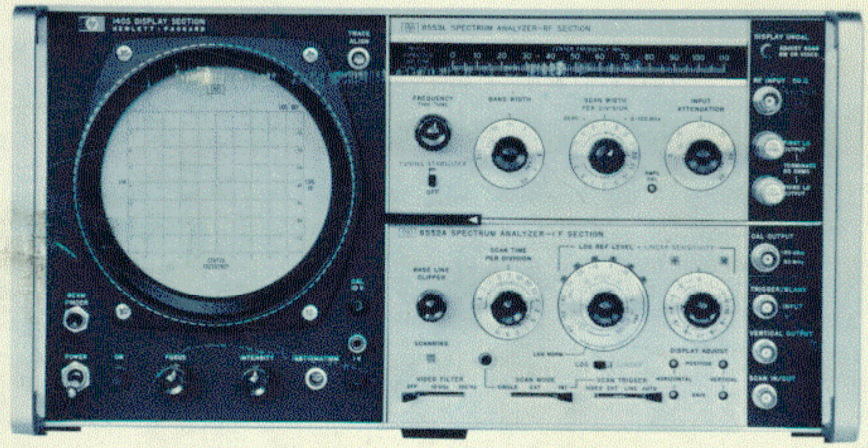
HP 8552A/8553L

OPERATING MANUAL

SPECTRUM ANALYZER

8552A/8553L



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HP 8552A/8553L

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CERTIFICATION

The Hewlett-Packard Company certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from the factory. The Hewlett-Packard Company further certifies that its calibration measurements are traceable to the U.S. National Bureau of Standards to the extent allowed by the Bureau's calibration facility.

WARRANTY AND ASSISTANCE

All Hewlett-Packard products are warranted against defects in materials and workmanship. This warranty applies for one year from the date of delivery, or, in the case of certain major components listed in the operating manual, for the specified period. We will repair or replace products which prove to be defective during the warranty period. No other warranty is expressed or implied. We are not liable for consequential damages.

For any assistance contact your nearest Hewlett-Packard Sales and Service Office.

SPECTRUM ANALYZER
8552A/8553L

SERIAL PREFIXES: 809- and 818-

This manual applies directly to HP Model 8552A IF Sections having serial prefix number 809 and HP Model 8553L RF Sections having serial prefix number 818.

SERIAL PREFIXES NOT LISTED

For serial prefixes above those listed, a Manual Changes sheet is included with this manual.

08552-90006 Printed: JUNE 1968

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FOREWORD

The spectrum analyzer consists of an 8552A IF section and an 8553L RF section together with any of the 140-series oscilloscope mainframes (Display Sections). The instrument can be ordered complete or the RF/IF sections can be separately ordered and used in a previously purchased 140-series oscilloscope. Because of instrument interchangeability, the related document are also flexible and operating instructions, calibration and adjustment data, and service information is available for any instrument configuration. The family of manuals pertaining to the spectrum analyzer is as follows:

OPERATING MANUAL FOR 8552A/8553L SPECTRUM ANALYZER -

Shows how to operate the instrument and provides some applications information. (Pertinent Application Notes are available on request.)

CALIBRATION AND ADJUSTMENT MANUAL FOR 8552A/8553L SPECTRUM ANALYZER -

Contains performance tests, calibration procedures, and adjustment instructions.

SERVICE MANUAL FOR 8552A/8553L SPECTRUM ANALYZER -

Contains schematics, theory, troubleshooting information, and other data required to service and maintain the instrument.

OPERATING AND SERVICE MANUAL FOR 140S DISPLAY SECTION -

Includes operating and service information for display section only.

OPERATING AND SERVICE MANUAL FOR 141S DISPLAY SECTION -

Includes operating and service information for 141S display section only.

OPERATING AND SERVICE MANUAL FOR 140A OSCILLOSCOPE -

Includes operating and service information for 140A oscilloscope mainframe only.

OPERATING AND SERVICE MANUAL FOR 141A OSCILLOSCOPE -

Includes operating and service information for 141A oscilloscope mainframe only.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

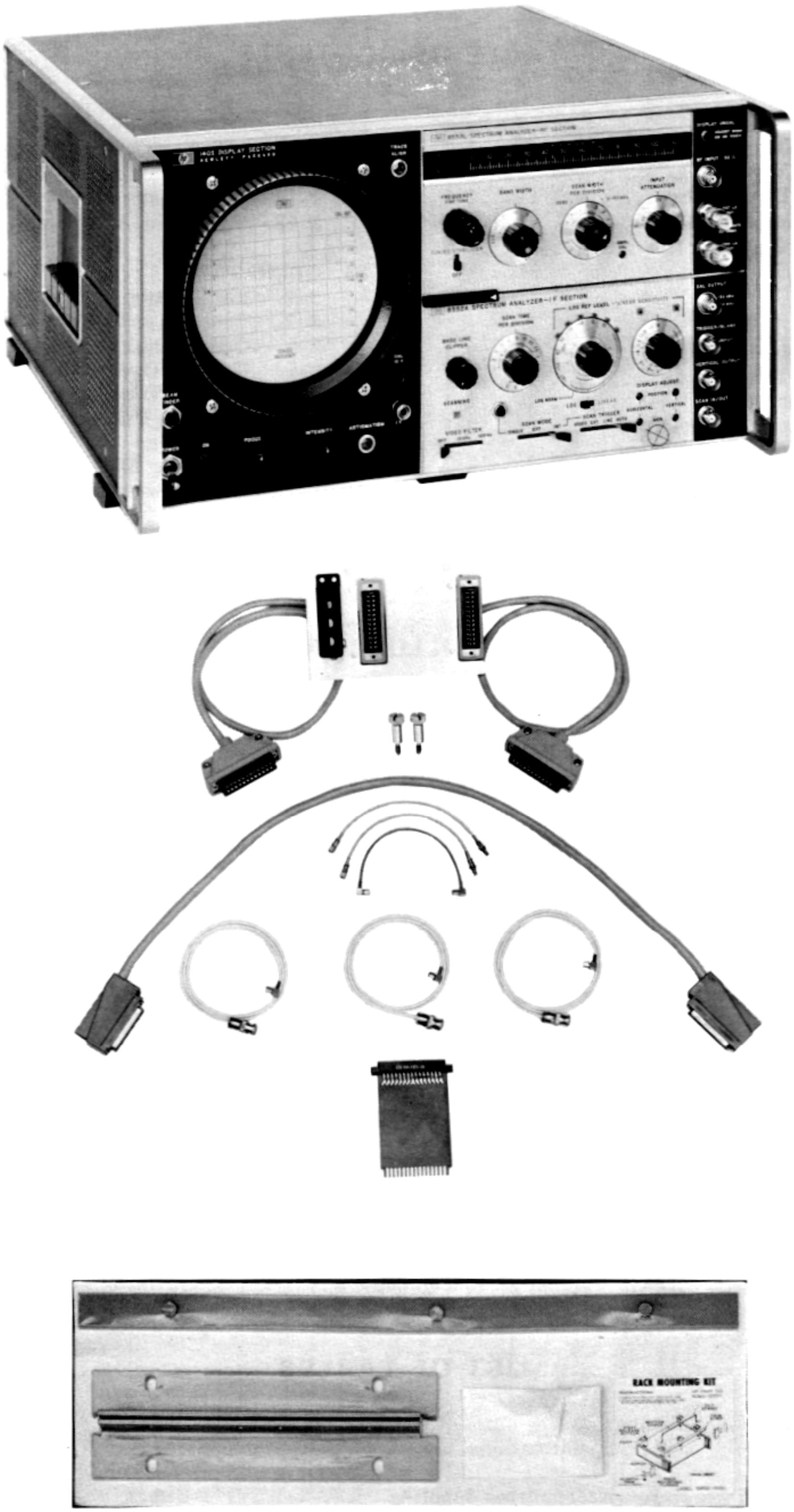


Figure 1-1. Spectrum Analyzer with Accessories Supplied and Those Required for Maintenance

SECTION I

GENERAL INFORMATION

1-1. MANUAL CONTENTS.

1-2. This manual provides operating instructions and limited applications information for the HP 8552A/8553L Spectrum Analyzer. The information presented here will acquaint the user with: (1) overall characteristics of the instrument, (2) how to install the instrument, (3) general operating data, and (4) other information of operational value. Although brief, the applications information provides an insight into operating versatility; also, it gives typical display patterns to be expected under prescribed conditions.

1-3. GENERAL DESCRIPTION.

1-4. The 8552A/8553L Spectrum Analyzer and its accessories are shown in Figure 1-1. The analyzer is a highly sensitive superheterodyne receiver with spectrum-scanning capabilities up to 110 MHz. Output video from the receiver circuits is applied to a CRT in the display section; thus, a signal or group of signals can be analyzed in the frequency domain. Input signals are plotted on the CRT as a function of amplitude versus frequency. The amplitude (Y-axis) of the CRT is calibrated in absolute units of power (dBm) or voltage (μV/mV); accordingly, absolute and relative measurements of both amplitude and frequency can be made.

1-5. Controls of the instrument are arranged so that the operator can identify, type, and measure signal parameters with a minimum of switching. For wide-spectrum analysis, the operator can choose a preset scan width of 0 to 100 MHz. For more detailed study, the spectrum width can be progressively narrowed to as little as 2 kHz, or the scanning capabilities can be eliminated altogether to use the instrument as a fixed-frequency receiver. A bandwidth of 300 kHz is automatically selected for fixed-scan operation; for variable-scan and fixed-frequency operation, bandwidths as small as 50 Hertz can be operator-selected.

1-6. Both the scan voltage and synchronizing trigger can be externally supplied; thus, real-time plots can be obtained for periodic and nonperiodic functions. The analyzer is also an excellent tool for making noise power-density measurements.

Table 1-1. Specifications

RF Input and Tuning Characteristics

Tuning: The instrument is tuned with two concentric controls — an outer coarse FREQUENCY control and an inner dual-range FINE TUNE VERNIER. The 10-turn coarse FREQUENCY control covers the 1 kHz to 110 MHz range with 10 kHz tuning resolution. Automatic tuning stabilization (see SPECTRAL PURITY specifications) reduces residual FM of the analyzer to achieve tuning resolution of 30 Hz with FINE TUNE vernier for scan widths of 20 kHz per division or less.

Frequency Range: 1 kHz to 110 MHz.

Frequency Response: ±0.5 dB, 1 kHz to 110 MHz (for attenuator settings ≥ 10 dB). Typical fine grain flatness, ≤ ±0.1 dB per MHz.

Input Impedance: 50Ω nominal.
Reflection Coefficient ≤ 0.09 (1.2 SWR, 21 dB return loss) for input attenuator settings ≥ 10 dB.

Reflection Coefficient ≤ 0.33 (2.0 SWR, 9.5 dB return loss) for input attenuator setting of 0 dB.

Maximum Input Level: Peak or average power to input mixer <+13 dBm (1.4 Vac peak; ±0.2 Vdc).

Sensitivity: $\frac{\text{Signal Power + Noise Power}}{\text{Noise Power}} = 2$

IF Bandwidth (kHz)	Sensitivity (dBm)	Frequency Range* (MHz)
1	-120	1-110
10	-110	1-110
100	-100	1-110

Tuning Dial Accuracy: Display center frequency is within ±1 MHz of indicated dial frequency.

Center Frequency Identifier: Marker in 0-100 MHz SCAN WIDTH mode identifies display center frequency of SCAN WIDTH/DIVISION and ZERO SCAN modes; marker quickly identifies signals for closer investigation on expanded scan.

*Typical sensitivity versus input frequency curves for frequencies from 1 kHz to 110 MHz are shown in Figure 1-2.

Table 1-1. Specifications (Cont.)

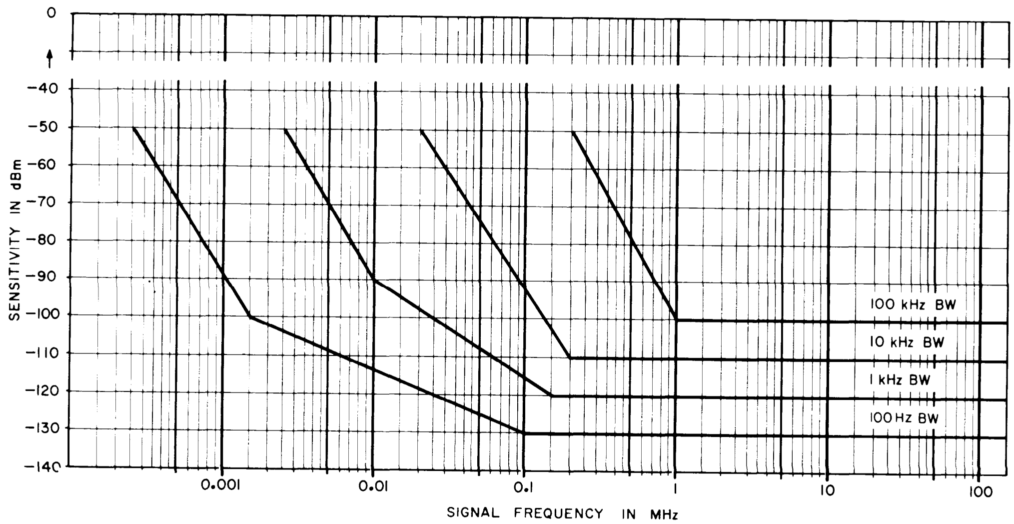


Figure 1-2. Typical Sensitivity vs. Input Frequency

Scan Characteristics

Scan Width: 15 calibrated scan widths from 200 Hz/div to 10 MHz/div in a 1, 2, 5, 10 sequence. Scan is displayed on a 10-division graticule. Selection of ZERO or preset 0 - 100 MHz SCAN in addition to calibrated SCAN WIDTH/DIVISION settings is provided.

Scan Width Accuracy: Scan widths 10 MHz/div to 1 MHz/div and 20 kHz/div to 200 Hz/div: Frequency error between two points on the display is less than ±3% of the indicated frequency separation between the two points. Scan widths 500 kHz/div to 50 kHz/div: Frequency error between two points on the display is less than ±10% of the indicated frequency separation.

Scan Time: 16 rates from 0.1 ms/div to 10 s/div in a 1, 2, 5, 10 sequence, INTERNAL and SINGLE SCAN modes only.

Scan Time Accuracy: 0.1 ms/div to 20 ms/div, ±10%. 50 ms/div to 10 s/div, ±20%.

Scan Mode:

INTERNAL: Analyzer repetitively scanned by internally generated ramp; synchronization selected by SCAN TRIGGER. SCANNING lamp indicates duration of scan.

SINGLE: Single scan actuated by front panel push-button. SCANNING lamp indicates duration of scan.

EXTERNAL: Scan determined by 0 to +8 volt external signal; analyzer input impedance >10 kΩ. Blanking: -1.5 V external blanking signal required.

Scan Trigger: Required only when INTERNAL SCAN mode selected.

AUTO: Scan free runs.

LINE: Scan synchronized with power line frequency.

EXTERNAL: Scan synchronized with external 2- to 20-volt signal (polarity selected by internally located switch of Model 8552A IF Section).

VIDEO: Scan internally synchronized to envelope of RF input signal (signal amplitude of 1.5 major divisions peak-to-peak required on display section CRT.)

Spectral Resolution

IF Bandwidth: 3-dB bandwidths of 50, 100, 300 Hz, and 1, 3, 10, 30, 100, and 300 kHz can be selected.

IF Bandwidth Accuracy: Individual bandwidths calibrated within ±20%; 10-kHz IF bandwidth calibrated within ±5%.

IF Bandwidth Selectivity: 60-dB/3-dB bandwidth ratio less than 20:1 for IF bandwidths from 1 kHz to 300 kHz.

60-dB/3-dB bandwidth ratio less than 25:1 for IF bandwidths from 50 Hz to 300 Hz.

Video Filter Bandwidth: Two post-detection bandwidths: 10 kHz and 100 Hz.

Video Filter Bandwidth Accuracy: Individual video bandwidths calibrated within ±20%.

Table 1-1. Specifications (Cont.)

Amplitude Characteristics

Vertical Display Calibration (8 divisions, full-scale deflection):

Logarithmic: Calibrated directly in dBm over 140-dB range from -130 dBm to +10 dBm, 10 dB/div on 0 to -70 dB CRT Display. LOG REFERENCE LEVEL control provides 90-dB range in 10-dB steps; log reference vernier provides calibrated continuous adjustment over 0- to 12-dB range. LOG REFERENCE LEVEL control and log reference vernier establish absolute power reference level in dBm for CRT display.

Linear: Calibrated directly in V/div from 0.1 μV/div to 100 mV/div in a 1, 2, 10 sequence. LINEAR SENSITIVITY and vernier controls establish absolute voltage calibration (deflection factor).

Calibrator: 30-MHz signal provided as operating standard for absolute vertical calibration of display. Frequency Accuracy: ±0.2 MHz. Amplitude: -30 dBm ±0.3 dB.

Vertical Display Accuracy:

	LOGARITHMIC dBm	LINEAR volts
Calibrator	±0.3 dB	±3.5%
Log Reference Level (Linear Sensitivity)	±0.2 dB	±2.3%
Log Reference Vernier (Linear Sensitivity Vernier)	±0.1 dB*	±1.2%*
RF Input Attenuator Accuracy (excluding flatness)	±0.2 dB	±2.3%
Analyzer Frequency Response (flatness)	±0.5 dB	±5.8%
Switching between Bandwidths (at 20°C)	±0.3 dB	±3.5%
Amplitude Stability:		
100 Hz - 300 kHz bandwidth	±0.5 dB/°C	±0.6%/°C
20 Hz bandwidth	±0.1 dB/°C	±1.2%/°C
CRT Display	±0.25 dB/dB but not more than ±1.5 dB over the full 70-dB display range	±2.8% of full 8-div deflection

*Vernier accuracy at 0, 6, and 12 dB; otherwise ±0.25 dB (±2.8%).

Display Uncalibrated Light: Panel Lamp warns operator of uncalibrated amplitude display if selected IF bandwidth or video bandwidth is too narrow for combination of scan width and scan time selected.

Spectral Purity

Automatic Stabilization: First local oscillator auto matically stabilized (phase-locked) to internal reference for scans of 20 kHz/div or less. Signal offset on display occurring with stabilization less than 20 kHz.

Long Term Stability (after approximately one hour warm-up):

Stabilized: 100 Hz/min; 500 Hz/10 min.

Unstabilized: 5 kHz/min; 20 kHz/10 min.

Residual FM:

Stabilized: Less than 20 Hz peak-to-peak.

Unstabilized: Less than 1 kHz peak-to-peak.

Noise Sidebands: More than 70 dB below CW signal 30 kHz or more away from signal, with a 1-kHz IF BANDWIDTH setting.

Spurious Responses: For -40 dBm signal level to input mixer: image responses, out-of-band mixing responses, harmonic and intermodulation distortion products, and IF feedthrough responses all more than 70 dB below the input signal level.

Residual Responses: 200 kHz to 110 MHz; < -110 dBm. 20 kHz to 200 kHz: < -100 dBm.

Model 140S Display Section

Plug-ins: Accepts Model 8552A/8553L Spectrum Analyzer plug-ins and Model 1400-series time domain plug-ins.

Cathode-ray Tube:

Type: Post-accelerator, 7300 volt accelerating potential; etched safety glass faceplate reduces glare; transparent coating reduces EMI. P11, medium-short persistence phosphor; light blue filter supplied.

Graticule: 8 x 10 divisions (approximately 7,2 x 9,0 cm) parallax-free internal graticule; five subdivisions per major division on horizontal and vertical axes.

Intensity Modulation: ac-coupled, +20 volt pulse will blank trace of normal intensity; input terminals on rear panel. Used only with time domain 1400-series plug-ins.

Writing Rate (using HP Model 197A Camera with f1.9 lens and Polaroid 3000 speed film): P11 Phosphor: 430 cm/μs.

Table 1-1. Specifications (Cont.)

Calibrator (used only with time domain 1400-series plug-ins):

Type: Line frequency rectangular signal, approximately 0.5 μs rise time.

Voltage: Two outputs: 1 V and 10 V peak-to-peak, ±1% from 15°C to 35°C, ±3% from 0°C to 55°C.

Beam Finger (used only with time domain 1400-series plug-ins): Pressing control brings trace on CRT screen regardless of settings of horizontal, vertical, or intensity controls.

Model 141S Variable Persistence Display Section

Plug-ins: Same as 140S.

Cathode-ray Tube:

Type: Post accelerator storage tube, 7300 volt accelerating potential; aluminized P31 phosphor; etched safety glass faceplate reduces glare.

Graticule: 8 x 10 divisions (approximately 6, 6 x 8, 2 cm) parallax-free internal graticule; five subdivisions per major division on horizontal and vertical axes.

Intensity Modulation: Same as 140S.

Persistence:

Normal: Natural persistence of P31 phosphor (approximately 0.1 second).

Variable:

Normal Writing Rate Mode: continuously variable from less than 0.2 second to more than one minute (typically two or three minutes).

Maximum Writing Rate Mode: Typically variable from 0.2 second to 15 seconds.

Erase: Manual; erasure takes approximately 100 ms: CRT ready to record immediately after erasure.

Writing Rate (Conventional Operation): (using HP Model 197A Camera with f/1.9 lens and Polaroid 3000 speed film): 100 cm/μs.

Writing Rate (Storage):

Normal Mode: Greater than 20 cm/ms.

Maximum Mode: Greater than 1 cm/μs.

Storage Time:

	NORMAL Writing Rate Mode	MAXIMUM Writing Rate Mode
STORE Mode (dim display)	longer than 1 hour	typically 15 minutes
VIEW Mode (Bright display)	longer than 1 minute (typically 2 or 3 minutes)	typically 15 seconds

Brightness: Greater than 100 footlamberts in NORMAL or VIEW; typically 5 footlamberts in STORE.

Calibrator: Same as Model 140S.

Beam Finder: Same as Model 140S.

General

CRT Baseline Clipper: Front panel control adjusts blanking of CRT trace baseline to allow more detailed analysis of low-repetition-rate signals and improved photographic records to be made.

Vertical Display Output: Approximately 0 to -0.8V for 8-div deflection on CRT; 5 kΩ output impedance.

Scan Output: Approximately -5 to +5 volts for 10-div CRT deflection; 5kΩ output impedance.

EMI: Conducted and radiated leakage limits are below requirements of MIL-I-16910C and MIL-I-6181D when 8553L and 8552A are combined in a 140S Display Section.

Temperature Range: Operating, 0° to +55°C; storage, -40° to +75°C.

Power Requirements; 115 or 230 volts ±10%, 50 to 60 Hz, normally less than 225 watts (varies with plug-in units used).

Weight: Model 8552A IF Section: Net, 9 lb (4 kg). Shipping, 14 lb (6, 4 kg).

Model 8553L RF Section: Net, 12 lb (5,5 kg). Shipping, 17 lb (7, 8 kg).

Model 140S Display Section: Net, 37 lb (16,8 kg). Shipping, 45 lb (20 kg).

Model 141S Display Section: Net, 40 lb (18 kg). Shipping, 51 lb (23 kg).

Dimensions: 9-1/16 in. high (including height of feet) x 16-3/4 in. wide x 18-3/8 in. deep (229 x 425 x 467 mm).

1-7. WARRANTIES AND ASSISTANCE.

1-8. Cathode-ray Tube. The CRT is manufactured by the Hewlett-Packard Company and is warranted against degraded performance and electrical failure for a period of one year from date of delivery. Claim and adjustment procedures pertaining to the CRT warranty are included at the back of this manual. Use the form included and follow claim instructions precisely when returning a CRT for adjustment under warranty.

1-9. Instrument. The 8552A/8553L Spectrum Analyzer is warranted and certified as indicated on the inner front cover. For further information and assistance, contact the nearest Hewlett-Packard Sales and Service Office; addresses are provided at the back of this manual.

1-10. OPTIONAL EQUIPMENT.

1-11. The 8553L RF Section and the 8552A IF Section can be used with any of the 140-series oscilloscopes. The 140A and 140S display sections are each equipped with a fixed-persistence/non-storage CRT, whereas the 141A and the 141S display sections are each equipped with a variable-persistence storage CRT. A set of overlays for the standard 140A and 141A is available to provide LOG and LINEAR graticule scales.

1-12. INSTRUMENT IDENTIFICATION.

1-13. Hewlett-Packard instruments carry an eight-digit serial number (see Figure 1-3). When the serial prefix on the instrument serial number plate is the same as the number on the inside title page of this manual, the manual applies to the instrument directly. When the instrument serial prefix and the manual serial prefix differ, change sheets and manual backdating information are provided.

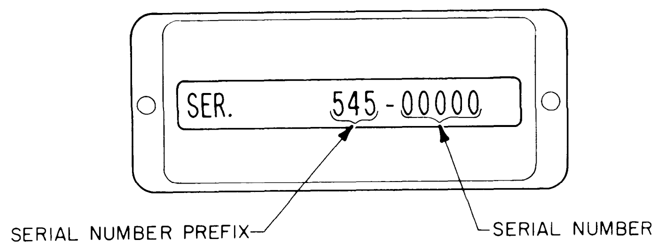


Figure 1-3. Instrument Identification

SECTION II
INSTALLATION

2-1. SHIPPING INFORMATION.

2-2. Because of individual customer requirements, shipping configurations are flexible. Procedures for initial inspection are based on the premise that the RF and IF sections are installed in the display section at the factory; thus, the instrument is physically and functionally complete upon receipt. If the RF and IF sections are received separately, the plug-ins must be mechanically fitted together, electrically connected, and inserted in an oscilloscope mainframe of the 140-series. For mechanical and electrical connections refer to Paragraph 2-19.

2-3. INITIAL INSPECTION.

2-4. MECHANICAL CHECK.

2-5. If shipping carton is damaged, ask that agent of carrier be present when instrument is unpacked. Inspect instrument for mechanical damage such as scratches, dents, broken knobs, or other defects. Also, check cushioning material for signs of severe stress.

2-6. PERFORMANCE CHECKOUT.

2-7. As soon as possible after receipt, the instrument should be performance-tested in accordance with the procedures given in the Calibration and Adjustment booklet.

2-8 CLAIMS FOR DAMAGE.

2-9. If the Spectrum Analyzer is mechanically damaged or fails to meet the specified performance tests, immediately notify the carrier and the nearest Hewlett-Packard Sales and Service Office. (A current list of sales and service offices appears at the back of this manual.) Retain shipping carton and padding material for inspection by the carrier. Any Hewlett-Packard Sales and Service Office will arrange for instrument repair or replacement without waiting for a claim settlement with the carrier.

2-10. POWER REQUIREMENTS.

2-11. SOURCE POWER.

2-12. The Spectrum Analyzer can be operated from a 50- to 60-hertz input line that supplies either 115-volt or 230-volt (±10% in each case) power. Consumed power varies with the plug-ins used but is normally less than 225 watts. Line power enters the display section mainframe and is distributed to the RF and IF sections via internal connectors.

2-13. PRELIMINARY POWER SETTINGS.

2-14. The 115/230 power selector switch at rear of display section must be set to agree with the available line voltage — that is, if the line voltage is 115 volts, the SLIDE switch must be positioned so that 115 is clearly visible. (The instrument is internally fused for 115-volt/60-hertz operation; if 230-volt/50-Hz power is used, refer to fuse replacement procedures in the display section service manual.

2-15. POWER CABLE.

2-16. To protect operating personnel, the National Electrical Manufacturers' Association (NEMA) recommends that instrument panel and cabinet be grounded. The analyzer is equipped with a three-conductor power cable; the third conductor is the ground conductor and, when the cable is plugged into an appropriate receptacle, the insturment is grounded. To preserve the protection feature when operating the instrument from a two-contact outlet, use a three prong-to-two-prong adapter and connect the green lead on the adapter to ground.

2-17. RACK-MOUNTING.

2-18. Althrough the Spectrum Analyzer can be easily used from a bench location, it can also be rack-mounted. Figure 2-1 provides pictorial instructions for rack-mounting the instrument.

2-19. CONNECTIONS.

2-20. If the RF and IF sections are shipped separately, the plug-ins must be mechanically fitted together, electrically connected, and then inserted into the display section mainframe. To make these connections, proceed as follows:

a. Set the 8552A IF section on a level bench. Locate slot near right rear corner of IF section; also, locate metal tab on RF section that engages with this slot.

b. Grasp the 8553L RF section near middle of chassis and raise until it is a few inches above the IF section.

c. Tilt RF section until front of assembly is 10 or 15 degrees higher than the rear.

d. Engage assemblies in such a way that metal tab on RF section slips through the slot on IF section.

e. With the preceding mechanical interface completed, gently lower RF section until electrical plug and receptacle meet.

f. Position RF section as required to mate the plug and receptacle. When plug and receptacle are properly aligned, only a small downward pressure is required to obtain a snug fit.

g. After the RF and IF sections are joined mechanically and electrically, the complete assembly is ready to insert in the display section mainframe.

h. Pick up the RF/IF sections and center in opening of display section. Push forward until assembly fits snugly into display section mainframe.

i. Push in front panel latch to securely fasten assembly in place.

2-21. To separate the RF/IF sections from display section and then to separate the RF section from the IF section, proceed as follows:

a. Push front panel latch in direction of arrow until it releases.

b. Firmly grasp the middle part of latch flange and pull RF/IF sections straight out.

c. Locate black press-to-release lever near right front side of RF section. Press this lever and simultaneously exert an upward pulling force on front edge of RF section.

d. When the two sections separate at the front, raise RF section two or three inches and slide metal tab at rear of RF section out of the slot with which it is engaged.

2-22. INSTALLATION CHECKOUT.

2-23. After equipping the display mainframe with the plug-in RF/IF sections (Paragraph 2-19), the installation procedures specified in Figure 2-2 should be performed. If the instrument is equipped with the RF/IF plug-ins upon receipt, the procedures in Figure 2-2 can be performed immediately.

Table 2-1. Accessories Supplied

Part No.	Name	Description
HP-11593A	50-ohm BNC termination	Two required to terminate FIRST LO OUTPUT and THIRD LO OUTPUT in 8553L RF Section
00140-61607 or 8120-0078	Power Cable	Detachable 3-conductor, 7-1/2 foot NEMA power cable.
5060-0076	Rack-Mounting Kit	Parts and hardware for mounting instrument is 19-inch rack.

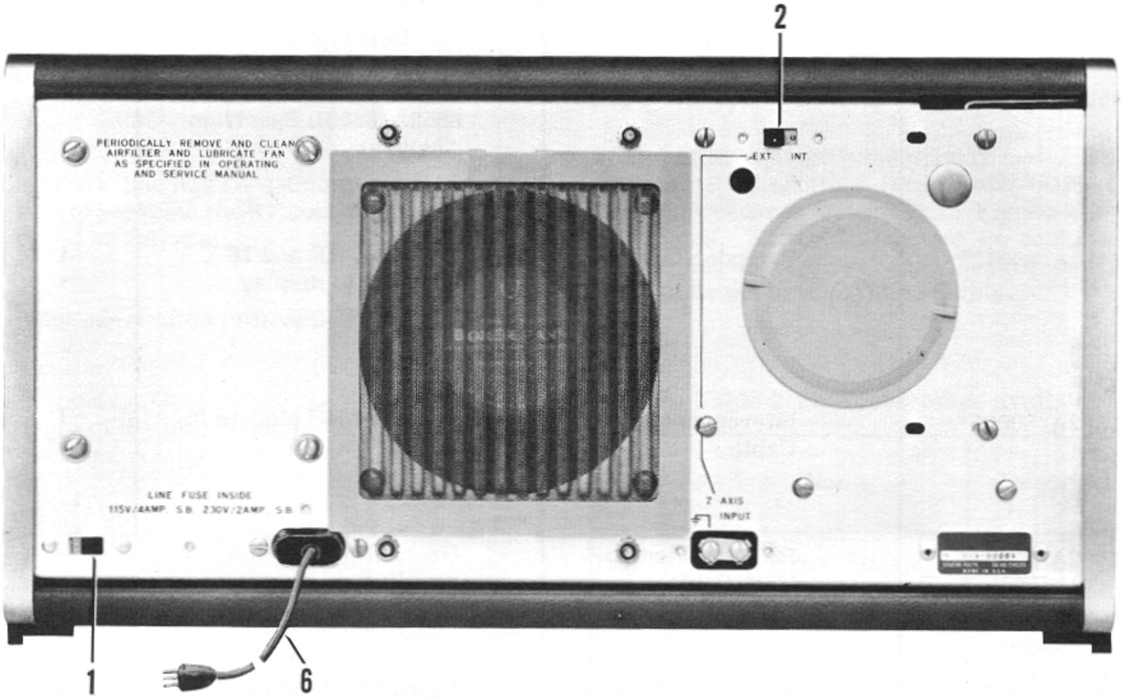
Table 2-2. Accessories Available

Part/ Model No.	Name	Description
1490-0714	Fixed Slides	For rack-mounting such that the instrument can be pushed in or pulled out like a drawer.
1490-0718	Pivot Slides	For rack-mounting such that the instrument can be pushed in or pulled out and also tilted down for easy maintenance.
1490-0712	Slide Adapter Kit	Required for installation of fixed or pivot slides.
8406A	Frequency Comb Generator	Provides frequency markers spaced at 1, 10, and 100 MHz for precise frequency calibration of analyzer ---- frequency accuracy of ±0.01%.

Table 2-3. Accessories Required for Maintenance

Part No	Name	Description	Quantity
11592A	Service Kit	General service of 8552A/8553L Spectrum Analyzer	1
11592A-60012*	Extender Cable	Connects RF and IF plug-ins to display mainframe	1
11592A/60005*	Interconnector Cable	Connects RF plug-in to IF plug-in	1
11592A/60001*	BNC to Selectro Test Cable	General purpose signal-coupling	3
11592A/60002*	Female to Female Selectro Test Cable	Special test cable	1
11592A/60003*	Male to Female Selectro Extender Cable	Special test cables	2
11592A/60011*	Extender Board Assembly	Extender for boards in 8552A and 8553L plug-ins	1
11592A/60010*	Fastener Assembly	Fasteners for extended boards in 8553 plug-in	

*These items make up the Service Kit.



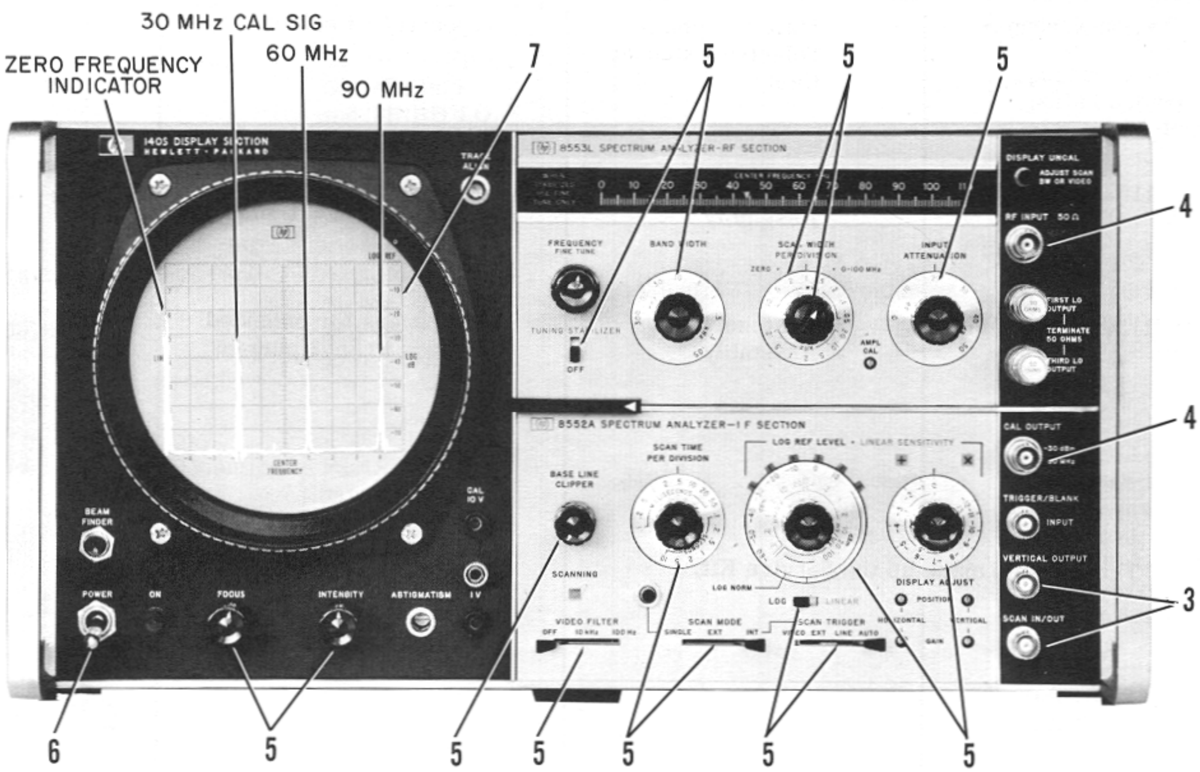


Figure 2-2. Installation Procedures, 8552A/8553L Plug-ins in 140S Display Section

1. Set power selector switch so that visible number (115 or 230) agrees with input power source. (Refer to Paragraph 2-10).

2. Set EXT/INT switch to INT.

3. Terminate FIRST LO OUTPUT and THIRD LO OUTPUT with 50-ohm BNC terminations (08553-6033).

4. Connect cable with BNC fittings from CAL OUTPUT to RF INPUT.

5. BANDWIDTH . . . . 300 kHz

   SCAN WIDTH (outer/black). . . Any position

   SCAN WIDTH (inner/red) . . . . 0-100 MHz

   INPUT ATTENUATION 0

   TUNING STABILIZATION . . . . . ON (up)

   BASE LINE CLIPPER . . . 9 o'clock pos

   SCAN TIME PER DIVISION . . . . 1 MILLISECOND

   LOG REF LEVEL . / LINEAR SENSITIVITY . . . Both controls set to black 0

   LOG/LINEAR . . . . LOG

   VIDEO FILTER . . . . OFF

   SCAN MODE . . . . INT

   SCAN TRIGGER . . . . AUTO

   INTENSITY . . . . Midrange

   FOCUS . . . . As required

6. Plug power cord into source outlet; set POWER switch to on (up) and listen for operation of fan.

7. Observe display pattern shown in Figure 2-2. If such a display is not obtained, refer to Paragraph 2-8.

Figure 2-2. Installation Procedures, 8552A/8553L Plug-ins in 140S Display Section

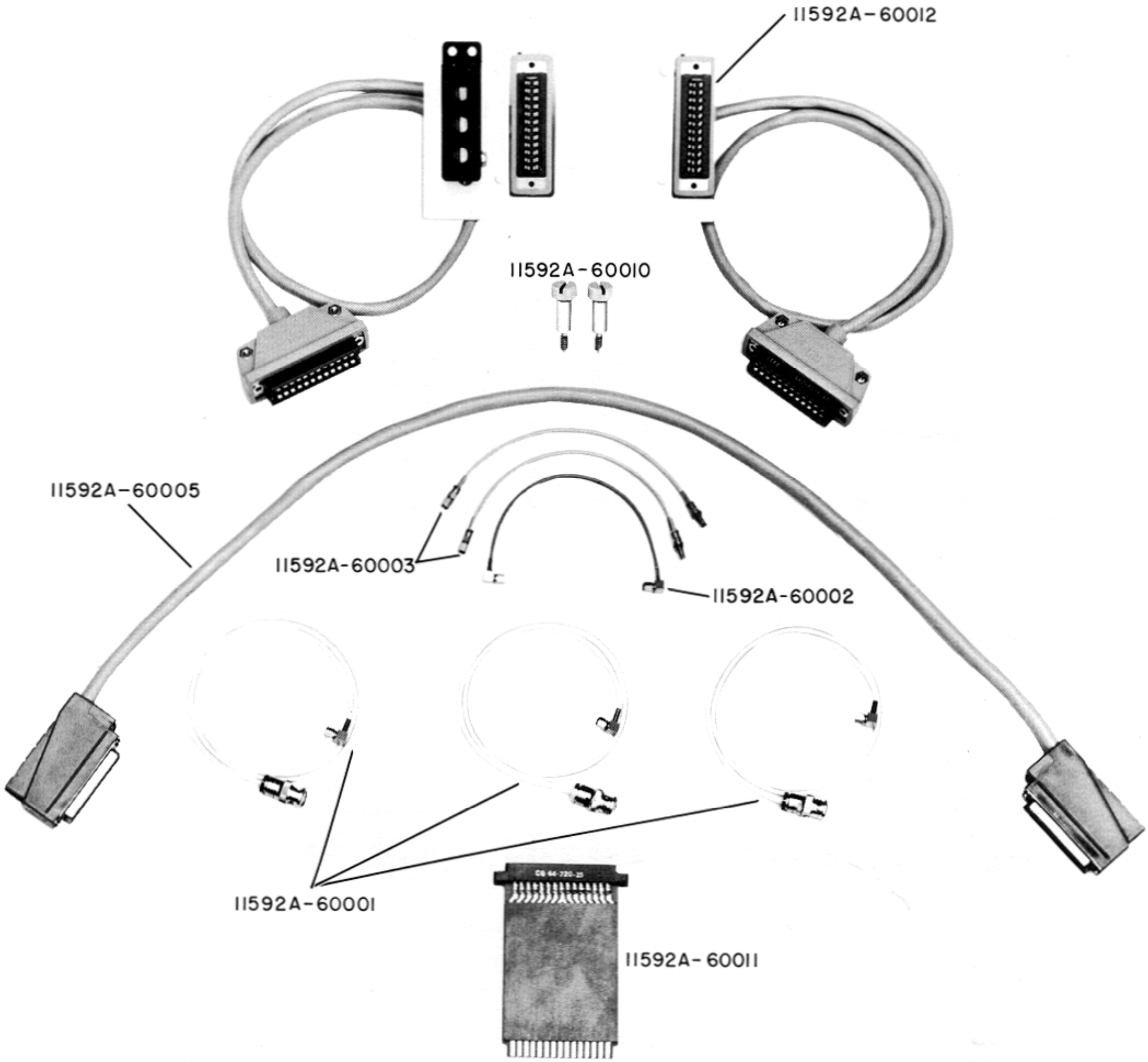


Figure 2-3. Service Kit Required for Maintenance

SECTION III

OPERATION

3-1. INTRODUCTION.

3-2. This section provides complete operation instructions for the HP 8552A/8553L Spectrum Analyzer. Front and rear panel controls and indicators are identified and briefly described in Figures 3-1 and 3-2. Operational adjustments are detailed in Figure 3-3 and general operating instructions are provided in Figure 3-4. The applications data discloses some of the measurements that are best made in the FREQUENCY-DOMAIN. Supplementary operating information is also provided in areas where it is useful.

3-3. CONTROLS, INDICATORS, AND CONNECTORS.

3-4. The RF/IF sections are commonly used with a 140S or a 141S Display Section; however, any display section in the HP 140 series can be used as a mainframe for the spectrum analyzer. The instruments shown in Figure 3-1 use, respectively, a 140S and a 141S mainframe. The rear panel of the instrument, shown in Figure 3-2, is the same for either display section. Front and rear panel illustrations are accompanied by control/indicators, connector, and receptacle descriptions.

3-5. OPERATIONAL ADJUSTMENTS.

3-6. During checkout at the factory, the spectrum analyzer is adjusted for proper operation and only minor adjustment of front panel controls is required upon receipt of the instrument. However, for instrument familiarity, the customer should make basic adjustments. Figure 3-3 provides adjustment information.

3-7. GENERAL OPERATING INSTRUCTIONS.

3-8. These instructions (Figure 3-4) will familiarize the operator with basic operating functions of the spectrum analyzer, regardless of whether the mainframe is a 140S (nonstorage CRT) or a 141S (Variable persistence and storage CRT). Additional information that is applicable only to the 141S display section is described in paragraphs 3-9 through 3-20. Refer to Paragraph 3-27 for details regarding specific setups and display interpretations.

3-9. STORAGE TUBE DEFINITIONS.

a. WRITE - transform an input signal to a CRT display.

b. STORE - retain display on CRT at reduced intensity.

c. VIEW - return stored display to CRT at normal intensity.

d. ERASE - remove displays previously stored or written on the CRT.

e. INTENSITY - brightness of a written signal.

f. PERSISTENCE - length of time a written signal on the CRT is visible.

g. BACKGROUND ILLUMINATION - greenish cloud on the CRT during turn-on and when intensity is excessive.

h. BLOOM - nonsymmetrical expansion of display when scan time and intensity settings are improperly correlated.

i. FADE POSITIVE - display obscured by slow-blooming.

j. FADE NEGATIVE - nonsymmetrical dimming of the display.

k. SCAN TIME - time required for beam to move across the screen.

m. BURN- permanent damage to CRT resulting from excessive intensity; the discolored (burned) area will remain for the life of CRT.

3-10. VARIABLE PERSISTENCE AND STORAGE FUNCTIONS.

3-11. PERSISTENCE AND INTENSITY. These controls largely determine how long a written signal will be visible. Specifically, PERSISTENCE controls the rate at which a signal is erased and INTENSITY controls the trace brightness as the signal is written. With a given PERSISTENCE setting, the actual time of trace visibility can be increased by greater INTENSITY. Since the PERSISTENCE control sets the rate of erasing a written signal, it follows that a brighter trace will require more time to be erased. Conversely, a display of low intensity will disappear more rapidly. The same principle applies to a stored display of high and low intensity.

CAUTION

Excessive INTENSITY will damage the CRT storage mesh. The INTENSITY setting for any sweep speed should just eliminate trace blooming with minimum PERSISTENCE setting.

3-12. PRESENTATION SELECTOR. This control selects the mode in which the CRT functions. In ERASE, the other three functions are disconnected and all written signals are removed from the CRT. In WRITE, a signal or signals can be written on the CRT. The STORE position disconnects the WRITE function and implements signal retention at reduced intensity. In STORE, PERSISTENCE and INTENSITY have no function. In VIEW, the stored display is intensified to a fixed brightness; again, PERSISTENCE and INTENSITY have no effect.

3-13. WRITING RATE. In MAX, the rate of erasing a written signal is decreased. Since the erasing rate is decreased, the entire screen becomes illuminated more rapidly and the display is obscured. Thus, effective persistence and storage time are reduced. After WRITING RATE is set to MAX, the old display should always be erased.

3-14. OPERATING TIPS.

3-15. These tips will familiarize the operator with the variable persistence and storage controls and assist in obtaining optimum presentations on the CRT.

a. To operate with normal persistence, set WRITING RATE to NORMAL, the presentation selector to WRITE, and turn PERSISTENCE fully counterclockwise. Adjust INTENSITY to a point where no trace blooming appears; then, set PERSISTENCE to NORMAL. Do not increase intensity. When sweep speed is changed, readjust INTENSITY for no-bloom trace.

b. For variable persistence operation, use the minimum INTENSITY and the maximum PERSISTENCE compatible with a well-resolved presentation.

c. Use WRITING RATE in MAX only for signals with a fast rise-time, single-sweep displays, or to improve uniformity of trace intensity. The MAX position causes a "fade positive" of the display; accordingly, persistence or storage time is reduced.

d. To store a display, set presentation selector to WRITE, adjust INTENSITY and PERSISTENCE for the desired display, and set presentation selector to STORE.

e. To view a stored display, set presentation selector to VIEW.

f. To store more than one display, set presentation selector to WRITE, set PERSISTENCE fully clockwise, and set INTENSITY as required; allow first display to be written on the CRT. Set INTENSITY fully counterclockwise and connect second signal to be stored. Slowly rotate INTENSITY clockwise until second display appears. To store both displays, set presentation selector to STORE.

g. Even with the instrument turned off, a stored display will remain for several days. To retrieve such a display, set presentation selector to VIEW before turning on the instrument.

h. To erase all persistent or stored displays, set presentation to WRITE and rotate PERSISTENCE counterclockwise; alternately, set presentation selector to ERASE for approximately two seconds and release.

i. To obtain a well-defined trace when using the instrument for single-sweep operation, the FOCUS control must be indirectly adjusted. Set SCAN MODE to SINGLE and erase CRT. Press the SINGLE sweep pushbutton and note trace definition. Vary FOCUS setting after each sweep until sharpest trace is obtained.

j. If only a portion of a slow-sweep display is desired, set presentation selector to STORE when trace has reached the desired point. At this point, the write gun is blanked and the written portion is stored.

k. To improve screen-display contrast, use a viewing hood.

m. If display is recorded at high intensity, more than one erase cycle may be required to clear the CRT. Intermittently repeat the 2-second erase cycle until CRT is cleared.

3-16. SINGLE-SWEEP OPERATION.

3-17. To write with persistence or to store a single sweep, trial-and-error setting of INTENSITY is the best approach. Signal amplitude and the required sweep time affect the persistence. For example, with maximum PERSISTENCE and some particular INTENSITY setting, a single-sweep trace may bloom; whereas, a single-sweep trace with several signal excursions will not bloom. To determine best INTENSITY setting, connect a signal of approximately the same amplitude as that of the signal to be written; set SCAN TIME PER DIVISION to obtain the necessary overall scan time. Set PERSISTENCE fully clockwise and press SINGLE sweep pushbutton. Set INTENSITY as far clockwise as possible without causing blooming. Repeat the single-sweep test signal; erase and reset INTENSITY after each trace until the display is optimized. Under these circumstances, maximum persistence should be obtained. To retain display, set presentation selector to STORE.

3-18. Single-sweep signals with exceptionally fast rise times can be written with more brightness by setting WRITING RATE to MAX. The screen will be unevenly illuminated after erasing when WRITING RATE is set to MAX: however, INTENSITY can be set high enough to make the display visible through the illumination. A signal written with WRITING RATE set to MAX will be obscured by positive fading more rapidly than a signal written with WRITING RATE set to NORMAL.

3-19. Single-sweep signals requiring slow-sweep times may have low brightness at the center of the screen. With INTENSITY and PERSISTENCE fully clockwise and WRITING RATE in NORMAL, initiate a single sweep of the test signal; if the center brightness is low, wait for one to three minutes for the low-brightness area to become brighter. Likewise, if the entire display brightness appears below a usable level, or if the display is not visible, wait for one to five minutes for the display to stabilize.

3-20. For single-sweep signals requiring an overall scan period of from one to five minutes, set PERSISTENCE and WRITING RATE to NORMAL: adjust INTENSITY, as required, to prevent blooms. Initiate sweep and after it is complete, set presentation selector to VIEW and set PERSISTENCE somewhere in its variable range. The completed display may then be viewed for up to one minute or stored (presentation selector to STORE) for up to one hour.

3-21. STORAGE TUBE DEGAUSSING.

3-22. When the CRT is operated near strong magnetic fields such as a BWO, the CRT storage elements can become magnetically polarized. Under these circumstances, the display is no longer accurately calibrated; it is also subject to geometrical distortion such as foldover, tilt, and partial skewing. To correct the problem, the tube must be degaussed; the following methods are recommended.

a. A small hand-held degausser can be used to demagnetize the tube without removing if from the instrument. Results are not as satisfactory, but for quick, convenient return-to-service, this method is recommended.

b. To thoroughly demagnetize the storage tube, remove it from instrument. Energize the degausser; place it next to glass exterior and, with unidirectional motions, slowly draw it across every surface of the tube. When all surfaces have been demagnitized, slowly draw degausser away from tube and turn it off. Re-install tube.

3-23. PHOTOGRAPHIC TECHNIQUES.

3-24. Excellent oscillographic photography is possible when the 8552A/8553L Spectrum Analyzer is used with proper optics and when proper techniques are employed in setting-up, taking, and processing. Either the HP 196B or the 197A Oscilloscope Camera can be used for recording on film; both cameras contain an Ultra-Violet light source. The UV light causes a uniform glow of the CRT phosphor; thus, a gray background is inherent in the finished photograph. The gray background is sharply contrasted with both the white trace and the black graticule lines; the oscillogram is, therefore, very easy to read. The UV illumination is normally used only when the CRT is of the nonstorage and fixed-persistence type (140A or 140S Display Section). For a storage or variable-persistence CRT (141A or 141S Display Section), a uniform gray background is obtained by simply taking the photograph in STORE rather than in VIEW. See Figure 3-5 for some recommended guidelines in taking good photographs.

3-25. To obtain a uniform gray background with a nonstorage and fixed-persistence CRT, the double-exposure technique is best.

a. Remove blue filter from face of CRT.

b. Determine the exposure required when, without any trace on the screen the graticule is illuminated by UV light. Photograph the display graticule and then turn off the UV light. (Using the HP 197A Oscilloscope Camera, a good starting point is with the GRAT ILLUM switch set to ON, the arrow on GRAT ILLUM control pointing to about the middle of the blue bar, and the SHUTTER SPEED and LENS f/NO controls set to the blue-coded numbers.)

c. With SCAN MODE switch of analyzer set to INT, bring up INTENSITY until display trace is about half of normal viewing brightness.

d. Move SCAN MODE switch to SINGLE and shut viewing window of camera. Set LENS f/NO control to T and press shutter release. Now press SINGLE scan pushbutton of analyzer and wait until SCANNING lamp extinguishes.

e. Press shutter release to close aperature. Remove film positive and process as specified in instructions furnished by the manufacturer.

3-26. To obtain quality photographs using a storage and variable-persistence CRT, proceed as follows.

a. Set GRAT ILLUM switch on camera to OFF.

b. Adjust FOCUS, INTENSITY, and PERSISTENCE of analyzer until the written display is sharp, without blooms, and evenly illuminated.

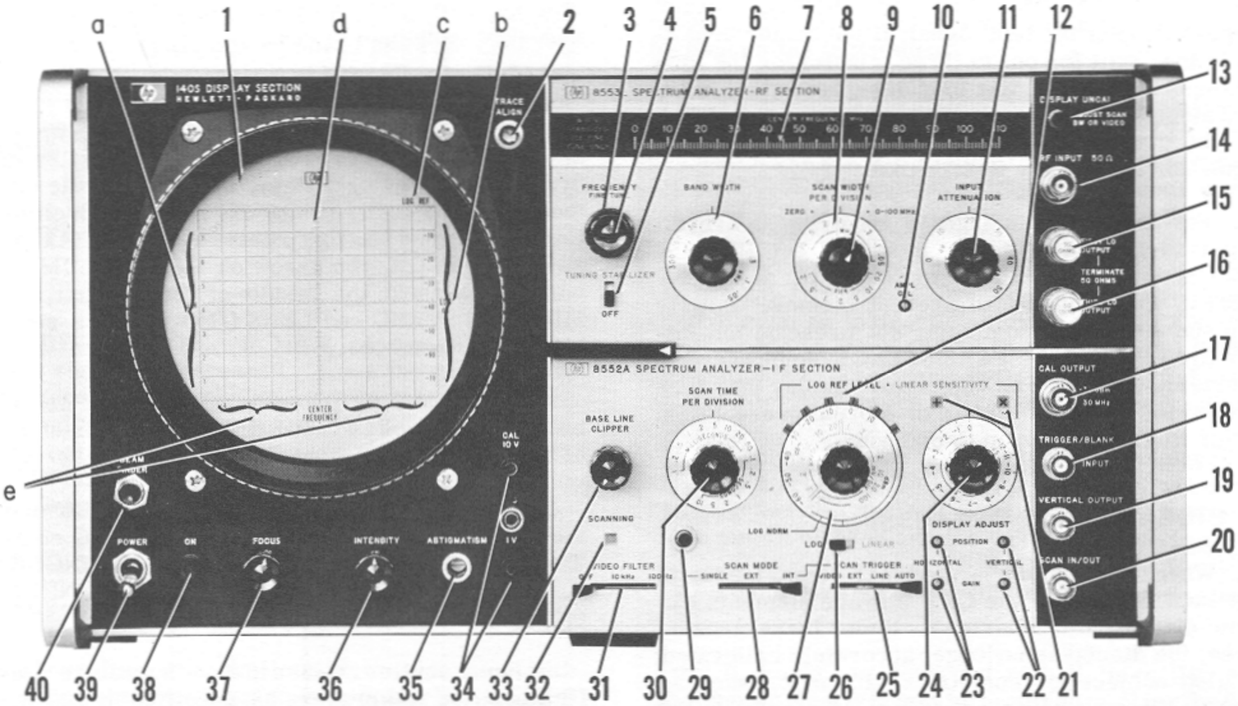
c. Store the written display.

d. Set SHUTTER SPEED and LENS f/NO controls of camera to the blue-coded numbers and take photograph.

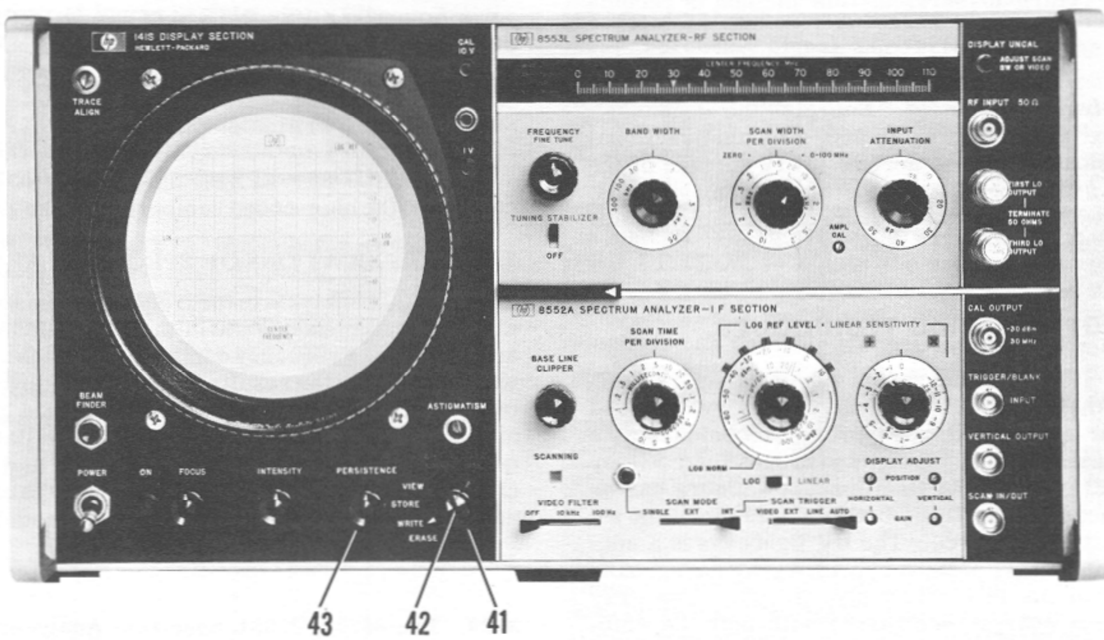
3-27. APPLICATIONS OF SPECTRUM ANALYSIS.

3-28. Signal analysis in the frequency domain is recognized as a tremendous aid in the evaluation of circuits and systems. Frequency-domain techniques are logical, easy to use, and the results are easy to interpret. Some of the more important frequency-domain phenomena are: spectral purity and distortion of oscillators, frequency response, parasitic oscillations, and distortion characteristics of amplifiers, frequency parameters of networks and filters, and all types of modulation.

3-29. The 8552A/8553L Spectrum Analyzer is capable of analytically resolving almost any problem whose unknowns are amplitude and frequency; thus, over and above the general-purpose applications, the instrument is a powerful observation-and-measurement fool for surveillance, EMC, and systems work. To define each instrument application is beyond the scope of this manual. Some significant applications of the 8552A/8553L Spectrum Analyzer are shown in Figure 3-6A through 3-6K.



A. With 140S Display Section



B. With 141S Display Section

Figure 3-1. Spectrum Analyzer, Controls, Indicators, and Connectors

1. Display Screen with Graticule.
   a. LINear calibration (read from bottom to top of screen).
   b. LOGarithmic calibration (read from top LOG REF line towards bottom of screen).
   c. Amplitude calibration reference. (Refer to item 12.)
   d. Center frequency of selected scan width.
   e. Relative frequencies with respect to center frequency.
2. Makes base line parallel with the horizontal graticule lines.
3. Coarse-tunes analyzer center frequency.
4. Fine-tunes analyzer center frequency.
5. In TUNING STABILIZER position, first LO is automatically phase-locked to a reference crystal harmonic for scan widths of 20 kHz/DIV and less.
6. Selects 3-dB IF bandwidths.
7. Indicates center frequency to which instrument is tuned.
8. Indicates per-division scan width.
9. Selects full-spectrum "preset" scan, per division scan as determined by setting of outer dial, or "fixed-frequency" receiver in 0 (zero scan) position.
10. RF amplitude gain calibration.
11. Attenuates input signal in 10-dB steps and lights one index lamp (12) for each of its six positions. The left index lamp lights for 0 (zero) attenuation. The lighted lamp and steps-in-attenuation then progress in clockwise order; thus, absolute amplitude calibration is preserved.
12. With LOG/LINEAR switch (27) set to LOG, lighted index lamp refers matching dB graduation to top LOG REF line of graticule; for example, if -30 dBm is opposite lighted lamp, then top LOG REF line is -30 dBm and so serves as an absolute amplitude reference. With LOG/LINEAR switch set to LINEAR, lighted index lamp indicates the matching voltage graduation to be used as a per-division multiplier for calibrated voltage readings. (Refer to item 27.)
13. Lights when relationship between scan time, scan width, bandwidth, and video filtering is such that accuracy of vertical calibration is impaired.
14. 50-ohm coaxial input connector.

CAUTION

To prevent mixer burnout, the values (1V rms/0.2 Vdc) shown adjacent to the connector must not be exceeded. Specifically, the squarewave calibrator (CAL - 1V and 10V) of the display section must not be connected to the RF INPUT.

15. Provides FIRST LO output voltage; terminated in 50 ohms when not in use.
16. Provides THIRD LO output voltage; terminated in 50 ohms when not in use.
17. Provides a 30-MHz signal at -30 dBm for amplitude calibration of spectrum analyzer.
18. Provides connection whereby scan ramp or blanking circuits can be externally triggered. Internal scan can be externally triggered and external scan can be externally blanked. (Refer to time 20.)
19. Detected video output proportional to vertical deflection on CRT.
20. For receiving an external scan ramp or output coupling for the internally-generated scan ramp. Input or output function determined by INT/EXT positions of SCAN MODE switch (28).

Figure 3-1. Spectrum Analyzer, Controls, Indicators, and Connectors

21. Plus "+" lights when logarithmic amplification (26) is selected; times "x" lights when linear amplifications "26" is selected. With "+" lighted, LOG REF line (12) is sum (black numerals) of LOG REF LEVEL . LINEAR SENSITIVITY controls. With "x" lighted, per/division absolute voltage amplitude is product (blue numerals) of LOG REF LEVEL . LINEAR SENSITIVITY controls.

22. Adjusts vertical position and gain of trace.

23. Adjusts horizontal position and gain of trace.

24. Indicates 1-dB increments for logarithmic amplification; indicates multiplication factors up to unity for linear amplification.

25. Selects scan trigger mode.

26. Selects logarithmic or linear amplification.

27. Assuming that dB graduation matches position of lighted index lamp, indicates power level black numerals of LOG REF graticule line when LOG/LINEAR switch (26) is set to LOG. With LOG/LINEAR switch set to LINEAR, indicates per-division multiplier for calibrated voltage amplitude for whatever voltage graduation (blue numerals) matches position of lighted index lamp.

28. Selects scan ramp mode. Ramp is internally generated for SINGLE/INT positions but it must be externally supplied for EXT position. (Refer to item 20.)

29. Press to initiate scan with SCAN MODE switch set to SINGLE.

30. Controls time for one scan.

31. Selects 100 Hz or 10 kHz low-pass filter for detected video.

32. Lights for duration of each scan.

33. Blanks lower part of trace to prevent over-exposure of photographs. Blanking function also prevents blooming with a variable-persistence/storage display section.

34. Provides 1- and 10-volt, peak-to-peak, 60-Hz square-wave outputs.

CAUTION

These calibrated outputs must never be used with the spectrum analyzer. (These outputs are for use only with the 1400-series oscilloscope plug-ins).

35. Used with FOCUS control (37) to obtain smallest spot with maximum roundness.

36. Adjusts brightness of CRT display.

CAUTION

Excessive brightness for a static or very slow-moving trace may burn the phosphor and permanently damage the CRT. This caution is applicable to both the fixed and variable-persistence/storage CRT; however, the latter is especially vulnerable to operational errors of this type.

37. Focuses CRT beam.

38. Lights when line voltage is applied.

39. Switches line voltage to instrument.

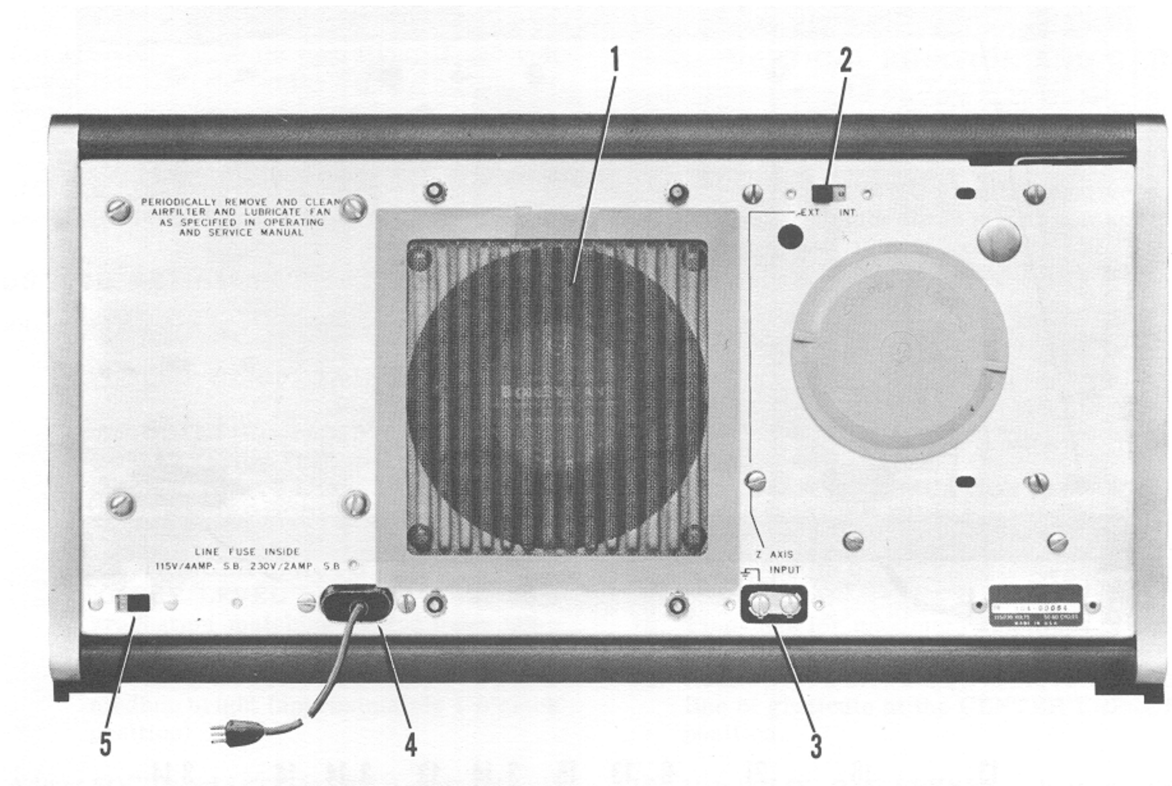
40. When used with 1400-series oscilloscope plug-ins, intensifies and returns beam to CRT, regardless of deflection potentials.

41. Selects VIEW, STORE, WRITE, or ERASE functions.

42. Selects writing rate.

43. Varies time the trace is visible.

Figue 3-1. Spectrum Analyzer, Controls, Indicators, and Connectors (Cont.)



1. Cooling fan and filter.

2. Selects INTernal or EXTernal modulation of CRT control grid.

3. Z-axis input connector.

4. Input power receptacle.

5. Set for operation from 115V/50-60 Hz or 220V/50 Hz line.

Figure 3-2. Spectrum Analyzer, Rear Panel Controls and Connectors

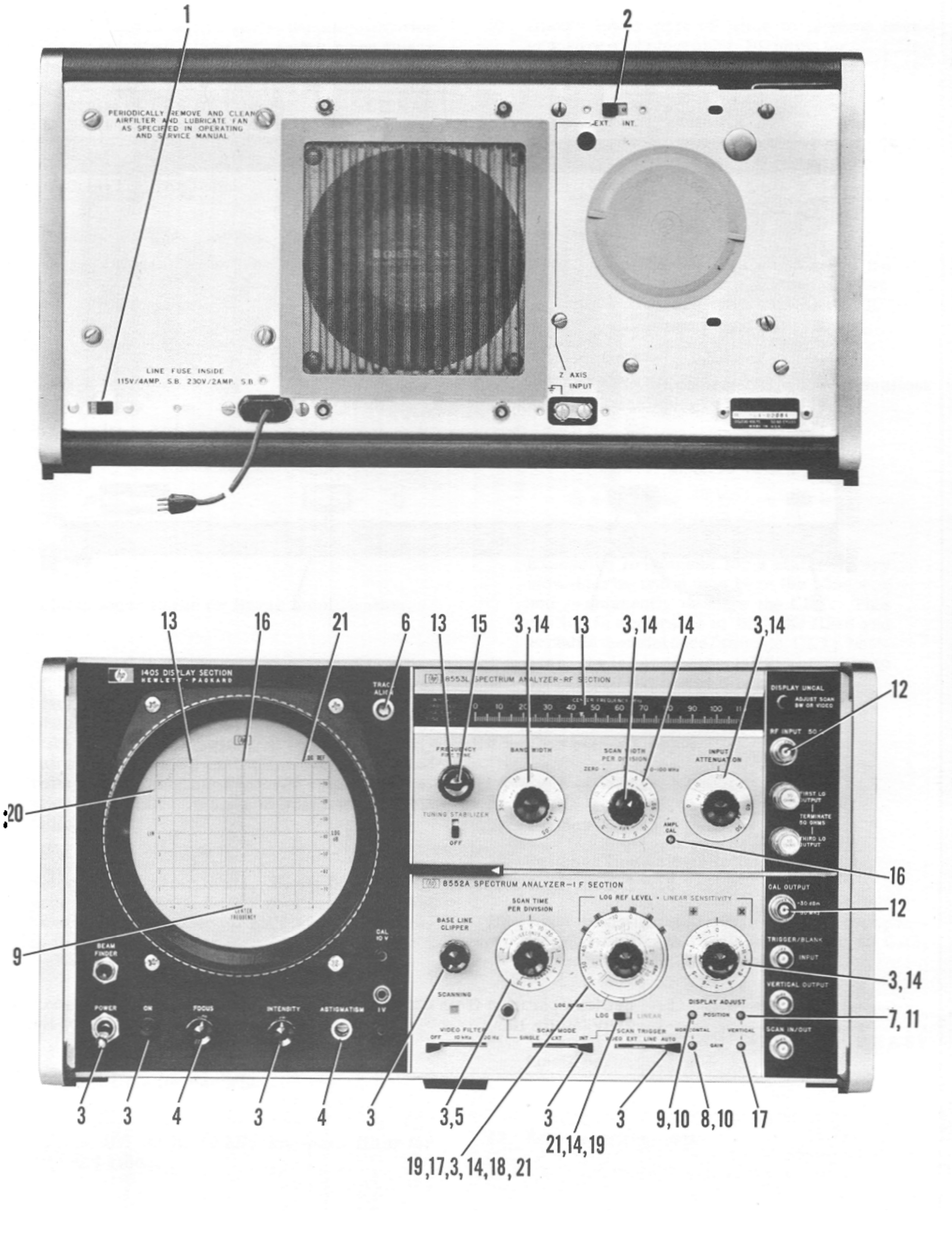


Figure 3-3. Operational Adjustments

INPUT POWER AND INTENSITY MODULATION.

1. Set 115/230 switch to correspond with available input voltage. (The instrument is fused for 115-volt, 50/60 Hz operation; if 230-volt power is used, refer to the service manual for fuse replacement procedures.)

2. Set INT/EXT switch to INT. (Set to EXT only if CRT is to be externally modulated — normally used with 1400-series time-domain plug-ins.)

FOCUS AND ASTIGMATISM ADJUSTMENTS

3. Set: POWER ON (up - observe that ON lamp lights
   BASE LINE CLIPPER fully counterclockwise
   SCAN WIDTH (inner/red) to ZERO
   INPUT ATTENUATION to 0 dB
   BANDWIDTH to .3 kHz
   SCAN TIME PER DIVISION to 10 SECONDS
   SCAN MODE to INT
   SCAN TRIGGER to AUTO
   LOG REF LEVEL controls: -20 dBm graduation matching lighted index lamp and vernier set to 0
   INTENSITY clockwise until trace is medium bright (approximately 1 o'clock position)

4. Adjust FOCUS and ASTIGMATISM controls until combined effect produces best resolution (maximum roundness without fuzz) of the dot.

TRACE ALIGNMENT

5. Set SCAN TIME PER DIVISION to 1 MILLISECOND.

6. If not already aligned, adjust TRACE ALIGN until trace is aligned with horizontal line of graticule.

HORIZONTAL POSITION AND GAIN

7. For convenience in making these adjustments, move trace to upper half of graticule by adjusting the VERTICAL POSITION control.

8. Rotate HORIZONTAL GAIN until trace is of minimum length.

9. Rotate HORIZONTAL POSITION until trace is centered on CENTER FREQUENCY line of graticule.

10. Alternately adjust HORIZONTAL POSITION/GAIN controls until trace begins at first line of graticule and ends at last.

11. Readjust VERTICAL POSITION until trace aligns with bottom line of graticule.

VERTICAL POSITION AND GAIN

12. Connect CAL OUTPUT (30 MHz/ -30 dBm) signal to RF INPUT; select 0-100 SCAN WIDTH.

13. Tune FREQUENCY until negative marker causes maximum dip in signal that appears on "-2" vertical line of graticule (30 MHz) red marker on CENTER FREQUENCY MHz scale should be pointing at 30.

14. Set: SCAN WIDTH (inner/red) to PER DIVISION
   SCAN WIDTH (outer/black) to 0.2 kHz
   BAND WIDTH to 300 kHz
   LOG-LINEAR to LOG
   INPUT ATTENUATION to 0
   LOG REF LEVEL: -30 dBm graduation to match lighted index lamp and vernier set to 0

15. Fine-tune for maximum amplitude of signal.

16. Rotate AMPL CAL until trace is centered on top line of graticule at the CENTER FREQUENCY position.

17. Rotate LOG REF LEVEL counterclockwise and note that the signal decreases one division (10 dB) for each calibrated switch position. If trace moves one division per step in lower part of graticule but the amplitude creeps upward near top of graticule, adjust VERTICAL GAIN until each step is equal.

LINEAR AND LOGARITHMIC ADJUSTMENT

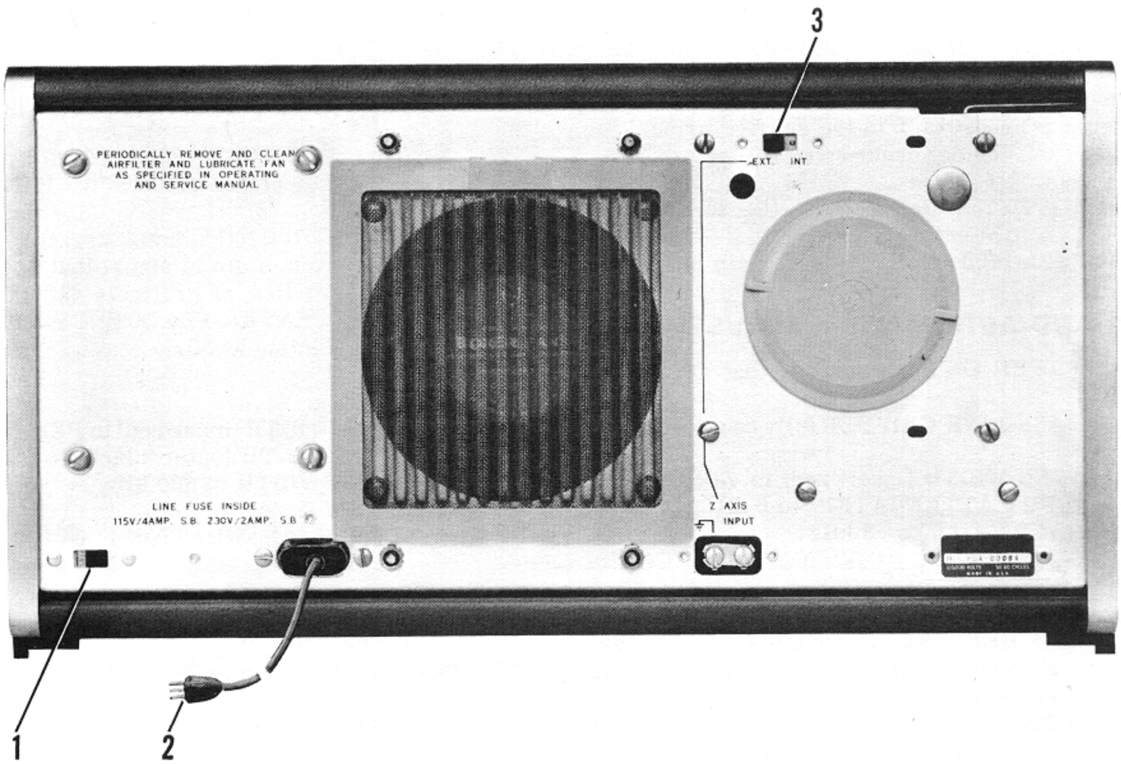
18. Rotate LOG REF LEVEL control until signal trace appears on fourth graticule line from bottom.

19. Set LOG/LINEAR switch to LINEAR and rotate LOG REF LEVEL control until 1 mV/DIV is matched with the lighted index lamp.

20. Reading from bottom of graticule (LIN scale), signal amplitude should be 7.07 millivolts. If it is not, repeat vertical position and gain adjustments until proper reading is obtained.

21. Rotate LOG REF LEVEL control until -30 dBm graduation matches the lighted index lamp. Set LOG/LINEAR switch to LOG. Signal trace should align with top (LOG REF) line of the graticule.

Figure 3-3. Operational Adjustments



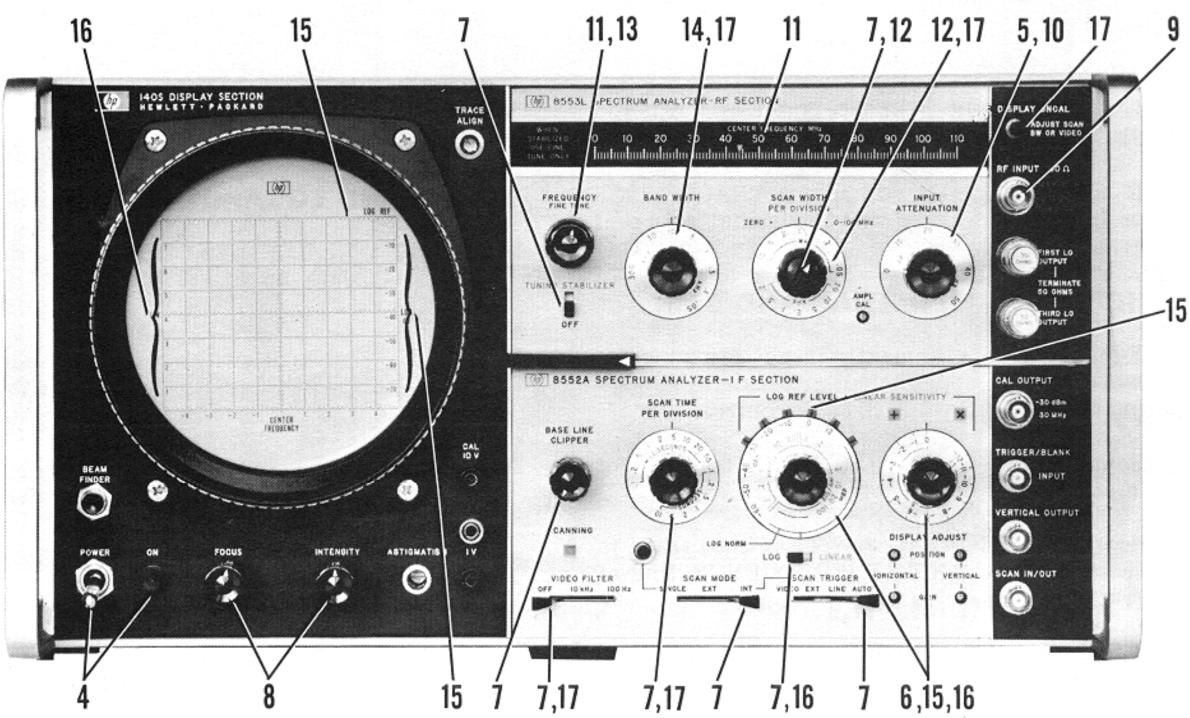


Figure 3-4. General Operating Instructions

PRELIMINARY SETTINGS

1. Set to correspond with available input voltage. (The instrument is fused for 115-volt/60 Hz operation; if 230-volt/50-Hz power is used, refer to fuse replacement procedures in manual on display section mainframe.

2. Plug into power outlet; use ground-pin adapter for electrical systems having no grounding wire.

3. Set to INT.

4. Set POWER switch to on (up); be sure that ON lamp lights and fan operates.

CAUTION

Do not use instrument if fan operation is abnormal. To do so may shorten the life of certain components; also, instrument warranty may be jeopardized.

5. Set INPUT ATTENUATION to 50.

6. LOG REF LEVEL · LINEAR SENSITIVITY controls: Rotate large control until one of the peripheral black marks aligns with LOG NORM. Rotate (vernier) small knob fully counterclockwise.

7. Set: VIDEO FILTER to OFF
   SCAN MODE to INT
   SCAN TRIGGER to AUTO
   LOG/LINEAR to LOG
   SCAN TIME PER DIVISION for viewing convenience
   BASE LINE CLIPPER fully counterclockwise
   SCAN WIDTH (inner/red) to 0-100 MHz
   BANDWIDTH (300 kHz automatically selected for 0-100 MHz scan)
   TUNING STABILIZER to on (up)

8. Adjust FOCUS and INTENSITY for best resolution of baseline trace.

SIGNAL CONNECTION AND IDENTIFICATION

CAUTION

To avoid circuit damage, input signals must not exceed 1 V rms or 0.2 Vdc.

9. Connect any unknown signal within frequency range of 1 kHz to 110 MHz.

10. Set INPUT ATTENUATION so that signal amplitude is adequate for viewing.

11. Tune with coarse FREQUENCY until negative marker causes maximum "dip" in signal of interest. Read frequency under red marker on CENTER FREQUENCY MHz scale.

EXPANDING SIGNAL FOR STUDY AND MEASUREMENT

12. Set SCAN WIDTH (inner/red) switch to PER DIVISION: set (outer/black) switch to provide the necessary spectrum detail. (Select blue numbers to narrow the viewed spectrum; select black numbers to widen the viewed spectrum.)

13. Adjust coarse and fine FREQUENCY controls to center the signal of interest.

14. Select BANDWIDTH compatible with input-signal parameters, but not one which causes DISPLAY UNCAL to light.

15. Use LOG REF LEVEL control to establish calibrated power level of LOG REF line of graticule. Read power level of signal directly by adding power figure (dBm) opposite the lighted index lamp to the difference between signal peak and LOG REF line. (Example: -50 dBm opposite lighted index lamp and signal peak at center graticule line of display.

    signal power level = -50 + (-40) = -90 dBm)

16. Set LOG/LINEAR switch to LINEAR. Use LOG REF LEVEL to establish per-division linear multipliers (μV/DIV and mV/DIV). If necessary, set vernier control for sub-multiplier. Multiply number of graticule divisions that enclose signal by selected multipliers. (Example: signal peak at center line of display graticule, 1 V/DIV opposite lighted index lamp, and vernier set to .5 — signal amplitude, reading from bottom of graticule = 4 divisions x 1μV 01V x .5 = 2μV.)

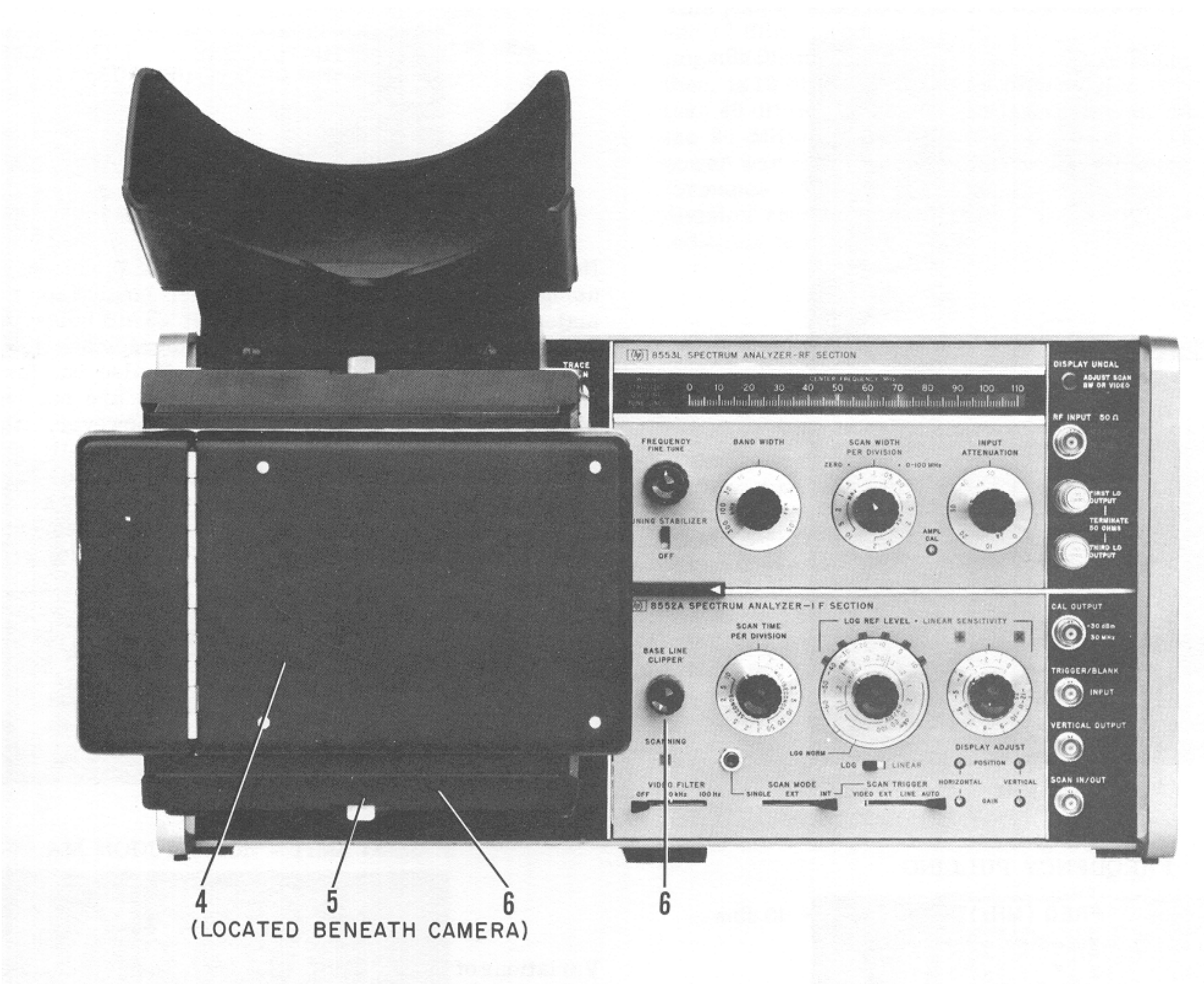
DISPLAY CALIBRATION

17. Absolute amplitude calibration of the CRT display is directly related to settings of the following controls: SCAN TIME, PER DIVISION, BAND WIDTH, SCAN WIDTH PER DIVISION, and VIDEO FILTER. During operation, the settings of these controls are continually monitored and, if the combination of settings will not permit a calibrated display, the DISPLAY UNCAL lamp lights. With the VIDEO FILTER switch set to OFF, typical values for ON/OFF conditions of the DISPLAY UNCAL lamp are given on following page.

Figure 3-4. General Operating Instructions

Table 3-1. Display Calibration Conditions

SCAN TIME PER DIVISION	BANDWIDTH	SCAN WIDTH PER DIVISION	DISPLAY UNCAL
1 ms	300 kHz	10 MHz	Off
1 ms	100 kHz	10 MHz	On
1 ms	100 kHz	5 MHz	Off
1 ms	30 kHz	5 MHz	On
5 ms	30 kHz	2 MHz	Off
5 ms	10 kHz	2 MHz	On
20 ms	10 kHz	1 MHz	Off
20 ms	3 kHz	1 MHz	On
0.1 s	3 kHz	.5 MHz	Off
0.1 s	1 kHz	.5 MHz	On
0.5 s	1 kHz	.2 MHz	Off
0.5 s	.3 kHz	.2 MHz	On
2 s	.3 kHz	.1 MHz	Off
2 s	.1 kHz	.1 MHz	On
10 s	.1 kHz	.05 MHz	Off
10 s	.05 kHz	.05 MHz	On
5 s	.1 kHz	20 kHz	Off
2 s	.1 kHz	20 kHz	On
2 s	.1 kHz	10 kHz	Off
1 s	.1 kHz	10 kHz	On
1 s	.1 kHz	5 kHz	Off
.5 s	.1 kHz	5 kHz	On
.5 s	.1 kHz	2 kHz	Off
.2 s	.1 kHz	2 kHz	On
.2 s	.1 kHz	1 kHz	Off
.1 s	.1 kHz	1 kHz	On
.1 s	.1 kHz	.5 kHz	Off
50 ms	.1 kHz	.5 kHz	On
50 ms	.1 kHz	.2 kHz	Off
20 ms	.1 kHz	.2 kHz	On



Note: Before taking pictures, read paragraph 3-23.

1. Perform the general operating instructions specified in Figure 3-4.

2. Install and align oscilloscope camera; adjust camera focus and reduction ratio. (Refer to the HP 197A manual for detailed mounting and adjustment instructions.)

3. Open back of camera; clean rollers and remove lint, dust, and any accumulated residue.

4. Load film pack; Polaroid® ASA 3000 is recommended.

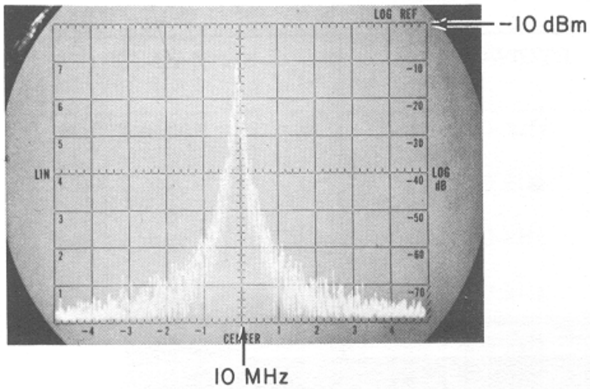
5. Adjust FOCUS control of analyzer for finset trace.

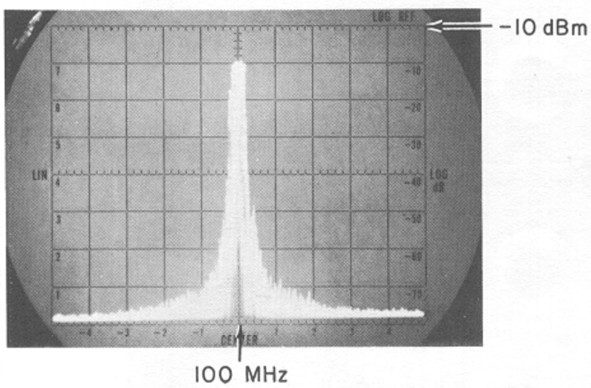
6. Adjust INTENSITY and BASE LINE CLIPPER to prevent blooming or fogging of the picture.

®Polaroid by Polaroid Corporation.

Figure 3-5. Photographic Procedures

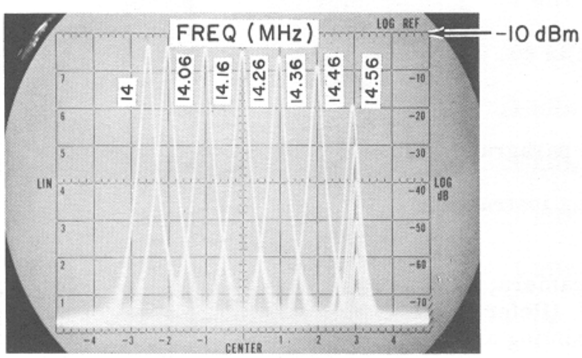
OSCILLATOR SPECTRAL PURITY





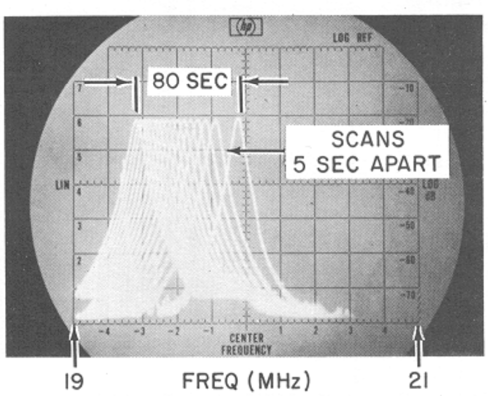
Here the spectral purity of oscillators is compared using a spectrum analyzer. In upper photograph the major noise sidebands are about 65 dB below the carrier. The oscillator in lower photograph has about the same sideband noise level, but it also has low-frequency residual FM. The sidebands are not resolved by the 0.3 kHz IF bandwidth; however, the *deviation rate is low enough so that you actually see* the back-and-forth movement of the CW signal. The peak-to-peak frequency deviation is about 4 kHz (10 kHz per division) and, since the center frequency is 100 MHz, stability is 4 parts in 10^5. The log reference level for both pictures is — 10 dBm.

FREQUENCY PULLING



Variations of an oscillator's load may result in changes in its output frequency and/or amplitude. The variable load may be an output attenuator, a rotary antenna coupler, a nonlinear buffer amplifier, etc. As the load is varied the frequency pulling of the oscillator is easily observed on the spectrum analyzer. In this oscillator, loading by an output attenuator pulls the frequency as much as 0.6 MHz. The frequency scale is 0.1 MHz per division and the LOG REFERENCE LEVEL is +10 dBm.

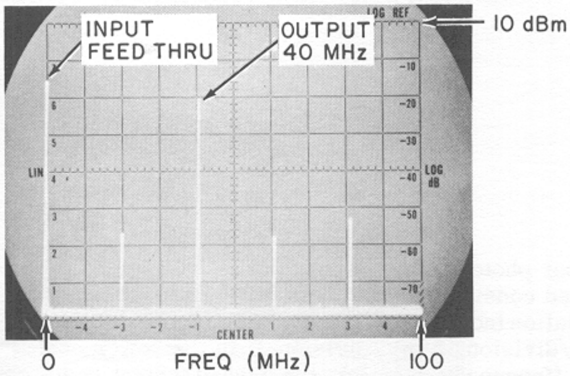
FREQUENCY DRIFT



The frequency drift of an oscillator during warm-up is measured here. Scans are independently triggered 5 seconds apart and are stored on the 141S Display Section CRT. The frequency scale is 0.2 kHz per division with the center frequency at 20 MHz. The initial drift rate is 600 Hz in 80 seconds.

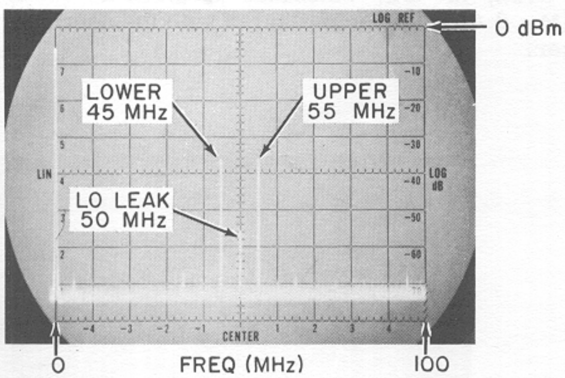
Figure 3-6A. Typical Measurements with 8552A/8553L Spectrum Analyzer

FREQUENCY DOUBLER driven by 20 MHz at +2 dBm



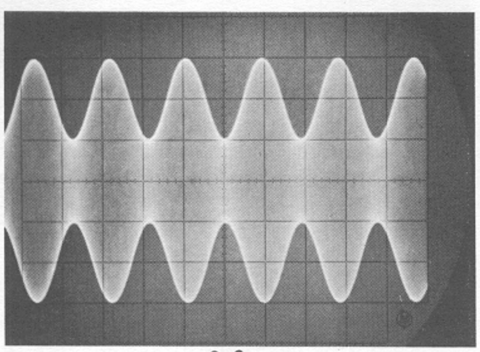
This photograph displays a doubler driven at 20 MHz and +2 dBm, producing a 40-MHz signal at -10 dBm (log reference level = +10 dBm). Conversion loss, then, is 12 dB. The 3rd and 4th harmonics are greater than 40 dB below the desired 2nd harmonic output and the 20-MHz feedthrough is 36 dB down. The input power was easily adjusted for optimum doubler performance. The spectrum analyzer scan is 10 MHz/division centered at 50 MHz. The zero frequency indicator is at the left-hand edge of the display.

MIXER OUTPUT



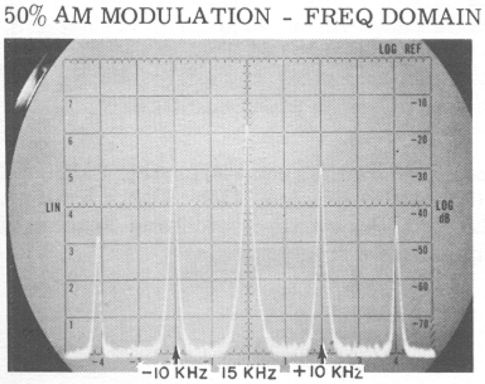
Driving a double balanced mixer with an LO of 50 MHz at 0 dBm and with a 5-MHz, -30 dBm signal, results in the output shown. The reference level is 0 dBm and the frequency scan is 10 MHz/division centered at 50 MHz. The two sidebands at 45 MHz and 55 MHz have a conversion loss of 6 dB (6 dB below the -30 dBm graticule line). The local oscillator (50 MHz signal) has 56 dB isolation. 5-MHz signal leak through is at -65 dBm, i.e., 35 dB isolation. Third harmonic distortion products at 35 and 65 MHz are 32 dB down.

50% AM MODULATION - TIME DOMAN



$M = \frac{6-2}{6+2} = 0.5$

50% AM MODULATION - FREQ DOMAIN

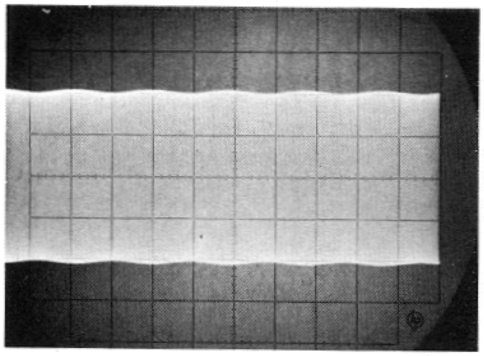


$20 \text{ LOG } {}^{2}/_{M} = 12 \text{ dB}$

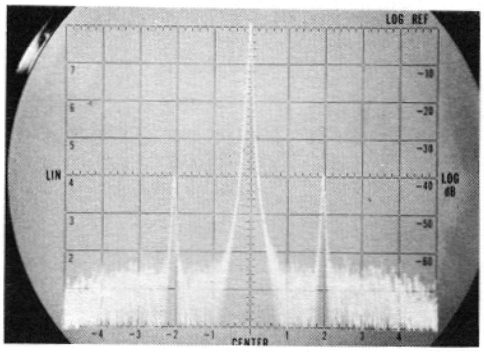
The upper photograph shows a time domain photograph of an amplitude-modulated carrier. The modulation index is: M = (6 - 2) / (6 + 2) = 4/8 = 50%. (Scope calibration 50 μs/division, 5 mV/division.) The same waveform is measured in the frequency domain in the lower photograph. Since the carrier and sidebands differ by 12 dB M = 50%. Frequency scan is 5 kHz/division at 15 MHz and the log reference is -11 dBm. You can also measure the 2nd harmonic distortion on this waveform. These sidebands, at $f_c \pm 2f_m$, are 22 dB down.

Figure 3-6B. Typical Measurements

2% AM MODULATION - TIME DOMAIN

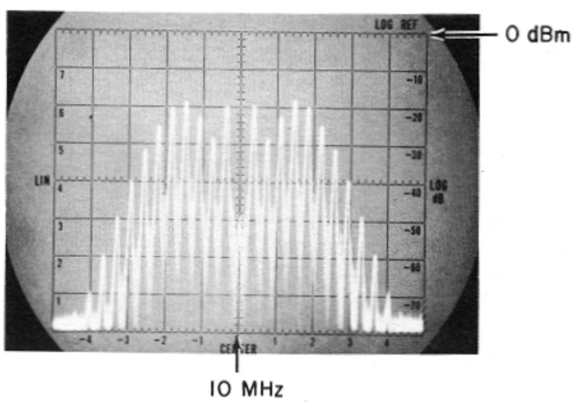


2% AM MODULATION - FREQ DOMAIN



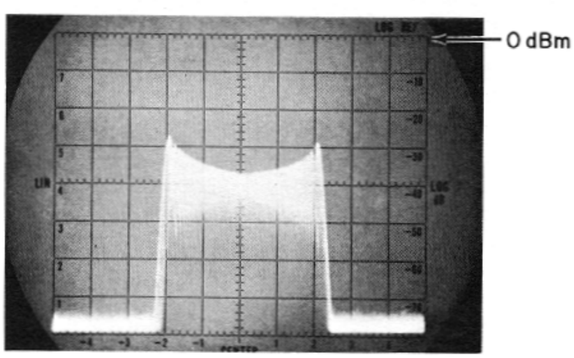
In upper photograph, the modulation voltage has been reduced considerably and it is difficult to measure the modulation index in the time domain. (Scope calibration 50 μs/division, 5 mV/division.) In the lower photograph (frequency domain), the measurement can still be made quite accurately. Since the sidebands are 40 dB down, M = 2%. Sidebands as much as 70 dB down (M = 0.06%) can be measured with the spectrum analyzer.

LOW DEVIATION FM



This is the spectrum for an FM signal at 10 MHz. The deviation has been adjusted for the second carrier null (M = 5.6). The sideband spacing is 20 kHz, the modulation frequency; therefore, Δf_{peak} = 5.6 x 20 kHz = 112 kHz. (50 kHz/division at 10 MHz, LOG REF = 0 dBm.)

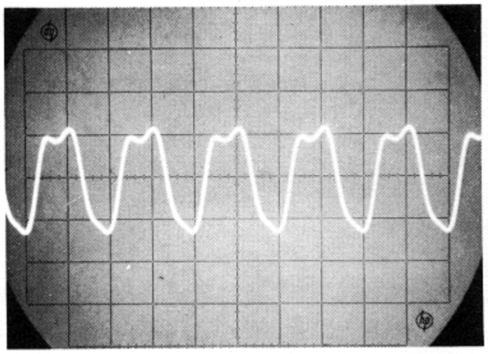
HIGH DEVIATION FM

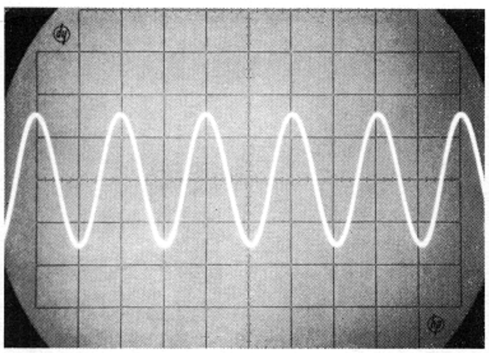


The transmission bandwidth required for this FM signal is 2.5 MHz (0.5 MHz/division, LOG REF = 0 dBm). Expanding the scale reveals a sideband spacing of 10 kHz, the modulation frequency.

Figure 3-6C. Typical Measurements

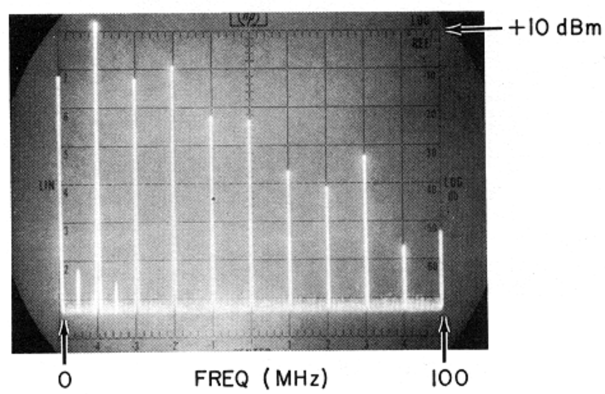
HARMONIC DISTORTION IN TIME DOMAIN

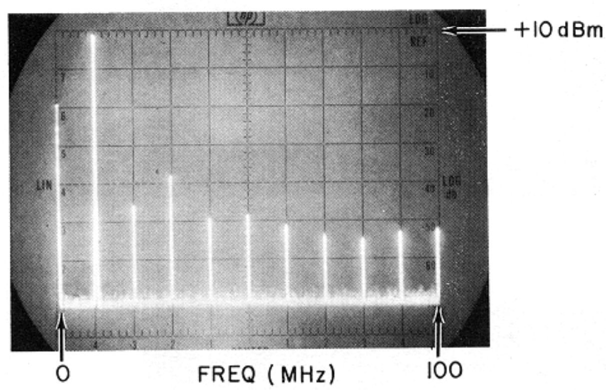




Overdriving an amplifier results in a severely distored waveform easily observed with the oscilloscope; however, quantitative measurements of distortion levels are difficult to obtain. The scope calibration is 1 volt/division vertical, 0.05 µs/division horizontal. When the input power level is reduced by 10 dB (lower photograph), the distortion is hardly observable. Scope vertical calibration changed to 0.5 volt/division.

HARMONIC DISTORTION IN FREQ DOMAIN

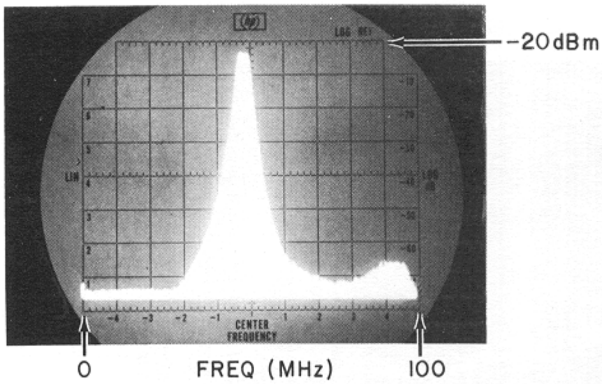




The spectrum analyzer easily gives quantitative information about the distortion of the two signals. The frequency scale is 10 MHz/division centered at 50 MHz and the reference level is + 10 dBm. (The response at the far left is the zero frequency indicator.) The 10 MHz signal input is at -20 dBm in upper photograph and at -30 dBm in the lower photograph. Since the normal amplifier gain is 40 dB, gain compression is about 7 dB in upper photograph, but only 1 dB in lower photograph. Second harmonic distortion is reduced from 14 dB down by the 10-dB reduction in signal input. The effect of input signal level on the other harmonics is also easily discerned.

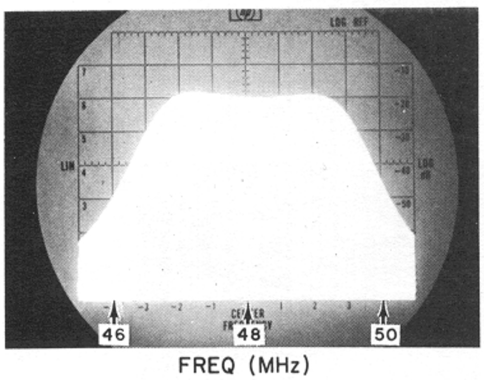
Figure 3-6D. Typical Measurements

FILTER FREQUENCY RESPONSE



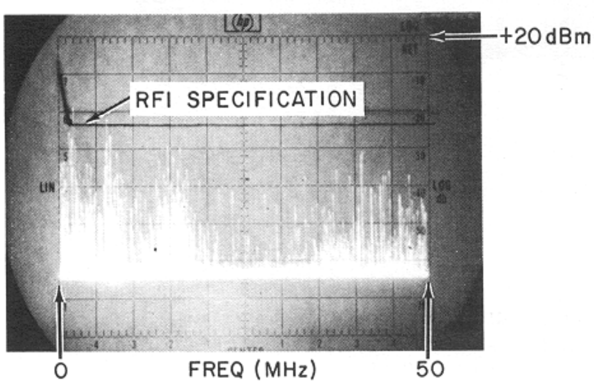
Using a signal generator and the 141S Variable Persistence Display Section, filter responses are easily measured and recorded with the spectrum analyzer. The filter input and the log reference level are both -20 dBm. Therefore, insertion loss is 3.5 dB. Scan width is 10 MHz/division centered at 50 MHz. The 3-dB bandwidth is approximately 4 MHz and the 60-dB bandwidth is 24 MHz, a ratio of 6 to 1. Stop band rejection is greater than 70 dB throughout most of the frequency range, but the stop band is only 66 dB down at 90 MHz.

FILTER PASSBAND

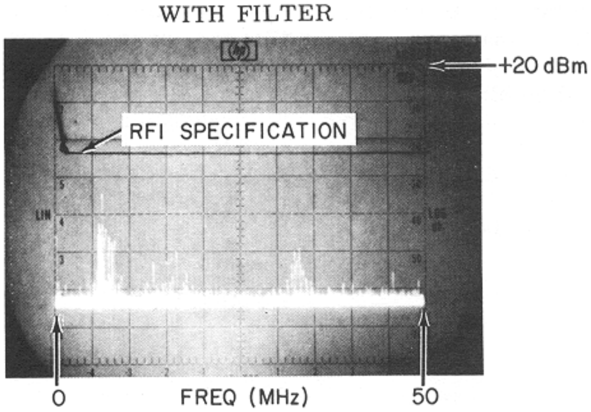


Setting the analyzer to LINEAR, the passband of the filter is examined in greater detail. The 3-dB points ($E_1/E_2 = \sqrt{2}$) are 3.5 MHz apart (scan width 0.5 MHz/division centered at 48 MHz). Insertion loss, using the IF substitution technique at the center frequency, was 3.6 dB.

WITHOUT FILTER

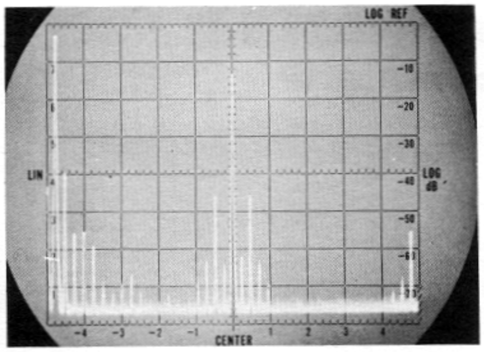


WITH FILTER



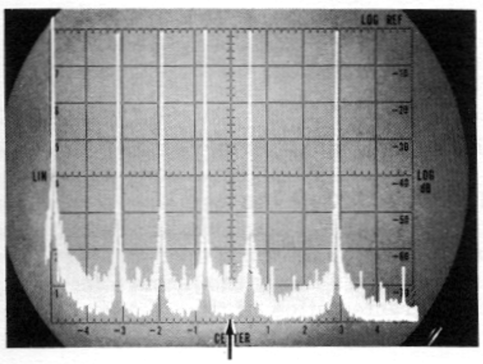
It is often more meaningful to test a filter by placing it in the circuit and observing the changes in the output. Here the effectiveness of an EMI line filter in reducing conducted interference to specification limits is being checked. (The line marked on the CRT graticule is the specification limit.) The broadband reference level is -20 dBm/MHz and the frequency scan is 5 MHz/division centered at 25 MHz. All conducted interference has been reduced below the specification line.

Figure 3-6E. Typical Measurements



In the SMPTE method of measuring distortion, the two test signals used are widely separated in frequency. The lower frequency signal modulates the higher, generating sidebands. The level of these sidebands is measured to characterize the distortion of the amplifier. The display shows a 500-kHz signal at -30 dBm modulating a 10-MHz signal at -40 dBm. The log reference level is +10 dBm and the horizontal calibration is 2 MHz/division centered at 10 MHz. Significant gain compression is occurring in the amplifier. The primary 500-kHz distortion sidebands around the 10-MHz signal are 52 dB down. However, the second order sidebands are only 34 dB down.

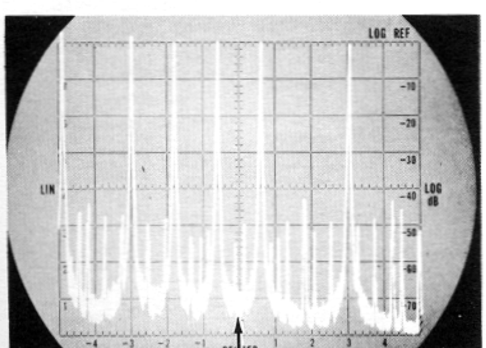
SLOT SIG/NOISE RATIO



250 MHz
(50 MHz/DIV)

This is a common "IM distortion" test for multiplex systems used in telemetry. A group of baseband carriers is shown in upper photograph. As indicated, the IM products are more than 65 dB below carrier amplitude. In the lower photograph IM distortion is clearly visible. Frequency of the IM products identifies which carriers are causing the IM. Carrier 5 is disabled in both tests to measure any IM products from other carriers that occur in channel 5.

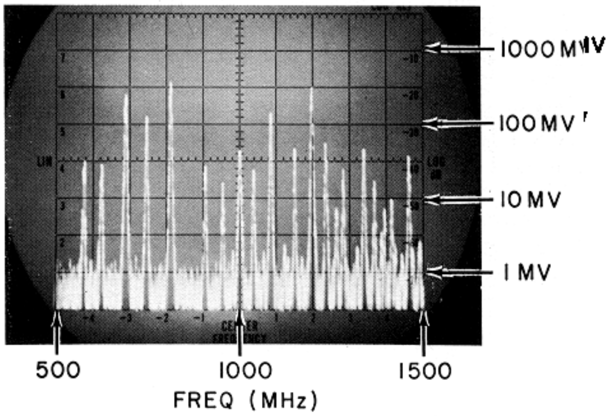
SLOT SIG/NOISE RATIO



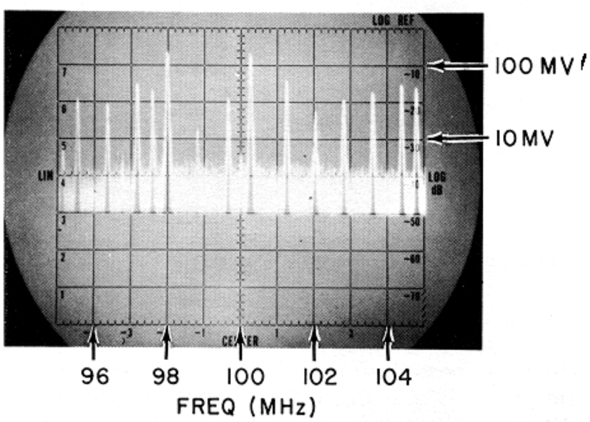
250 MHz
(50 MHz/DIV)

Figure 3-6F. Typical Measurements

AM STATIONS (SF BAY AREA)



FM STATIONS (SF BAY AREA)



The spectrum analyzer is much more than just a good design tool. As evidenced in these photographs, the analyzer with a good antenna system becomes an excellent monitor device. Spurious or uncontrolled transmissions in a communication spectrum are easy to detect. Likewise, it is easy to measure frequency and amplitude characteristics of any carrier or sub-carrier in the viewed spectrum.

TV/FM STATIONS (SF BAY AREA)

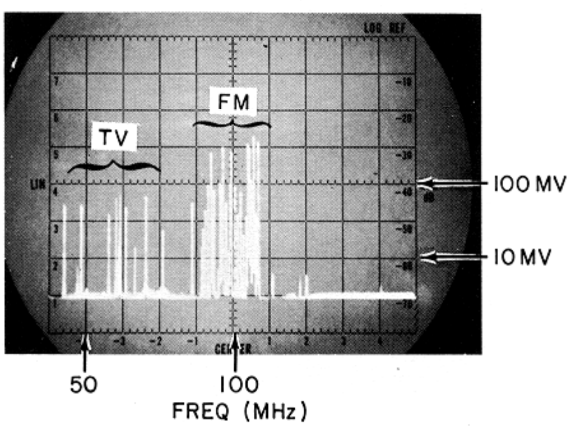


Figure 3-6G. Typical Measurements

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PRINTED IN U.S.A.