HEWLETT hp PACKARD

SPECTRUM ANALYSIS...
Using The 8558B Spectrum Analyzer

July 1973

Application Note 150A

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CONTENTS

CHAPTER 1

SPECTRUM ANALYSIS

The purpose of this Application Note is to acquaint the reader with the operation, application, and measurement capability of the 8558B Spectrum Analyzer. A detailed discussion of spectrum analyzer theory will not be done here since several application notes are available on the subject. These notes are:

The Spectrum Analyzer for Design Engineers (HP Lit. No. 5952-0932)
AN-150 Series

WHAT IS THE FREQUENCY DOMAIN?

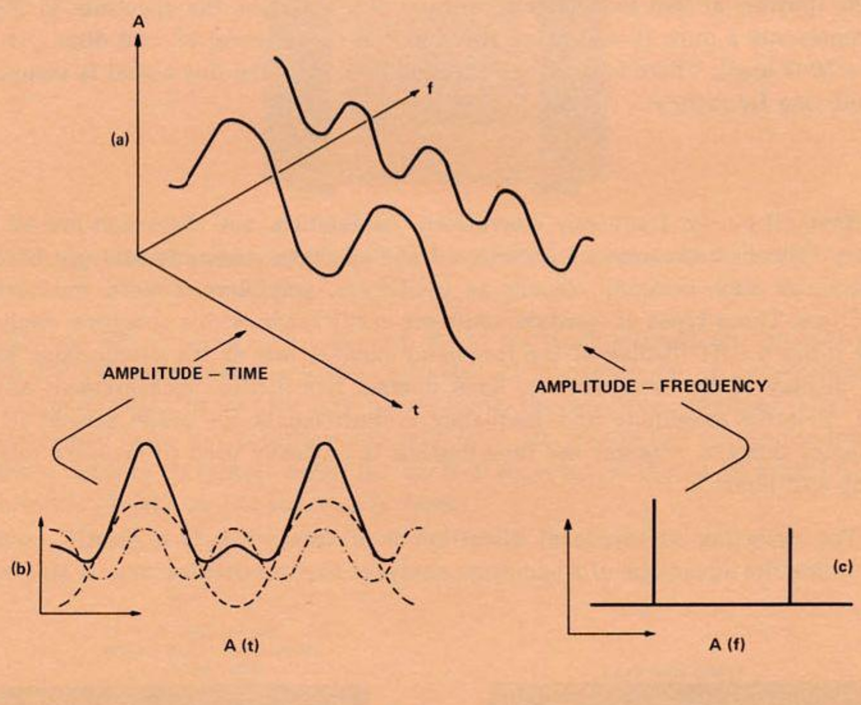

Figure 1-1. The time and frequency domains: (a) Three-dimensional coordinates showing time, frequency, and amplitude. The addition of a fundamental and its second harmonic is shown as an example. (b) View seen in the A(t) plane. On an oscilloscope, only the composite $f_1 + 2f_1$ would be seen. (c) View seen in the A(f) plane. Note how the components of the composite signal are clearly seen here.

The frequency domain is a plot of amplitude versus frequency of a signal, whereas the time domain is a plot of amplitude versus time. The relationship between the frequency and time domains is shown in Figure 1-1. In the frequency domain complex signals (signals of more than one frequency, e.g., square wave) can be separated into their components. These components appear as spectral lines along the frequency scale with amplitudes proportional to the amount of

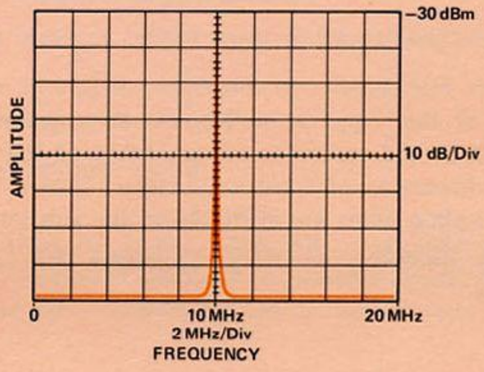

Figure 1-2. Schematic of a spectrum analyzer CRT display when a 10 MHz, —30 dBm sine wave is applied to the input.

energy (power) at that particular frequency. For example, the spectrum in Figure 1-2 represents a pure 10 MHz sine wave with a power level of −30 dBm (7.1 mV into a 50 Ω load). There is only one spectral line, meaning this signal is composed of only one frequency.

WHY FREQUENCY DOMAIN?

Spectral purity, frequency conversion, modulation, and distortion are all frequency domain measurements. Combinations of these measurements are used to characterize such common circuits as oscillators, amplifiers, mixers, modulators, and filters. These types of measurements are easily made with a spectrum analyzer, since it has a CRT display of the frequency domain just as the oscilloscope has a CRT display of the time domain. Each domain has distinct measurement advantages. Relative amplitude and frequency measurements are made easiest in the frequency domain, whereas the time domain is normally used to measure relative timing and phase.

The detection of low-level distortion in a sine wave is a classic example illustrating the advantage of a spectrum analyzer over an oscilloscope. A sine wave

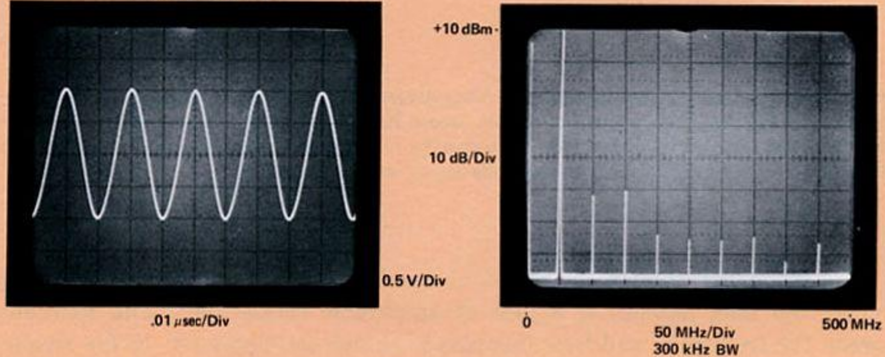

Figure 1-3. The photo at the left shows a 50 MHz sine wave in the time domain. The photo at the right shows the frequency domain which illustrates distortion components spaced 50 MHz apart.

may look good in the time domain. However, when viewed in the frequency domain, harmonic components can be seen. This ability to see low-level signals (distortion) in the presence of high-level ones (fundamental) is an important advantage of the spectrum analyzer (see Figure 1-3).

THE 8558B SPECTRUM ANALYZER

The HP 8558B Spectrum Analyzer is a fully calibrated spectrum analyzer designed for simple operation. It is a plug-in which fits into any HP 180 Series oscilloscope mainframe (see Figure 1-4). The analyzer has a frequency range from 100 kHz to 1500 MHz and a digital LED readout for more accurate frequency measurements. Absolute Amplitude calibration and a large screen display enable accurate voltage and power measurements to be made. Through the use of coupled controls, the instrument can be made to operate using only three knobs. Simple three-knob operation means the inexperienced user needs very little training. Furthermore, an overloaded input can be readily detected because the trace is forced off screen. These and other features of the 8558B Spectrum Analyzer will be described in the subsequent chapters.

A set of auxiliary outputs used to connect other instruments, such as an X-Y recorder, are furnished as Option 807 to the oscilloscope mainframe. This is further described in Appendix C.

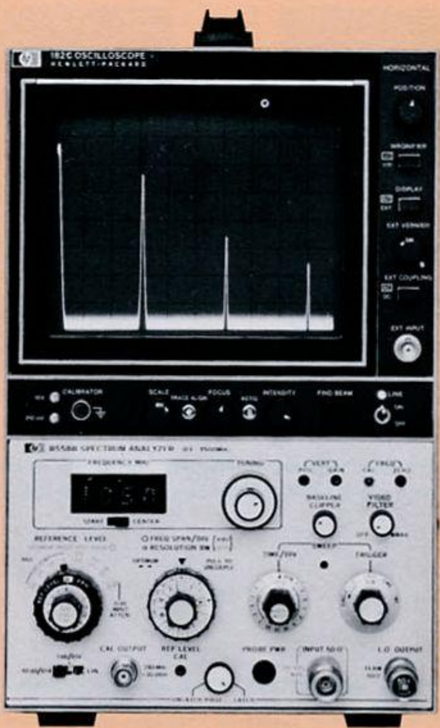

Figure 1-4. The 8558B Spectrum Analyzer plug-in and HP 182C Oscilloscope Mainframe.

CHAPTER 2

APPLICATIONS

The need for spectrum analysis is particularly crucial in the areas of communication, control, radar, and navigation. In the communications industry, for example, testing and maintenance require checking for signal quality, power transmission, crosstalk, noise, etc. This usually necessitates the identification of specific components in a frequency spectrum. These components could be harmonic distortion, intermodulation distortion, extraneous sidebands, or simply unwanted signals. The detection of such signals requires the careful analysis of the frequency spectrum. This can be done using the techniques described in this chapter.

SPECTRUM SURVEILLANCE

One of the basic spectrum analyzer applications is the identification of the frequency components of a signal. Figure 2-1 shows the FM broadcast frequency spectrum. The various frequency components of the spectrum can be identified by adjusting the reference level, frequency span, and tuning until the frequency of interest appears at the center of the CRT screen. Then the proper amplitude and frequency measurement can be made.

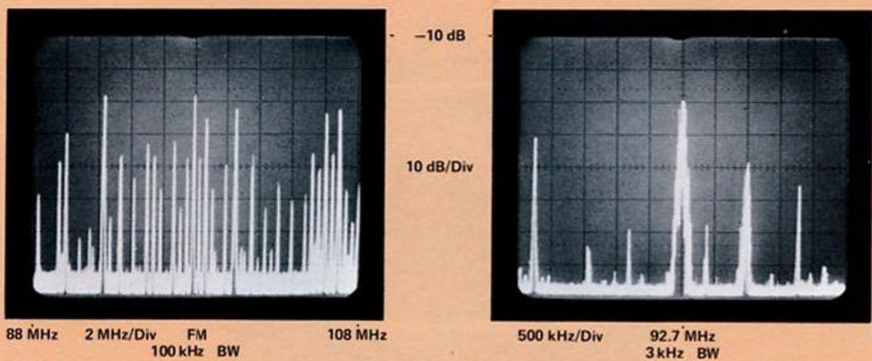

Figure 2-1. The FM broadcast frequency spectrum at Palo Alto, California, is shown in the photo at the left. Identification of a 92.7 MHz signal in the FM broadcast band is shown in the photo at the right.

DISTORTION

Amplifier and frequency converters, such as multipliers, detectors, mixers, and modulators, are devices which are used to change the level or the frequency of an input signal. These devices use the nonlinear characteristics of active devices to achieve the desired conversion. The nonlinearity of these devices causes harmonic and intermodulation distortion. The distortion components are easily measured on

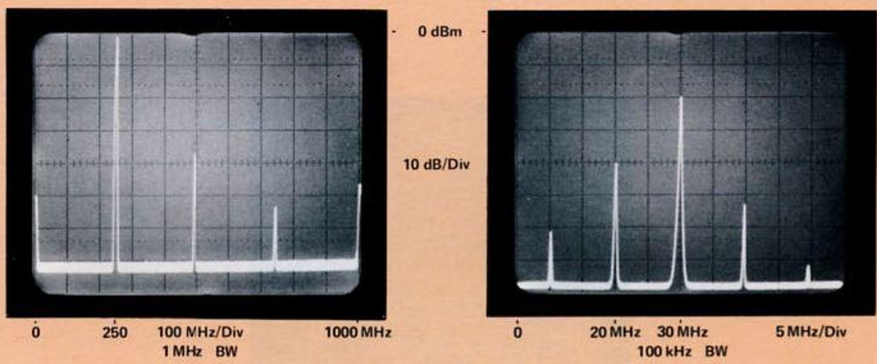

Figure 2-2. A 250 MHz signal with harmonic distortion components at 500, 750, and 1000 MHz is shown at the left. The right photo shows two input signals at 20 MHz and 30 MHz with resulting intermodulation distortion at 10, 40, and 50 MHz.

the spectrum analyzer. Figure 2-2 (left photo) illustrates the harmonic distortion of a 250 MHz sine wave produced by a signal generator. Intermodulation distortion requires the harmonic mixing of two or more frequencies. In Figure 2-2 (right photo), two frequency components of 20 MHz and 30 MHz are intermodulated, producing distortion components of 10, 40, and 50 MHz.

MODULATION

As mentioned earlier the spectrum analyzer is more sensitive to small signals in the presence of large ones than an oscilloscope. This is particularly important when measuring low-level modulation. The 2% AM in Figure 2-3 is barely resolved on a scope, but can be easily measured on the analyzer as illustrated in the right photo in Figure 2-3. Carrier frequency, modulation frequency, modulation level, and

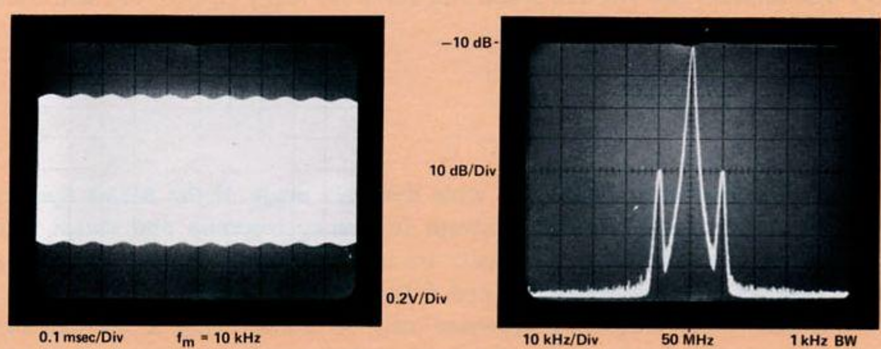

Figure 2-3. The left photograph is a time domain view of a 50 MHz signal with 2% AM. The carrier frequency, sideband levels (% modulation and distortion), and modulation frequency are easily measured in the frequency domain shown in the right photograph.

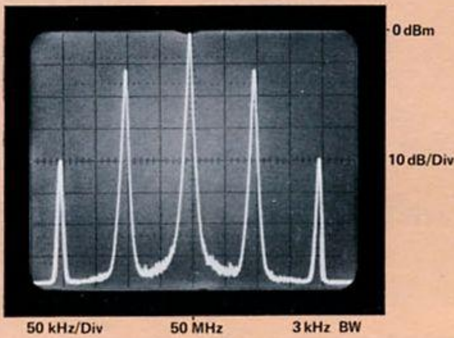

Figure 2-4. Frequency domain of a 50 MHz signal with 50% AM and 4% second harmonic distortion.

modulation distortion can be measured on the spectrum analyzer. Figure 2-4 shows an AM signal in the frequency domain. The modulation level can be measured by comparing the sideband and carrier frequency levels. Since the first sidebands are 12 dB down from the carrier the modulation level is 50%. Second harmonic distortion is seen to be 4% (28 dB down from the first sidebands).

The analyzer can also be used for measuring frequency modulated and pulsed RF signals. The measurable FM parameters include modulation frequency, modulation index, peak carrier deviation, incidental AM, and transmission bandwidth. The pulsed RF parameters that can be measured include pulse repetition frequency, pulse period, pulse width, peak pulse power, on-off ratios, incidental AM, and energy distribution. See AN 150-1 and AN 150-2 for more on AM, FM and Pulsed RF.

FREQUENCY RESPONSE

The broad frequency range and wide dynamic range of the 8558B Spectrum Analyzer make it possible to make swept frequency response and swept return loss measurements. These measurements are useful in characterizing the performance of devices such as amplifiers and filters. Amplifier gain as a function of frequency and filter frequency response can be made using a leveled signal generator or sweeper as a source, and feeding the output from the device-under-test into the analyzer. Reflection coefficient or return loss measurements can be made by using a leveled sweep oscillator as a source and measuring the reflection from the device-under-test through the use of a directional bridge or directional coupler. Figure 2-5 illustrates the frequency response of a 50 MHz low pass filter.

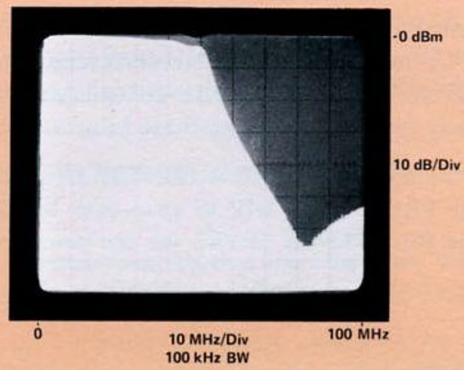

Figure 2-5. Frequency response of a 50 MHz LPF as seen on an HP 182C Variable Persistence Display.

CHAPTER 3

OPERATION

The 8558B Spectrum Analyzer has been designed for simple operation. Most measurements can be made using only three knobs. These are the TUNING, REFERENCE LEVEL, and FREQ SPAN/DIV controls shown in Figure 3-1. Making a measurement usually requires following these basic steps:

1. TUNING to the desired START or CENTER frequency
2. Adjusting the FREQ SPAN/DIV to span over the desired frequency range
3. Adjusting the REFERENCE LEVEL for optimum amplitude signal display.

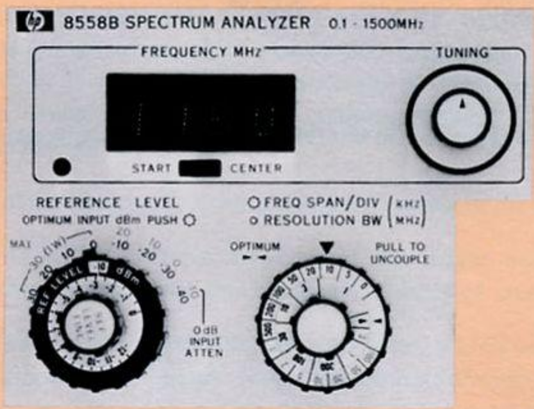

Figure 3-1. Three knob settings for simple operation.

Before using the analyzer to make measurements, it should first be calibrated. This can be done by following the step-by-step Calibration Adjustment Procedure discussed in Chapter 5. Calibrating the instrument is a quick and easy way for the reader to become familiar with the controls.

ADJUSTING THE FREQUENCY SCALE

The frequency scale (horizontal axis) is determined by the TUNING and FREQ SPAN/DIV settings. The frequency span is symmetrical about the CENTER frequency or starts from the left edge of the display, depending on the position of the START-CENTER switch. The START and CENTER frequencies are determined by the TUNING control.

There are two basic requirements of the frequency scale:

1. To display wide frequency ranges
2. To resolve closely spaced signals.

When displaying wide frequency ranges, fast sweep times are important. Fast sweep times usually require wide bandwidths. On the other hand, narrow bandwidths are needed to resolve closely spaced signals. Narrow bandwidths usually mean slow sweep times unless the frequency span is reduced proportionately.

The FREQ SPAN/DIV control can automatically control RESOLUTION BW and SWEEP TIME/DIV, thus eliminating the need to adjust them separately. The FREQ SPAN/DIV and RESOLUTION BW controls can be coupled together (PUSHED IN). This makes it possible to treat them as one control. They should be coupled on OPTIMUM (►◄) for general-purpose operation. SWEEP TIME/DIV is automatically adjusted for all FREQ SPAN/DIV, RESOLUTION BW and VIDEO FILTER settings if left in AUTO. The other SWEEP TIME/DIV settings are useful when viewing signals in the time domain (0 kHz FREQ SPAN/DIV), frequency drift of signals with time, or when synchronizing the analyzer with other instruments, such as X-Y recorders.

The frequency span to be used depends largely on the application. For instance, harmonic distortion may best be observed with a wide frequency span. Simply set the START-CENTER switch to START, and tune the analyzer to the fundamental frequency of the signal. With the FREQ SPAN/DIV control set to 100 MHz, a full 1000 MHz above the fundamental frequency can be viewed. The harmonic distortion components of a 250 MHz signal are shown in Figure 3-2, using this technique.

Any signal in the entire 100 kHz to 1500 MHz range of the analyzer can be viewed easily by tuning the CENTER frequency of the analyzer to 500 MHz, setting the FREQ SPAN/DIV control to 100 MHz, and switching the START-CENTER switch from CENTER to START. Note that there is a 500 MHz overlap when switching the tuned frequency from CENTER (0 Hz to 1000 MHz) to START (500 MHz to 1500 MHz).

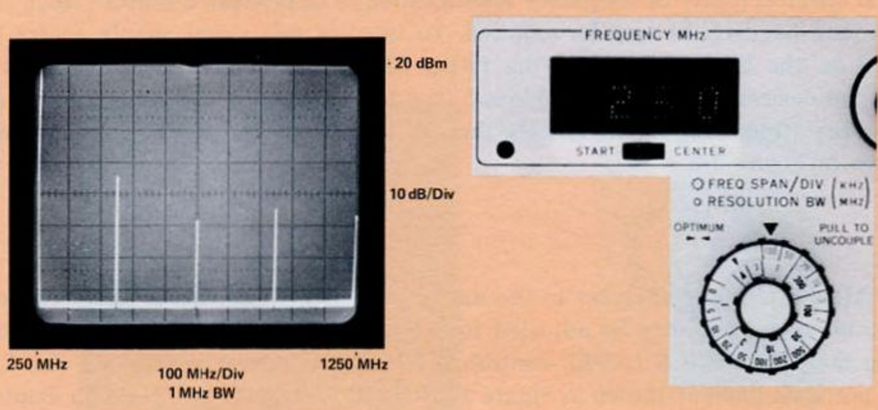

Figure 3-2. Harmonic distortion of a 250 MHz signal.

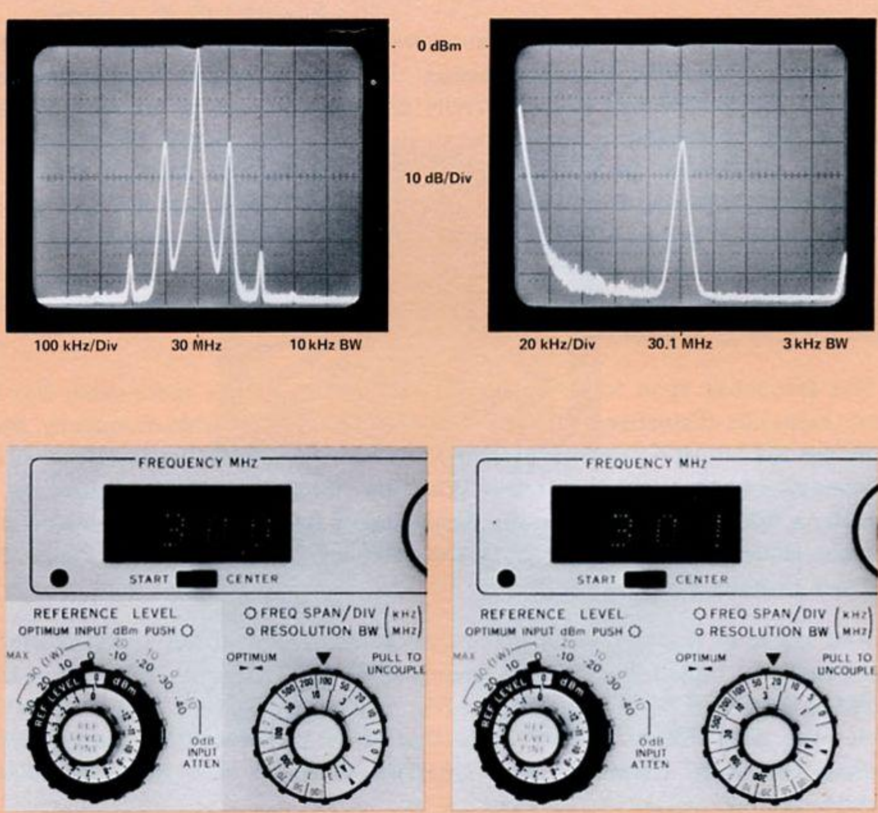

Figure 3-3. A 30 MHz signal frequency modulated by a 100 kHz signal is shown in the left photo. The right photo identifies the frequency of the first-order upper sideband as 30.1 MHz.

If spectral purity or frequency identification is of interest, a narrow frequency span (and bandwidth) may be required. To identify any signal simply center the signal on the CRT and reduce the FREQ SPAN/DIV (and RESOLUTION BW) until the desired resolution is achieved. The LED readout will indicate the center frequency (frequency of the signal), thereby identifying it. An example of this is shown in Figure 3-3.

ADJUSTING THE AMPLITUDE SCALE

After tuning the analyzer to the desired frequency and setting the frequency span, the amplitude may be adjusted for an optimum display. This is easily done using the REFERENCE LEVEL control to adjust the reference level on the CRT (top graticule line), as shown in Figure 3-4. The REFERENCE LEVEL knob displays three things: REF LEVEL dBm, REF LEVEL FINE, and OPTIMUM INPUT dBm. The main purpose of the REF LEVEL control is to identify the absolute power of the reference level on the CRT display. The REF LEVEL dBm is adjusted in 10 dB steps with the outer control and continuously with the smaller concentric vernier control,

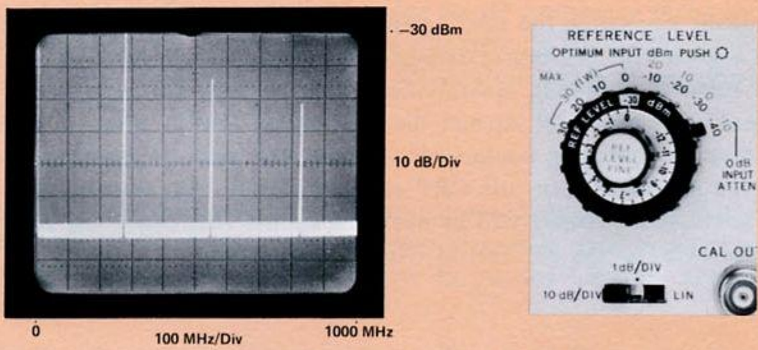

Figure 3-4. Relationship between REFERENCE LEVEL control and reference level on CRT.

REF LEVEL FINE. The amplitude scale may be set to read in divisions of 10 dB/DIV, 1 dB/DIV, and LIN. LIN is normally used for relative voltage measurements. The reference level on the CRT is always in dBm. Therefore, to make absolute voltage measurements, convert the REF LEVEL dBm to volts. For convenience, a dBm to voltage conversion chart is shown in Figure 3-5.

Coupled to the REF LEVEL dBm control is a 0 to 70 dB input attenuator (OPTIMUM INPUT dBm). Its purpose is to adjust the level of the input signal to the mixer for either linear operation or a spurious-free display (optimum dynamic range). For any setting of the OPTIMUM INPUT dBm, two numbers can be read on the front panel. The blue number indicates the maximum input level for a spurious-free display, and the red number indicates the maximum input level for calibrated amplitude measurements (i.e., less than 1 dB gain compression).

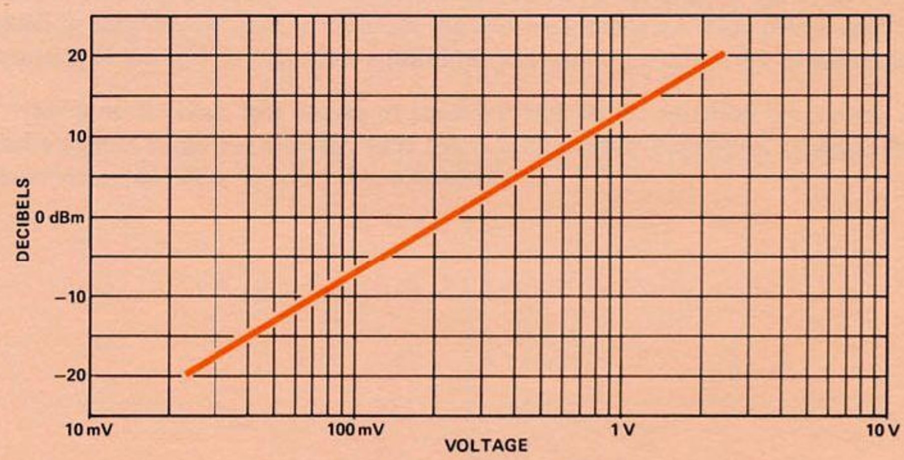

Figure 3-5. Conversion from dBm to voltage (50 Ω). For power levels outside this chart remember that a 20 dB change in power means a change in voltage by a factor of 10. Example: −63 dBm is −3 dBm with a 60 dB change. From the chart, −3 dBm = 160 mV, and −60 dB is a change in voltage of x 10^{-3}. Therefore, −63 dBm = 160 x 10^{-3} mV = 160 μV.

OPTIMUM DYNAMIC RANGE

Whenever measuring the relative amplitude of two or more signals, it is best to set the analyzer for the largest dynamic range possible. To optimize the dynamic range for relative amplitude measurements two settings are important. First, the input signal level must not exceed the OPTIMUM INPUT dBm. If it does, the analyzer may be operating nonlinearly. Second, the peak of the largest signal to be displayed should rest on the CRT reference level. This ensures that at least 70 dB of spurious-free range will be available on the CRT when the largest signal displayed is equal to the OPTIMUM INPUT dBm setting.

CHAPTER 4

SPECIAL TOPICS

VIDEO FILTER

The VIDEO FILTER control is a variable post-detection low pass filter which can be used to average signal noise. Noise averaging is increased as VIDEO FILTER is increased (video bandwidth is reduced). This is particularly useful for low-level signals which are difficult to distinguish, such as the one in Figure 4-1 (left photo). The right photo in Figure 4-1 shows the signal when VIDEO FILTER is on.

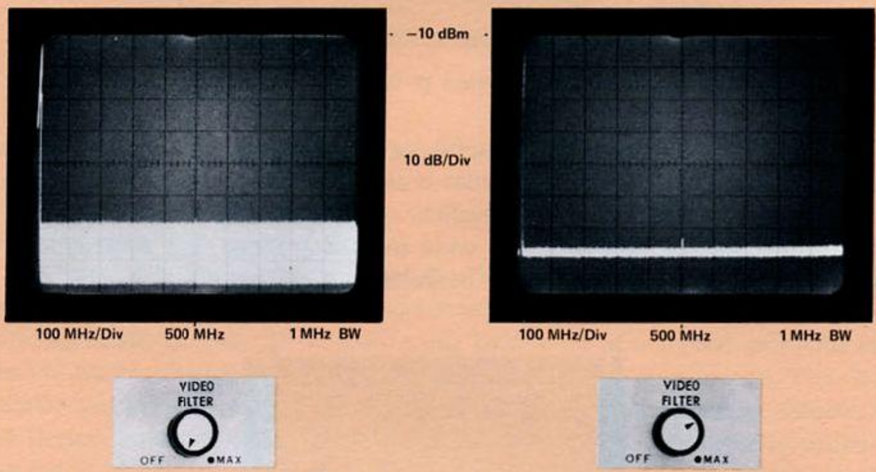

Figure 4-1. Effect of VIDEO FILTER on a low-level signal.

The video bandwidth varies with resolution bandwidth to maintain a constant degree of smoothing (averaging). When the SWEEP TIME/DIV is set to AUTO, the sweep rate slows down as VIDEO FILTER is increased. This results because of the narrower video bandwidths being used which require slower sweep rates to charge up the filter and maintain amplitude calibration. In the OFF position, the VIDEO FILTER has no effect because the video bandwidth is wider than the RESOLUTION BW of the analyzer. In the MAX detent position, the VIDEO FILTER averages all signals through a 1.5 Hz bandwidth filter. In this position the analyzer can be used for noise level measurements. Figure 4-2 shows how noise is averaged when the VIDEO FILTER control is in the MAX position. The MAX position should **not** be used for measuring signals other than noise. Note also that VIDEO FILTER should not be used when making pulsed signal measurements.

FIXED-TUNED OPERATION

In the 0 kHz FREQ SPAN/DIV setting, the spectrum analyzer becomes a fixed-tuned receiver at the frequency indicated by the START or CENTER frequency. In this position, amplitude variations are displayed versus time on the CRT. Variable sweep times are available on the SWEEP TIME/DIV control. The

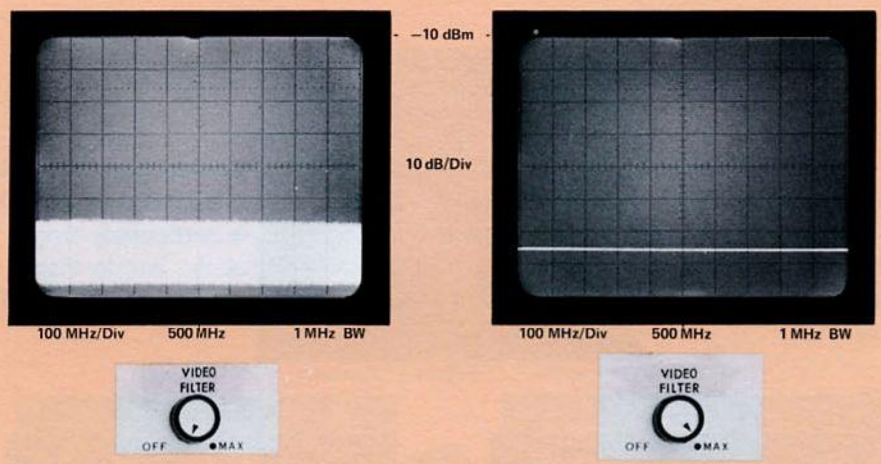

Figure 4-2. Noise averaging effect of the VIDEO FILTER MAX position.

0 kHz, FREQ SPAN/DIV setting is useful for recovering modulation on a signal as shown in Figure 4-3. In fact, individual broadcasts can be heard simply by connecting a set of earphones to the vertical output. Usually the bandwidth is set wide to accommodate recovery of a wide frequency range. See Application Note 150-1 for more detail on recovering modulation.

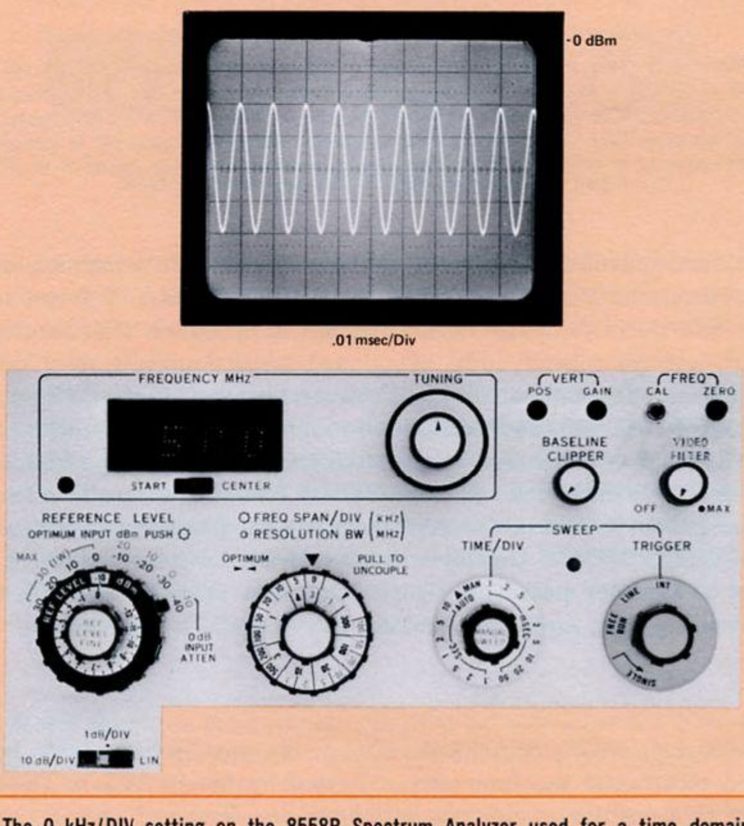

Figure 4-3. The 0 kHz/DIV setting on the 8558B Spectrum Analyzer used for a time domain view of a 500 MHz signal with 50% AM and 100 kHz modulation frequency.

MORE ACCURATE FREQUENCY MEASUREMENTS

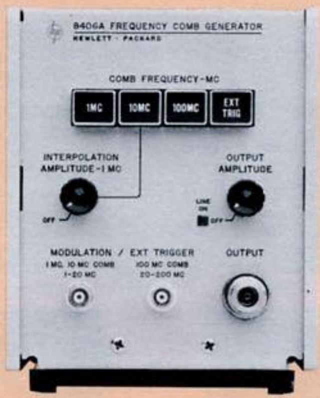

Figure 4-4. HP 8406A Frequency Comb Generator.

The internal frequency accuracy of the 8558B Spectrum Analyzer is adequate for most applications. However, the reader may wish to increase the accuracy for specific applications. This can be done using harmonics of a crystal oscillator such as the HP 8406A Frequency Comb Generator as a frequency reference. The Comb Generator can increase accuracy to about ±0.01%. Typical accuracy without the Comb Generator is ±3 MHz. The 8406A Frequency Comb Generator is shown in Figure 4-4. It generates a series of very narrow pulses at fixed frequencies 1, 10, and 100 MHz apart. These pulses can be fed into the analyzer along with the signal to be measured as illustrated by the block diagram in Figure 4-5.

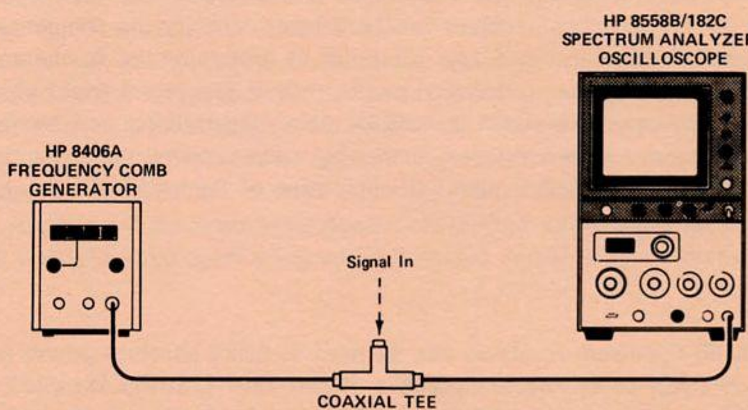

Figure 4-5. Block diagram of instruments used to make accurate frequency measurements.

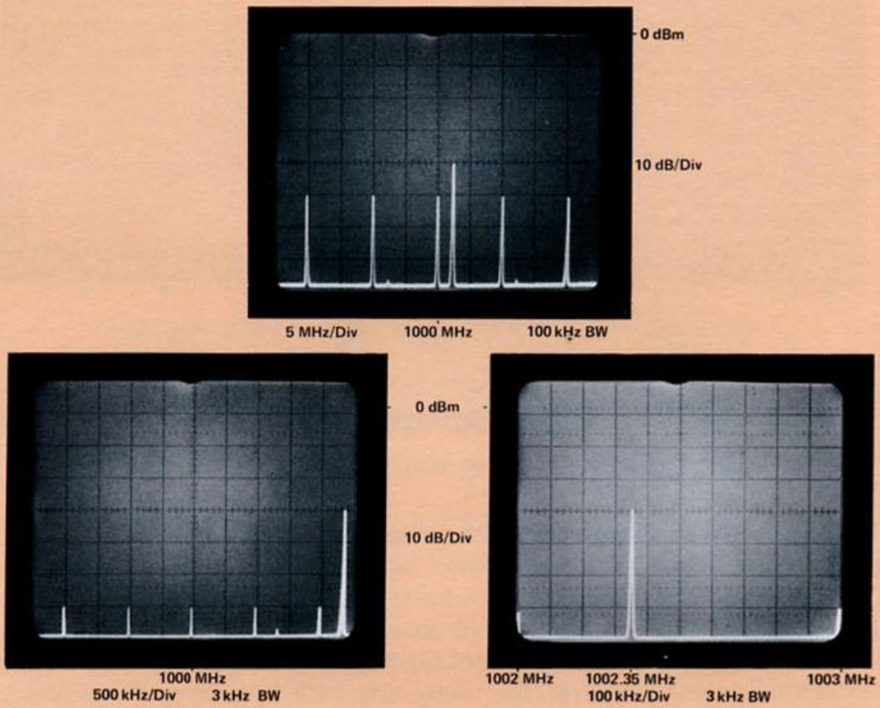

Figure 4-6. The 8406A Frequency Comb Generator is used to improve the accuracy of frequency determination. In the photo at the top, a 10 MHz comb is used to reference the unknown signal. In the left photo, the comb is reduced to 1 MHz for greater accuracy. In the photo at the right, the frequency span is reduced and the frequency of the unknown signal is determined (1002.35 MHz ±117 kHz). Accuracy is ±0.01% of reading ±5% of frequency separation between nearest comb tooth and signal to be measured.

Figure 4-6 shows a typical example of the comb generator being used to determine the frequency of an unknown signal. The accuracy of the frequency measurement is increased by reducing the frequency span of the analyzer while increasing the resolution of the comb generator. In the left photo in Figure 4-6 the comb teeth are 1 MHz apart. The analyzer can be used to identify the frequency of the comb teeth which then are used as a reference to determine the frequency of the unknown signal. Interpolating between comb teeth in Figure 4-6 (right photo), the frequency of the unknown signal is 1002.35 MHz. The stability and resolution of the comb generator can be increased further by using external triggering or modulation. Application Note 63D explains the operation of the 8406A Frequency Comb Generator in more detail.

ACCURATE ABSOLUTE POWER MEASUREMENTS

The 8558B Spectrum Analyzer can be used to make absolute power measurements about equal to the accuracy (±1.4 dB) of the IF attenuator (REF LEVEL dBm) and frequency response (flatness) of the analyzer. This is done by eliminating the error introduced by the RF attenuator, bandwidth setting, CRT display, impedance mismatch, and calibration signal. Impedance mismatch is negligible if the OPTIMUM INPUT dBm (RF attenuator) is set to −30 dBm or higher because return loss is increased substantially. Leaving the RF attenuator at the same setting for both calibration and measurement will eliminate its effect. The nonlinearity of the CRT display is eliminated by using IF substitution which is described below.

IF SUBSTITUTION

The method for achieving power level measurement accuracy described here is called IF substitution because the accurate IF gain is used in place of the less accurate CRT display. The steps to follow in making accurate absolute power measurements are as follows:

1. Set the RF attenuator (Optimum Input dBm) to 10 dB or more of attenuation (Optimum Input ≥ −30 dBm).
2. Set the FREQ SPAN/DIV and RESOLUTION BW to any convenient position (uncoupled if necessary).
3. Set the REF LEVEL dBm to the amplitude of the calibrating signal (−30 dBm).
4. Calibrate the analyzer.
5. Connect the signal to be measured.
6. Use **only** the REF LEVEL dBm control to return the signal level to the point on the CRT where calibration was completed (top graticule line).
7. Read the signal amplitude from the REF LEVEL dBm setting.

The accuracy at this point is dependent on frequency response (flatness), calibration signal level, and the REF LEVEL dBm control. The error due to the analyzer frequency response can be eliminated by calibrating the analyzer at the same frequency at which the measurement is made. This can be done by using a more accurate standard, such as the 435A Power Meter, to calibrate a signal generator which in turn can be used to calibrate the spectrum analyzer. This leaves only the accuracy of the REF LEVEL dBm control (IF attenuator) to affect the measurement.

Most of the time, this degree of accuracy will not be required. Therefore, the reader should study the specifications listed in the 8558B Spectrum Analyzer Data Sheet before deciding to apply this procedure.

CHAPTER 5

CALIBRATION ADJUSTMENT PROCEDURE

Whenever an 8558B Spectrum Analyzer plug-in is installed in an HP 180 Series oscilloscope, the spectrum analyzer should be calibrated to ensure proper correlation between plug-in and display. It is good practice to execute this adjustment procedure periodically (recommended daily) to correct for changes in calibration which may occur over a period of time. These adjustments are also an excellent way for the new user to become acquainted with the spectrum analyzer. For reference, a front panel view appears in Appendix A.

The following procedure is for any HP 180 mainframe. However, if an HP 181 Variable Persistence Oscilloscope is being used, begin by setting the PERSISTENCE maximum counterclockwise and push in the WRITE button.

1. Turn the analyzer ON and make the following control settings:

Function		Setting
START-CENTER		CENTER
FREQUENCY MHz—TUNING		>10 MHz
BASELINE CLIPPER		MAX CCW
VIDEO FILTER		MAX CCW
OPTIMUM INPUT dBm (push to uncouple)		−40 dBm (blue)
REF LEVEL dBm		MAX CCW (−10 dBm)
REF LEVEL FINE		MAX CCW (0 dBm)
FREQ SPAN/DIV	uncouple	100 kHz
RESOLUTION BW	uncouple	30 kHz
SWEEP TRIGGER		FREE RUN
SWEEP TIME/DIV		MAN
MANUAL SWEEP		Center
10 dB/DIV - 1 dB/DIV - LIN		LIN
VERT POS		MAX CW

Intensity may be adjusted as needed.

2. Adjust FOCUS and ASTIG for smallest round dot possible.

3. Reset SWEEP TIME/DIV to AUTO. Center trace horizontally with the HORIZONTAL POSITION control. If the horizontal deflection is not exactly 10 divisions then adjust the HORIZ GAIN control (located on the spectrum analyzer rear panel) for a 10 division wide horizontal deflection. Note: The analyzer must be removed from the mainframe to adjust the HORIZ GAIN.

4. Adjust TRACE ALIGN so that CRT trace is parallel to the horizontal graticule lines.

5. Adjust VERT POS until trace aligns on bottom graticule line.

6. Tune the analyzer to 00.0 Hz (LO feedthrough) and press FREQ CAL button to correct for hysteresis effects. Signal should appear in center of CRT. If not, adjust FINE TUNING to center the LO feedthrough signal.

7. Set digital frequency readout to read 00.0 MHz by adjusting the FREQ ZERO control.

The analyzer is now calibrated to make frequency measurements.

8. Set REF LEVEL dBm to −30 dBm (**NOT** OPTIMUM INPUT dBm).

9. Connect the internal 280 MHz, −30 dBm CAL OUTPUT signal to INPUT of analyzer and tune to 280 MHz. The calibration signal should appear in center of CRT. If not, press FREQ CAL button to correct for hysteresis effects and adjust FINE TUNING control to center trace.

10. Set FREQ SPAN/DIV to 20 kHz/DIV.

11. Set 10 dB/DIV - 1 dB/DIV - LIN switch to 10 dB/DIV. If the peak of the signal is not on the top graticule line, then adjust the VERT GAIN control to put it there (See Figure 5-1).

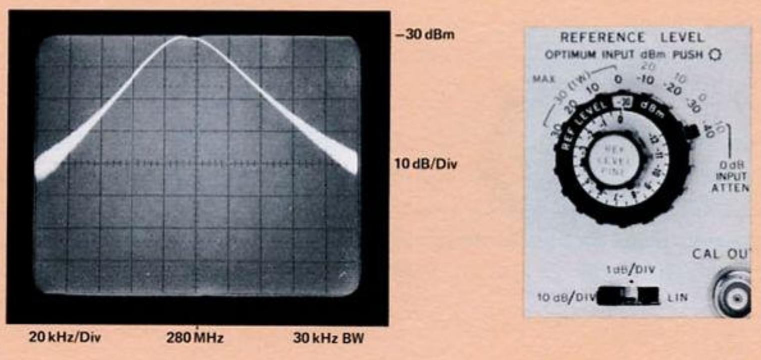

Figure 5-1. To calibrate the vertical scale for 10 dB/DIV, set the vertical scale for 10 dB/DIV and set the peak of the CAL signal on the reference level with the VERT GAIN adjust.

12. Set 10 dB/DIV - 1 dB/DIV - LIN switch to LIN. If the peak of the signal is not on the top graticule line then adjust the REF LEVEL CAL control to put it there (See Figure 5-2).

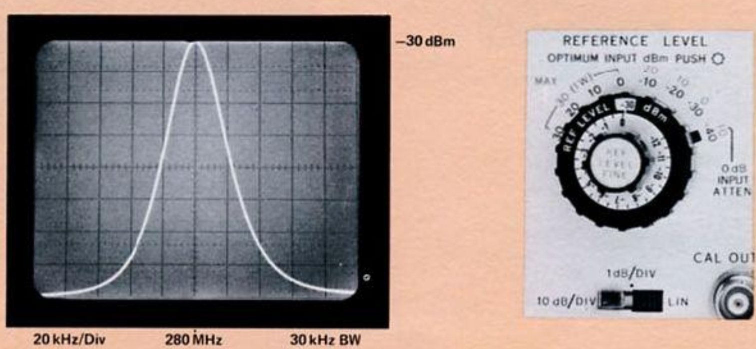

Figure 5-2. To calibrate the reference level, set the vertical scale for LIN and set the peak of the CAL signal on the reference level with the REF LEVEL CAL adjust.

13. Repeat steps 11 and 12 until the peak of the signal remains on or near the top graticule when the 10 dB/DIV - 1 dB/DIV - LIN switch is switched between 10 dB/DIV and LIN.

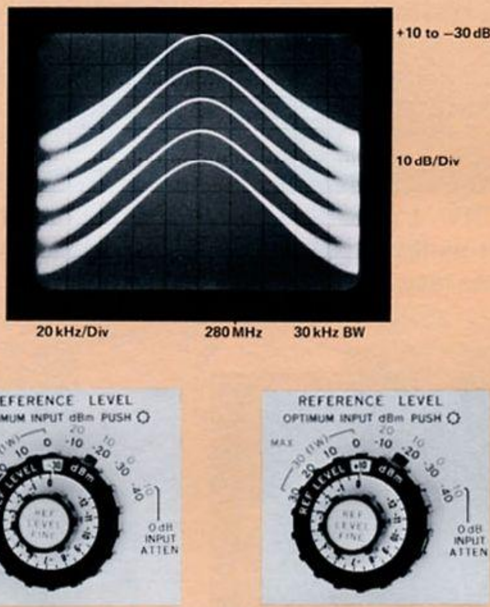

Figure 5-3. To check the 10 dB/DIV calibration of the vertical scale, change REF LEVEL dBm in 10 dB steps and see if the trace moves one division for each 10 dB change.

The analyzer is now calibrated for absolute amplitude and frequency measurements.

APPENDIX A

CONTROL "GLOSSARY"

Following is a general description of the 8558B Spectrum Analyzer controls. To help the reader familiarize himself with the function and location of the controls, a view of the front panel is shown in Figure A-1 (foldout) and the rear panel is shown in Figure A-2.

1. FREQUENCY MHz: Displays the CENTER or START FREQUENCY on a digital LED display.
2. START-CENTER: Determines whether the frequency displayed on the digital LED readout is at the START or CENTER of the CRT screen.
3. TUNING: Tunes the CENTER or START FREQUENCY with a FINE TUNE to allow high resolution adjustments in narrow spans and signal identification in wide spans.
4. OPTIMUM INPUT dBm (PUSH to set): Blue numbers indicate OPTIMUM INPUT level for 70 dB dynamic range. Red numbers, -10 to 20 dB, indicate maximum INPUT level resulting in less than 1 dB gain compression by input mixer. MAX 30 (1 W) indicates maximum safe INPUT level to input attenuator (30 dB or 1 watt). 0 dB INPUT ATTEN indicates zero attenuation of INPUT signal ahead of input mixer.
5. REF LEVEL dBm—REF LEVEL FINE: The sum of the two control settings determines the REFERENCE LEVEL (top graticule line on CRT) in dBm. The REF LEVEL FINE control provides continuous control of logarithmic amplification of input signal from 0 to 12 dB. The REF LEVEL dBm control provides logarithmic control of the input signal in 10 dB steps.
6. 10 dB/DIV - 1 dB/DIV - LIN: Selects display mode for logarithmic display with scale factors of 10 dB per division or 1 dB per division or LINEAR display.
7. FREQ SPAN/DIV: Selects the CRT horizontal calibration (frequency scale). Can be coupled to RESOLUTION BW by pushing in on the control. When OPTIMUM markings are aligned (►◄) the proper resolution for any frequency span will automatically be selected.
8. CAL OUTPUT: —30 dBm, 280 MHz signal used for calibrating amplitude.
9. RESOLUTION BW: Selects bandwidth of the spectrum analyzer from 1 kHz to 3 MHz in a 1, 3 sequence. See item 7 for OPTIMUM marking (► ◄).
10. REF LEVEL CAL: Calibrates display amplitude for absolute power measurements.
11. PROBE PWR: +15 V, —12.6 V, 150 mA for powering high impedance probes such as the HP 1120A, 1121A, 1124A.
12. SWEEP TIME/DIV: Selects time required to scan one major division on CRT display. Control acts as time base for time domain operation in the zero FREQ SPAN/DIV setting.

AUTO: Automatically selects the proper SWEEP TIME/DIV to match the FREQ SPAN/DIV, RESOLUTION BW, and VIDEO FILTER settings to maintain absolute amplitude calibration.
MAN: Permits MANUAL SWEEP.

13. MANUAL SWEEP: Controls spectrum analyzer horizontal scan when SWEEP TIME/DIV is set to MAN.

14. INPUT: 50-ohm unbalanced input for signals to be measured. For 75-ohm operation, use HP 11674A Matching Transformer (10 - 1500 MHz).

15. LO OUTPUT: +10 dBm, 50 ohms output from the 2.05 - 3.55 GHz voltage tunable oscillator (first LO).

16. SWEEP TRIGGER: Selects synchronizing trigger.
    INT: Scan internally synchronized to envelope of RF input signal. Signal amplitude of 0.5 divisions p-p (min) required on CRT display.
    LINE: Scan synchronized to power line frequency.
    FREE RUN: Sweep triggered repetitively by internally generated ramp.
    SINGLE: Single scan initiated by twisting SWEEP TRIGGER clockwise momentarily.

17. SWEEP LAMP: Remains lit during analyzer sweep in all sweep modes.

18. BASELINE CLIPPER. Allows blanking of the bright baseline area of the CRT for better photography and improved display of transient phenomena.

19. VIDEO FILTER: A post-detection low pass filter, which smooths the display by averaging background noise, varies the amount of video filtering required to average noise. The MAX detent position selects a 1.5 Hz video filter for maximum noise averaging. MAX is convenient for noise level measurements, but it should **not** be used for CW signal measurements.

20. FREQ: The CAL button reduces hysteresis effects in the analyzer which may cause the CRT display and FREQUENCY MHz LED readout to be unmatched. The ZERO adjusts the FREQUENCY MHz LED readout to correspond with the CRT display.

21. VERT: These controls adjust the deflection circuit GAIN and offset levels (POS) to match the 8558B Spectrum Analyzer plug-in to a particular display section.

The following controls appear on the 180 Series oscilloscope mainframe.

22. LINE: Toggle switch with indicator light for turning power ON and OFF.

23. FIND BEAM: Intensifies trace and always returns display to on-screen with time domain plug-ins only.

24. EXT INPUT: BNC connector for coupling an external horizontal input signal to the horizontal amplifier (not used with spectrum analyzer).

25. EXT COUPLING: Selects ac or dc coupling for EXT INPUT (not used with spectrum analyzer).

26. EXT VERNIER: Provides continuous adjustment of deflection factor for external horizontal input signals. In CAL detent position, deflection factor is selected by MAGNIFIER control (not used with spectrum analyzer).

27. DISPLAY: Selects source of horizontal input (should be left in INT).

28. MAGNIFIER: Allows expanded display for time domain (0 FREQ SPAN/ DIV operation). Control should be left in X1 position for spectrum analysis.

29. HORIZONTAL POSITION: Single knob provides coarse and fine adjustment of display horizontal position.

30. INTENSITY: Adjusts the intensity of the trace on the CRT.

31. ASTIG: Adjusts the shape of the CRT spot.

32. FOCUS: Focuses CRT spot for best definition.

33. TRACE ALIGN: Adjusts the CRT trace align with the horizontal graticule lines.

34. SCALE: Controls graticule illumination.

35. Ground connection: Provides a chassis ground connection point.

36. CALIBRATOR: Provides a 1 kHz square wave at two amplitudes: 250 mV and 10 V p-p (for calibrating 1800 Series plug-ins ONLY).

When using 180 Series oscilloscopes other than the 182C, these controls may be of importance:

A. AC/DC: Same as EXT COUPLING (item 25).

B. PWR: Push-button switch with indicator light for turning power ON and OFF.

C. CAL 10 V: Provides a 1 kHz square wave signal at 10 V p-p (for calibrating 1800 Series plug-ins ONLY).

Note: Controls D through J appear on the 181A/AR variable persistence display.

D. STORE: Retains displayed signal at reduced intensity for extended viewing or photography. The CRT does not write in the STORE mode.

E. VIEW: Intensifies stored display to brightness level for viewing.

F. NORM: Selects operation as standard oscilloscope with P-31 phosphor.

G. WRITE: Operates CRT at normal writing rate with variable persistence.

H. MAX W: Operates CRT at fast writing rate with variable persistence.

I. PERSISTENCE: Controls fade rate of displayed signal.

J. ERASE: Removes stored or written displays.

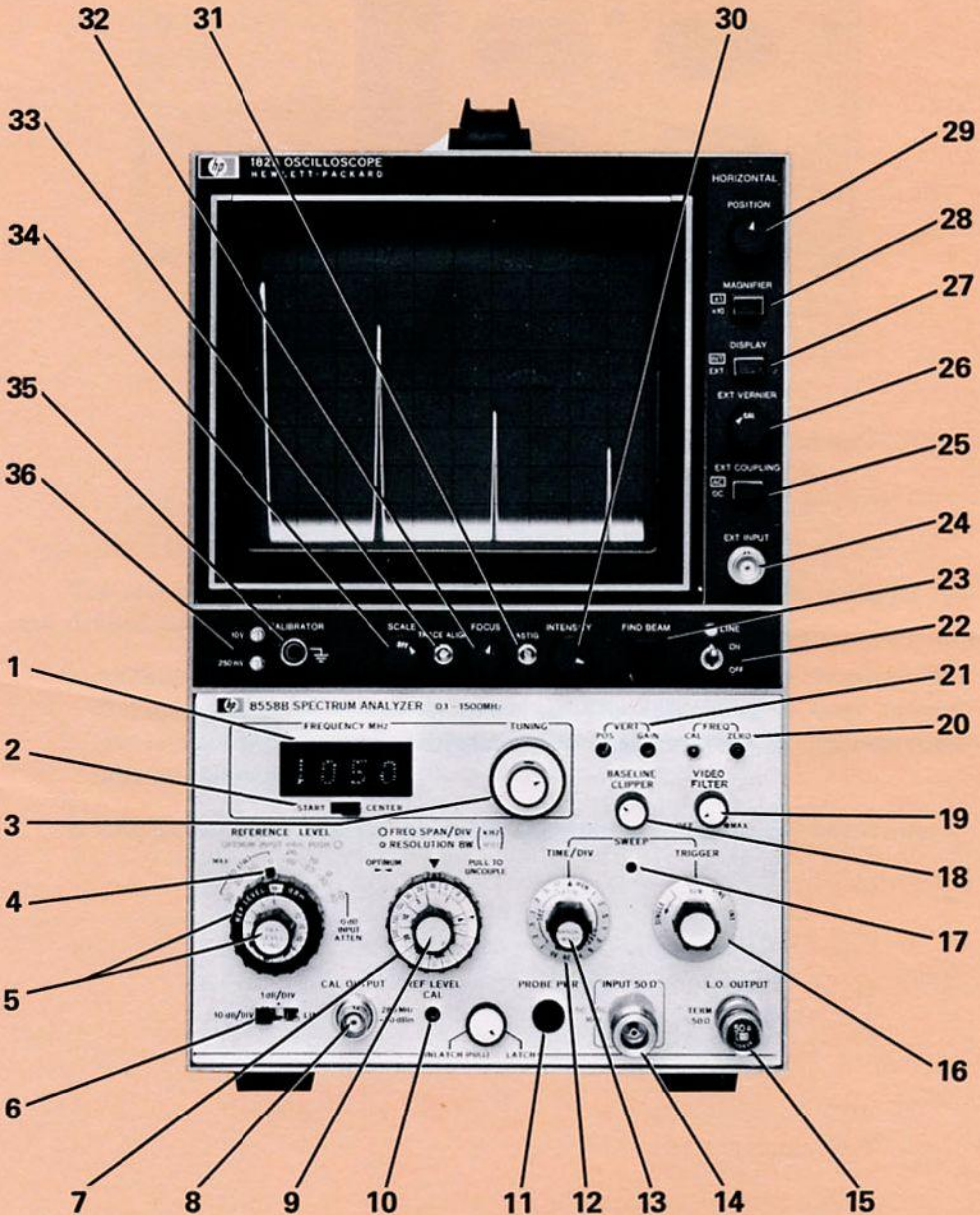

Figure A-1. Front panel of the 8558B Spectrum Analyzer in an HP 182C Oscilloscope mainframe.

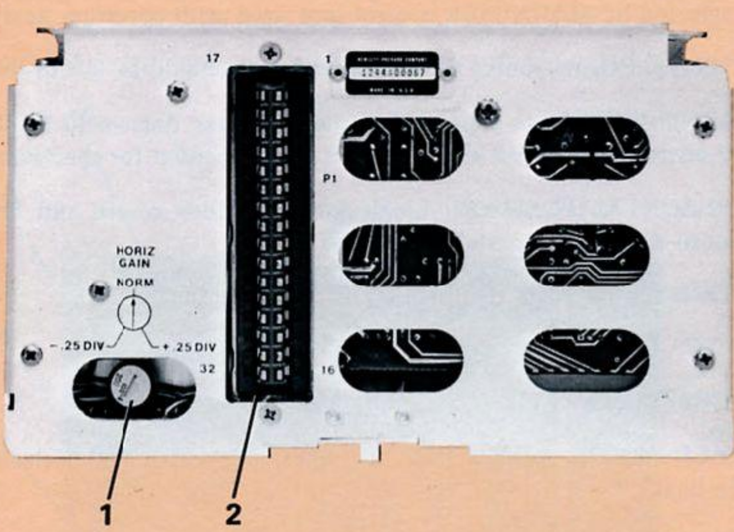

Figure A-2. Rear panel of the 8558B Spectrum Analyzer.

The rear panel controls on the 8558B Spectrum Analyzer shown in Figure A-2 are defined as follows:

1. HORIZ GAIN: This control adjusts the horizontal gain ±¼ division for a full 10 divisions of horizontal deflection. The adjustment is made to compensate for differences in horizontal gain characteristics of different oscilloscope mainframes.

2. Connector: Interconnects spectrum analyzer to oscilloscope mainframes.

APPENDIX B

THEORY OF OPERATION

The purpose of this section is to give the reader a basic description of the 8558B Spectrum Analyzer circuit operation. Some front panel controls will be described in order to give a more complete understanding of the overall system. Figure B-1 is a simplified block diagram of the analyzer circuitry.

The 8558B Spectrum Analyzer is basically a superheterodyne receiver with a YIG (Yttrium-Iron-Garnet) tuned oscillator for the first LO (local oscillator). The first LO is the only LO that is swept. The sweep width is determined by the frequency span attenuator which attenuates the ramp driving the LO. This ramp is produced by the frequency span generator. The ramp also drives the horizontal sweep of the CRT, and is available at a rear panel BNC to synchronize other instruments to the analyzer, such as X-Y recorders.

The RF INPUT to the analyzer passes through an attenuator network which adjusts the signal level to the input mixer. The OPTIMUM INPUT dBm control on the front panel sets the input signal level needed for a wide dynamic range. From the attenuator, the signal goes to the first mixer. Here it is mixed with a 2.05 to 3.55 GHz output from the YIG oscillator to produce a 2.05 GHz IF signal. The lower sideband of this IF signal is passed by a 2.05 GHz IF amplifier immediately following the mixer. The signal enters a second mixer where it is mixed with a fixed 1748.6 MHz signal from a fixed-cavity local oscillator producing a 301.4 MHz IF signal which is amplified and fed into a third mixer. This time, the signal is mixed with a 280 MHz signal from a crystal oscillator resulting in a 21.4 MHz IF signal. The final 21.4 MHz signal is amplified, detected, and filtered by the low pass VIDEO FILTER before being sent to the vertical deflection amplifier of the CRT. The vertical CRT deflection corresponds to the RF INPUT signal amplitude. The 280 MHz signal from the crystal oscillator is fed out the front panel for use as a —30 dBm calibration reference.

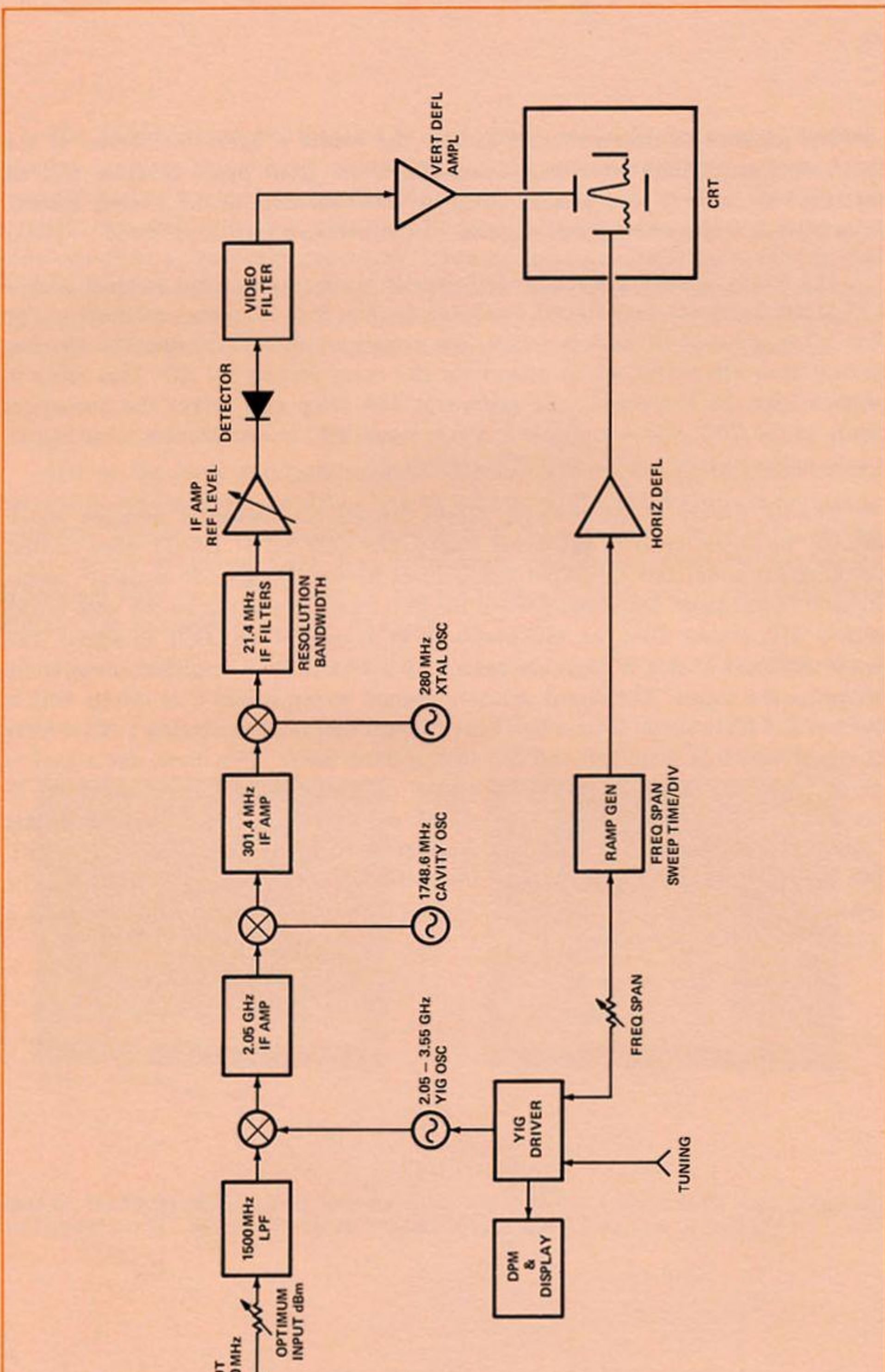

Figure B-1. Block diagram of the 8558B Spectrum Analyzer circuitry.

APPENDIX C

MAINFRAME OPTION 807

Figure C-1. Rear panel view of the HP 182C Oscilloscope mainframe with Option 807.

Option 807 consists of a complete set of auxiliary outputs on the rear panel of all HP 180 mainframes and also provides P7 phosphor on all non-persistence mainframes. Using these auxiliary connections, the spectrum analyzer output can be connected to an X-Y recorder, magnetic tape, etc. Figure C-1 shows the location of these outputs. A typical setup for an X-Y recorder is shown in Figure C-2. A description of each output function is listed.

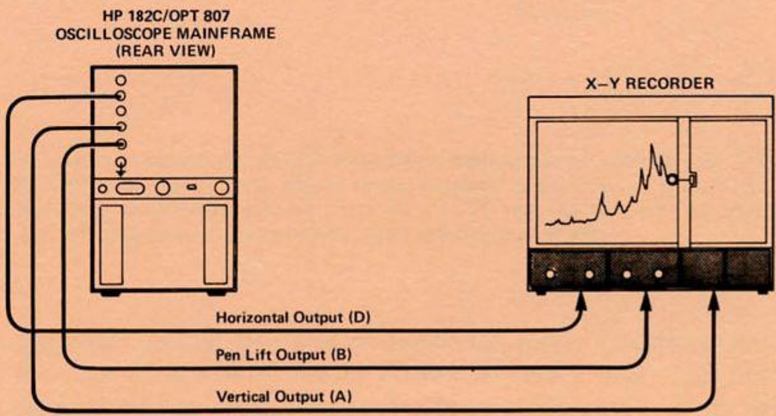

Figure C-2. Using Option 807 to connect an X-Y recorder to the 8558B Spectrum Analyzer.

Aux. A: Vertical amplifier output.

Aux. B: Penlift or blanking output from horizontal amplifier (retrace).

Aux. C: 21.4 MHz IF output. Amplitude and bandwidth are controlled from front panel of spectrum analyzer.

Aux. D: Horizontal amplifier output.

See HP Service Notes 180A/AR/C/D-1, 181A/AR-7, and 182A-1 for the information needed to modify standard displays to provide auxiliary outputs. For a description of other rear panel connections see the oscilloscope manual.

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