

DOCUMENTATION DE L'ANALYSEUR DE SPECTRE HP 8553B

FICHE N° 3964

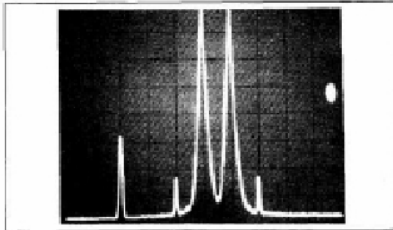
Période de fabrication : 1950-1974
Fabricant : Hewlett-Packard Company
Domaines : Physique
Sous-domaines : Electronique
Organisme : Université de Rennes
Ville : Rennes
Modèle : HP 8553B
Matériaux : Papier

Description

Cette documentation, extraite du catalogue Hewlett-Packard de 1970, décrit en détail les caractéristiques principales de l'analyseur de spectre HP 8553B : fréquence, calibre, résolution, applications...

Utilisation

Cet analyseur de spectre, en provenance du CELAR de Bruz, près de Rennes, a été utilisé en travaux pratiques d'électronique par les étudiants de Maîtrise EEA. De part sa gamme de fréquence très large, il permettait d'analyser différents signaux produits par des montages électronique et d'effectuer ainsi des expériences de traitement du signal.



A two-tone intermodulation test was performed on a single sideband transmitter. The carrier appears at the left of the photo and is suppressed 47 dB below the sideband outputs. The transmitter was modulated by two audio tones at 600 Hz and 800 Hz. (The spectrum analyzer scan is 200 Hz per division centered at 1.3 MHz.) Third order intermodulation products can be measured 63 dB below the desired two-tone modulation. Expanding the scan, you could measure second order intermodulation products or harmonics of the carrier frequency being radiated by the transmitter.

Specifications

Frequency

Frequency Range: 1 kHz-110 MHz (0-11 MHz and 0-110 MHz tuning ranges).

Frequency Response (Flatness): ± 0.5 dB, 1 kHz to 110 MHz.

Scan Width: (as 10 division CRT horizontal axis)

Per Division: 15 calibrated scan widths from 10 MHz/div to 30 Hz/div in a 1, 2, 5 sequence.

Preset: 0.100 MHz.

Zero: Analyzer is fixed-tuned receiver.

Scan Time: 10 internal scan rates from 0.1 ms/div to 10 sec/div in a 1, 2, 5 sequence, or manual scan.

Resolution

Bandwidth: IF bandwidths of 10 Hz to 300 kHz provided in a 1, 3 sequence.

Bandwidth Accuracy: Individual IF bandwidth 3 dB points calibrated to $\pm 0.2\%$ (10 kHz bandwidth $\pm 5\%$).

Bandwidth Selectivity: 60 dB/3 dB IF bandwidth ratios $\leq 11:1$ for IF bandwidths 10 Hz to 3 kHz, $\leq 20:1$ for IF bandwidths from 10 kHz to 300 kHz, 60 dB points separated by ≤ 100 Hz for 10 Hz bandwidth.

Stability

Residual FM:

Stabilized: Sidebands > 60 dB down, 50 Hz or more from CW signal, scan times 1 sec/div, 10 Hz bandwidth.

Unstabilized: < 1 kHz peak-to-peak.

Noise Sidebands: More than 70 dB below CW signal, 80 kHz or more away from signal with 1 kHz IF bandwidth, 10 Hz Video Bandwidth.

Amplitude

Absolute Amplitude Calibration Range:

Log: From -130 to $+10$ dBm, 10 dB/div on a 70 dB display; on 8 dB/div on a 10 dB display.

Linear: From 0.1 μ V/div to 100 mV/div in a 1, 2 sequence on an 8-division display.

Dynamic Range

Average Noise Level: < -110 dBm with 10 kHz IF bandwidth.

Spurious Responses: For -40 dBm signal level at the input mixer.* Image responses, out-of-band mixing responses, harmonic and intermodulation distortion are all more than 70 dB below the signal level at input mixer, 12 MHz to 110 MHz, 60 dB, 1 kHz to 2 MHz. Third Order Intermodulation Products: For -40 dBm total signal level at input mixer,* third order intermodulation products are more than 70 dB down for input signals of 100 kHz to 110 MHz; signal separation > 300 Hz.

Residual Responses: 200 kHz - 110 MHz < -110 dBm, 20 MHz - 200 kHz < -85 dBm.

Input Impedance: 50 Ω nominal. Reflection coefficient < -15 (1.3 SWR), input attenuator ≥ 20 dB.

Maximum Input Level: Peak or average power $+13$ dBm (1.4 V ac peak), ± 50 V dc.

Calibrator Output:

Amplitude: -30 dBm, ± 0.3 dB.

Frequency: 30 MHz, ± 5 kHz.

Video Filter: Averages displayed noise 10 kHz, 100 Hz, and 1 Hz bandwidths.

Display

Variable Persistence/Storage (Model 141T)

Cathode-ray Tube:

Type: Fast-accelerator storage tube, 4000 volt accelerating potential; ultraviolet P31 phosphor; etched safety glass faceplate reduces glare.

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 to two or three minutes).

Erase: Manual erase takes approximately 350 ms; CRT ready to record immediately after erase.

Storage Time: Normal writing rate more than 1 hour at reduced brightness (typically 4 hours). More than one minute at maximum brightness.

Normal Persistence (Model 140T):

Cathode-ray Tube:

Type: Fast-accelerator, 7500 volt potential medium-short persistence (P7) phosphor; tinted and etched safety glass faceplate reduces glare. (Normal persistence of P7 phosphor approximately 3 sec.)

General

EMI: Conducted and radiated interference are within requirements of MIL-1-16910C and MIL-3-6151B and methods CEE3, and REC2 of MIL-STD-461 (except 35 to 40 kHz) when 8553B and 8552B are combined in a 140T or 141T Display Section.

Power Requirements: 115 or 230 volts $\pm 10\%$, 50 to 60 Hz, normally less than 225 watts.

Dimensions:

Model 140T or 141T Display Section: 9-1/5 in. high (including height of feet) $\times$ 18-3/4 in. wide $\times$ 18-3/8 in. deep (229 $\times$ 468 $\times$ 467 mm).

Model 1435 Display Section: 21 in. high (including height of feet) $\times$ 18-3/4 in. wide $\times$ 18-3/8 in. deep (533 $\times$ 468 $\times$ 467 mm).

Weight:

Model 8553B RF Section: Net, 32 lb (15.5 kg). Shipping 17 lb (7.8 kg).

Model 8552B IF Section: Net, 9 lb (4.1 kg). Shipping, 34 lb (15.4 kg).

Model 140T Normal Persistence Display Section: Net, 37 lb (16.8 kg). Shipping, 43 lb (20 kg).

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

Model 1435 Large Screen Display Section: Net, 62 lb (28.1 kg). Shipping, 81 lb (36.7 kg).

Accessory Required for Service: 11502A Service Kit, \$185.00. Includes extender cables, connector adaptors, etc.

Prices

Model 8553B RF Section	\$2,200.00
Model 8552B IF Section	\$2,850.00
Model 141T Variable Persistence Display	\$1,700.00
Model 140T Normal Persistence Display	\$ 575.00
Model 1435 Large Screen Display	\$1,500.00

*Signal level at input mixer. ** Signal level at RF input - INPUT ATTENUATOR.

SIGNAL ANALYZERS


SPECTRUM ANALYZER
 High Resolution, 1 kHz to 110 MHz
 Models 8553B/8552B


8553B/8552B

The HP 8553B/8552B is the first spectrum analyzer to combine high resolution analysis with wide scan capability. With a frequency range of 1 kHz to 110 MHz, the 8553B/8552B has the capability to scan as wide as 100 MHz or as narrow as 200 Hz. This single system allows wide band measurements of such phenomena as harmonic distortion or out-of-band emissions with the capability to "zoom-in" on a particular signal for modulation measurements or in-band distortion analysis.

High Resolution: The 8553B/8552B features 10 Hz equal signal resolution throughout the frequency range. More significant, such phenomena as line related sidebands may be resolved even when they are 60 dB or more below the carrier level. IF bandwidths as narrow as 10 Hz with 60 dB/3 dB shape factors less than 13:1 allow this high resolution capability.

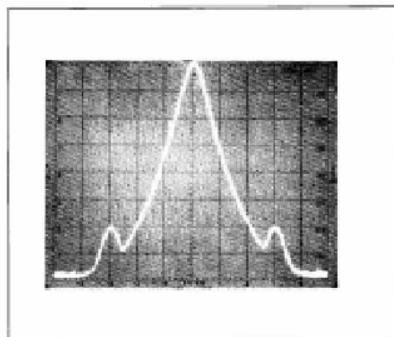
High Stability: Accurate high resolution analysis requires an extremely stable measurement system. With residual FM less than 1 Hz, the 8553B/8552B becomes the stable reference necessary for full use of narrow bandwidth operation.

Absolute Amplitude Calibration: The spectrum analyzer has absolute amplitude calibration in addition to a fully calibrated display. Absolute signal levels in either dBm or voltage may be read directly from the CRT. External calibration signals are not required to obtain accurate amplitude information. Excellent ± 0.5 dB flatness across the full frequency range makes direct measurements accurate and simple.

70 dB Display: A dynamic display range of 70 dB, free from spurious and image responses, allows meaningful measurements over a wide amplitude range. Three display modes are provided on the spectrum analyzer: 10 dB per division logarithmic; 2 dB per division logarithmic; and linear display with selectable scale factors from 0.1 μ V per division to 100 mV per division.

High Sensitivity: Low level signals may be accurately characterized with ease due to the -140 dBm (25 nV) sensitivity of the spectrum analyzer. A wide measurement range from -140 dBm to +10 dBm provides great flexibility for a variety of measurements.

Variable Persistence Display: High resolution analysis requires slow scanning rates. These slow rates are made practical through the use of the 141T Variable Persistence Display Section which provides a flicker-free display at even the slowest scan rates. With normal persistence, the trace would appear merely as a slowly moving dot on the CRT. Trace storage is also provided on the 141T Display Section for side-by-side comparison of spectra.



In many cases, complete characterization of system performance requires measurement of line related sidebands on output signals. In this photo, a receiver local oscillator was measured for stability and spectral purity. This oscillator was crystal controlled and had excellent frequency stability. The power supply used, however, produced considerable 60 Hz ripple causing sidebands 60 dB below the oscillator output. (The 10 Hz IF bandwidth also permits measurement of 60 Hz sidebands.) The spectrum analyzer scan is 20 Hz per division centered at 30 MHz. The LOG REF level (top graticule line) is -20 dBm.

SPECTRUM ANALYZERS *continued***Absolute amplitude calibration**
Model 8553B/8552A

quency stabilization system provides a display free of drift and jitter. This system phase-locks the first local oscillator to a crystal reference to provide crystal-solid stability over the entire frequency range. Stabilized operation automatically reduces residual FM to less than 20 Hz peak-to-peak for scan widths less than 50 kHz/div. Signal generator residual FM and frequency drift is easy to check because virtually no drift or jitter is contributed by the analyzer; all analyzer noise sidebands are more than 70 dB down.

Absolute amplitude calibration—highest sensitivity

With the analyzer's absolute amplitude calibration you can measure signal amplitudes directly in microvolts (0.07 μ V to .8 V) or dBm (-130 dBm to $+10$ dBm). The ex-

treme sensitivity of 0.07 μ V (-130 dBm) ensures that even very small signals can be measured. With ± 0.5 dB flatness, signals widely spaced in frequency can be compared and their amplitudes read directly from the CRT.

Distortion-free 70 dB display

The full 70 dB analyzer display range is free of distortion products. With the INPUT ATTENUATOR you can check for input mixer overload. The full 0-50 dB range of attenuation prevents input mixer overload and keeps analyzer distortion products 70 dB below any signal input level to $+10$ dBm. With this clean display you can measure distortion levels as low as 0.03% in the output of oscillators, amplifiers and other active devices.

Partial Specifications 8553B/8552A
RF and IF Sections

(refer to Technical Data Sheet for complete specifications)
RF input and tuning characteristics

Frequency range: 1 kHz to 110 MHz. Tuning dials calibrated for 0-110, 0-11 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: 50 Ω nominal. Reflection coefficient ≤ 0.15 (1.3 SWR) for input attenuator setting ≥ 10 dB.

Maximum input level: peak or average power to input mixer $\leq +13$ dBm (1.4 V ac peak; ± 50 V dc).

Noise level: the average noise level of the analyzer depends on IF bandwidth and determines its sensitivity for small signals, see Figure 3.

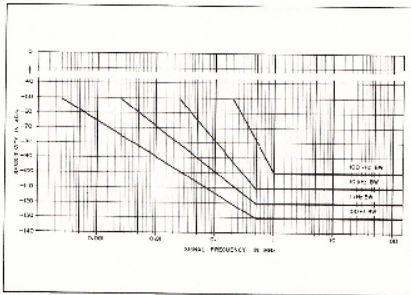


Figure 3. Noise level vs. Input Frequency.

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. Measurement accuracy at least ± 1.5 dB using suitable measurement techniques.

Linear: calibrated directly in V/div from 0.1 μ V/div to 100 mV/div in a 1, 2, 10 sequence.

Calibrator: 30-MHz signal, -30 dBm ± 0.3 dB.

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 selectivity: 60 dB/3 dB bandwidth ratio less than 20:1 for IF bandwidths from 1 kHz to 300 kHz. 60 dB/3 dB bandwidths ratio less than 25:1 for IF bandwidths from 50 Hz to 300 Hz.

Video filter bandwidths: 10 kHz and 100 Hz.

Spectral purity

Stabilization: automatic phase-lock reduces residual FM to less than 20 Hz peak-to-peak for scans 20 kHz/div or less.

Noise sidebands: more than 70 dB below CW signal 50 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 Signal Level at Input Mixer. (Signal Level at RF INPUT — INPUT ATTENUATOR).

Residual responses: 200 kHz to 110 MHz: ≤ -110 dBm. 20 kHz to 200 kHz: ≤ -95 dBm.

Scan characteristics

Scan width: 20 Hz/div to 10 MHz/div in a 1, 2, 5, sequence plus ZERO and preset 0-100 MHz scan.

Scan time: 0.1 ms/div to 10 s/div in a 1, 2, 5, sequence.

General

Price: 8553B, \$2050; 8552A, \$2050.

For accessories and required display see page 408.

Highest resolution 8553B/8552A

8553B/8552A Spectrum Analyzer 1 kHz - 110 MHz



The 8553B/8552A Spectrum Analyzer has fully calibrated swept coverage from 1 kHz to 110 MHz. This single instrument can be used over many decades of frequency to examine audio spectra, baseband modulation, system IF's, and modulated RF carriers into the VHF region. System performance tests for absolute levels of power, distortion or spurious radiation are easy to perform using this analyzer. New features such as absolute amplitude calibration are made possible by flat frequency response and highly stable instrument gain. These features simplify tedious measurements in RF circuit design and system analysis. The spurious free instrument response and absolute amplitude calibration make it easy to make unambiguous, accurate measurements over a wide frequency range. The completely calibrated instrument controls are simple to operate and the display is easy to interpret.

Wide frequency range—expanded dial

With the flat 1 kHz to 110 MHz frequency coverage you can optimize RF circuit designs across the entire frequency range. Only signals in this frequency range are viewed; a low-pass filter rejects all out-of-band signals giving an unambiguous display. Both tuning resolution and dial readability are extremely important in a low-frequency analyzer. A unique feature to increase the 8553B low-frequency dial

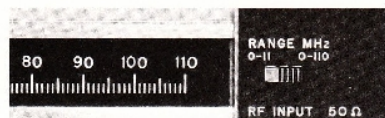


Figure 1. Expanded Dial Scale. When the Expanded Dial Scale is selected the 0 - 110 MHz dial becomes 0 - 11 MHz. Dial resolution is 200 kHz; tuning resolution much easier.

readability is an expanded dial scale. When the low-frequency expand position is selected, Figure 1, the 0 - 110 MHz frequency dial becomes 0 to 11 MHz. In this range tuning dial resolution is improved to 200 kHz making low-frequency measurements easy. A ten-turn fine-tuning knob provides better tuning resolution making it easy to select individual sidebands and spectral lines in high resolution measurements. System subcarriers are simple to identify and measure.

Calibrated scan widths—0 - 100 MHz

A preset 0 - 100 MHz scan is provided, as well as selectable, calibrated scan widths. In preset scan a frequency marker identifies the center frequency selected by the tuning control. Switching to PER DIVISION scan provides ten division symmetrical scan from 10 MHz/div. to 20 Hz/div. about the center frequency selected by the frequency marker. Calibrated scan widths and narrow bandwidths make it easy to resolve and measure signals regardless of spacing, see Figure 2.

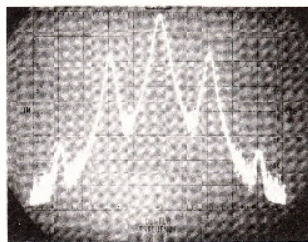


Figure 2. LOG Display of Amplitude Modulated Carrier. SCAN WIDTH is 200 Hz/div; IF BANDWIDTH is 50 Hz. The modulation frequency is measured directly from the display as 400 Hz (2 division spacing of carrier and sidebands). The modulation percentage is measured from the 16 dB amplitude ratio of the carrier and sidebands . . . modulation percentage is 30%. It is easy to measure the modulation distortion from the display; the 800 Hz second harmonic distortion components are 40 dB below the fundamental, indicating 1% distortion. LOG REFERENCE is -30 dBm . . . with absolute calibration carrier is -31 dBm.

Excellent resolution

The resolving capability of a spectrum analyzer is largely determined by its IF bandwidth and frequency stability. The highly selective IF filters of the 8553B/8552A have 3 db bandwidths as narrow as 50 Hz with a shape factor better than 25:1. Sidebands on a carrier 30% amplitude modulated by 400 Hz are resolved easily. These sidebands appear 16 db below the carrier and 400 Hz away, Figure 2. Second harmonic modulation distortion products of only 1% appear 40 db below the fundamental sidebands. Select the optimum bandwidth for your measurements, 50 Hz for highest resolution to 300 kHz for rapid wideband analysis.

Stability

For critical examination of individual spectral lines, the analyzer must be very stable. A completely automatic fre-

SPECTRUM ANALYZERS *continued*

70 dB Dynamic Range
Models 8553B/8554L

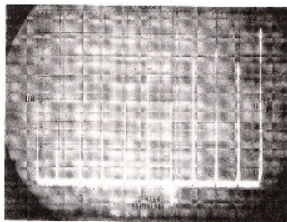


Figure 1. Preset SCAN displays output (fundamental through 10th harmonic) of comb generator. Highly linear scan makes it simple to measure the frequency of any component accurately. Note inverted scan marker beneath 8th harmonic; switching to SCAN WIDTH PER DIVISION expands the spectral display symmetrically about the frequency the marker identifies.

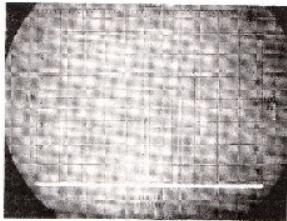


Figure 2. Signal selected by the marker from the comb of Figure 1. Signal amplitude is 38 dB below REF, and the display is LOG (power). The LOG REFERENCE LEVEL (from fig. 3) is -30 dBm, therefore amplitude is -68 dBm.

Absolute Amplitude Calibration

Signal amplitudes are measured directly in μ V or dBm with absolute vertical calibration. The LOG REFERENCE or LINEAR SENSITIVITY controls determine the display calibration. Figures 3, 4. With the exceptional flatness of these analyzers, it is only necessary to calibrate at a single frequency using the internal calibrator. External generators and calibration curves are eliminated; absolute amplitude measurements are made with confidence directly from the CRT display. Less time is required to make measurements and the possibility of error is reduced.

Resolution—Automatic Stabilization

Resolution, the ability to separate closely-spaced signals, is determined largely by the IF bandwidth of a spectrum analyzer. Resolution increases as narrow IF filters are selected, but filter response time also increases. If the filter does not fully respond in the scan time selected, inaccurate measurements result. A red UNCAL light warns if a combination of control settings (scan, bandwidths, etc.) affects the absolute calibration. The slow scan time required for full filter response and highest resolution produces a slow-

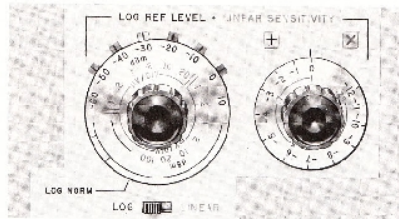


Figure 3. Settings of the INPUT ATTENUATOR and LOG REFERENCE LEVEL controls determine the scale factor for absolute amplitude calibration. Here, LOG is selected and the "X" lamp lights to indicate that LOG REFERENCE LEVEL is the sum of the black color-coded dial readings; i.e., LOG REF -30 dBm - 0 dBm = -30 dBm.

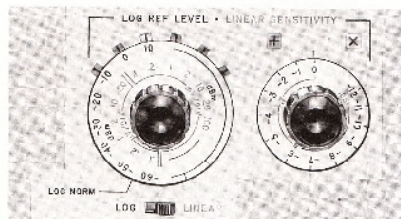


Figure 4. Settings of INPUT ATTENUATOR and LINEAR SENSITIVITY analyzer controls determine scale factor for absolute voltage calibration. The "X" lamp indicates that the scale factor is the product of the LINEAR SENSITIVITY dial readings (blue color-coded): 0.2 mV/div $\times$ 1 = 0.2 mV/div.

moving CRT spot. Although suitable for making photo or recorder records, the slow-moving spot makes direct measurements difficult. The 141S variable persistence display makes direct viewing of such signals easy and practical; simply adjust the display persistence to match the sweep speed for a flicker-free display.

An automatic stabilization system phase-locks the first local oscillator to a stable crystal reference. High stability and excellent resolution make it easy to measure signal generator residual FM and frequency drift.

Single Instrument—Wide Application

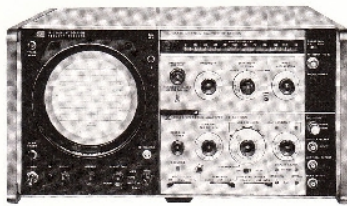
These highly sensitive, calibrated analyzers can be used as RF voltmeters or power meters. You can measure signal purity in an amplifier or oscillator as a function of output level and check output levels of sources and generators. Field intensity measurements are easy to make using a calibrated antenna. A video filter is provided to smooth the detected signal before it is displayed and extract small signals from the residual noise. This is especially useful for averaging noise as when making broadband power density measurements.

ABSOLUTE CALIBRATION
Spectrum analyzer system
Models 8553B/8552A, 8554L/8552A



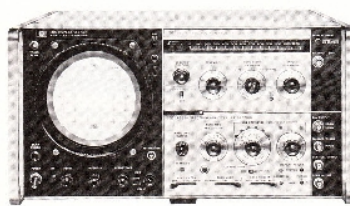
SIGNAL ANALYZERS

1 kHz to 110 MHz



8553B/8552A
(In 141S Display Section)

500 kHz to 1250 MHz



8554L/8552A
(In 141S Display Section)

These Hewlett-Packard Spectrum Analyzer systems offer absolute amplitude calibration over a wide frequency range. The 8553B/8552A coverage extends from 1 kHz to 110 MHz, the 8554L/8552A from 500 kHz to 1250 MHz. Both are designed as general purpose instruments to make circuit design and systems evaluation easier. Absolute amplitude calibration, exceptional flatness and wide dynamic range set these new analyzer systems apart from other spectrum analyzers. Simple, easy-to-use controls and a calibrated display eliminate tedious substitution measurements and calculations to save you measurement time.

Each analyzer system is composed of either the 8553B or 8554L RF Section in the frequency range of your choice, an 8552A IF Section, and a 140 series display section. The 141S, a variable-persistence/storage display, provides a flicker-free display for high resolution or transient measurements. Fixed persistence displays are also available; the 140S for bench use or the 143S, an 8 x 10 inch display for improved visual resolution or classroom/group viewing. All display sections have an internal, parallax-free graticule with special log and linear scale calibrations.

70 dB Distortion-free Display

Up to 70 dB of dynamic range can be viewed, free of any distortion. All image responses, out-of-band mixing responses, harmonic and intermodulation distortion products are at least 70 dB below the input signal. Figure 1 shows the output of a comb generator spread across the calibrated frequency range of the analyzer. Signals differing by more than 70 dB can be quickly identified and measured with precision on the clean, distortion-free display.

Calibrated Scan Widths—Preset and Selectable

The analyzer provides three calibrated scan modes; preset scan, selectable PER DIVISION scan and ZERO scan. Preset scan displays essentially the entire swept frequency range of the analyzer on a single scale. You can view the broad-band effects of circuit adjustments and refinements as they are made. The FREQUENCY tuning knob moves the dial pointer on the frequency dial and a corresponding frequency marker on the CRT display. Each response can be identified by reading frequency directly from the calibrated CRT or by tuning the frequency marker to the signal and reading the frequency dial.

Once the frequency marker selects a signal, you can switch to PER DIVISION scan and place the selected spectra at the CRT center, Figure 2. In this mode the analyzer scans symmetrically about this frequency in selectable frequency spans. Locate RF circuit harmonics and spurious responses in preset scan; then switch to PER DIVISION scan for detailed examination of sidebands and signal purity. System parameters such as baseband frequencies and carrier separation are easy to identify and measure using the calibrated scan widths. Selectable scan widths and narrow bandwidths make it easy to resolve and measure signals regardless of spacing.

In the third scan mode, ZERO scan, the analyzer becomes a fixed frequency, selectable bandwidth receiver, manually tuned by the FREQUENCY control. The CRT displays the demodulated amplitude information in the time domain; the scan time control provides a calibrated time base.

1970 *ELECTRONICS FOR*

MEASUREMENT
ANALYSIS
COMPUTATION

Acoustical Instruments
Automatic Test Systems
Calculators and Peripherals
Communications Test Equipment
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Data Acquisition Systems
DC Power Supplies
Digital Analyzers
Electronic Counters
Frequency and Time Standards
Graphic Recorders
Magnetic Recorders
Meeters, Multifunction
Microwave Test Equipment
Network Analyzers
Oscilloscope Systems
Signal Analyzers
Signal Generators
Signal Sources
Spectrum Analyzers



Pour nous citer :

Base de la Mission nationale de sauvegarde et de valorisation du patrimoine scientifique et technique contemporain, PATSTEC, Documentation de l'analyseur de spectre HP 8553B (Hewlett-Packard Company), <https://www.patstec.fr/ressources/objets/detail?id=15982>, consulté le 2026-10-23