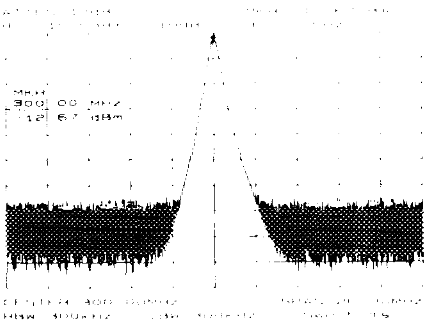


Fig. 1.4. Marker reads out frequency and amplitude.

Many measurements require only these four steps.

To return the instrument to its initial power-on state, press [PRESET].

CHAPTER 2
INTRODUCING MENUS AND SOFTKEYS

While executing the measurement in Chapter 1, you may have noticed that when you pressed dedicated front-panel keys, menus of additional functions appeared along the right-hand side of the display. These keys are not needed to make most simple measurements. To make more advanced measurements, begin as you did for simple measurements: select the appropriate front-panel key. This key causes a **menu** of related, more extensive functions to appear. Use these **softkeys** to complete the measurement.

Single, dedicated keys for simple measurements, along with menus of additional functions for more complex measurements, simplify the human interface. There are no shift keys, and the total number of buttons on the front panel is reduced. The result is a spectrum analyzer that is friendly to first-time users, yet flexible enough for experienced operators making sophisticated measurements.

Most front-panel keys activate menus. For example, press **FREQUENCY**. This calls up the menu of related frequency functions shown in Figure 2.1. Note on the menu the function labeled CENTER. CENTER also appears in the active function block, indicating that it is the active frequency function and can now be changed using the data controls.

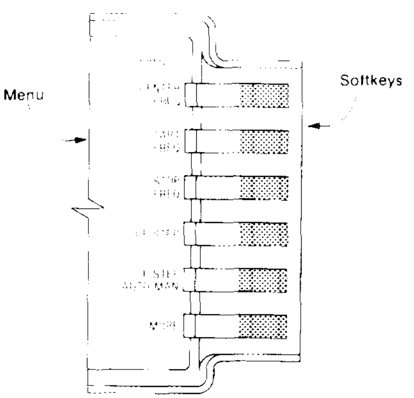


Fig.2.1. Menu and softkeys. Press a softkey to activate a function on the menu.

To activate a different frequency function — in this case, the start frequency — press the softkey to the right of START. START now appears in the active function block, indicating its currently active status. On the bottom of some menus a softkey labeled MORE gives access to additional, related softkeys. At the top of the menu a **menu title** names the front-panel key pressed to obtain the current menu. To activate other frequency functions, press the appropriate softkeys. To select a different menu, press another front panel key.

Now, to become more familiar with softkeys and to learn reference level calibration, we focus on the following examples.

CALIBRATE USING SOFTKEYS

Note: If the spectrum analyzer has just been plugged into an electrical outlet, allow for a 5-minute warmup before calibration.

The spectrum analyzer reference level calibration function is stored under the softkey REF LVL CAL in the [ ] menu. To calibrate the instrument, first set the frequency, span, and amplitude; then activate the calibration softkey. This sequence is described in the following two steps.

1. Set the Frequency, Span, and Amplitude:
   Connect the CAL OUT output to the RF INPUT. Set the center frequency to 300 MHz, the span to 20 MHz, and the amplitude to −10 dBm. (See Figure 2.2. To review setting these functions, refer to Chapter 1.)

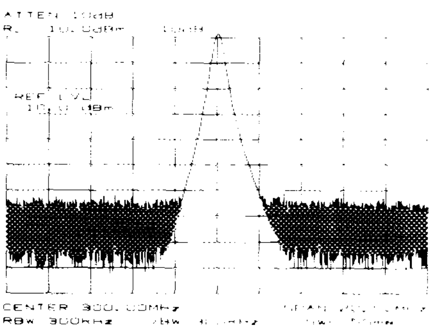


Fig.2.2. Frequency, span, and amplitude set for calibration.

2. Activate REF LVL CAL:
   Note the menu on the right side of the display, which was called up when you pressed [illegible]. The last function on this menu, labeled MORE, provides access to additional amplitude functions; press the softkey next to MORE to call up these functions. The first function on this new list, labeled REF LVL CAL, allows you to calibrate the instrument. Press REF LVL CAL to activate the function. To calibrate the spectrum analyzer, use the knob on the front panel and adjust the peak of the signal to the reference level, as shown in Figure 2.3. Note the number that appears in the active function block. This number, which ranges from −255 to 255, is a relative figure indicating how much amplitude correction was required to calibrate the spectrum analyzer. The number is usually around 0. If the amplitude correction is at either end of the range, or if it cannot be adjusted to within this range, consult the Installation and Support Manual. To store the value, press the softkey STORE REF LVL.

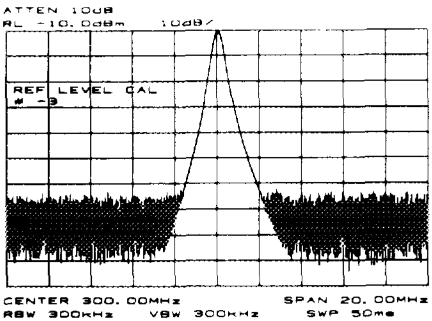


Fig.2.3. Signal peak calibrated to the reference level.

Recalibrating the reference level is usually necessary only when the ambient temperature changes more than 10°C. Because the HP 8562A/B continually monitors and reduces any IF errors, executing the IF calibration is seldom necessary.

DEMODULATE AND LISTEN WITH SOFTKEYS

The functions listed in the menu under the [DEMOD] key allow you to quickly demodulate and hear signal information displayed on the spectrum analyzer. Simply place a marker on a signal of interest, activate AM or FM demodulation, then listen. Refer to the 3-step procedure below.

1. Connect an antenna to the spectrum analyzer input. Select a frequency range on the spectrum analyzer, such as the range for FM radio broadcasts (76 MHz - 108 MHz*). Press [FREQUENCY] and the softkey START, then key in [8] [8] [MHz]. Press the softkey STOP and key in [1] [0] [8] [MHz] (see Figure 2.4).

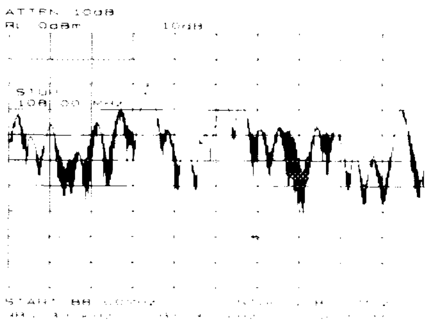


Fig.2.4. Spectrum analyzer tuned to sweep the FM band.

2. Press [DEMOD] to view the menu of demodulation functions. Activate a marker by pressing the softkey PEAK SEARCH to place a marker on the highest-amplitude signal or by pressing MARKER NORMAL to move the marker to a signal of interest (see Figure 2.5). Press the AM DEMOD or FM DEMOD softkey for the desired demodulation (FM DEMOD for this example) and to hear the audio information. Adjust the volume using the keys in the upper right-hand corner of the analyzer.

*88 MHz to 108 MHz in the U.S.A.

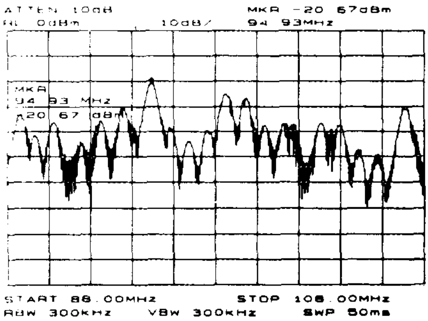


Fig.2.5. Marker placed on a signal to be demodulated.

3. Press the softkey MORE to view additional demodulation softkeys. The function DEMOD TIME sets the length of time that the spectrum analyzer will pause at the marker. The default value is one second. If desired, the time may be adjusted using the data keys.

Now that you are familiar with softkeys, you may want to try more of them. First, however, acquaint yourself with the groups of front-panel keys on the spectrum analyzer and with the display annotation. Chapter 3 briefly describes these. Later, in Chapter 4, we will use additional softkey functions to make measurements.

The following paragraphs briefly describe the groups of front-panel keys on the spectrum analyzer as shown in Figure 3.1. More detailed information for each function is available in the Operating and Programming Manual.

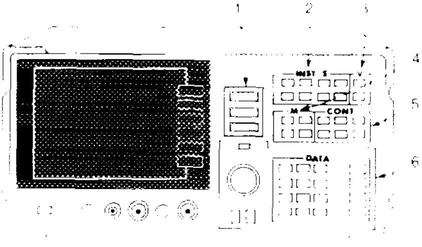


Fig.3.1. Groups of front-panel keys.

1. FREQUENCY, SPAN, and AMPLITUDE are the fundamental functions for most measurements.
2. INSTRUMENT STATE functions generally affect the state of the entire spectrum analyzer, not just of a single function.
3. VOL functions control the volume of the speaker in the spectrum analyzer.
4. MARKER functions, to describe a few, read out frequencies and amplitudes along a spectrum analyzer trace; allow you to make relative measurements; automatically locate the highest amplitude signal on a trace; and automatically track a signal.
5. CONTROL functions allow you to adjust the resolution and video bandwidths, the sweeptime, and the display, and to vary other functions that control spectrum analyzer measurement capabilities.
6. DATA keys, STEP keys, and the knob allow you to change the numeric value of an active function. The HOLD key freezes the active function and holds it at a set value until the function key is pressed again. Hold also clears the softkey menu from the display.

Figure 3.2 illustrates the display annotation.

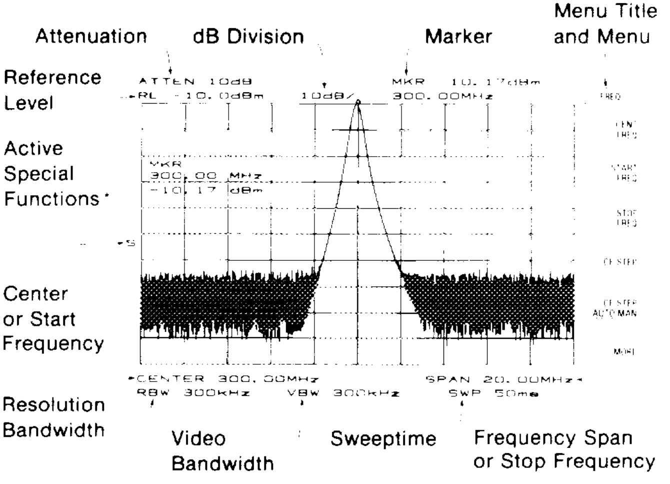


Fig.3.2. Spectrum analyzer display annotation.

*Sometimes unexpected operation can occur because you have forgotten to turn off special operating modes that were previously activated. For example, if signal track is not turned off, it will keep returning a signal to center-screen. As a reminder, any currently active special modes are displayed in a vertical line as follows:

T = Trigger mode set to line, video, or external
D = Detector mode set to sample, negative, or positive
S = Single sweep active
F = Frequency offset active
X = External frequency reference active
R = Reference offset active
A = Automatic IF adjust off
K = Signal track active
M = Trace math active
+ = Positive external bias on
− = Negative external bias on

Now that you have seen how the spectrum analyzer operates, we will move ahead and perform two common but important spectrum analyzer measurements, third-order intermodulation distortion and total harmonic distortion. These two measurements use a variety of spectrum analyzer functions. Practicing these measurements will refine your operating skills and increase your understanding of what each function does. You will then be able to apply these functions to your own measurements.

PROCEDURE 1: THIRD-ORDER INTERMODULATION DISTORTION

What is Intermodulation Distortion?

In crowded communication systems, signal interference of one device with another is a common problem. For example, two-tone, third-order intermodulation is often a problem in narrow band systems. When two signals (F_1 and F_2) are present in a system, they can mix with the second harmonics generated ($2F_1$ and $2F_2$) and create third-order intermodulation distortion products, which are located close to the original signals at $2F_2 - F_1$ and $2F_1 - F_2$ (see Figure 4.1). Higher order intermodulation distortion can also occur. These distortion products are generated by such system components as amplifiers and mixers.

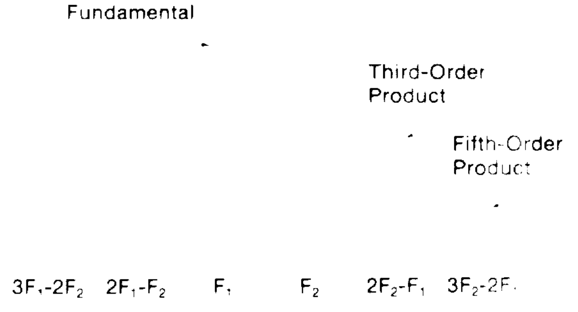


Fig.4.1. Two input signals and resulting intermodulation distortion products.

The Functions Used

The procedure below describes how to measure third-order intermodulation distortion. It shows how to tune two signals onto the spectrum analyzer display and demonstrates setting the resolution bandwidth, mixer level, and reference level. It also incorporates several marker functions.

Measurement Overview

Briefly, to measure third-order intermodulation distortion, tune the spectrum analyzer frequency so that the two source signals appear on the spectrum analyzer display, making sure to use a frequency span wide enough to include the third-order distortion products. Next, select the spectrum analyzer resolution bandwidth, mixer level, and reference level. Finally, using the delta marker mode, measure the distortion products relative to the test tones. This measurement procedure is described more specifically in the following five steps.

Stepping Through the Measurement

To test a device for third-order intermodulation, connect the equipment as shown in Figure 4.2. This example uses two sources set to 20 MHz and to 21 MHz. Other source frequencies, of course, may be substituted, but maintain a frequency separation of approximately 1 MHz to best follow this example. The low-pass filters are not required if this procedure is used only to practice using the instrument.

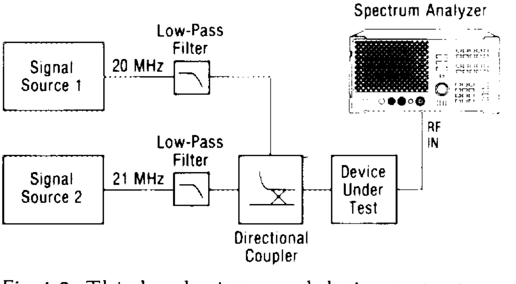


Fig.4.2. Third-order intermodulation test setup.

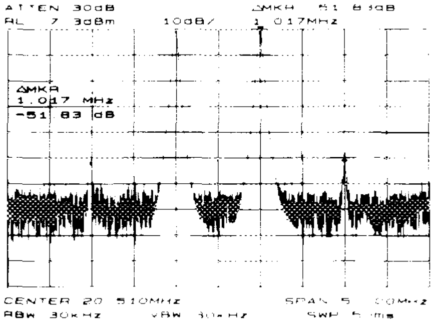


Fig.4.5. Intermodulation distortion measured in dBc. Marker sequence here is PEAK SEARCH, NEXT PK RIGHT. Marker threshold set to −70 dB.

6. You may want to store the measurement information for future use. The functions [SAVE] and [RECALL] allow you to store data for later viewing. The SCREEN TITLE function allows you to create a title on the screen and a label for the [RECALL] menu. To create make a title, press [DISPLAY] and the softkeys MORE and SCREEN TITLE. Next, use the softkeys from the SCREEN TITLE menu and the knob (to choose the letters) to create a title. The title appears in the upper right corner of the graticule and can be one or two rows of 16 characters each (see Figure 4.6). Press the softkey TITLE DONE when the title is complete.

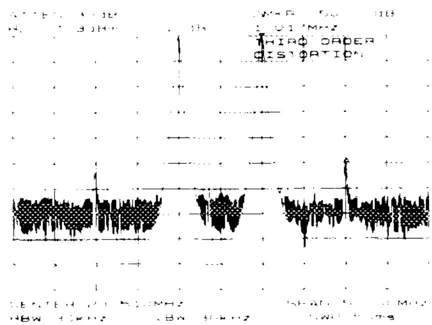


Fig.4.6. Display with title.

7. To save the instrument state, press [SAVE] and the softkey SAVE STATE; then press a softkey to enter the instrument state data into whichever register (0 - 9) you select. The first sixteen characters of the title are used to label the register on the [RECALL] menu. To view this menu, press [RECALL] and the softkey RECALL STATE (see Figure 4.7). If a stored state has not been titled, the menu reads STATE followed by the register number chosen.

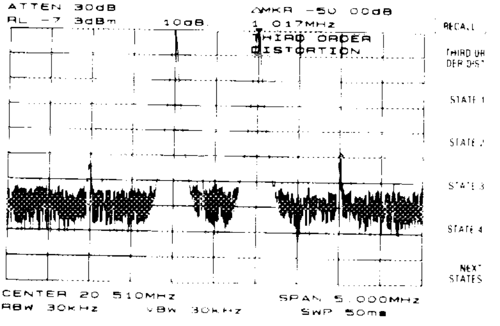


Fig. 4.7. [RECALL] menu.

PROCEDURE 2: HARMONIC DISTORTION

Why Measure Harmonic Distortion?

Most transmitting devices and signal sources contain harmonics. Measuring the harmonic content of such sources is frequently required. In fact, measuring harmonic distortion is one of the most common uses of a spectrum analyzer. Harmonic distortion can be checked very quickly using the measurement routine described below, which measures harmonic amplitudes relative to the source frequency.

The Functions Used

The harmonic distortion measurement below employs an important set of spectrum analyzer operating skills: setting the frequency span using start and stop frequencies; setting the video bandwidth; and making relative measurements using two markers. Also demonstrated are how to set a signal to the center frequency using a marker and how to set the frequency step size to the value of the center frequency.

"Fast Measurement" Overview

There are two common ways to measure harmonic distortion using a spectrum analyzer. The following procedure illustrates the faster method, which permits simultaneous display of the fundamentals and its harmonics. A second procedure is also given, and although it is somwhat lengthier to perform, it provides a better *measurement of harmonics closer to the noise floor.*

To quickly measure harmonic distortion, first set the spectrum analyzer start frequency to a value slightly less than that of the source (fundamental) frequency and set the stop frequency to a value just greater than that of the last harmonic you wish to measure. Next, place a marker on the peak of the fundamental. Activate a second marker using the function NEXT PEAK and move the marker along the trace. This allows you to measure the frequencies and amplitudes of the harmonics relative to the fundamental.

The example below measures the harmonic content of the 300 MHz calibration signal. If desired, you may use another source, but *be sure to adjust the spectrum analyzer start and stop frequencies* to accommodate the source frequency and its harmonics.

Making Fast Harmonic Measurements

Connect the signal source to the spectrum analyzer input and complete the following steps. Start from a preset state (i.e., press [PRESET]).

1. For measuring the 300 MHz fundamental and its first two harmonics, set the start frequency to 270 MHz and the stop frequency to 1000 MHz. This displays the fundamental frequency and the second and third harmonics, as shown in Figure 4.8. To improve visibility, smooth the video bandwidth: press [BW] and the softkey VIDEO BW; then use the STEP [↓] key as desired.

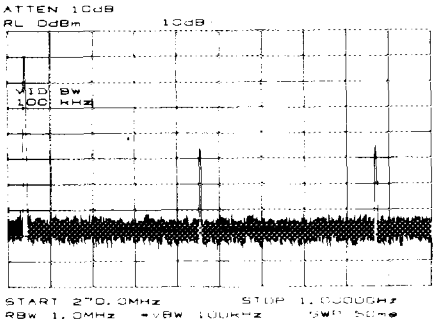


Fig.4.8. Input signal and harmonics.

2. For greatest measurement accuracy, raise the peak of the fundamental to the reference level by pressing [PEAK SEARCH], [MKR →], and then the softkey MKR → REF LVL. To measure the difference between the fundamental and a harmonic, activate a second marker by pressing the front-panel key [PEAK SEARCH] and the softkeys MARKER DELTA and NEXT PK RIGHT. This places the second marker on the peak of the second harmonic, as shown in Figure 4.9. The difference in amplitude between the fundamental and second harmonic shown in the figure is approximately −35 dB, or 1.8% harmonic distortion (see Figure 4.10). To measure the third harmonic, press NEXT PK RIGHT again. The marker in this example reads approximately −37 dB, or 1.5% distortion. Continue reading amplitudes and comparing them to Figure 4.10 for each additional harmonic you wish to measure.

   Another easy way of determining percent of distortion is to change the units to VOLTS: press [AMPLITUDE] and the softkeys MORE, UNITS, and VOLTS. The marker readout automatically switches to voltage units. To determine percent of distortion, use the ratio given by the marker and move the decimal point of this value two places to the right.

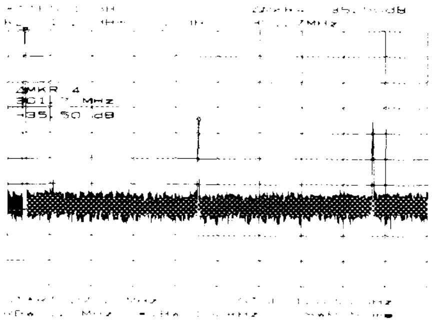


Fig.4.9. Harmonic distortion measured in dBc. Marker threshold set to −70 dB.

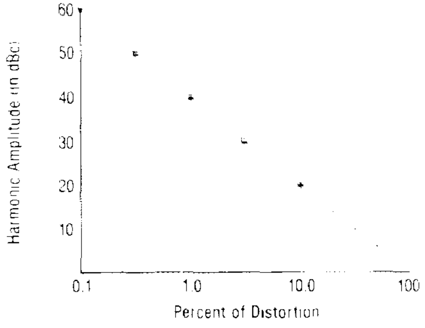


Fig.4.10. Percent of distortion vs. harmonic amplitude.

3. You may want to plot the display for hard-copy documentation. To do this, simply connect a graphics plotter (such as an HP 7440A ColorPro) to the analyzer via HP-IB. Set the plotter address to 5. On the spectrum analyzer, press [DISPLAY] and PLOT MENU to view available plot functions. Press PLOT ALL to transfer the entire display contents to the plotter. Other plotter functions allow you to select certain traces or parts of the display for plotting. The PLOT ORG function lets you choose plotter reference points to correlate to the display (DSP) or to the display graticule (GRAT).

Getting the Most Accurate Harmonic Distortion Measurements

An alternate method for measuring harmonics is described below. This method is somewhat lengthier, but because each signal is measured in a narrower span and resolution bandwidth, the signal-to-noise ratio is improved, making the results more accurate.

1. Using the present setup, clear the markers from the screen: press [OFF]. To measure the fundamental, press [PEAK SEARCH]. Move the fundamental to the center frequency; press [PEAK SEARCH] and the softkey SIG TRK ON. Reduce the frequency span to 15 MHz by pressing [SPAN] [1] [5] [MHz]. The signal track function allows you to quickly "zoom" to a narrower span without losing the signal from the screen. After the span is reduced, turn off the signal track function. Next, set the center frequency step size to 300 MHz by pressing [MKR →] and MKR → CF STEP. The resulting display should resemble Figure 4.11.

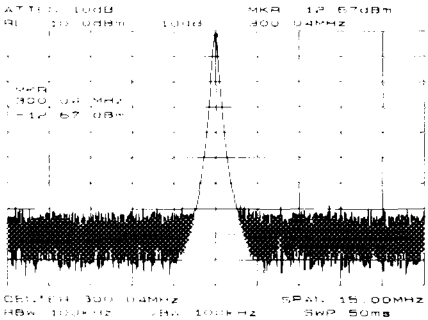


Fig.4.11. Input signal displayed in a 15 MHz span.

2. To measure the second harmonic, press MARKER DELTA, [FREQUENCY] and the [↑] key. This step retunes the spectrum analyzer center frequency to the second harmonic. Adjust the harmonic to the reference level. This displays the amplitude of the second harmonic as shown in Figure 4.12. The difference between the second harmonic and the fundamental can be converted to a percentage of distortion using Figure 4.10. Again, units can be changed to VOLTS in order to read the voltage ratio of the two signals.

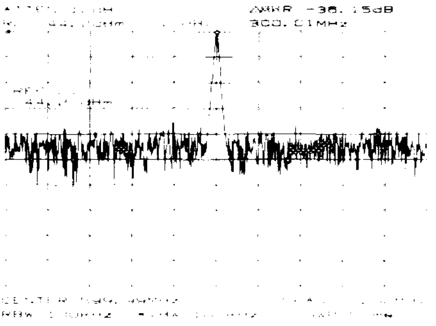


Fig.4.12. Second harmonic displayed in dBc.

For each additional harmonic you wish to measure simply press the [↑] key and adjust the reference level.

Percent of Harmonic Distortion

Measuring the total percent of harmonic distortion of a signal is also performed frequently. For this measurement, the amplitude of each harmonic must be measured in linear units (e.g., volts) instead of dBc. (To display amplitude units in volts, press AMPLITUDE and the softkeys MORE, UNITS, and VOLTS.) The amplitude values of these signals are used in the equation below to compute total harmonic distortion.

Percent of distortion =

$$\frac{\sqrt{(A_2)^2 + (A_3)^2 + (A_4)^2 \ldots + (A_n)^2}}{A_1} \times 100$$

Where A_1 = the amplitude of the fundamental frequency, in volts

A_2 = the amplitude of the second harmonic, in volts

A_3 = the amplitude of the third harmonic, in volts

A_4 = the amplitude of the fourth harmonic, in volts

A_n = the amplitude of the n harmonic, in volts

If the signal amplitudes are measured carefully, as in the previous example, this procedure measures percent-of-harmonic distortion very accurately. However, such calculations make manual operation tedious. Therefore, a complete program that automatically measures percent-of-total harmonic distortion is included in Chapter 6.

Good Work! You now know how to use many common spectrum analyzer functions. You also know several important techniques for making accurate measurements. To help you locate specific functions, Appendix A contains menu trees that depict each menu as it appears on the spectrum analyzer display and from each associated front-panel key. To provide more information about individual functions, the Glossary of Spectrum Analyzer Functions contains brief descriptions of the functions available from each front-panel key and its related menu. For detailed descriptions of all functions, refer to the Operating and Programming Manual.

Since you are now expert at manual operation, you may want to learn about remote operation. Chapter 5 describes how to turn manual measurement procedures into programs.

CHAPTER 5
REMOTE OPERATION

This chapter is an introductory guide to programming the HP 8562A/B. It begins with instructions on how to set the analyzer address and execute commands remotely, then introduces you to using variables and numeric formats in a program. From these simple concepts it develops a program that illustrates important spectrum analyzer programming techniques: how to control the spectrum analyzer sweep; how to use markers to set a signal to the reference level; and how to query the analyzer for amplitude and frequency values of an active marker, read the values, and enter them into variables. Programming examples are given throughout the section. While the programs and programming examples in this chapter are written in HP BASIC 4.0 using HP 9000 Series 300 Computers, other versions of BASIC, and any computer that complies with the Institute of Electrical and Electronic Engineers (IEEE-488) standards, may be used. Important reference information (spectrum analyzer commands, status registers, etc.) is found in the Appendixes. To best understand this section, general knowledge of the BASIC language is required.

CONNECTING THE ANALYZER TO THE COMPUTER

Figure 5.1 illustrates how to connect a computer that complies with IEEE-488 standards to the spectrum analyzer. When the analyzer is operated remotely, a single softkey (RMT LCL) appears on the display and allows you to return to local mode.

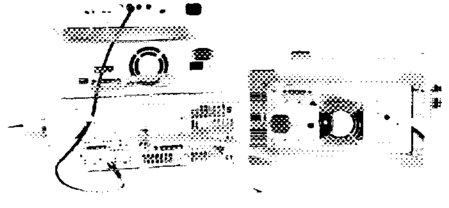


Fig.5.1. HP 8562A/B connected to an HP 9000 Series 300 computer.

SETTING THE ADDRESS

The spectrum analyzer address is displayed in the active function block (see Figure 5.2). To read the address, press [PRESET] and the softkey HP-IB ADDR. To change the address, use the data keys to enter the desired number, then terminate the entry with [ENTER]. For example, to set the address to 18, press [PRESET] HP-IB ADDR [1] [8] [ENTER].

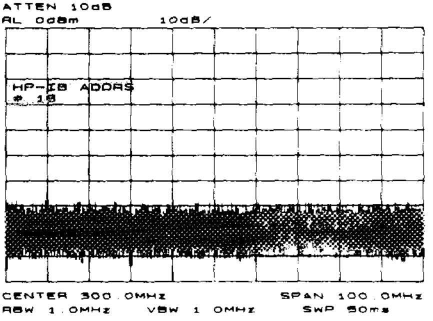


Fig.5.2. Address displayed on the screen.

HOW TO PROGRAM COMMON SPECTRUM ANALYZER FUNCTIONS

Nearly all manual functions on the spectrum analyzer have corresponding programming commands. For example, the commands CF and SP activate center frequency and frequency span, respectively. The following example illustrates how to set the center frequency to 300 MHz and the frequency span to 20 MHz.

Example 1

```
10      OUTPUT 718;"CF 300MHZ;"
20      OUTPUT 718;"SP 20MHZ;"
```

In the program lines above, "OUTPUT" is a BASIC command that designates the computer as the "talker" on the bus. "OUTPUT" is also used to direct command strings to the spectrum analyzer (at address 18); these spectrum analyzer commands are contained in quotation marks. For example, executing line 10 sets the spectrum analyzer center frequency to 300 MHz.

Note the quotation marks that contain the spectrum analyzer commands in each line and the semicolon at the end of each line. All spectrum analyzer commands must be contained within quotation marks. The semicolons appearing in the examples above conform to IEEE-728, which recommends placing semicolons in between spectrum analyzer commands and at the end of a line. This makes programs easier to read and prevents the spectrum analyzer from misinterpreting commands.

Programming with numerical constants is the easiest way to control the spectrum analyzer remotely. However, for all but the simplest of programs, variables provide greater measurement flexibility. Variables allow you to set the center frequency and span using values that you have selected, as in the following example.

Example 2

```
10    A=300
20    B=20
30    OUTPUT 718 USING "K";"CF";A;"MHZ;"
40    OUTPUT 718 USING "K";"SP";B;"MHZ;"
```

This programming technique allows you to change the center frequency and span by changing the values of variables A and B. Also, by using variables, you can enter numeric values via the computer keyboard. Note that the variables are not actual spectrum analyzer commands; thus they are not placed within the quotation marks.

In the example above, the USING statement creates a format (K) for the data. In this case, the format uses 15 characters to send numeric values. Formats, though not required, ensure accurate transfer of data by allowing you to control the resolution of the data sent. However, using 15 characters to transfer numbers such as 300 and 20 does not provide the best control over a data transfer. The following example illustrates a more concise format.

Example 3

```
10    A=300
20    B=20
30    IMAGE K,5D.DD,K
40    OUTPUT 718 USING 30;"CF",A,"MHZ;"
50    OUTPUT 718 USING 30;"SP",B,"MHZ;"
```

In the example above, the IMAGE statement (K,5D.DD,K) creates a format for the data. In this case the format allows two character strings (each represented by the letter K) and a numeric variable consisting of up to five significant digits plus two decimal places (represented by 5D.DD). Not only does this format save time, but an IMAGE statement can be reused in other parts of the program. Simply use the line number on which the IMAGE statement appears, as in lines 40 and 50.

The format 5D.DD provides numeric accuracy to within 10 kHz. To increase the resolution — for example to 100 Hz — increase the number of decimal places to four (5D.4D).

The order in which you set spectrum analyzer functions is also important; the following checklist shows the best order in which to activate these functions.

- Set the center frequency and span or set the start and stop frequencies.
- Set the input attenuation.
- Set the resolution and video bandwidths and the sweeptime. (As a general rule, these functions can be left in auto mode and set by the spectrum analyzer.)
- Set the reference level.
- Activate markers.

DEVELOPING A SIMPLE PROGRAM

The best way to begin automating a measurement procedure is to first perform it manually. This allows you to select the exact functions you will want to use in your program. Choosing the right functions beforehand usually reduces program de-bugging. By now you should be familiar with making a basic measurement (i.e., setting the frequency, span, reference level, and marker), so we will use these functions to create a programming example.

The first spectrum analyzer commands to use in a program are those that execute an instrument preset (programming command IP) and activate the single sweep mode (programming command SNGLS). The instrument preset sets the spectrum analyzer to a known condition from which to begin your setup. Single sweep mode gives you explicit control of spectrum analyzer sweeps and of the input and output of data.

Example 4

```
10    OUTPUT 718;"IP;SNGLS;"
```

Next, select spectrum analyzer measurement settings. For this example, we can use the program segment from the previous section.

Example 5

```
10     OUTPUT 718;"IP;SNGLS;"
20     A=300
30     B=20
40     IMAGE K,5D.DD,K
50     OUTPUT 718 USING 40;"CF",A,"MHZ;"
60     OUTPUT 718 USING 40;"SP",B,"MHZ;"
```

After the settings have been programmed, execute a take sweep command (TS). This ensures that, for the entire sweep, the analyzer functions are set to the values selected and that any measurements on the trace will be made with these settings. If the single sweep and take sweep commands were not included, the spectrum analyzer might transfer data before completing a full sweep. As a result, part of the trace data may not be valid, since it might have been taken from previous settings. Under these conditions, it would be hard to know if the measurement data were valid. The preferred method is shown below.

Example 6

```
10     OUTPUT 718;"IP;SNGLS;"
20     A=300
30     B=20
40     IMAGE K,5D.DD,K
50     OUTPUT 718 USING 40;"CF",A,"MHZ;"
60     OUTPUT 718 USING 40;"SP",B,"MHZ;TS;"
```

At this point in the program, we can be sure that all measurements will be made in reference to the selected settings.

As with manual measurements, reading the signal amplitude at the reference level provides the best measurement accuracy. Once a signal is present, a convenient method for setting the reference level uses the "marker to reference level" function. After a marker has been activated, the marker to reference level function can set the reference level to the value of the marker. This function is particularly useful for setting the reference level to the value of the highest point on a trace. The peak search function (MKPK HI) finds the highest point on a trace and places a marker on it. The marker to reference level function (MKRL) sets the reference level to the value of this point. To read the marker values, take another sweep, then "re-peak" the marker. This marker command routine is illustrated in line 70 of the programming example below.

Example 7

```
10    OUTPUT 718;"IP;SNGLS;"
20    A=300
30    B=20
40    IMAGE K,5D.DD,K
50    OUTPUT 718 USING 40;"CF",A,"MHZ;"
60    OUTPUT 718 USING 40;"SP",B,"MHZ;TS;"
70    OUTPUT 718;"MKPK HI;MKRL;TS;MKPK HI;"
```

Note the placement of the TS command in line 70. Using TS ensures that the spectrum analyzer makes a complete sweep with the new settings before executing any additional commands that follow TS.

Reading Marker Frequency and Amplitude

Now that you have set up the spectrum analyzer to find the marker values, the next logical step is to read marker information from the spectrum analyzer and enter it into variables. The following example, which continues from the last, shows how to find the amplitude and frequency values of a marker and enter them into variables.

Example 8

```
10    OUTPUT 718;"IP;SNGLS;"
20    A=300
30    B=20
40    IMAGE K,5D.DD,K
50    OUTPUT 718 USING 40;"CF",A,"MHZ;"
60    OUTPUT 718 USING 40;"SP",B,"MHZ;TS;"
70    OUTPUT 718;"MKPK HI;MKRL;TS;MKPK HI;"
80    OUTPUT 718;"MKA?"
90    ENTER 718;Amplitude
100   OUTPUT 718;"MKF?"
110   ENTER 718;Frequency
120   PRINT "MARKER AMPLITUDE = ",Amplitude
130   PRINT "MARKER FREQUENCY = ",Frequency
140   END
```

The question marks in lines 80 and 100 query the spectrum analyzer for the amplitude and frequency of the marker. The ENTER statement designates the spectrum analyzer as the talker so it can send information over to the computer, which becomes the listener. The spectrum analyzer can then output these values into variables and into the computer. Lines 90 and 110 enter these values into the variables Amplitude and Frequency; lines 120 and 130 print the values on the computer screen. Of course, the variables can be used later in the program. Most spectrum analyzer commands can be queried in order to return values.

The marker values are returned to the computer in the "K" format. To select another format for the results (such as the format in Line 40), simply insert formatting statements on lines 90 and 110, similar to those on Lines 50 and 60.

SUMMARY

The programming tips discussed in this chapter are highlighted below.

- First, perform the measurement manually, keeping track of the function sequence.
- Execute an instrument preset and single sweep before setting other spectrum analyzer functions.
- Use variables for function values.
- Format data.
- Activate functions in a logical order.
- After setting the analyzer functions, execute a take-sweep command before reading data.
- To read marker values after setting or changing spectrum analyzer functions, first take a sweep, then reactivate a marker.

These programming techniques also appear in the complete, fully annotated program that measures percent-of-total harmonic distortion. This program is located in Chapter 6.

The harmonic distortion program presented here illustrates how to program the spectrum analyzer. Many of the programming suggestions discussed in Chapter 5 have been incorporated into this program, which is fully annotated with line-by-line explanations.

PERCENT OF HARMONIC DISTORTION

Measuring percent-of-total harmonic distortion is tedious when performed manually: it involves tuning to the fundamental and to each harmonic of interest, noting the amplitude of each signal, converting these amplitudes to linear units (volts), and calculating the result from a formula. The following program measures percent-of-total harmonic distortion automatically, quickly, and accurately.

The program operates in the following manner. The program prompts you to connect a source to the spectrum analyzer and enter the source frequency. It sets the spectrum analyzer center frequency to the value of the source, or fundamental, frequency and sets other analyzer functions for optimum measurement accuracy. It measures and records the amplitude of the fundamental, then measures and records the amplitude of the second, third, and fourth harmonics. These values are then used to compute percent-of-harmonic distortion. The percent-of-harmonic distortion results, plus harmonic amplitudes in dBc, are displayed on the computer.

HARMONIC DISTORTION PROGRAM

```
!* file:DISTORTION ... rev date: 860528 ... author: ** *!
OPTION BASE 1
ASSIGN @Sa TO 718
DIM Harm(2:4)
Clear_screen$=CHR$(255)&CHR$(75)
!*
OUTPUT KBD;Clear_screen$;
PRINT TABXY(22,4);"**** HARMONIC DISTORTION ****"
PRINT TABXY(15,7);"CONNECT SOURCE TO SPECTRUM ANALYZER INPUT, THEN"
PRINT TABXY(15,8);"ENTER FREQUENCY OF FUNDAMENTAL IN MHz ... ?"
PRINT TABXY(18,10);"READY !!!   =>   press ENTER (RETURN)..."
INPUT Fund
OUTPUT KBD;Clear_screen$;
!*
OUTPUT @Sa;"IP;TS;ML -40 DB;AUNITS V;"
OUTPUT @Sa;"CF ";Fund;"MZ;"
OUTPUT @Sa;"SP ";Fund/10;"MZ;TS;"
OUTPUT @Sa;"MKTRACK ON;SP100KZ;TS;"
OUTPUT @Sa;"MKTRACK OFF;SNGLS;"
```

```
20    OUTPUT @Sa;"TS;MKPK HI;"
21    OUTPUT @Sa;"MKSS;MKCF"
22    OUTPUT @Sa;"TS;MKPK HI;"
23    OUTPUT @Sa;"MKRL;TS;RL?"
24    ENTER @Sa;Ref_level
25    OUTPUT @Sa;"AT MAN;MKPK HI;MKA?"
26    ENTER @Sa;First
27    FOR Number=2 TO 4
28      OUTPUT @Sa;"CF UP;TS;MKPK HI;"
29      OUTPUT @Sa;"MKRL;TS;MKPK HI;MKA?"
30      ENTER @Sa;Harm(Number)
31      OUTPUT @Sa;"RL ";Ref_level;"V;"
32    NEXT Number
33    !*
34    OUTPUT @Sa;"MKOFF;CF ON ON ON;CONTS;AT AUTO;"
35    LOCAL @Sa
36    !*
37    OUTPUT KBD;Clear_screen$;
38    Sum_sqr=0
39    FOR Number=2 TO 4
40      Sum_sqr=Sum_sqr+Harm(Number)^2
41    NEXT Number
42    Prcnt=SQR(Sum_sqr)/First*100
43    OUTPUT CRT USING "5/,22X,K";"****** HARMONIC DISTORTION ******"
44    OUTPUT CRT USING "/,20X,K";"FUNDAMENTAL ..."
45    OUTPUT CRT USING "32X,K,5D.D,K";" FREQUENCY = ";Fund;" MHz"
46    OUTPUT CRT USING "32X,K,5D.D,K";"AMPLITUDE = ";10*LGT(First/.0 ... );" dBm"
47    OUTPUT CRT USING "21X,K";" HARMONICS ..."
48    OUTPUT CRT USING "34X,K,5D.D,K";" SECOND = ";20*LGT(Harm(2)/First);" dBc"
49    OUTPUT CRT USING "34X,K,5D.D,K";"  THIRD = ";20*LGT(Harm(3)/First);" dBc"
50    OUTPUT CRT USING "34X,K,5D.D,K";" FOURTH = ";20*LGT(Harm(4)/First);" dBc"
51    OUTPUT CRT USING "/,23X,K,3D.D,K";"PERCENT DISTORTION = ";Prcnt;" %"
52    !*
53    END
```

PROGRAM ANNOTATION

Line 2: Specify the lower bound of the program arrays as 1.

Line 3: Assign the spectrum analyzer address path (718) to @Sa.

Line 4: Create the array "Harm" to store amplitude values of the second, third, and fourth harmonics.

Line 5: Assign string variable "Clear__screen" to perform the computer keyboard function Clear Screen.

Lines 7-13: Clear the computer screen, then print the measurement instructions on the computer screen and wait for the user entry.

Line 15: Preset the instrument and take a sweep in order to start from a known state. Set the mixer level to −40 dB for maximum distortion-free dynamic range for this type of measurement. Select the amplitude units as volts, since voltage values are used for percent of harmonic distortion calculations.

Lines 16-17: Set the center frequency to the fundamental frequency and reduce the span to 10% of center frequency.

Lines 18-19: Activate the marker-track function to ensure that the signal remains on the screen while the span is set. Deactivate marker track and set the spectrum analyzer to single sweep mode for synchronous control of the sweep.

Lines 20-26: Measure the frequency of the fundamental and set the center frequency step size to this value. This allows you to step up the center frequency to the next harmonic. Find the value of the reference level and store it in Ref_level for later use. Set the attenuation to manual in order to "hold" it at a constant level for distortion-free dynamic range. Peak the marker to measure the fundamental amplitude and store this value in First.

Lines 27-32: Measure the second, third, and fourth harmonics using the FOR/NEXT loop.

Lines 28-32: Step up the center frequency to measure a harmonic. Find the amplitude of the harmonic and set the reference level to this value for best measurement accuracy. Measure the amplitude and store it in the appropriate array cell. Set the reference level back to its original value (stored in Ref_level) and repeat for the next harmonic.

Lines 34-35: Return the analyzer to its initial state and return to local mode.

Lines 37-42: Clear the computer screen. Calculate the percent of harmonic distortion using the sum of the squares.

Lines 43-51: Print on the computer screen the fundamental frequency and amplitude; the second, third, and fourth harmonics in dBc; and the percent of distortion.

Line 53: End the program.

This appendix lists the HP 8562A/B programming commands, status bytes and messages, and softkey menus. The programming commands are listed in alphabetical order, followed by a brief command name and (if applicable) the corresponding key. Also included are menus and the front-panel key that activates that menu. A cross reference is also provided, which lists the softkeys in alphabetical order. Next to each softkey is the front-panel key under whose menu the softkey is found.

PROGRAMMING COMMANDS

COMMAND	NAME	KEY
ADJALL	Execute Turn-on Adjustments	
ADJCRT	CRT Adjustment Pattern	CRT ADJ PATTERN
ADJIF	Execute IF Adjustments	FULL IF ADJ
AMB	Trace A Minus Trace B	A-B →A
AMBPL	Trace A Minus Trace B Plus Display Line	A-B+DL →A
ANNOT	Annotation On Off	ANNOT ON OFF
APB	Trace A Plus Trace B	A+B →A
AT	Input Attenuator	ATTEN ON OFF
AUNITS	Absolute Amplitude Units	UNITS
AUTOCPL	Autocouple All "AUTO" *Functions*	ALL
AXB	Trace A Exchange Trace B	A EXCH B
BLANK	Blank Trace	BLANK A, BLANK B
BML	*Trace A Minus Display Line*	B-DL →B
CF	Center Frequency	CENTER,
CLRW	Clear Write Trace	CLR-WRT A, CLR-WRT B
CNVLOSS	External Mixer Conversion Loss	CONV LOSS
CONTS	Continuous Sweep	CONT
DEMOD	Demodulation	AM DEMOD ON OFF FM DEMOD ON OFF
DEMODAGC	Demodulation Automatic Gain Control	
DEMODT	Demodulation Time	DEMOD TIME
DET	Detection Mode	DETECTOR MODES
DL	Display Line	DISP LINE ON OFF
DONE	Done	
ERR	Command *Error*	
ET	Elapsed Time	ELAPSED TIME
FA	Start Frequency	START FREQ
FB	Stop Frequency	STOP FREQ
FDIAG	Frequency Diagnostics	FREQ DIAG NOISE
FDSP	Frequency Display	FREQ DSP ON OFF
FOFFSET	*Frequency Offset*	FREQ OFFSET
FREF	Frequency Reference	10 MHz INT EXT

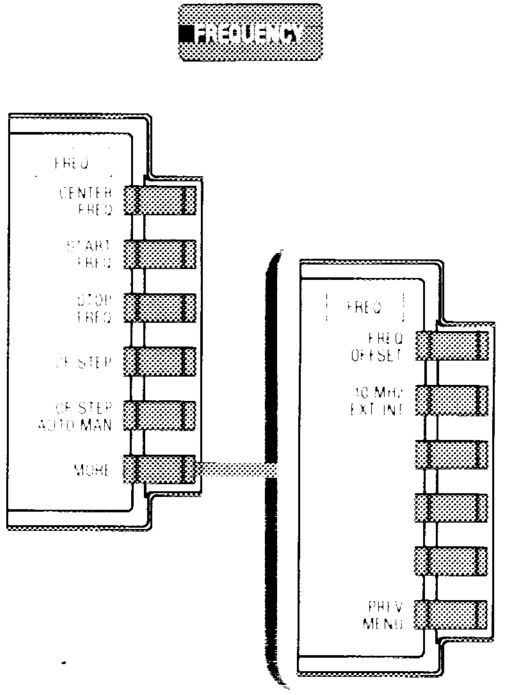
FS	Full Span	FULL SPAN
FULBAND	Full Band	FULL BAND
GRAT	Graticule On/Off	GRAT ON OFF
HD	Hold	HOLD
HNLOCK	Harmonic Number Lock	LOCK ON OFF
HNUNLK	Unlock Harmonic Number	LOCK ON OFF
ID	Output Identification	
IDCF	Signal Identification Frequency to Center Frequency	SIG ID → CF
IDFREQ	Signal Identification to Frequency Found	
IP	Instrument Preset	RECALL PWR ON, PRESET
LG	Logrithmic Display Scale	LOG dB/DIV
LN	Linear Display Scale	LINEAR
MBIAS	Mixer Bias	BIAS
MINH	Minimum Trace Hold	
MKA	Marker Amplitude	
MKCF	Marker to Center Frequency	MARKER → CF
MKD	Marker Delta	MARKER DELTA
MKDR	Marker Delta Reciprocal	MARKER 1/DELTA
MKF	Marker Frequency	
MKFC	Marker Frequency Count	COUNTER ON OFF
MKFCR	Marker Frequency Count Resolution	COUNTER RES
MKMIN	Marker to Minimum	
MKN	Marker Normal	MARKER NORMAL
MKNOISE	Marker Noise	MKRNOISE ON OFF
MKOFF	Marker Off	OFF
MKPK	Marker Peak Search	PEAK SEARCH PEAK SEARCH
MKPX	Marker Peak Excursion	PEAK EXCURSN
MKREAD	Marker Readout	
MKRL	Marker to Reference Level	MARKER → REF LVL
MKSP	Marker Delta to Span	MKRΔ → SPAN
MKSS	Marker to Center Frequency Step Size	MARKER → CF STEP
MKT	Marker Time	MARKER 1/DELTA (when span > 0Hz)
MKTRACK	Marker Signal Track	SIG TRK ON OFF
ML	Mixer Level	MAX MXR LVL
MXMH	Maximum Hold	MAX HOLD A MAX HOLD B
OP	Output Display Parameters	
P1P2	Set P1, P2, of Display	PLOT ORG DSP GRAT
PLOT	Plot Display	PLOT ALL
PP	Preselector Peak	PRESEL AUTO PEAK
PRESEL	Preselector Data	RECALL PRSEL PK FACTORY PRSEL PK
PSTATE	Protect State	SAVELOCK ON OFF
RB	Resolution Bandwidth	RES BW AUTO MAN
RBR	Resolution Bandwidth to Span Ratio	RBW:SPAN

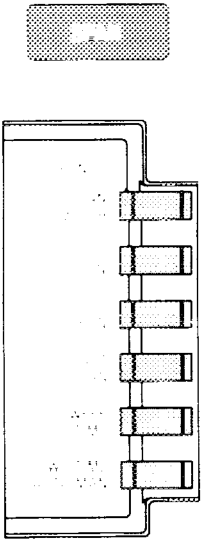
RCLS	Recall State Register	RECALL STATE
RCLT	Recall Trace Register	RECALL TRACE
REV	Output Revision Number	
RL	Reference Level	REF LVL [ ]
RLCAL	Reference Level Calibration	REF LVL CAL
ROFFSET	Reference Level Offset	REF LVL OFFSET
RQS	Request Service Conditions	
SAVES	Save State	SAVE STATE
SAVET	Save Trace	SAVE TRACE
SER	Serial Number	
SIGDEL	Signal Amplitude Delta	
SIGID	Signal Identify	SIG ID ON OFF
SNGLS	Single Sweep	SINGLE
SP	Frequency Span	[ ]
SQUELCH	Squelch for Demodulation	SQUELCH
SRQ	Service Request	
SS	Center Frequency Step Size	CF STEP AUTO MAN
ST	Sweep Time	SWP TIME AUTO MAN
STB	Status Byte Query	
SWPOUT	Sweep Output	REAR PANEL OUTPUT
TDF	Trace Data Format (Parameter Units ASCII or Binary)	
TITLE	Title Entry	SCREEN TITLE
TM	Trigger Mode	[TRIGGER]
TRA	Trace A Data Input Output	
TRB	Trace B Data Input/Output	
TS	Take Sweep	
VAVG	Video Average	VID AVG ON OFF
VB	Video Bandwidth	VIDEO BW AUTO MAN
VBR	Video Bandwidth Resolution Bandwidth Ratio	VBW:RBW
VIEW	View Trace	VIEW A, VIEW B
VOL	Volume	VOLUME [●], [((●))]
VTL	Video Trigger Level	VIDEO

STATUS REGISTER

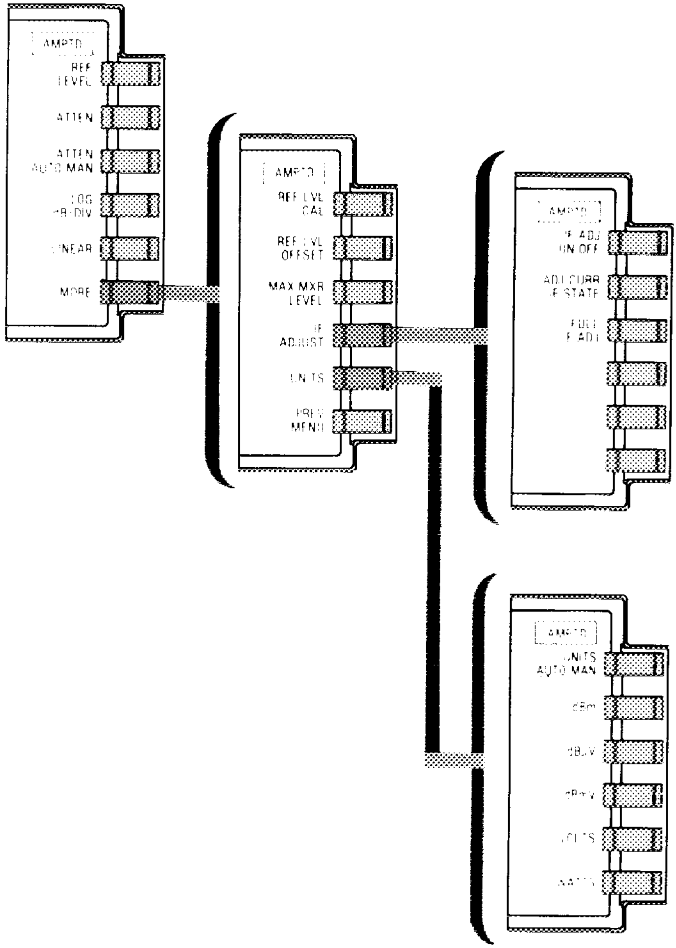
BIT NUMBER	DECIMAL EQUIVALENT	ANALYZER STATE	DESCRIPTION
7	128		NOT USED
6	64	RQS	NOT USED
5	32	ERROR PRESENT	SET WHEN ERROR REGISTER CONTAINS AN ERROR
4	16	COMMAND COMPLETE	SET WHEN COMMAND EXECUTION IS COMPLETED
3	8		NOT USED
2	4	END OF SWEEP	SET WHEN SWEEP IS COMPLETED
1	2	MESSAGE	SET WHEN THE UNCAL (UNCALIBRATED) MESSAGE APPEARS ON THE SCREEN
0	1		TRIGGER IS ACTIVATED

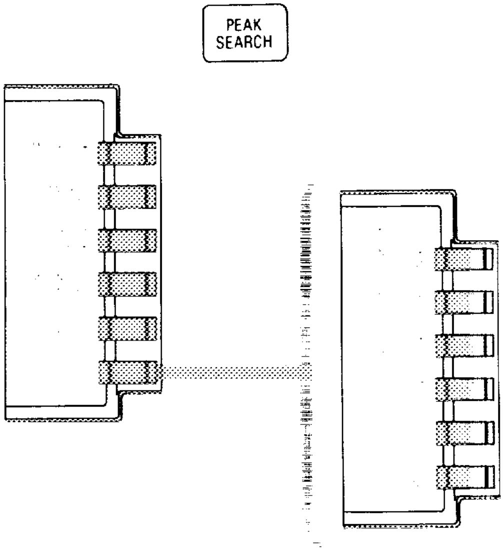
Table A.1. Spectrum Analyzer Status Byte

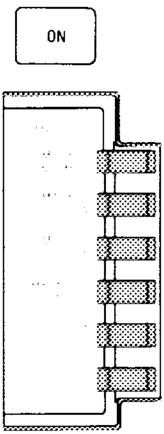

FREQUENCY
FREQ
CENTER FREQ
START FREQ
STOP FREQ
CF STEP
CF STEP AUTO MAN
MORE
FREQ
FREQ OFFSET
10 MHz EXT INT
PREV MENU



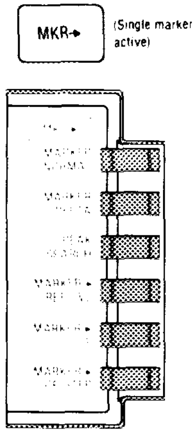
AMPLITUDE

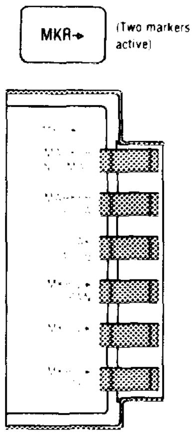

AMPTD
REF LEVEL
ATTEN
ATTEN AUTO MAN
LINEAR
MORE
AMPTD
REF LVL CAL
REF LVL OFFSET
MAX MXR LEVEL
IF ADJUST
UNITS
PREV MENU
AMPTD
ADJ CURR IF STATE
AMPTD
UNITS AUTO MAN
dBm





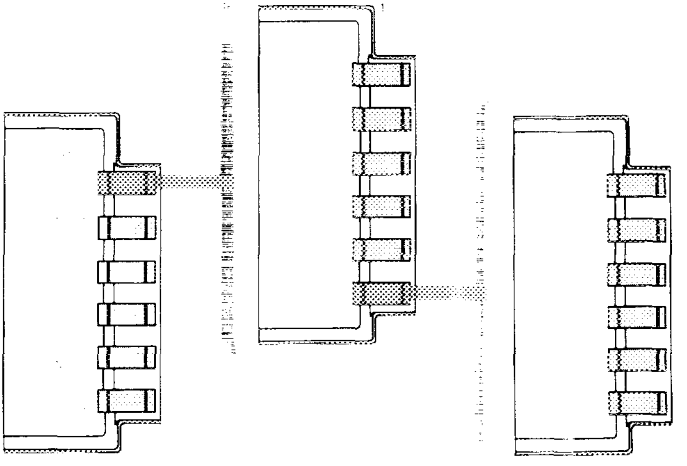
[1]Active when SPAN > 0Hz





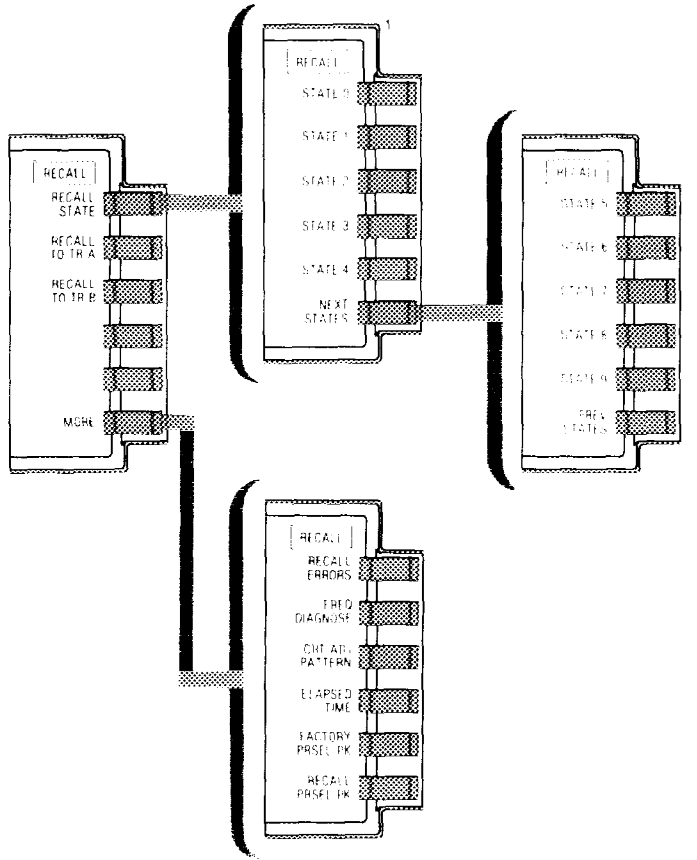
[1]Active when SPAN > 0Hz
[2]"Δ" changes to "1/Δ" when SPAN = 0Hz

SAVE

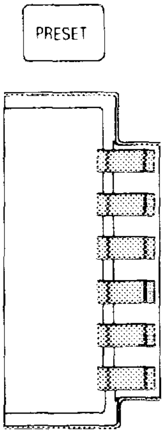


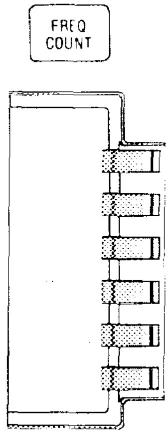
When SAVE TRACE functions are activated, "STATE" is replaced with "TRACE". For states and traces stored from titled displays "STATE", "TRACE" and numbers are replaced with the first 16 characters of the title

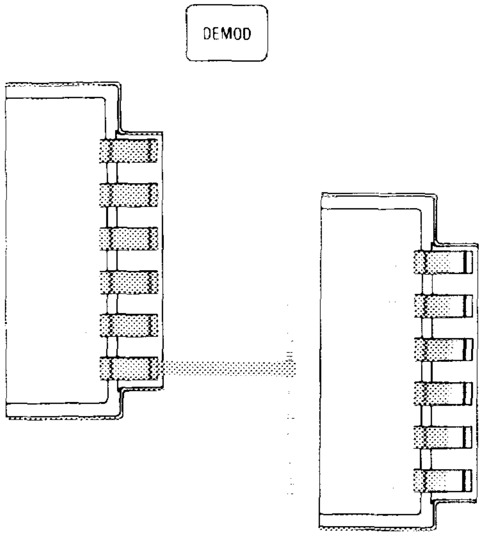
RECALL



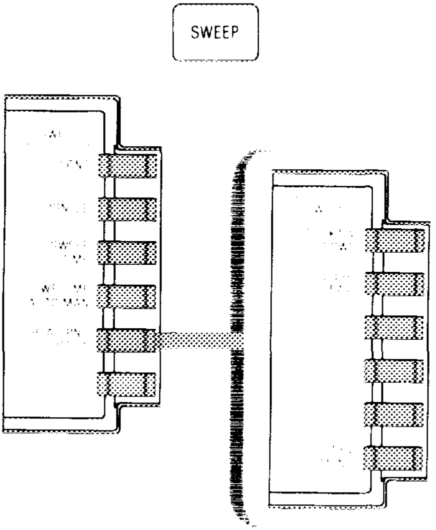
[1]When RECALL "TRACE" functions are activated, "STATE" is replaced with "TRACE." For states and traces stored from titled displays, "STATE," "TRACE," and numbers are replaced with the first 16 characters of the title.

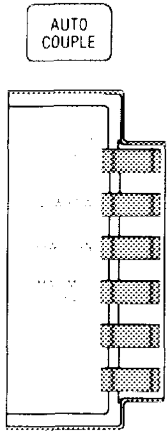


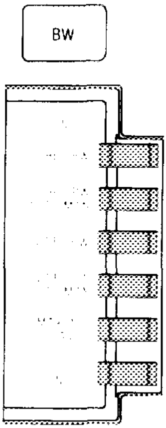


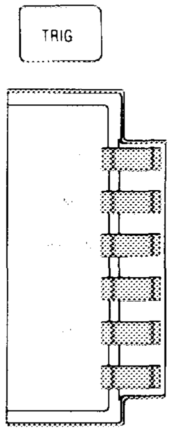


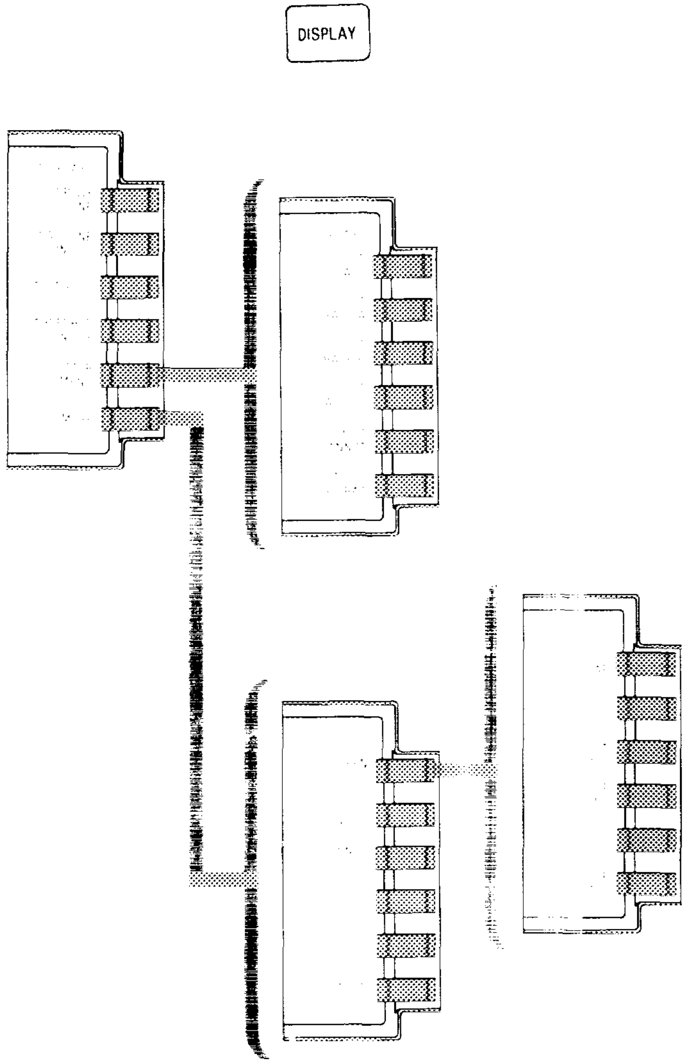
Reads MARKER DELTA when two markers are active or CENTER FREQ when SPAN ...


SWEEP

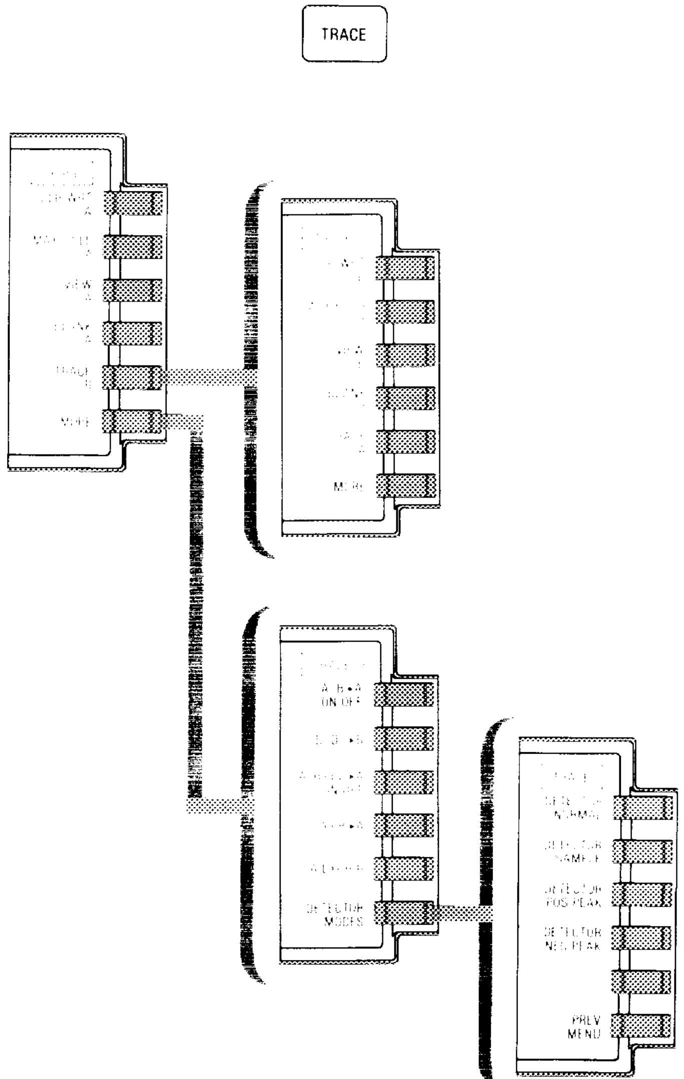

AUTO
COUPLE


BW


TRIG



[1]For outdoor use, maximum intensity is 255. For indoor use, keep intensity around 55.



[1]TRACE A returns to TRACE A MENU

G

GRAT ON OFF	DISPLAY

H

HP IB ADDRESS	PRESET

I

IF ADJ ON OFF	[illegible]
IF ADJUST	[illegible]
INTEN	DISPLAY

L

LAST SPAN	[illegible]
LAST STATE	PRESET
	RECALL
LINE	TRIGGER
LINEAR	[illegible]
LOCK HARMONIC	EXT
LOCK ON OFF	EXT
LO FREQ	RECALL
LOG dB DIV	[illegible]

M

MAIN ROLLER	RECALL
MARKER DELTA	FREQ COUNT
	MKR →
	ON
	PEAK SEARCH
MARKER NORMAL	DEMOD
	FREQ COUNT
	ON
	MKR →
MARKER →CF	MKR →
	PEAK SEARCH
MARKER →CF STEP	MKR →
MARKER →REF LVL	MKR →
MARKER 1 DELTA	ON
MAX HOLD A	TRACE
MAX HOLD B	TRACE
MAX MXR LEVEL	[illegible]
	AUTO COUPLE
MAX NO. VID AVGS	BW
MKRNOISE ON OFF	ON
	PEAK SEARCH
MKR Δ →CF	MKR →
MKR Δ →CF STEP	MKR →
MKR Δ →SPAN	MKR →
MKR 1 Δ →CF	MKR →
MKR 1 Δ →CF STEP	MKR →

N

NEGATIVE BIAS	EXT
NEG PEAK DETECTOR	TRACE
NEXT PEAK	DEMOD
	FREQ COUNT
	PEAK SEARCH
NEXT PEAK LEFT	PEAK SEARCH
NEXT PEAK RIGHT	PEAK SEARCH
NORMAL DETECTOR	TRACE

O

Softkey	Key
OFFSET ROLLER	RECALL

P

Softkey	Key
PEAK EXCURSN	PEAK SEARCH
PEAK SEARCH	DEMOD
	FREQ COUNT
	MKR →
PEAK THRSHLD	PEAK SEARCH
PLOT ORG DSP GRAT	DISPLAY
PLOTTER MENU	DISPLAY
PLOT TRACE A	DISPLAY
PLOT TRACE B	DISPLAY
POSITIVE BIAS	EXT
POS PEAK DETECTOR	TRACE
PRESEL AUTO PK	INT
PRESEL MAN ADJ	INT
PWR ON STATE	SAVE

R

Softkey	Key
RBW:SPAN	AUTO COUPLE
REALIGN LO & IF	DISPLAY
REAR PNL OUTPUT	SWEEP
RECALL ERRORS	RECALL
RECALL PRSEL PK	RECALL
RECALL PWR ON	PRESET
RECALL STATE	RECALL
RECALL TO TR A	RECALL
RECALL TO TR B	RECALL
REF LVL	AMPLITUDE
REF LVL CAL	AMPLITUDE
REF LVL OFFSET	AMPLITUDE
RES BW	BW
RES BW AUTO MAN	BW

S

Softkey	Key
SAMPLE DETECTOR	TRACE
SAMPLER FREQ	RECALL
SAMPLER HARMONIC	RECALL
SAVELOCK ON OFF	SAVE
SAVE PRSEL PK	SAVE
SAVE STATE	SAVE
SAVE TRACE A	SAVE
SAVE TRACE B	SAVE
SCREEN TITLE	DISPLAY
SELECT CHAR	DISPLAY
SIG ID AT MKR	EXT INT
SIG ID ON OFF	EXT INT
SIGID→CF	EXT INT
SIGNAL IDENT	EXT
SIG TRK ON OFF	ON
	PEAK SEARCH
SINGLE	SWEEP
	TRIGGER
SPACE	DISPLAY
SPAN WIDTH	SPAN
SQUELCH	DEMOD
SQUELCH ON OFF	DEMOD
START FREQ	FREQUENCY
STOP FREQ	FREQUENCY
SWEEP TIME	SPAN
	SWEEP
SWP TIME AUTO MAN	SPAN
	SWEEP

T

10 MHz INT EXT	FREQUENCY	TRACE A	TRACE
THRESHLD	DISPLAY	TRACE B	TRACE
THRESHLD ON OFF	DISPLAY	TRANSFER ROLLER	RECALL
TITLE DONE	DISPLAY		

U

UNITS	[illegible]	UNITS AUTO MAN	[illegible]

V

VBW:RBW	AUTO COUPLE	VIEW A	TRACE
VIDEO AVG ON OFF	BW	VIEW B	TRACE
VIDEO	TRIGGER	VOLTS	[illegible]
VIDEO BW	BW	VOLUME	DEMOD
VIDEO BW AUTO MAN	BW		(●)) ((●))

W

WATTS	[illegible]

Z

ZERO SPAN	[illegible]	0 – +10 V LO SWP	SWEEP

APPENDIX B
RESOLUTION BANDWIDTH

Signal resolution is determined by the Intermediate Frequency (IF) filter bandwidth. The spectrum analyzer traces the shape of its IF filter as it tunes past a signal. Thus, if two equal-amplitude signals are close enough in frequency, the filter shapes can fall on top of one another and appear as a single response. If two signals are not equal in amplitude but are still close together, the smaller signal can be hidden under the response of the larger one.

The resolution bandwidth function (RES BW) selects the appropriate IF bandwidth for a measurement. (Hewlett-Packard specifies resolution bandwidth as the 3-dB bandwidth of a synchronously-tuned filter.) The following guidelines can help you determine the appropriate resolution bandwidth to choose.

INPUT SIGNALS OF EQUAL AMPLITUDE

Generally, to resolve two signals of equal amplitude, the resolution bandwidth must be less than or equal to the frequency separation of the two signals. For example, to resolve two signals of equal amplitude with a frequency separation of 1 kHz, a resolution bandwidth of 1 kHz or less should be used (see Fig. B.1). Further, to resolve two signals with a frequency separation of 2 kHz, a 1 kHz resolution bandwidth again must be used (see Figure B.2). Since the spectrum analyzer uses bandwidths in a 1, 3, 10 sequence, the next larger filter, 3 kHz, would exceed the 2 kHz separation and thus would not resolve the signals.

Keep in mind that phase noise can also affect resolution.

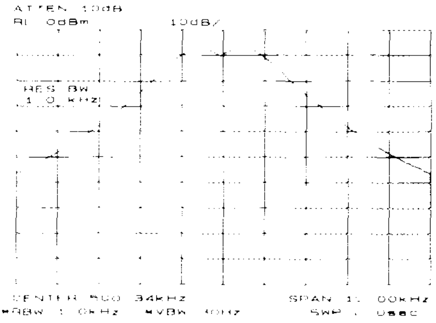


Fig.B.1. 1 kHz resolution bandwidth resolves signals 1 kHz apart. (Video bandwidth used to smooth trace.)

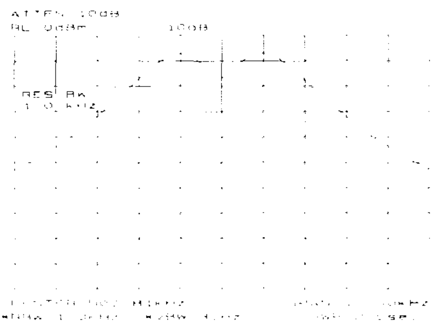


Fig.B.2. 1 kHz resolution bandwidth resolves signals 2 kHz apart. (Video bandwidth used to smooth trace.)

INPUT SIGNALS OF UNEQUAL AMPLITUDE

To resolve two signals of unequal amplitude, the resolution bandwidth must also be less than or equal to the frequency separation of the two signals. However, in this case the largest resolution bandwidth that will resolve the two unequal signals is determined primarily by the shape factor of the IF filter, rather than by the 3-dB bandwidth. (Shape factor is defined as the ratio of the 3-dB bandwidth to the 60-dB bandwidth of the IF filter, as in Figure B.3. The IF filters in this spectrum analyzer have shape factors of 15:1 or better.) Therefore, to resolve two signals of unequal amplitude, the half-bandwidth of a filter at the point equal to the amplitude separation of the two signals must be less than the frequency separation of the two signals.

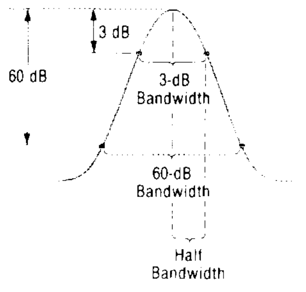


Fig.B.3. Shape factor equals 60 dB bandwidth divided by 3 dB bandwidth.

For example, consider resolving a third-order intermodulation distortion product with a frequency separation of 700 kHz and an amplitude separation of 60 dB. Using a 100 kHz filter with a typical shape factor of 12:1, the filter will have a 60-dB bandwidth of 1.2 MHz and a half-bandwidth value of 600 kHz. This half-bandwidth is narrower than the frequency separation, so the two input signals will be resolved (see Fig B.4). However, using a 300 kHz filter, the 60-dB bandwidth is 3.6 MHz and the half-bandwidth value is 1.8 MHz. Since this half bandwidth is wider than the frequency separation, the signals most likely would not be resolved (see Fig. B.5).

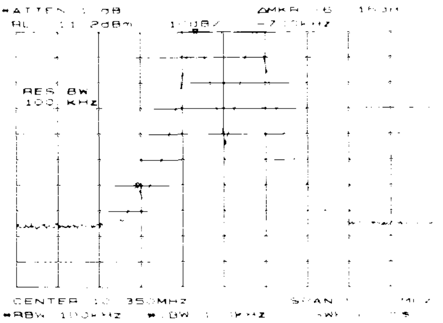


Fig.B.4. 100 kHz bandwidth resolves input signal and distortion product.

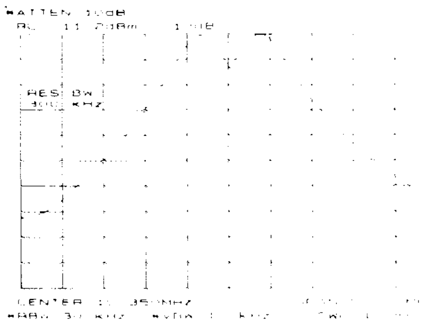


Fig.B.5. 300 kHz bandwidth is too wide to resolve signals.

Note: Spectrum analyzer sweeptime is inversely proportional to the square of the resolution bandwidth. So, if the resolution bandwidth is reduced by a factor of ten, the sweeptime is increased by a factor of 100. For fastest measurement times, use the widest resolution bandwidth that still permits resolution of all desired signals.

APPENDIX C
AMPLITUDE MODULATION

This appendix provides general amplitude modulation information. Figure C.1 illustrates an amplitude-modulated signal as seen on a spectrum analyzer display. Note the carrier signal. To determine its frequency, simply press [PEAK SEARCH]. Additional modulation information can be easily determined from the carrier signal and a sideband. For example, the difference between the carrier frequency and the sideband frequency can be found by pressing [PEAK SEARCH], MARKER DELTA, and NEXT PEAK. The markers read the frequency difference between the two signals, which is equal to the modulating frequency. The marker also reads the difference in amplitude. This difference in amplitude between the two signals can be used to determine percent of modulation (refer to Fig. C.2).

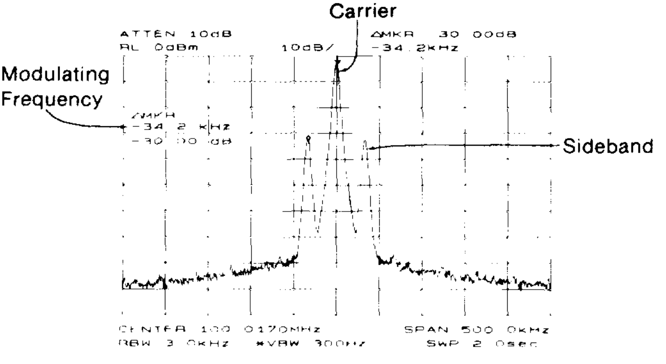


Fig.C.1. An amplitude-modulated signal.

Note: Unequal amplitudes of the lower and upper sidebands indicate incidental FM on the input signal. Incidental FM can reduce the accuracy of percent-of-modulation measurements.

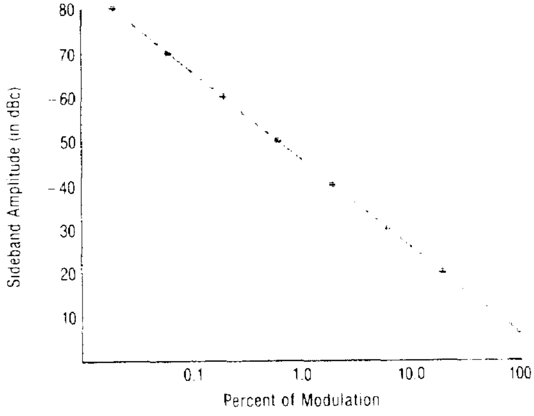


Fig.C.2. Percent of modulation vs. sideband amplitude.

The following equation also determines percent of modulation using amplitude units in volts:

$$M = \frac{2As \times 100}{Ac}$$

Where As = sideband amplitude, in volts

Ac = carrier amplitude, in volts

APPENDIX D
FREQUENCY MODULATION AND HOW TO CALCULATE FM DEVIATION

This appendix contains general information about frequency modulation, as well as a procedure for calculating FM deviation using a spectrum analyzer.

Figures D.1, D.2, and D.3 illustrate a frequency-modulated signal as it appears on a spectrum analyzer. Figure D.4 contains Bessel functions for determining modulation index. (Tables D.1 and D.2 also contain modulation index numbers for carrier nulls and first sideband nulls.)

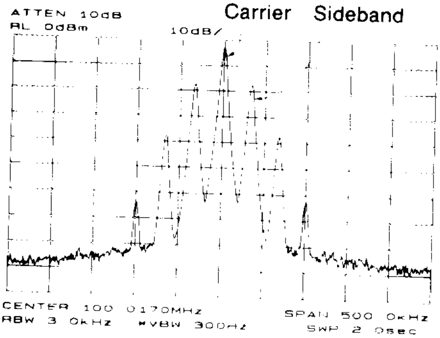


Fig.D.1. An FM-modulated signal.

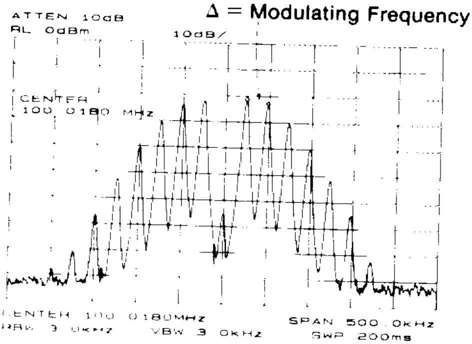


Fig.D.2. FM signal with carrier at a null.

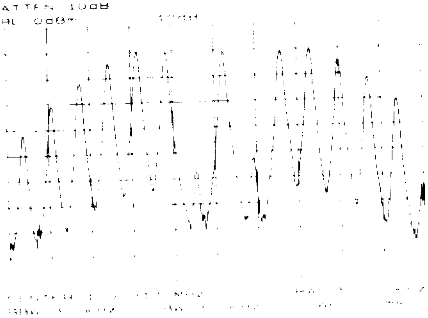


Fig.D.3. FM signal with first sidebands at a null

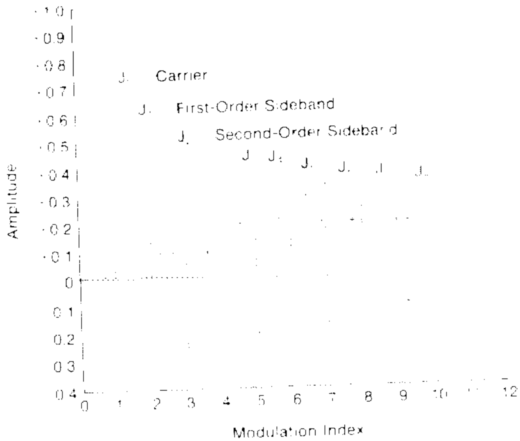


Fig.D.4. Bessel functions for determining modulation index.

ORDER OF CARRIER NULL	MODULATION INDEX
1	2.401
2	5.520
3	8.653
4	11.791
5	14.931
6	18.071
n (n > 6)	18.071 + π(n − 6)

Table D.1. Carrier nulls and modulation indexes.

ORDER OF FIRST SIDEBAND NULL	MODULATION INDEX
1	3.83
2	7.02
3	10.17
4	13.32
5	16.47
6	19.62

Table D.2. Sideband nulls and modulation indexes.

For sinusoidal modulation where either the modulation frequency or the FM deviation can be varied, the spectrum analyzer can be used to accurately set up a modulation index corresponding to a bessel null. The following example illustrates how to verify the FM deviation accuracy of a signal generator with FM capability. We will use a carrier frequency of 100 MHz and test for FM deviation accuracy at a 25 kHz rate using the modulation index for the first carrier null (2.401). Figure D.5 illustrates how to setup the equipment for this measurement.

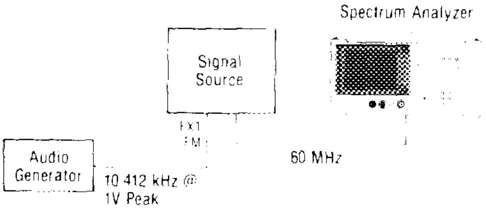


Fig. D.5. FM deviation test setup.

Beginning with the spectrum analyzer in a preset state, connect the source to the spectrum analyzer input. Set the source to 100 MHz. Set the center frequency of the spectrum analyzer to 100 MHz and the span to 45 kHz. Knowing that the desired deviation is 25 kHz, and choosing the modulation index of the first carrier null, calculate the modulating frequency as follows:

$$25 \text{ kHz} \div 2.401 = 10.412 \text{ kHz}$$

Set the modulation rate on the signal generator to 10.412 kHz. If the signal generator doesn't have an accurate internal audio source, use an external audio source. You can use the delta count mode of the HP 8562A/B to accurately set the audio source frequency as follows: activate the counter function, then use the delta count mode to read the difference between two sideband peaks (see Figure D.6). Now adjust the frequency deviation for a maximum null of the carrier. Calculate the FM deviation by multiplying the modulation index (from Table D.1) by the modulation rate:

$$10.412 \text{ kHz} \times 2.401 = 25 \text{ kHz deviation}$$

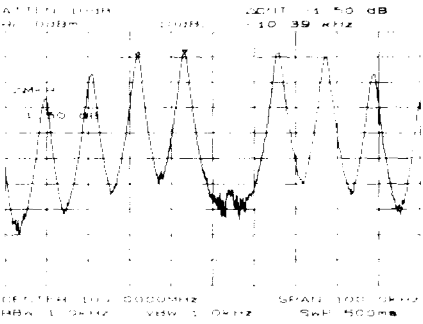


Fig.D.6. Markers show modulating frequency

Note: Incidental AM from a source signal can cause the frequency null to shift, resulting in errors to the procedure above. Incidental AM is very low for most RF signal generators, but can be significant in microwave signal generators. Nonsymetrical sidelobes indicate the presence of incidental AM. In such cases, the best technique for measuring FM is to downconvert and use a Modulation Analyzer such as the HP 8901A/B.

This appendix contains information on pulsed-RF and illustrates several procedures for measuring characteristics of a pulsed-RF signal. The procedures explain how to measure center frequency, pulse width, and pulse repetition frequency.

PULSE MODE

Pulsed RF measurements are generally made in the "pulse" mode. To set the spectrum analyzer for pulse-mode measurements, begin by setting the video bandwidth to 3 MHz and activate the positive peak detector (press [TRACE], MORE, DETECTOR MODES, and DETECTOR POS PEAK). Select the center frequency, then adjust the span until the center lobe and at least one pair of side lobes appear on the display (see Figure E.1). Increase the sweeptime (i.e., the sweep becomes slower) until the display fills in and becomes a solid line. See Figure E.2. If this line does not fill in, the instrument is not in pulse mode, in which case the following procedures for sidelobe ratio, pulse width, and peak pulse power do not apply. For further reference, consult Hewlett-Packard Application Note 150-2, entitled Pulsed RF.

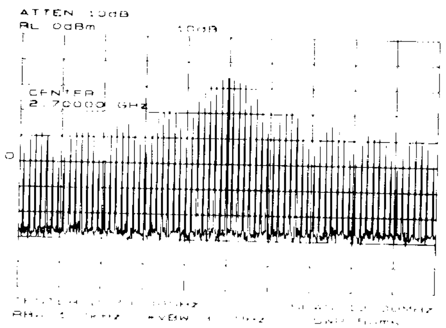


Fig.E.1. Main lobe and side lobes.

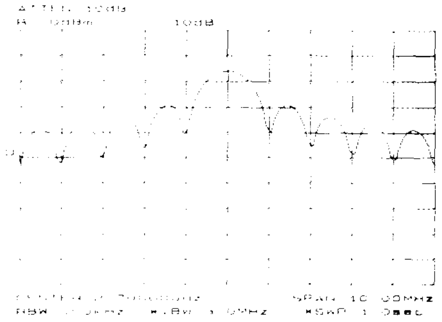


Fig.E.2. Slow-sweeping trace displays as a solid line.

CENTER FREQUENCY, SIDELOBE RATIO, AND PULSEWIDTH

For a pulsed RF signal, the center frequency is at the center of the main lobe (see Figure E.3). To identify this frequency, simply use the spectrum analyzer peak search function. The marker also reads the mainlobe amplitude.

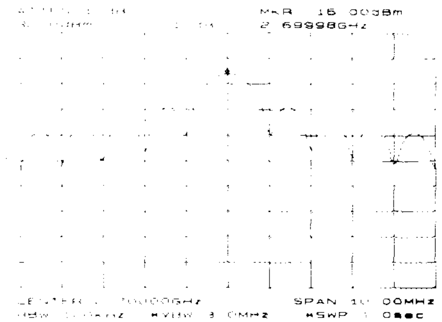


Fig.E.3. Center frequency at center of main lobe

To measure the sidelobe ratio, with the marker still at the center frequency of the main lobe, press the softkeys MARKER DELTA and NEXT PEAK (see Figure E.4). The difference between the amplitude of the main lobe and the side lobe is the sidelobe ratio.

The pulse width is also easy to identify. The pulse width is the reciprocal of the frequency difference between two envelope peaks. To determine this difference, continuing from the last procedure, press the softkeys MARKER DELTA, MORE, and NEXT PEAK; then press [ON], and MARKER 1/DELTA. The pulse width is equal to the time value displayed on the spectrum analyzer screen, as in Figure E.5. For best pulse-width accuracy, measure the distance between two adjacent lobe nulls, by manually adjusting the marker positions. If desired, first reduce the resolution bandwidth for sharper nulls.

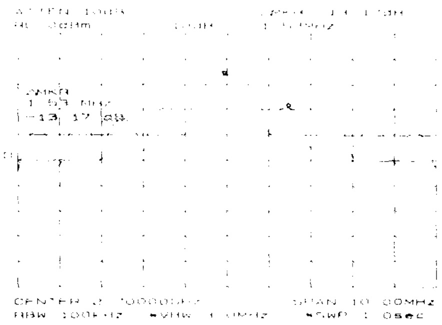


Fig.E.4. Markers show sidelobe ratio.

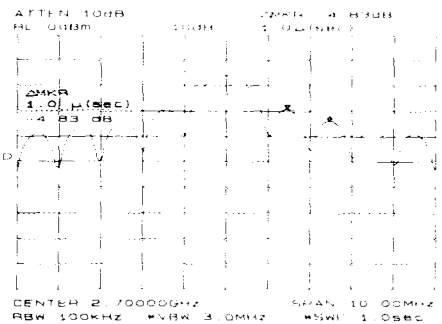


Fig.E.5. Markers show pulse width.

PULSE REPETITION FREQUENCY (PRF)

Pulse repetition interval (PRI) is the spacing in time between any two adjacent pulse responses, shown in Figure E.1. Using the MARKER 1/DELTA function, PRI can easily be inverted to read PRF instead. To measure PRI, set the span to 0 Hz and adjust amplitude of the main lobe to the reference level. Set the amplitude scale to linear and readjust the signal so that it is on screen. Next, decrease the sweeptime (i.e., the sweep becomes faster) until the display resembles Figure E.6. Select the SINGLE trigger mode. Finally, press [PEAK SEARCH] and the softkeys MARKER DELTA, MORE, and NEXT RIGHT or NEXT LEFT. The difference displayed between the two markers is equal to the pulse repetition interval. Simply press [ON] and MARKER 1/DELTA for the PRF, as shown in Figure E.6.

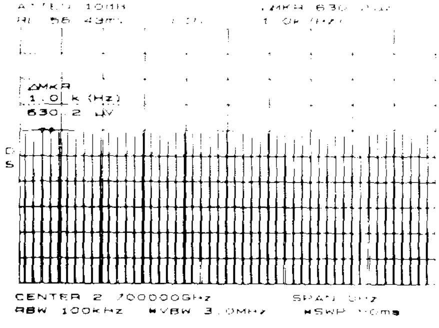


Fig.E.6. Spectral line separation equals PRI. MARKER 1/DELTA function reads PRF.

PEAK PULSE POWER AND DESENSITIZATION

Now that you know the main-lobe amplitude, the pulse width, and can easily note the spectrum analyzer resolution bandwidth, the peak pulse power can be derived from a relatively simple equation:

$$\text{Peak Pulse Power} = \text{Mainlobe Amplitude} - 20 \log (T_{eff} \cdot BW_i)$$

Where T_{eff} = pulse width, in seconds
BW_i = impulse bandwidth, in Hertz
= 1.5 · resolution bandwidth used to measure pulse width.

Note: While measuring the main-lobe amplitude, change the spectrum analyzer attenuation and check that the main lobe amplitude does not change. If it changes by more than 1 dB, the analyzer is in compression and the RF attenuation must be increased. For carrier frequencies above 2.7 GHz, be sure to peak the preselector to accurately measure the main-lobe amplitude.

The difference between the peak pulse power and the main-lobe amplitude is called pulse desensitization.

The term "pulse desensitization" can be somewhat misleading, because pulsed signals do not reduce spectrum analyzer sensitivity. Rather, apparent desensitization occurs because the power of a pulsed CW carrier is distributed over a number of spectral components (i.e., the carrier and sidebands). As a result, each spectral component contains only a fraction of the total power. For a complete discussion of pulse desensitization, refer to Application Note 150-2 (literature number 5952-1039) or Appendix A of Application Note 330-1 (literature number 5954-2705).

APPENDIX E
EXTERNAL HARMONIC MIXING AND SIGNAL IDENTIFICATION

The frequency range of the HP 8562A/B can be easily extended using external harmonic mixers. This appendix explains how to connect external mixers to the spectrum analyzer and how to use its automatic signal identification functions.

EQUIPMENT SETUP

Figure E.1 illustrates how to connect an external harmonic mixer to the spectrum analyzer.

Caution: The spectrum analyzer LO output is +16 dBm. Be sure your mixer can accommodate this power level before connecting it to the analyzer.

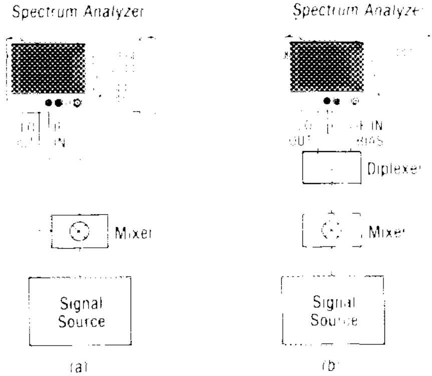


Fig.E.1. External mixer setup (a) without bias; (b) with bias.

Be sure to connect the mixer to the spectrum analyzer using Hewlett-Packard SMA-type cables, part number 5061-5458. Do not overtighten the cables.

To select a frequency above 22 GHz, press [EXT] to set the analyzer to external mixer mode, then enter the desired frequency directly using the center frequency function. Note in Table E.1, however, that some frequencies overlap and fall into two bands. Using the above method to select a frequency in an overlapping area will set the analyzer to one of the two bands, but it may not be the band you desire. To be sure the desired band is selected, refer to Table F.1 and select a desired frequency band, then use the FULL BAND function to enter this band. Press [EXT] and the softkey FULL BAND, then press the STEP [↑] key until the letter following FULL BAND corresponds to the chosen frequency band. The HARM LOCK function "locks" the spectrum analyzer in that band, ensuring that the spectrum analyzer sweeps only the chosen band.

FREQUENCY BAND	FREQUENCY RANGE (GHz)	MIXING HARMONIC	CONVERSION LOSS
K	18.0 - 26.5	6-	30 dB
A	26.5 - 40.0	8-	30 dB
Q	33.0 - 50.0	10-	30 dB
U	40.0 - 60.0	10-	30 dB
V	50.0 - 75.0	14-	30 dB
E	[illegible] - 90.0	15-	30 dB
W	75.0 - 110.0	18-	30 dB
F	90.0 - 140.0	[illegible]	30 dB
[illegible]	110.0 - 170.0	[illegible]	30 dB
G	140.0 - 220.0	[illegible]	30 dB
Y	170.0 - 260.0	34-	30 dB
J	220.0 - 325.0	54-	30 dB

Table F.1. External mixer frequency ranges.

CONVERSION LOSS

Table F.1 lists default conversion loss values that are stored in the analyzer for each frequency band. These values approximate the values for HP 11970 Series Mixers. Other conversion-loss values may be entered into the spectrum analyzer with the AVERAGE CNV LOSS function. To activate this function, press [EXT] and the softkeys AMPTD CORRECT and AVERAGE CNV LOSS; then enter the appropriate conversion-loss value. On HP 11970 Series Mixers, these values are charted on the mixer.

SIGNAL IDENTIFICATION

The IF output of a harmonic mixer contains many mixer products (LO ± source, 2LO ± source, 3LO ± source . . . nLO ± source). As a result, within a single harmonic band, a single input signal can produce many responses, only one of which is valid. These responses come in pairs, where the members of the valid pair are spaced 621.4 MHz apart (see Figure F.2) and the right-most member of the pair is the correct response (for this analyzer, the left member of a pair is not valid).

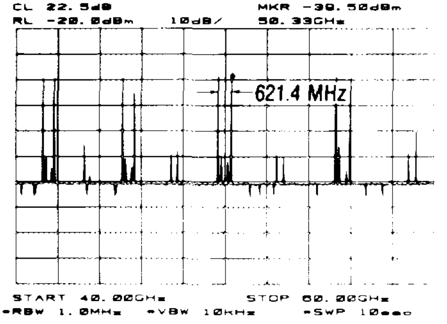


Fig.F.2. Signal responses produced by a 50 GHz signal in U band.

The **frequency shift method** of identifying valid signals employs the spectrum analyzer function SIG ID ON OFF. To activate this function, press [EXT] and the softkeys SIGNAL IDENT and SIG ID ON OFF. Any signal not produced by the currently selected harmonic will be shifted horizontally on alternate sweeps (see Figure F.3). The correct signal that has been produced by the selected harmonic will be shifted in a vertical direction only, as in Figure F.4. To ensure accuracy, limit the frequency span to a maximum of 20 MHz.

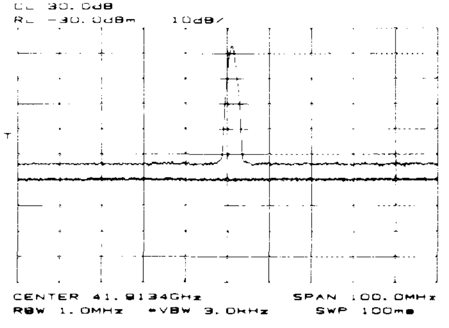


Fig.F.3. Response for invalid signals.

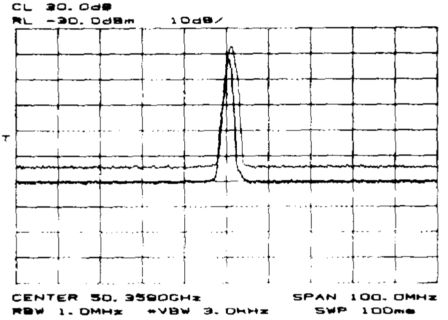


Fig.F.4. Response for valid signals.

There is also a function for identifying signals in wide frequency spans. This function, SIG ID AT MKR, employs a **harmonic search method** of signal identification. SIG ID AT MKR automatically determines the proper frequency of a signal and displays its value on the spectrum analyzer. To activate SIG ID AT MKR, place a marker on a signal and press [EXT], the softkey SIGNAL IDENT, and the softkey SIG ID AT MKR.

BIAS

The HP 11970 Series Mixers mentioned in the section above do not require bias. Mixers requiring bias* can also be used with the HP 8562A/B. Bias gives these mixers minimum conversion loss; however, bias must be adjusted for every measurement made. Mixers requiring bias are connected as shown in Figure E.2 (with mixer bias supplied via the IF line). To measure a signal, access a band as described above. To activate the bias, press [EXT] and the softkey BIAS; then press the softkey corresponding to the bias polarity (positive or negative) that your mixer requires. Use the knob on the spectrum analyzer to adjust the bias and to peak the signal for maximum amplitude. Finally, activate the signal identification method you desire. On most mixers, the optimum bias varies with frequency, so the bias should be adjusted for every signal measured.

Warning: The open-circuit bias voltage can be as great as ±3.5V through a source resistance of 300 ohms. Such voltage levels may appear when recalling an instrument state in which an active bias has been stored.

Note: The bias value that appears on the spectrum analyzer display is expressed in terms of short-circuit current (i.e., the amount of current that would flow if the IF line were shorted to ground). The actual amount of current flowing into the mixer will be less.

*HP 11517A Series Harmonic Mixers and Tektronix and KitchenAid Mixers, for example.

GLOSSARY OF SPECTRUM ANALYZER FUNCTIONS

This summary briefly describes the spectrum analyzer functions available from each front-panel key and its related menu. If you would like more information about these functions, refer to the HP 8562A/B Operating and Programming Manual.

[AMPLITUDE] activates the reference level function and calls the amplitude menu to the display. Other functions on this menu allow you to manually select the input attenuation; set the display scale for 1, 2, 5, or 10 dB per division; and set the amplitude scaling to log or linear. Functions are also available that set the mixer level, initiate IF adjustments, offset the reference level, and select the units for amplitude values.

[AUTO COUPLE] allows the spectrum analyzer to automatically select the appropriate values for all functions that have an "AUTO" mode. Additional functions display and set the coupling ratio between video bandwidth and resolution bandwidth, or between frequency span and resolution bandwidth, and also set the input mixer level.

[BANDWIDTH] calls up a menu of functions that allow you to select resolution and video bandwidths or allow the spectrum analyzer to select them automatically. Additional functions include video averaging and selecting the number of video-averaged sweeps.

[DEMOD] calls up a menu of functions that demodulate AM and FM signals, activate markers, select demodulation time, and control the speaker volume.

[DISPLAY] functions provide a display line, a threshold, plotter functions for plotting a display on an external plotter, and display controls for writing titles on a display. Additional functions allow you to vary display intensity and to focus or turn the display graticule and annotation on or off.

[EXT] (See Appendix F or the Operating and Programming Manual).

[FREQ COUNT] activates a marker and reads the frequency with counter accuracy or, if two markers are active and on the screen, reads the frequency difference between the two signals. Additional functions on the counter menu allow you to select the counter resolution, activate markers, and find the highest or next-highest amplitudes on a trace.

[illegible] activates the center frequency function and displays the menu of related frequency softkey functions. These functions set the start and stop frequencies, set the center-frequency step increments, and offset the frequency by a value that you choose. A function allowing an external 10 MHz reference is also available.

[INT] functions on this menu allow you to peak the preselector tracking manually or automatically, and activate manual or automatic signal identification.

Like [ON], [MKR →] activates a marker that reads amplitude and frequency (or time) and calls a marker menu to the display. Some of the functions from this menu find the highest amplitude on a trace, set the reference level to the marker amplitude, set the center frequency to the marker frequency or set the center frequency step-size to the marker frequency.

[MKR OFF] turns off all markers and softkey annotation.

[ON] activates a marker that reads the amplitude and frequency or, if the frequency span is zero, the amplitude and relative time of a point on a trace. [ON] also calls a marker menu to the display. Other marker functions on this menu give the amplitude and frequency (or time) differences between two markers, take the reciprocal of this difference, and enable tracking of a signal on the display.

[MODULE] (See the Operating and Programming Manual).

[PEAK SEARCH] places a marker on the highest amplitude of a trace and reads the amplitude and frequency. Marker functions available from the PEAK SEARCH menu are similar to the functions of the [ON] menu. The PEAK SEARCH menu also includes a function that searches for the next highest point on a trace and displays the difference in frequency between this next-highest point and the previous one. Functions that determine peak excursion and peak threshold are also included.

[PRESET] sets the instrument to a predefined state, allow you to adjust the L.O. and I.F., and check or change the HP-IB address.

[RECALL] allows you to recall to the display previously saved states, traces, and preselector data. Several service functions are also included; refer to the Service Manual.

[SAVE] allows you to save an instrument state with a label in one of ten registers, make the instrument "power up" in the current state, save a single trace and a label in one of eight registers, or save preselector peak data.

[SPAN] activates the span width function and calls the span menu to the display. Additional span functions on the menu select the full band or "largest" span for the current center frequency, or toggle between the current frequency span and the previously selected span. Zero span allows you to view a signal in reference to time.

[SWEEP] allows you to adjust the sweeptime or allow the spectrum analyzer to automatically select an appropriate sweeptime. Additional functions send the sweep ramp or sweep voltage to the sweep output on the rear panel.

Two [TRACE] displays, A and B, are available. For the active trace, functions clear the trace and write a new one, blank the trace, and allow you to view the trace. Functions to perform math operations using both traces are also available. Additionally, detector modes (normal, sample, positive peak, and negative peak) are found here.

[TRIGGER] provides functions that allow triggering from line, video, or external sources. Trigger functions may activate single or continuous sweeps. The trigger function defaults to FREE RUN mode.

[VOLUME] controls speaker volume (no menu).

-A-

-B-

-C-

-D-

-E-

-F-

Simplified Block Diagram of the 8562A/B