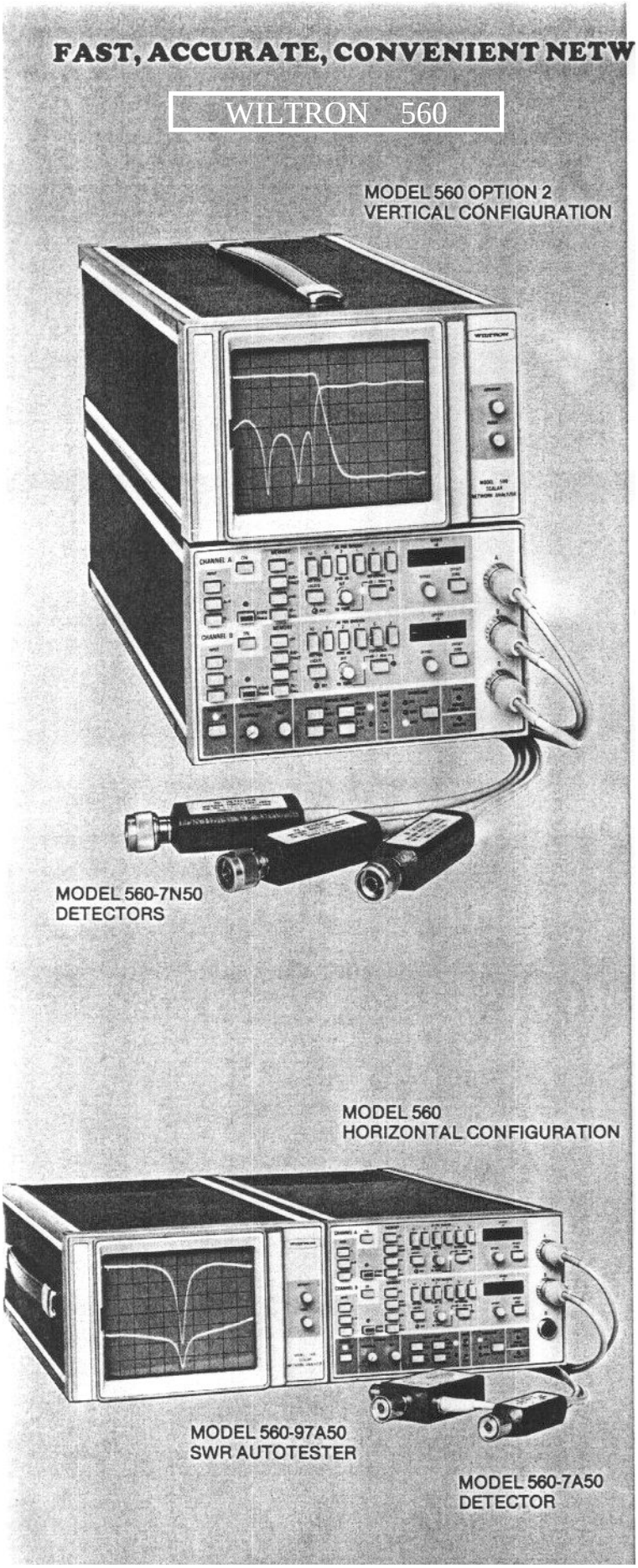
FAST, ACCURATE, CONVENIENT NETWORK ANALYSIS TO 34 GHz— ON GPIB

WILTRON 560



NEW GPIB NETWORK ANALYZER

With the introduction of the first GPIB microwave network analyzer, WILTRON brings automatic network analysis within reach of virtually every laboratory and production line. The powerful capabilities of modern digital technology have been applied to improve markedly the ease, speed, and accuracy of microwave measurements. When used with the WILTRON 610D Sweep Generator, the test set provides swept measurements over the 10 MHz to 34 GHz range of transmission loss or gain, return loss, and absolute power. Because the Model 560 has a 66 dB (+16 dBm to −50 dBm) dynamic range, GPIB programmability, and 40 dB directivity, it may be used in applications that are beyond the capability of other network analyzers.

Unequaled return loss measurement accuracy is made possible by a new SWR Autotester (directional bridge detector) that has a directivity of 38 dB or 40 dB (depending upon connector type) over the full 10 MHz to 18 GHz range. Measurement accuracy has also been improved through the use of memory. The memory stores the average of open/short reflections and other system residuals for subtraction from test data. The resulting normalized data is then displayed with state-of-the-art accuracy.

On or off the GPIB, operation of the 560 is easy to understand. Push-button controls and LED readouts are positioned in logical, functional groups. The awkward mechanical-type readouts used on other analyzers are noticeably missing. LED readouts and continuously variable potentiometers are used instead, resulting in measurements which are free of tedious adjustments and uncertain data.

FLEXIBLE SYSTEM CONFIGURATIONS

The simplest automatic network analyzer system consists of the 560, its SWR Autotester and Detector, a 610D Sweep Generator, and a desktop GPIB controller. Peripheral equipment such as recorders or plotters may be added as required. The 610D/6247D Sweep Generator is the natural companion to the 560. Its frequency range of 10 MHz to 18.5 GHz, as well as that of the SWR Autotesters, spans the frequencies most used in automatic test systems. Tests are made without interruption to switch bands manually or to change components and plug-ins. The 560 may be used with other sweep generators, including the HP 8620. Rear panel connectors are clearly identified to assure proper operation. System automation is accomplished with any GPIB controller, including the Hewlett-Packard 9825 Desktop Computer, the Tektronix 4051 Graphics System, and the Commodore PET 2001-8 Personal Computer. WILTRON Sales Engineers will be glad to assist in selecting the optimum system configuration for any application.

STRAIGHTFORWARD SYSTEM SETUP

A frequently used test setup is shown in Figure 1. The reflected signal from the test device is connected to channel A. The detected transmission signal is connected to channel B. After subtracting system residuals, which are stored in memory during calibration, the unit simultaneously displays return loss and transmission loss/gain. Determination of loss or gain is made by moving the trace vertically with the OFFSET control until the trace crosses the reference line at the frequency where test data is desired. Because trace positioning is continuous and made from a single control, the shortcomings of mechanical readout controls are absent. For example, resolution of a mechanical control may be limited by the large step size of the last digit. Therefore, determining the point at which the trace crosses the reference line may require inexact interpolation. Furthermore, if the required positioning control range exceeds the range of one digit, final positioning may require time-consuming adjustment of several digits. The 560 arrangement overcomes these incon-

veniences. Control is continuous. Loss, gain, and power are read directly in dB or dBm from an LED readout with 0.1 dB resolution.

Absolute power measurements are easy. It's not even necessary to make an independent calibration—it's done automatically. Just push the dBm button. Read power over the +16 dBm to −50 dBm range.

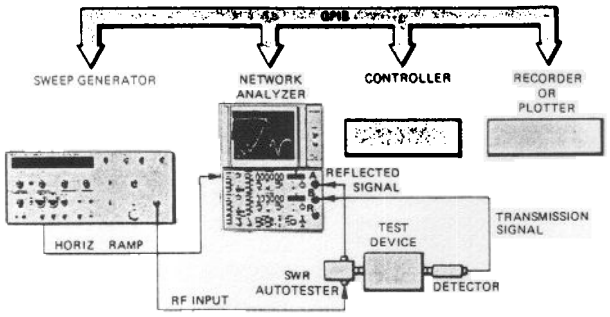
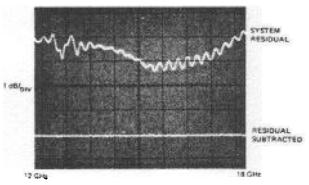


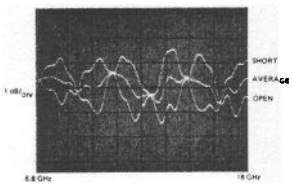
FIGURE 1. Typical test setup for simultaneous transmission loss/gain and return loss measurements.

MEMORY SIMPLIFIES OPERATION

Many measurements do not require the use of the R channel. In conventional analyzers, R is used to detect the input signal. The effects of variations in the input signal amplitude are then removed by taking the ratio of A/R and B/R. The 560 memory accomplishes the same thing and a lot more:



- Stored system residuals are automatically subtracted from test data—no need for grease pencil reference lines.
- One detector is used to measure each parameter—no errors resulting from lack of tracking between A and R or B and R Detectors.
- The R channel amplifier is not used—no errors from lack of perfect amplifier linearity.
- Only two detectors are used for dual trace display—no unnecessary costs or setup complexity.



- Memory automatically averages open/short reflections—no need for cumbersome and inaccurate estimates.
- The memory is an integral and dedicated part of the 560—no inconvenience of an external normalizer box that was designed for general purpose use.

Should an application require an R channel, the 560 has push-button selection of A, B, R, A-R, and B-R.

HIGHEST RETURN LOSS ACCURACY

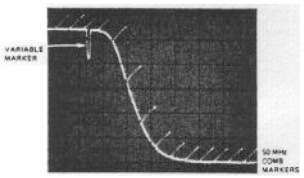
To avoid the use of error producing adapters, the 560 SWR Autotesters are available with APC-7, type N, and the new WSMA connectors. The 560-97A50 Option 1 with APC-7 connector has 40 dB directivity; the 560-97N50 Option 1 with type N and the 560-97S50 Option 1 with WSMA have 38 dB over the 10 MHz to 18 GHz range. The new WSMA connector provides a 10 dB improvement in return-loss measurement accuracy over a conventional SMA. In addition, the WSMA life expectancy is substantially longer, at least 20-fold.

The WSMA is also available on the 560-7S50 Detectors. Return loss specifications of 17 dB from 40 MHz to 18.5 GHz and 13 dB up to 26.5 GHz make these detectors the world's most accurate. By using recently developed zero-biased Schottky diodes, all Detectors and SWR Autotesters are free of the circuit complexity and power drift errors associated with biased diodes. Furthermore, all components may be used interchangeably without adjustment.

The 560 does not require modulation of the input signal. Channel amplifiers are self-balancing to assure stability at low input levels. The benefits of the 560 scheme are:

- Errors due to modulation asymmetry are avoided.
- Without the insertion loss of a modulator, measurements can be made at higher signal levels, increasing the measurement range.
- Test devices which are sensitive to modulation can be measured without degradation in accuracy.

In many applications, especially when characteristics change rapidly with frequency, the accuracy with which frequency is determined is important. For this reason, the 560 includes threshold and tilt control of the variable and comb markers generated in the 610D Sweep Generator. For applications which require the greatest return loss accuracy, the WILTRON perfected "Ripple Averaging" and "Magnified Reflection" techniques described in *The Wiltron Technical Review* Nos. 5 and 8 are recommended.



A DISPLAY MODE FOR EVERY APPLICATION

Four modes are available to display the characteristics of the many components, sub-assemblies, and systems that can be tested with the 560:

REAL TIME DISPLAY MODE. The horizontal sweep is synchronized with the ramp from the 610D Sweep Generator and may be varied from approximately 10 msec to 100 sec per sweep.

REFRESH DISPLAY MODE. The ramp from the 610D is digitized and stored in a 1024 point memory (512 points for dual trace). To provide a flicker-free display, the stored data is continuously updated at the sweep generator sweep rate while the refreshed display is swept at a 14 msec per sweep rate. Even though the 610D may sweep at a slow rate, the 560 presents a steady, non-flickering display.

REFRESH HOLD DISPLAY MODE. The updating of the display is stopped, and the display is frozen for analysis or photography.

X-Y PLOT DISPLAY MODE. The refresh sweep rate is slowed to approximately 30 sec per sweep for making plots on a mechanical recorder. A hard copy of any display, single or dual trace, may be made. Dual trace recordings are made automatically by sequentially plotting the A and B channels.

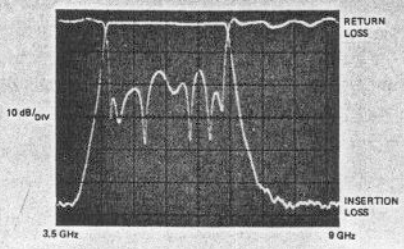
GPIB OPERATION

When the 560 is used under GPIB control, vertical display data is digitized to 0.01 dB resolution and sent to the bus. Data can be selected from A, B, R, A-R, and B-R or directly from the CRT. To assure compatibility with a wide selection of controllers, a rear panel switch selects either carriage return (CR) or carriage return and linefeed (CR/LF) as data delimiters. In addition, the 560 may be programmed for XY plot, smoothing, and service request (SRQ) data output recognition. SRQ can be inhibited for use with controllers lacking SRQ capability.

COMPLETE SYSTEM CAPABILITY

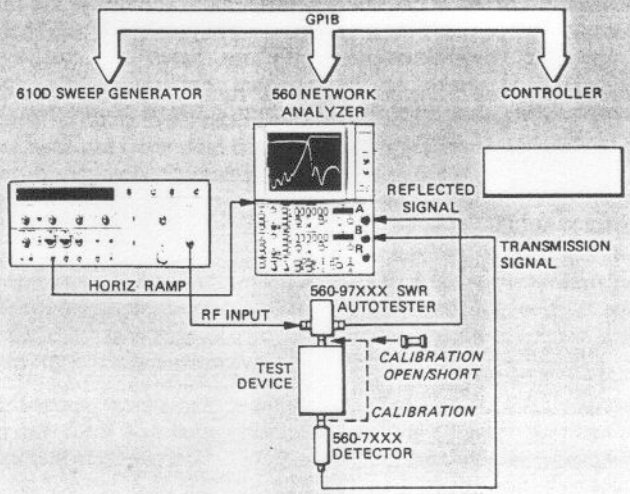
WILTRON offers its customers complete automatic network analyzer system capability. A wide selection of turnkey systems including programs are available from the Model 5610 family of automatic network analyzers.

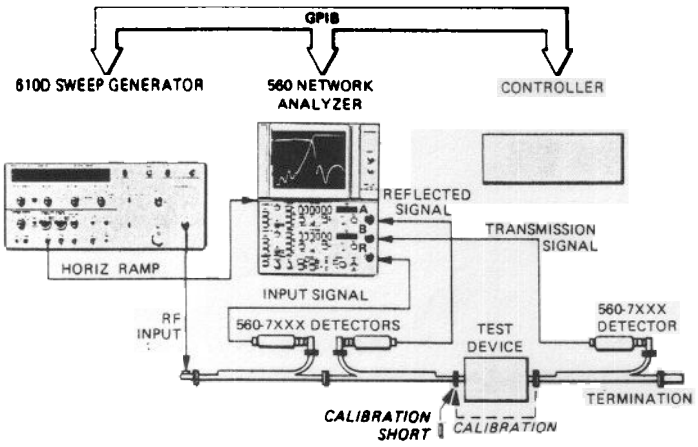
APPLICATIONS

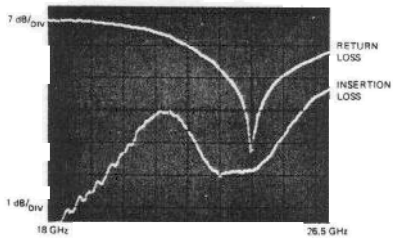


INSERTION LOSS/GAIN AND RETURN LOSS MEASUREMENTS

Simultaneous display of insertion loss (or gain) and return loss permits rapid alignment and measurement of test devices. During calibration, the B channel Detector is connected directly to the test port, and system residuals are stored in memory. Similarly, reflections from an open/short are automatically averaged and stored in memory for channel A. As test data is taken, the stored residuals are subtracted, leaving only the true characteristics of the test device for display. The use of memory to enhance accuracy enables the 560 to make these measurements using only channels A and B. However, if desired, channel R may be used to sample input power, which is then subtracted from A and B. Independent controls for A and B provide adjustment of offset, reference line position, and resolution over a 66 dB dynamic range. Test data may be placed on GPIB, plotted, as well as displayed on the CRT.

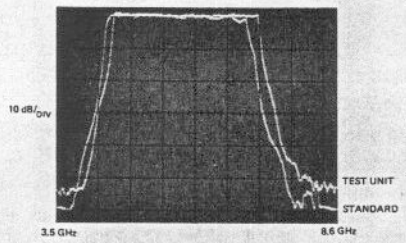






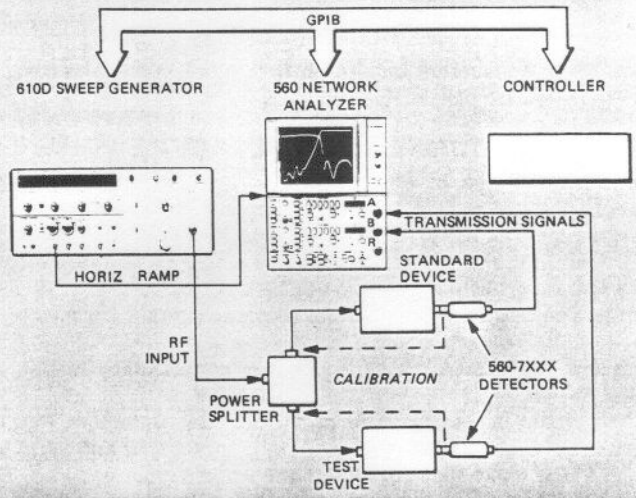
WAVEGUIDE REFLECTOMETER MEASUREMENTS

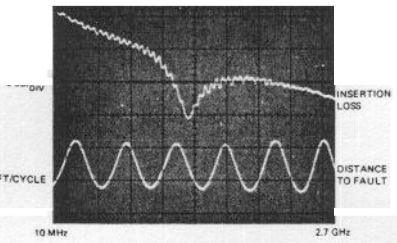
The block diagram shows the 560 in a common reflectometer setup. Before installing the test device, calibration is performed by storing residuals for B–R and A–R (with a short on the test port) for later subtraction from test data. The photo shows the characteristics of a waveguide section. Other typical test devices include antennas, transmission lines, mixers, couplers, filters and isolators. All standard waveguide frequency ranges up to 40 GHz are covered by plug-ins for the 610D Sweep Generator.



COMPARISON MEASUREMENTS

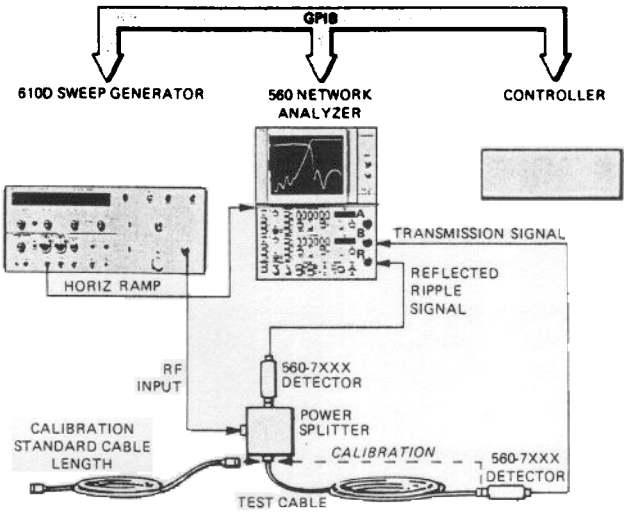
The 560's wide dynamic range and ability to subtract one characteristic from another make it ideal for comparing the insertion loss of a test device with that of a standard unit. Alignment of the test device to eliminate differences between it and the standard may be made while viewing the outputs of both devices or simply the difference between them. When used on a production line, this setup reduces alignment costs substantially.

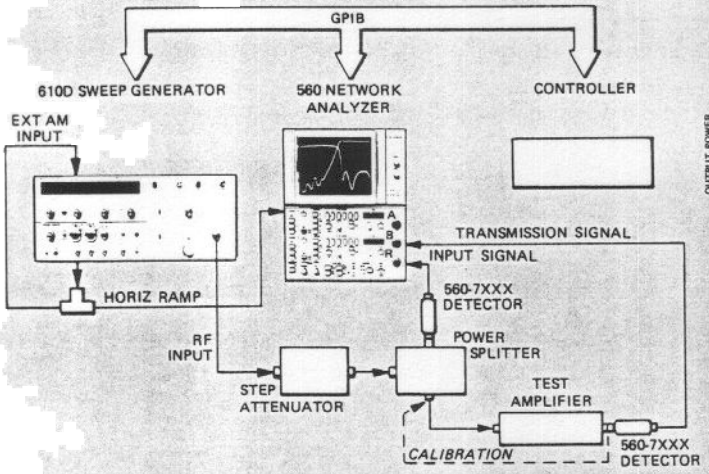


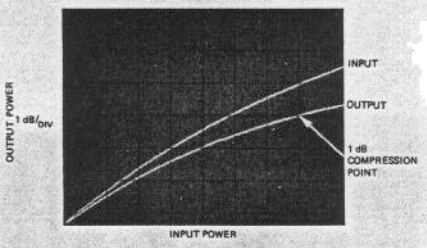


CABLE TRANSMISSION LOSS AND DISTANCE TO FAULT MEASUREMENTS

The 560 provides a fast, direct method for testing RF cables. After calibration and storage of B–R residuals, transmission loss may be measured from 10 MHz to 34 GHz. When a fault is detected, the R channel may be used to indicate the distance to the fault. Calibration of the R channel consists of connecting a known length of cable to the test port and adjusting the 610D ΔF sweep until there is one cycle of ripple for each foot of cable length. Locating the fault in the test cable is accomplished by switching to the preset ΔF sweep and counting the number of cycles (feet). The photo shows a 10 dB fault located 5-3/4 feet down the cable. Overall performance of systems containing power splitters, filters, couplers, amplifiers, and switches may be determined by observing output less input characteristics. Because the 560 is compact and light weight, it is well suited to testing cables aboard ships and aircraft or on the range. Extender cables up to 200 feet are available for long cable measurements.

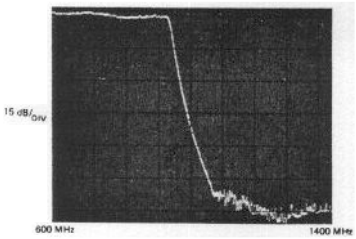






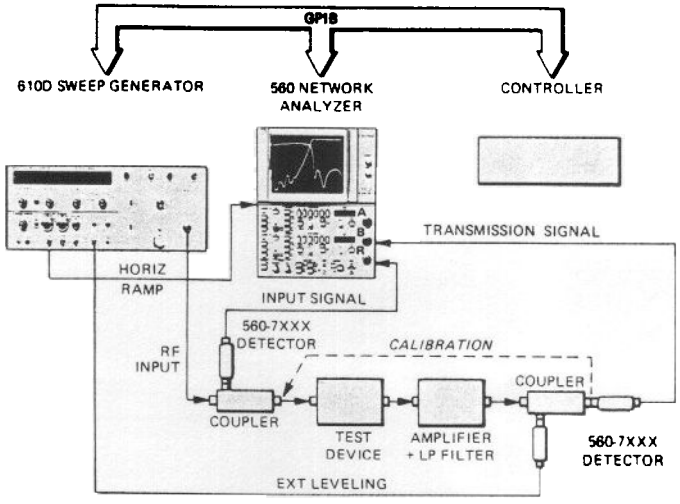
AMPLIFIER INPUT VS OUTPUT/GAIN AND 1dB COMPRESSION POINT MEASUREMENTS.

The ability to measure power and to display amplifier input vs output characteristics is a powerful measurement tool. In the setup shown, the 610D horizontal sweep ramp is used to modulate the RF input and to provide CRT horizontal deflection proportional to power. The vertical scale may be used to determine output power (B), gain (B–R), or the difference between input (R) and output (B) curves. With the addition of filters, fundamental and harmonic power levels may be measured. The 1 dB compression point of a solid state amplifier is shown in the photo.



EXPANDED DYNAMIC RANGE MEASUREMENTS

The dynamic range over which the 560 operates is limited on one end by available input power and on the other by detector noise level. The block diagram illustrates one method of extending dynamic range. Because the amplifier output is leveled, the input amplitude (R) follows the test device characteristics from the R detector noise level up to maximum leveled output power. As the test device attenuation increases further, the test device characteristic is tracked by the B detector down to its noise level. With proper selection of input power, coupling factors, and amplifier characteristics, the combined dynamic range of R and B detectors can be increased at least 20 dB. The photo shows a low pass filter over a greater than 90 dB range.



560 SCALAR NETWORK ANALYZER SYSTEM

WILTRON 610D Sweep Generator with Option 16 GPIB programmability is the ideal signal source for the 560.

RESOLUTION of 0.2, 0.5, 1, 2, 5 and 10 dB or any combination permits accurate measurement of fine or gross variations.

ACCURATE POWER MEASUREMENTS are made on channels A and B over the +16 dBm to −50 dBm range. Simply set the trace to the reference line and read power in dBm.

MEASUREMENT ACCURACY is enchanced by memory which stores system residuals and the average of short/open reflections. Residuals are subtracted from traces, leaving true characteristic of the test device.

Momentarily displays reference line for fast confirmation of preset **REFERENCE LINE POSITION.**

PUSH BUTTONS SELECT DISPLAY of A, B, R, A–R, and B–R, all with memory enhanced accuracy.

INDEPENDENT CONTROLS for channels A and B mean that two parameters can be displayed with optimum settings for each.

ZERO SET CONTROL positions reference line for either trace to any convenient point on screen. Test unit characteristics may be viewed over 66 dB range.

THRESHOLD AND TILT CONTROL of sweep generator variable and comb markers enable accurate frequency measurements.

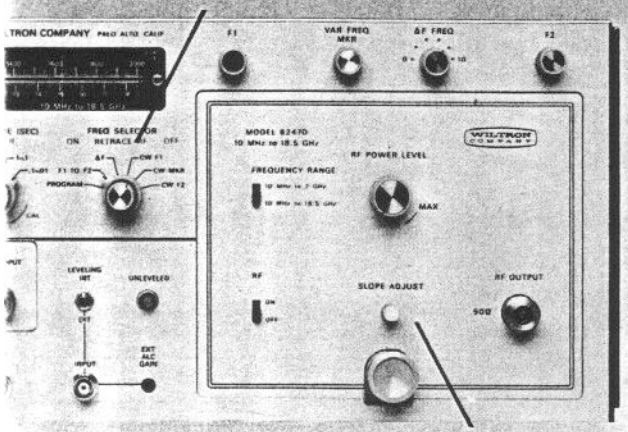
REFRESH MEMORY provides steady, unflickering traces regardless of sweep generator sweep rate. Refresh Hold freezes the display for analysis or photographs. Real-Time plotting is also included.

Three levels of smoothing **FILTERS REDUCE NOISE** on low level signal displays.

X–Y PLOT mode enables recorder to plot duplicate of single or dual traces displayed on CRT.

560 REAR PANEL CONNECTORS

Operating modes include broadband $F_1 \rightarrow F_2$ sweep, narrow band ΔF sweep, stable CW, and remote control.



WILTRON 6247D Plug-in sweeps continuously from 10 MHz to 18.5 GHz, making it the natural selection for use with the 560 Detectors and SWR Autotesters.

READOUT of transmission ain or return loss in dB and ute power in dBm over dB range with 0.1 dB tion.

Detectors and/or SWR Autotesters may be used on channels A, B, and R interchangeably without need for adjustment. **RF INPUT SIGNALS** are not modulated, eliminating distortion of test data taken on modulation sensitive devices.

CONTINUOUS OFFSET CONTROL for A and B assures fast, precise positioning of trace on reference line. Accurate reading of loss, gain, or power at crossover point is displayed on LED readout.

Because application requirements vary widely, there is no single best controller for the 560. Choices include the Tektronix 4051, the HP 9825, and the Commodore PET 2001.

SPECIFICATIONS

WILTRON

MODEL 560 NETWORK ANALYZER SPECIFICATIONS

GENERAL

DESCRIPTION: The Model 560 Network Analyzer provides swept frequency displays of transmission loss/gain, return loss, and power. A Network Analyzer Test Set consists of a receiver/display unit, an SWR Autotester and Detectors, which supply detected signals to the receiver. A sweep generator (WILTRON 610D) is commonly used as a signal source. A controller is required if programming on GPIB is desired.

FREQUENCY RANGE:

With standard Detectors:	10 MHz to 18.5 GHz
With Option 2 WSMA Detectors:	10 MHz to 26.5 GHz
With Option 3 WSMA Detectors:	10 MHz to 34 GHz
With SWR Autotesters:	10 MHz to 18 GHz

CHANNELS: Three (A, B, R) with push-button selection of A, B, R, A-R and B-R. Detected input signals supplied by Detectors or SWR Autotester, which may be interchanged without adjustment. Two channels are displayed simultaneously.

DYNAMIC MEASUREMENT RANGE AND SENSITIVITY:

A and B with Detectors:	66 dB (+ 16 dBm to − 50 dBm)
A and B with SWR Autotester:	66 dB (+ 16 dBm to − 50 dBm)*
R with Detector:	46 dB (+ 16 dBm to − 30 dBm)

*As seen by internal detector, typically 13 dB below input power.

OFFSET CONTROL: Positioning of A and B traces is independently and continuously adjustable over > ± 65 dB range. When trace is on reference line, power is displayed in dBm on 3 digit LED readout with 0.1 resolution. Offset is displayed in dB relative to a 0 dB reference level.

ZERO dB REFERENCE SET: Positions reference trace at selected 0 dB or 0 dBm reference line.

REFERENCE LOCATOR: Displays reference trace to locate reference line. Position is screwdriver adjusted.

OFFSET ZERO POSITION: Momentarily moves trace to position it would have were Offset adjusted to 0 dB or 0 dBm.

RESOLUTION: Independent control for A and B in steps of 0.2, 0.5, 1, 2, 5, 10 dB per division. Other values (3, 6, 15 dB, etc.) obtained by making multiple selections.

MEMORY:

STORE TRACE: Stores displayed trace(s) in 512 point memory. Used to store system residuals and the average of open/short reflections for subtraction from input test data.

AVERAGE: Averages data in memory with input test data and displays the result. Used to average system open/short return loss characteristics for subtraction from input test data.

SUBTRACTION: Subtracts data in memory from input test data and displays result.

RECALL: Displays stored data.

UNCALIBRATED SWEEP INDICATOR: Lights when external sweep generator sweep rate is too fast for memory.

SPECIFICATIONS

DISPLAY MODES:

REAL TIME: Horizontal sweep is synchronized with ramp from external sweep generator.

REFRESH: External sweep generator ramp is digitized and stored in 1024 point memory (512 points for dual trace). Stored data is updated continuously at sweep generator sweep rate. Steady, non-flickering display is provided regardless of sweep generator sweep rate. Vertical resolution is 512 points for single or dual traces.

REFRESH HOLD: Updating of display data is stopped. Display is frozen.

X-Y PLOT (REAL TIME): Provides pen lift, vertical, and horizontal signals for XY plot, coincident with external sweep generator ramp. Dual traces are automatically recorded by sweeping A and B channels sequentially.

X-Y PLOT (REFRESH): Display is frozen and then plotted at 30 second sweep rate. Dual traces are automatically recorded by sweeping A and B channels sequentially. After 1 second, sweep may be aborted and returned to start.

SMOOTHING FILTERS: Three levels of filtering optimize low level signal displays.

MARKERS: Threshold and tilt control of externally applied birdie or video markers.

ACCURACY

OVERALL RETURN LOSS MEASUREMENT ACCURACY: Uncertainties resulting from SWR Autotester and sweep generator frequency response and system open/short characteristics are subtracted automatically from test data. Overall accuracy is then:

RETURN LOSS ACCURACY = SWR AUTOTESTER ACCURACY + A AND B CHANNEL ACCURACY

SWR AUTOTESTER ACCURACY:

TEST PORT CONNECTOR		MODEL	DIRECTIVITY	ACCURACY① 10 MHz to 8 GHz	ACCURACY① 8 GHz to 18 GHz
APC-7		560-97A50	36 dB	0.016 ± 0.06 ρ^2	0.016 ± 0.1 ρ^2
		Option 1	40 dB	0.01 ± 0.06 ρ^2	0.01 ± 0.1 ρ^2
Type N	Male	560-97N50	35 dB	0.018 ± 0.08 ρ^2	0.018 ± 0.12 ρ^2
	Female	560-97NF50			
		Option 1	38 dB	0.013 ± 0.08 ρ^2	0.013 ± 0.12 ρ^2
WSMA	Male	560-97S50	35 dB	0.018 ± 0.08 ρ^2	0.018 ± 0.12 ρ^2
	Female	560-97SF50			
		Option 1	38 dB	0.013 ± 0.08 ρ^2	0.013 ± 0.12 ρ^2

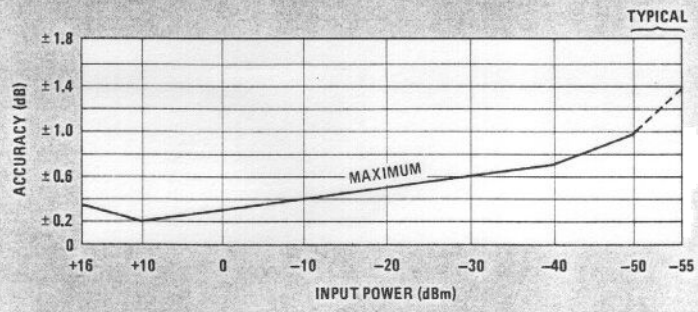
① *Where ρ is measured reflection coefficient of test device. Accuracy includes effects of test port reflections and directivity.*

OVERALL TRANSMISSION LOSS/GAIN MEASUREMENT ACCURACY: Uncertainties resulting from frequency response of Detectors, SWR Autotester, sweep generator and other test system components are subtracted automatically from test data. Overall accuracy is then:

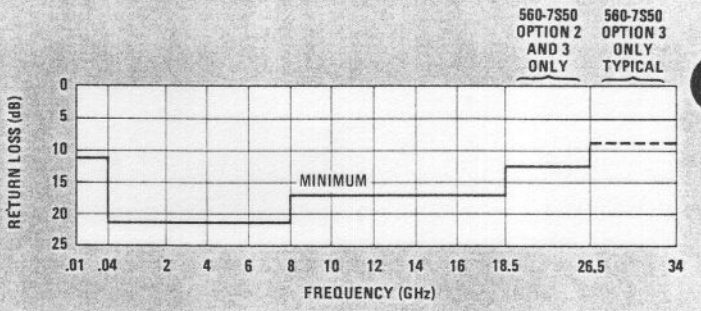
TRANSMISSION LOSS/GAIN ACCURACY = A AND B CHANNEL ACCURACY*

**Effects of sweep generator, test device, and Detector mismatch may be significant. Mismatch errors are minimized by the exceptionally low reflection characteristics of the 560 Detectors (See Detector Return Loss specifications).*

A AND B CHANNEL ACCURACY:



DETECTOR RETURN LOSS:



RECORDER / PLOTTER OPERATION

RECORDER / CRT MONITOR CONTROL: Rear Panel V/H OUT switch selects appropriate horizontal, vertical, blanking, and pen lift output voltages for external CRT monitor or mechanical recorder.

PEN LIFT OUTPUT: Provides normally-open relay contacts for lifting recorder pen during retrace. Lifted pen is held off paper until new sweep is started. Internal jumper available for normally-closed contacts.

VERTICAL OUTPUT: Varies from 0 to ± 4V (1V/div.) in proportion to display trace position. When V/H OUT switch is in CRT position, voltage alternates between A and B. When V/H OUT switch is in RCDR position and an XY plot is initiated, voltage first varies in proportion to A over full swept range and then in proportion to B. Pen-lift voltage lifts recorder pen between sweeps. Rear panel BNC connector.

SPECIFICATIONS

CRT DISPLAY

CATHODE RAY TUBE (CRT): 8 vertical by 10 horizontal divisions. One division ≅1.22 cm. Single beam, standard persistence (P31) phosphor CRT with internal graticule.

CRT BEAM CONTROL: Intensity and Focus.

CAMERA: Compatible with Tektronix C5B Option 01 camera with P/N 016-0642-00 Graticule Illumination Flash Unit.

HOOD: Compatible with Tektronix 016-0260-00 Hood

INPUT/OUTPUT CONNECTIONS

HORIZONTAL SWEEP RAMP INPUT: Screwdriver adjustment of horizontal position and gain permits input range of −1V to +1V at sweep start and of +5V to +20V at sweep end. Rear panel BNC connector, 100K ohms input impedance.

EXTERNAL BLANKING INPUT: +3V to +10V signal blanks CRT Z axis. Rear panel BNC connector, 10K ohms input impedance.

MARKER INPUT: 1mV to 10V peak input, rear panel BNC connector, 100K ohms input impedance. In addition, a −3V to −10V input to SEQ SYNC rear panel connector provides markers.

SEQUENTIAL SYNC INPUT: +3 to +10V blanks and maintains trace amplitude during switching of sweep generator oscillators. −3V to −10V introduces markers which are controlled by Threshold and Tilt. Rear panel BNC connector, 10K ohms input impedance.

HORIZONTAL SWEEP RAMP OUTPUT: 0 to 10V in synchronism with sweep display. Rear panel BNC connector.

BLANKING OUTPUT: Positive TTL compatible voltage during display retrace. Rear panel BNC connector.

GPIB

DIGITAL INTERFACE: Conforms to IEEE 488 and IEC 625 standard digital interface for programmable instrumentation.

GPIB ADDRESS: TALK and LISTEN addresses selected by rear panel switches.

DATA DELIMITER: Rear panel switch selects either CARRIAGE RETURN (CR) or CARRIAGE RETURN and LINE FEED (CR/LF) as data delimiters when in the TALK mode.

SRQ: Instrument can be programmed to generate a service request (SRQ) when data is available. If SRQ implementation is not desired, handshake will be completed when data is available.

REMOTE INDICATOR: Lights when test set is operating on GPIB.

PHYSICAL

TEMPERATURE RANGE: Operating: 0°C to +50°C
Storage: −40°C to +70°C

POWER: 100V/120V/220V/240V +5%, −10% selectable on rear panel. 50 Hz to 400 Hz, 85VA maximum

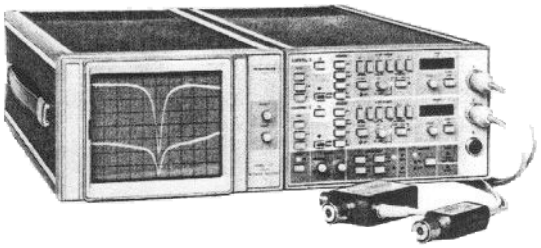
WEIGHT:
560 Horizontal or 560 Option 2 Vertical Configuration: 11 Kg (24.5 lb.)
560 Option 1 Rack Mounting: 13.5 Kg (30 lb.)

SIZE:
560 Horizontal Configuration:
133 mm H × 429 mm W × 500 mm D
(5.25 × 16.9 × 19.7 in)

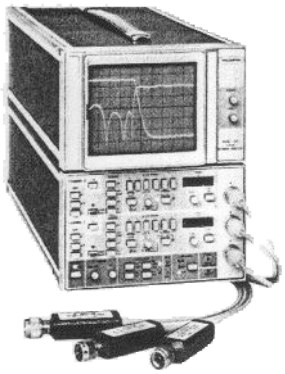
560 Option 2 Vertical Configuration:
267 mm H × 213 mm W × 500 mm D
(10.5 × 8.4 × 19.7 in)

560 Option 1 Rack Mount:
133 mm H × 483 mm W × 500 mm D
(5.25 × 19 × 19.7 in)

RACK MOUNTING (OPTION 1): Units supplied with mounting ears and chassis track slides (90° tilt) installed.



560 HORIZONTAL CONFIGURATION



560 OPTION 2 VERTICAL CONFIGURATION

PRICES:
560 Horizontal Configuration
560 Option 1 Horizontal Configuration with Rack Mount
560 Option 2 Vertical Configuration
560 Option 3 GPIB Programmability
560-D-7094 GPIB Field Installation Kit