HP 8901B
MODULATION ANALYZER

Operation and Calibration Manual

HEWLETT PACKARD

SAFETY CONSIDERATIONS

GENERAL

This product and related documentation must be reviewed for familiarization with safety markings and instructions before operation.

This product is a Safety Class I instrument (provided with a protective earth terminal).

BEFORE APPLYING POWER

Verify that the product is set to match the available line voltage and the correct fuse is installed.

SAFETY EARTH GROUND

An uninterruptible safety earth ground must be provided from the main power source to the product input wiring terminals, power cord, or supplied power cord set.

SAFETY SYMBOLS

⚠ Instruction manual symbol: the product will be marked with this symbol when it is necessary for the user to refer to the instruction manual (refer to Table of Contents).

Indicates hazardous voltages.

⏚ Indicates earth (ground) terminal.

WARNING The WARNING sign denotes a hazard. It calls attention to a procedure, practice, or the like, which, if not correctly performed or adhered to, could result in personal injury. Do not proceed beyond a WARNING sign until the indicated conditions are fully understood and met.

CAUTION The CAUTION sign denotes a hazard. It calls attention to an operating procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product. Do not proceed beyond a CAUTION sign until the indicated conditions are fully understood and met.

WARNING

Any interruption of the protective (grounding) conductor (inside or outside the instrument) or disconnecting the protective earth terminal will cause a potential shock hazard that could result in personal injury. (Grounding one conductor of a two conductor outlet is not sufficient protection).

Whenever it is likely that the protection has been impaired, the instrument must be made inoperative and be secured against any unintended operation.

If this instrument is to be energized via an autotransformer (for voltage reduction) make sure the common terminal is connected to the earth terminal of the power source.

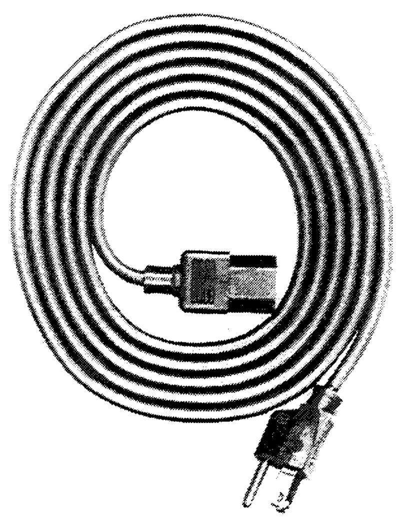
Servicing instructions are for use by service-trained personnel only. To avoid dangerous electric shock, do not perform any servicing unless qualified to do so.

Adjustments described in the manual are performed with power supplied to the instrument while protective covers are removed. Energy available at many points may, if contacted, result in personal injury.

Capacitors inside the instrument may still be charged even if the instrument has been disconnected from its source of supply.

For continued protection against fire hazard, replace the line fuse(s) only with 250V fuse(s) of the same current rating and type (for example, normal blow, time delay, etc.). Do not use repaired fuses or short circuited fuseholders.

MODEL 8901B



LINE POWER CABLE

Figure 1–1. *HP 8901B Modulation Analyzer and Supplied Accessories*

1–7. HEWLETT-PACKARD INTERFACE BUS (HP-IB)

Compatibility

The Modulation Analyzer's capabilities are defined by the following interface functions: SH1, AH1, T5, TE0, L3, LE0, SR1, RL1, PP0, DC1, DT1, C0. The Modulation Analyzer interfaces with the bus via open-collector TTL circuitry. An explanation of the compatibility code may be found in IEEE Standard 488–1978, *IEEE Standard and Digital Interface for Programmable Instrumentation* or the identical ANSI Standard MC1.1.

For more detailed information relating to programmable control of the Modulation Analyzer, refer to *Remote Operation, Hewlett-Packard Interface Bus* in Section 3 of this *Operating Information* manual.

Selecting the HP-IB Address

The HP-IB address switches are located within the Modulation Analyzer. The switches represent a five-bit binary number. This number represents the talk and listen address characters which the controller must generate. In addition, two more switches allow the Modulation Analyzer to be set to talk only or to listen only. A table in Section 2 shows all HP-IB talk and listen addresses. Refer to *HP-IB Address Selection* in Section 2 of this *Operation and Calibration* manual.

1–8. ADDITIONAL EQUIPMENT INFORMATION

Options

Options are variations on the standard instrument which can be ordered during the purchase. The following list defines all currently available options. Refer to *Electrical Equipment Available* in this section for retrofit part numbers that can be ordered after the purchase.

Option 001. This option provides rear-panel (instead of front-panel) connections for RF INPUT, SENSOR input, MODULATION OUTPUT/AUDIO INPUT, and AM/FM and RF POWER CALIBRATION OUTPUTs.

Option 002. This option provides a high-stability (1×10^{-9}/day) internal reference oscillator in place of the standard reference oscillator. In addition, a 10 MHz time base output is provided on the rear panel.

Option 003. This option provides both an output for the internal local oscillator signal and an input for an external local oscillator signal. Both connections are located on the rear panel. (This output is provided automatically with option 030 series instruments.)

Option 004. This option allows operation at line frequencies ranging from 48 to 400 Hz. Operation at frequencies greater than 66 Hz is restricted to less than 126.5 Vac line input.

Option 030. The High Selectivity Measurement option provides the capability to measure single-sideband carrier noise (AM or phase) quickly and accurately up to 1.3 GHz with an external LO. (An output for the internal local oscillator and an input for an external local oscillator signal is provided with these options.) This option is ordered with one of the following filter options:

Option 032. This option provides a 12.5 kHz adjacent channel filter.

Option 033. This option provides a 25 kHz adjacent channel filter.

Option 035. This option provides a 30 kHz (Cellular Radio) alternate channel filter.

Option 037. This option provides a carrier noise filter.

Options 907-909. These options are described in *Mechanical Equipment Available.*

Option 910. This option provides an extra copy of both the *Operation and Calibration Manual* and the *Service Manual.*

Accessories Supplied

The Accessories Supplied are pieces of equipment which are shipped automatically with every Modulation Analyzer.

Line Power Cable. The line power cable may be supplied in several plug configurations, depending on the destination of the original shipment. Refer to *Power Cables* in Section 2 of this *Operating Information* manual.

Fuses. Fuses with a 2.5A rating for 115 Vac (HP 2110-0083) and a 1.5A rating for 230 Vac (HP 2110-0043) are supplied. One fuse is factory installed according to the voltage available in the country of original destination. Refer to *Line Voltage and Fuse Selection* in Section 2 of this *Operating Information* manual.

Electrical Equipment Available

This equipment is available to be ordered for the Modulation Analyzer after the time of sale.

HP-IB Controller. The Modulation Analyzer has an HP-IB interface and can be used with any HP-IB compatible computing controller or computer for automatic systems applications.

Sensor Module. The HP 11722A and 11792A Sensor Modules enable you to characterize a signal using a single input connector. Switching back and forth between the Modulation Analyzer's SENSOR input and RF INPUT connectors happens automatically with these modules (which contain an internal switch). The HP 11722A covers the frequency range 100 kHz to 2.6 GHz; the HP 11792A covers the range 50 MHz to 26.5 GHz and is intended for use with the HP 11793A Down Converter. Special care is taken with each sensor module to minimize input SWR and resulting errors. A low SWR attenuator isolates the power sensor from the source-under-test, reducing mismatch. Microwave hardware and a selected RF input cable further improve SWR and insertion loss.

Down Converter. The HP 11793A Down Converter, when used with a suitable local oscillator, extends the useful range of the Modulation Analyzer into the microwave region. Provisions have been made in the Modulation Analyzer to account for the frequency of the local oscillator and provide direct display of the frequency of the microwave input signal.

Test Source. The HP 11715A AM/FM Test Source produces extremely linear AM and FM at high rates as well as a low-noise CW signal. This source is required for performance testing and adjusting the Modulation Analyzer; however, it is an excellent stand-alone instrument for generating very low-distortion FM in the broadcast band.

Service Accessory Kit. A Service Accessory Kit (HP 08901-60287) is available which contains accessories (such as extender boards and cables) useful in servicing the Modulation Analyzer.

Front-to-Rear-Panel Connectors Retrofit Kit (Option 001). This kit contains all the necessary components and full instructions for converting front-panel connections to rear-panel connections. Order HP part number 08901-60282.

Rear-to-Front-Panel Connectors Retrofit Kit (Standard). This kit contains all the necessary components and full instructions for converting Option 001 instruments with rear-panel connections to instruments with front-panel connections. Order HP part number 08901-60283.

High-Stability, Internal-Reference Retrofit Kit (Option 002). This kit contains all the necessary components and full instructions for installation of the high-stability, internal-reference oscillator. Order HP part number 08901-60281.

Rear-Panel Local Oscillator Connections Retrofit Kit (Option 003). This kit contains all the necessary components and full instructions for installation of rear-panel local oscillator connections. Order HP part number 08901-60280. (These connections are already included in all Option 030 Series instruments.)

Conversion to 400 Hz Line Operation. Modulation Analyzers not equipped to operate at line power frequencies greater than 66 Hz may be converted to operate at line frequencies from 48 to 440 Hz. However, operation at line frequencies greater than 66 Hz will be restricted to line voltages less than or equal to 126.5 Vac. To convert to 400 Hz operation, order HP part number 08901-60095. After installation, performance will be identical to the HP 8901B Option 004.

Mechanical Equipment Available

The following kits might have been ordered and received with the Modulation Analyzer as options. If they were not ordered with the original shipment and are now desired, they can be ordered from the nearest Hewlett-Packard office using the appropriate part number.

Front-Handle Kit (Option 907). Ease of handling is increased with the front-panel handles. Order HP part number 5061-9690 for the basic kit and 2190-0048 for lockwashers (8 required).

Rack-Flange Kit (Option 908). The Modulation Analyzer can be solidly mounted to the instrument rack using the flange kit. Order HP part number 5061-9678.

Rack-Flange and Front-Handle Combination Kit (Option 909). This is not a front-handle kit and a rack-flange kit packaged together; it is composed of a unique part which combines both functions. Order HP part number 5061-9684 for the basic kit and 2190-9609 for lockwashers (8 required).

Chassis Slide-Mount Kit. This kit is extremely useful when the Modulation Analyzer is rack mounted. Access to internal circuits and components or the rear panel is possible without removing the instrument from the rack. Order HP part number 1494-0017 for 432 mm (17 in.) fixed slides. (To order adapters for non-HP rack enclosures, use HP part number 1494-0023.)

Chassis-Tilt, Slide-Mount Kit. This kit is the same as the Chassis Slide Mount Kit above except it also allows the tilting of the instrument up or down 90°. Order HP part number 1494-0025 for 432 mm (17 in.) tilting slides. To order adapters for non-HP rack enclosures, use HP part number 1494-0023.

1-9. DESCRIPTION OF THE MODULATION ANALYZER

The HP Model 8901B Modulation Analyzer is a complete measurement system for accurately characterizing signals in the 150 kHz to 1300 MHz frequency range. It combines the capabilities of four separate instruments in its ability to measure RF power, carrier frequency, modulation and the characteristics of the demodulated audio signal (as well as those of external audio signals). This flexibility allows you to make those measurements most commonly needed to totally characterize a signal.

The Modulation Analyzer can measure an RF signal's frequency, frequency drift, power level (broadband, and off-channel), amplitude modulation (AM), frequency modulation (FM), phase modulation (ΦM), and AM and FM noise components. It recovers the modulating signal and can measure the audio signal's frequency and distortion.

The Modulation Analyzer is fully automatic and all major measurements can be made by pushing a single key. The Modulation Analyzer's large digital display shows measurement results with excellent resolution and is easy to read. All Modulation Analyzer operations can be controlled and all measurement results can be transferred via the Hewlett-Packard Interface Bus (HP-IB). (HP-IB is Hewlett-Packard's implementation of IEEE Standard 488 and ANSI Standard MC1.1.)

RF Power Measurements

The Modulation Analyzer delivers the accuracy and resolution of a high-performance power meter. The HP 8901B, with the HP 11722A Sensor Module, measures power from +30 dBm to −20 dBm at frequencies from 100 kHz to 2.6 GHz. (Refer to Table 1-1, *Specifications*, for specified frequencies limits using other power sensors. The HP 8901B also accepts all HP 8480 series power sensors for extended measurement capability.)

Input Power Protection. The Modulation Analyzer is equipped with input power protection to prevent damage from the accidental application of excessive power. (This is a common cause of damage in equipment used to measure transmitters.) The Modulation Analyzer is tested for inputs up to 2W. Protection is provided by limiting diodes and an RF relay. When excessive power is applied, the relay opens and protects sensitive components, and the Modulation Analyzer displays an error message. The circuit automatically resets whenever a key is depressed.

RF Power Calibration. RF Power Calibration is accomplished with the 50 MHz, 1 mW standard available in every instrument. Also, the front-panel ZERO function enables you to zero the sensor module without removing it from the source-under-test. After the ZERO key is pressed, the new zero offsets are stored automatically.

RF Power Calibration Factors. RF Power Calibration Factors can be entered from the power sensor into the Modulation Analyzer's non-volatile memory. The instrument automatically compensates for the power sensor's efficiency and mismatch loss at each frequency.

High Selectivity Measurements. Options 030–037 add selective power measurement capability to the HP 8901B Modulation Analyzer. Used with a low-noise external LO, the HP 8901B performs fast, accurate single-sideband (SSB) carrier noise measurements to 1.4 GHz.

RF Frequency Measurements

In automatic operation, the Modulation Analyzer has the performance of a high-quality, 150 kHz to 1300 MHz frequency counter. The frequency counter automatically adjusts itself as the input level changes. There is no need to manually set or adjust the input attenuator. Because the Modulation Analyzer is usually used to measure modulated signals, its frequency counter also accurately measures signals with significant levels of AM.

Modulation Measurements

The Modulation Analyzer has extremely low internal noise. Incidental AM, FM, and ΦM can be measured on a wide range of simple and complex modulated signals. To complement its modulation measurement capability, the HP 8901B characterizes audio signal level, frequency, and distortion. (These features are also available for external audio signals.)

Filters, De-emphasis Networks and Modulation Calibrators

Post-Detection Audio Filters. The Modulation Analyzer has two high-pass and three low-pass post-detection audio filters for filtering the recovered modulation. These filters can be selected individually or in combination. Their cutoff frequencies have been chosen to match those needed for applications such as transmitter or signal generator testing. The >20 kHz filter is a Bessel filter. It minimizes overshoot for square-wave modulation so that this type of modulating waveform can also be accurately measured.

De-Emphasis Networks. The Modulation Analyzer contains four de-emphasis networks that can be used in addition to the audio filters. These are the ones commonly used in FM communications—25, 50, 75, and 750 μs. When selected, the de-emphasis networks always affect the demodulated output. You can select whether the de-emphasis network affects the deviation measured. The ability to select either the actual or "de-emphasized deviation" increases the usefulness of the Modulation Analyzer in many applications.

Modulation Calibrators. One of the most difficult problems involved in making very accurate measurements of AM depth or FM deviation is generating a precisely modulated signal to use as a calibration standard. In all instruments, a precise AM and FM modulation standard is included.

When the output of the calibrator is connected to the Modulation Analyzer's input, the amount of modulation is measured to create a calibration factor. The calibration factor can be used to automatically compensate all subsequent measurements. The calibration factor is the ratio of the measured modulation to the internally-computed modulation of the calibrator, expressed in %.

Additional Features

Tuning Features. In automatic operation, the Modulation Analyzer automatically tunes to the input signal and measures it.

In manual operation, you can determine the frequency to which the Modulation Analyzer tunes. Entering the approximate frequency on the keyboard causes all but very close interfering signals to be eliminated. This allows the Modulation Analyzer to selectively measure signals other than the largest.

A track mode feature enables you to track a signal, as it changes frequency, from either automatic or manual tune operation.

Store and Recall functions. These functions enable you to store eight complete instrument settings in non-volatile memory and recall them as needed.

Display Flexibility. The Modulation Analyzer offers numerous data-display formats. For example, RF power can be displayed in watts, dBm, V, dBV, mV, dBmV, μV, and dBμV. Use the RATIO and LOG/LIN keys to display results in dB or % relative to either a measured value or a value entered from the keyboard. These features eliminate the need for recalculating measurement results.

Special Functions

The Modulation Analyzer can do more than is apparent from the front panel. Many functions are accessed using the numeric keys and a Special Function key. The Special Functions provide access to other measurements and functions, manual control of instrument functions, instrument operation verification, and service aids.

All instrument functions not set using these Special Functions remain in the automatic mode. This allows you to select any combination of manual or automatic operations. By depressing the special key alone, the display shows ten digits that indicate which functions are in automatic and the state of those manually set.

There are also numerous Special Functions that can be used in verifying that the instrument and its various sections are operating properly. These, along with service special functions, make diagnosing and repairing the Modulation Analyzer faster and easier.

Those Special Functions that are most commonly used in operating the Modulation Analyzer are described on the *Special Function Information* pull-out card under the front panel.

Extending Measurement Range

Operation to 42 GHz is accomplished when an external LO and mixer are included in the measurement path. This system then functions as a single instrument making microwave modulation, frequency, power, and level measurements. You control operation from the Modulation Analyzer's front panel. When the external LO frequency must be changed, the Modulation Analyzer requests an external controller to make the change. A separate, non-volatile calibration factor table is available in Frequency Offset mode for your microwave power sensor.

Programmability

The Modulation Analyzer is completely programmable via the Hewlett-Packard Interface Bus (HP-IB). This, coupled with the diversity of measurements the Modulation Analyzer can make, the speed with which these measurements can be made, and the flexibility of the Special Functions, make the instrument ideal for systems applications. In many instances it can reduce the number of instruments in a system, speed measurements, reduce complexity and improve accuracy.

When the Modulation Analyzer is in remote, the front-panel annunciators make it very easy to determine the state the instrument is in; whether it is in the talk, listen, or service request state.

1-10. PRINCIPLES OF OPERATION USING A SIMPLIFIED BLOCK DIAGRAM

The Modulation Analyzer is a calibrated, superheterodyne receiver, which converts the incoming signal to a fixed, intermediate frequency (IF), which is then demodulated. As in a radio receiver, the Modulation Analyzer contains an RF amplifier, a local oscillator (LO), a mixer, an IF amplifier and bandpass filter, a demodulator (detector or discriminator), and audio filters (tone controls). The Modulation Analyzer, however, contains additional features which make it much more versatile:

- automatic tuning,
- selectable measurement mode: signal frequency, power level, or modulation (AM, FM, or Phase Modulation (ΦM)),
- selectable audio detector (peak, average, or rms responding),
- audio counter,

- audio distortion analyzer,
- measurement calibrators (AM, FM, or power level), and
- HP-IB programmability.

The entire operation of the instrument is governed by a microprocessor-based Controller. The Controller sets up the instrument at turnon, interprets keyboard entries, executes changes in internal hardware, and displays measurement results and error messages. The computing capability of the Controller is also used to simplify circuit operation. For example, it forms the last stage of the Counter, calculates the AM or FM generated by the AM and FM Calibrators, and converts measurement results into ratios (in % or dB). The Controller also contains routines useful for servicing the instrument.

RF Circuitry

The RF input signal normally enters an external Sensor Module such as an HP 11722A. (See Figure 1-2.) For all measurements except RF Power, the Sensor Module routes the signal to the RF input connector of the Modulation Analyzer. For the RF Power measurement, the input signal passes directly into the Power Sensor, which converts the RF power absorbed by the RF Power Sensor into a low-frequency, chopped, ac voltage whose amplitude is proportional to the average RF power. The Power Meter amplifies the chopped signal and converts it to a dc voltage which is then measured by the voltmeter. (The voltmeter includes the Audio Peak Detector, Audio Average Detector, Voltage-to-Time Converter, and Counter.) The calibration of the Power Meter can be verified by connecting the Sensor Module to the CALIBRATION RF POWER OUTPUT connector on the front panel. (The 50 MHz Power Reference Oscillator is an accurate 1 mW reference.)

CAUTION

The Power Sensor is unprotected against and is easily damaged by sudden, large overloads. Refer to Table 1-1 under RF Power, Supplemental Characteristics, RF Power Ranges of HP 8901B Modulation Analyzer with HP 11722A Sensor Module, for information on maximum operating levels.

When the RF Peak Detector senses that the input signal level exceeds 1W, it opens the Overpower Relay. This is done without intervention of the Controller. The output from the RF Peak Detector, read by the voltmeter, is used to set the Input Attenuator to optimize the level applied to the Input Mixer.

The Input Mixer converts the input signal to the intermediate frequency (IF). For frequencies greater than 10 MHz, the IF is 1.5 MHz with the Local Oscillator (LO) tuned 1.5 MHz above the input frequency; an IF of 455 kHz can be manually selected for this frequency range. The 455 kHz IF is selected automatically for input signals between 2.5 MHz and 10 MHz. Below 2.5 MHz, the input passes directly through the Input Mixer without down-conversion.

NOTE

For the input signal to pass through the Input Mixer without down-conversion, the LO must still be present to turn the mixer diodes on. An LO frequency of 101.5 MHz is arbitrarily used. Thus the instrument will respond to input frequencies of 100 or 103 MHz as well as frequencies between 150 kHz and 2.5 MHz.

The instrument can be manually tuned to a desired signal even in the presence of larger signals, although filtering may be necessary since low-frequency signals pass directly into the IF. The RF High-Pass Filter can be inserted (via a Special Function) in the RF path for this purpose.

To measure the input frequency, the Counter measures the frequency of the LO and the frequency of the IF from the output of the IF Amplifier and Filter. The Controller computes and displays the difference between the two frequencies. For input frequencies below 2.5 MHz, only the IF is counted, which equals the input frequency.

LO Circuitry

The LO drives the high-level port of the Input Mixer and is one of several inputs to the Counter. The LO has four main modes of operation:

- tuning to the frequency required to down-convert a signal whose frequency is entered from the keyboard (manual tune mode),
- automatically searching for an input signal, then tuning the LO to the frequency required to down-convert the signal (automatic tune mode),
- automatically searching for an input signal, then configuring the LO in a feedback loop that automatically tracks the signal (automatic tune track mode), and
- tuning to the frequency required to down-convert a signal whose frequency is entered from the keyboard, then configuring the LO in a feedback loop that automatically tracks the input signal (manual tune track mode).

The manual tune track mode is useful when it is desired to follow an unstable signal in the presence of other signals. The non-track modes are used when the LO noise (residual FM) must be minimized.

IF Circuitry

The gain of the IF Amplifier is fixed. The IF Filters determine the frequency response of the IF. When the 1.5 MHz IF is selected, the IF filter consists of a 150 kHz to 2.5 MHz bandpass filter (with a nominal center frequency of 1.5 MHz). When the 455 kHz IF is selected, the IF filter is the Wide 455 kHz Bandpass Filter (with a bandwidth of 200 kHz).

In instruments with Option Series 030, the IF signal is further processed by the Channel Filters (which also include a precision, variable-gain amplifier) and detected by the IF RMS Detector. The Channel Filters set the IF bandwidth and gain for the Selective Power measurement. The measurement is made by entering a series of Special Functions which establish an IF reference in the center of the Channel Filter, then allow the relative IF level to be displayed as the IF frequency is detuned by a pre-determined offset.

Audio Circuitry

The modulation on the IF is demodulated by either the AM or the FM Demodulator. Phase modulation is recovered by integrating the demodulated FM in the Audio Filters and Gain Control circuitry.

The demodulated signal is amplified and filtered in the Audio Filters and Gain Control circuitry. The filters are selected from the front panel, and for FM, the filtering may also include de-emphasis. The processed signal is passed to the front-panel MODULATION OUTPUT/AUDIO INPUT connector and the voltmeter.

The audio signal from the Audio Filters and Gain Control is converted to a dc voltage by the Audio Peak Detector, the Audio Average Detector or the Audio RMS detector. The Audio Average and RMS Detectors are used primarily for measuring noise. The output from the detectors is routed into the Voltage-to-Time Converter.

The Voltage-to-Time Converter within the voltmeter converts the dc input into a time interval. During the interval, the 10 MHz Time Base Reference is counted by the Counter, and the resultant count represents the dc voltage. Other inputs to the voltmeter, which are not shown, include outputs from an audio level detector and the AM calibrator.

The Distortion Analyzer measures the distortion of either the internal demodulated signal or an audio signal applied externally to the MODULATION OUTPUT/AUDIO INPUT connector. The frequency of the input signal must be either 1 kHz or 400 Hz. The distortion on the signal is determined by measuring the amplitude of the signal before and after a notch filter that is set to 1 kHz or 400 Hz. The two ac signals are converted to dc by a the Audio RMS Detector and then measured by the voltmeter. Distortion is computed as the ratio of the voltage out of the notch filter to the voltage into the filter. (The Audio RMS Detector can also be used to measure the demodulated AM, FM, or ΦM internally or the ac level of an external audio signal applied to the MODULATION OUTPUT/AUDIO INPUT connector.)

The frequency of the audio signal at the MODULATION OUTPUT/AUDIO INPUT connector, whether internal or external, is measured by a reciprocal-type Audio Counter. In the Audio Counter, the input signal is used to gate the 10 MHz Time Base Reference into the main Counter. (This gating function is also used by the Voltage-to-Time Converter.) The number of time base pulses received during the count is read by the Controller which computes and displays the signal frequency.

The AM and FM Calibrators provide a nominal 10.1 MHz signal with a precisely known amount of AM or FM. When this signal is applied to the instrument's RF INPUT connector (either directly or via the Sensor Module), the modulation is measured and the calibration factor of the AM or FM Demodulator is computed and displayed. Related front-panel functions are automatically set for proper demodulation of the calibrator signal.

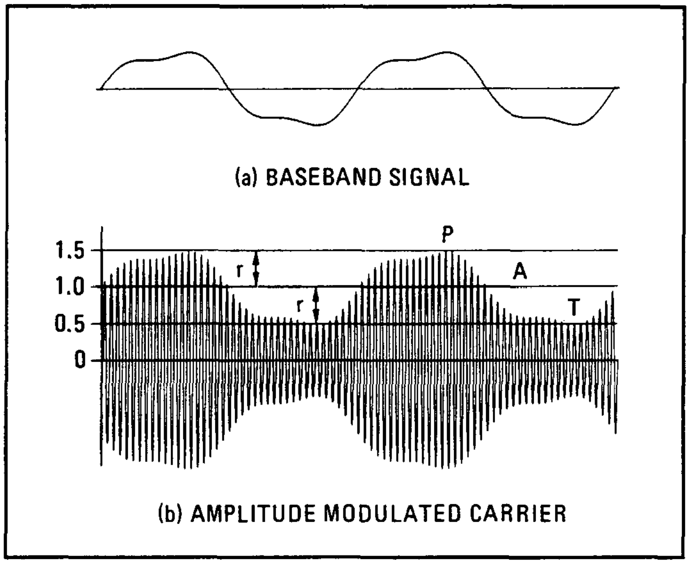


Figure 1–3. *A Baseband Signal and the Corresponding Amplitude Modulated Carrier*

1-11. MODULATION BASICS

The Modulation Analyzer can demodulate and measure three types of modulation: amplitude modulation (AM), frequency modulation (FM), and phase modulation (ΦM). In general, modulation is that characteristic of a signal which conveys the information. A signal without modulation is said to be a continuous-wave (CW) signal. CW signals contain two information-carrying parameters: amplitude and frequency. These two parameters, however, are static (time invariant). Consequently, the information conveyed by them is scant—you know only that a signal is present at a certain frequency. When one or both of these parameters is altered as a function of time, the signal is said to be modulated.

The RF signal which is modulated is called the carrier. The modulating signal is referred to as the baseband signal and can be of any arbitrary form (for example, voice, tone, noise). Demodulation is the process of recovering the baseband signal from the modulated carrier. The Modulation Analyzer can measure the modulation on carriers in the range of 150 kHz to 1300 MHz. Measurement accuracy is specified for modulation rates generally between 20 Hz and 100 kHz. The demodulated signal is present at the MODULATION OUTPUT connector.

Amplitude Modulation

As the name implies, a carrier is amplitude modulated when its amplitude is varied as a function of time. Figure 1-3 shows a carrier with amplitude modulation and, for reference, also shows the baseband signal. As you can see, the tips of the carrier trace out a waveform that resembles the baseband signal. This trace is called the envelope. The envelope rises to a maximum called the peak and drops to a minimum called the trough. A quantity which describes the amount of AM or the AM depth is the modulation index. If the peak amplitude is called P and the trough amplitude is called T, the modulation index m (usually expressed in %) is defined as

$$m = \frac{P - T}{P + T} \times 100\%.$$

In the example of Figure 1-3, $P = 1.5$ and $T = 0.5$; therefore,

$$m = \frac{1.5 - 0.5}{1.5 + 0.5} \times 100\% = 50\%.$$

Figure 1-4 shows AM signals with modulation indexes varying from 0 to 100%.

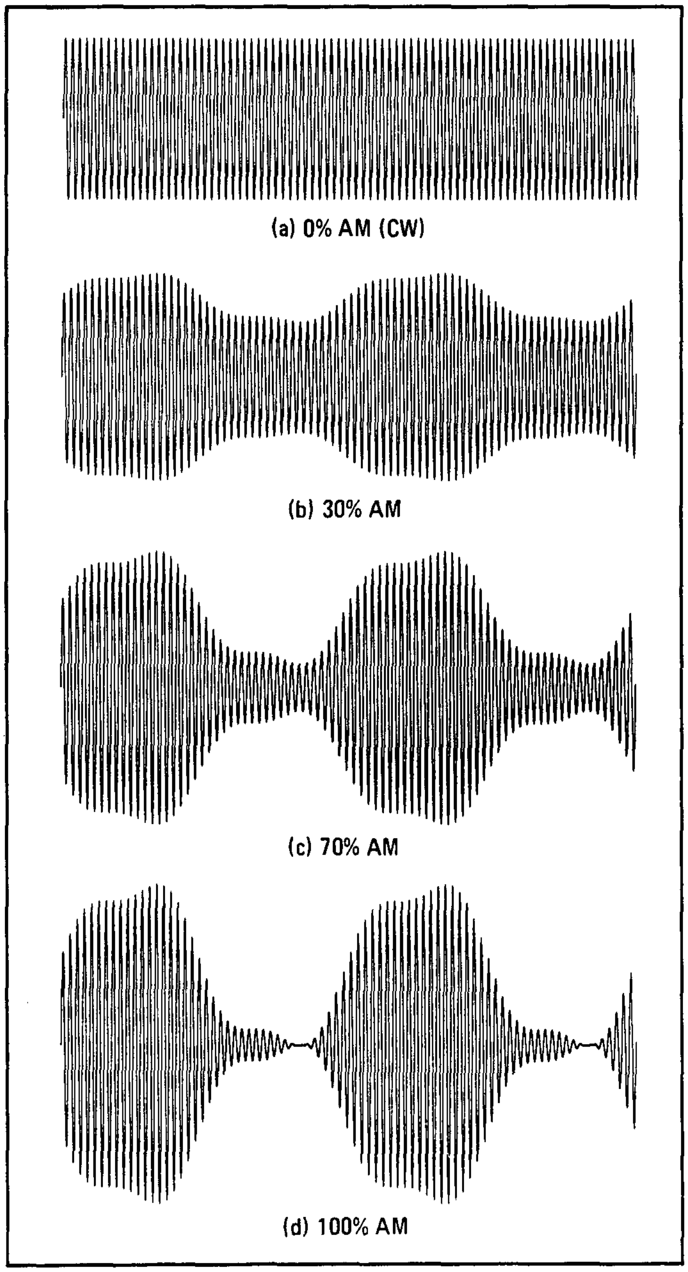


Figure 1-4. *AM for Various Depths*

When the baseband signal is symmetrical, the modulation index can also be expressed in terms of the average carrier level, A, and the envelope peak, r, relative to the carrier. Then $P = A+r$, and $T = A-r$, and the expression for modulation index becomes

$$m = \frac{A+r-A+r}{A+r+A-r} \times 100\% = \frac{2r}{2A} \times 100\% = \frac{r}{A} \times 100\%.$$

This is the expression which the Modulation Analyzer evaluates when making an AM measurement. Referring back to Figure 1-3, it is apparent that $A = 1$ and $r = 0.5$ so, as before

$$m = \frac{0.5}{1} \times 100\% = 50\%$$

The Modulation Analyzer makes an AM measurement by forcing the average carrier level, A, to a known, fixed level by means of an automatic level control (ALC) circuit. The signal is then demodulated, and the amplitude of the recovered baseband signal is measured with a peak detector. The output of the detector is r, which is (in effect) multiplied by the constant $100/A$ and displayed as the % AM.

Figure 1-5 illustrates an AM signal with an asymmetrical baseband source. The first definition of modulation index still applies here. For it, $m = 46\%$. The second definition, however, does not apply since $P-A \neq A-T$. The Modulation Analyzer detects a different value for r if the positive peak of the recovered signal is detected than if the negative peak is detected. Thus a different modulation index is measured in PEAK+ than PEAK−.

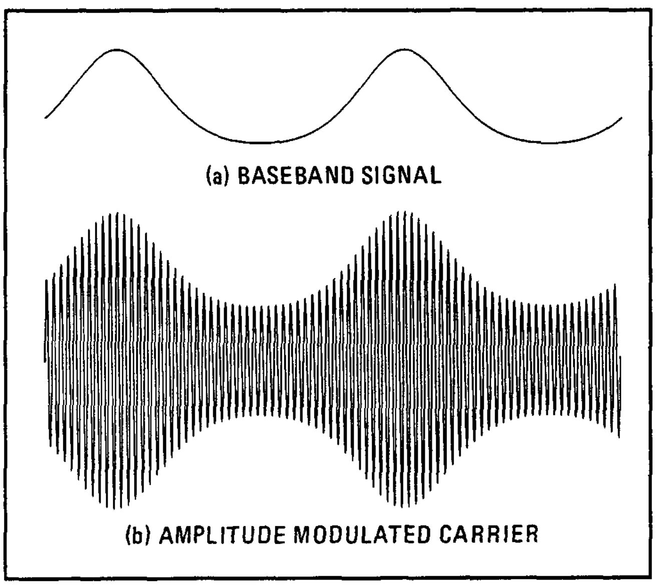


Figure 1–5. *AM with an Asymmetrical Baseband Signal*

The range of modulation indexes for AM measurements by the Modulation Analyzer is essentially 0 to 100%. There are, however, types of modulation that produce modulation indexes greater than 100%. An example of such is suppressed-carrier AM. The Modulation Analyzer is not intended for measuring such signals. Nevertheless, there are cases, when the Modulation Analyzer will display a modulation index that exceeds 100%. This can occur, for example, on an asymmetrical waveform where a narrow peak is greater than the average carrier level. This is illustrated in Figure 1-6.

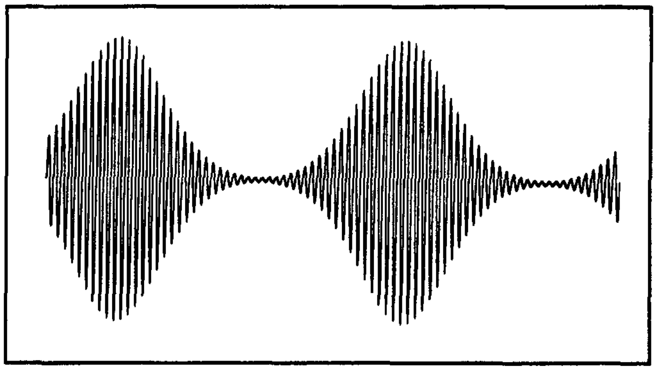


Figure 1-6. *AM with Modulation Exceeding 100% as Measured by the PEAK+ Detector*

Exponential Modulation

Exponential (or angular) modulation is the generic name given to modulation in which the frequency or phase of the carrier is varied. Frequency and phase modulation are very closely related. In fact, it is impossible to tell whether the signal was produced by a frequency modulator or phase modulator by analyzing the received signal unless specific information about the baseband signal is given.

It is certainly true to say that a signal is frequency modulated when the modulation is generated by a frequency modulator. A varactor diode across the tank circuit of an LC oscillator will produce FM when the varactor bias is varied. It is also true that a signal is phase modulated when the modulation is generated by a phase modulator. A varactor diode across an RF filter will produce ΦM when the varactor bias is varied. (It is assumed that the carrier is on the slope of the filter and that the filter is driven from a well-buffered carrier source. This modulator simultaneously produces AM.)

The signal from both modulators will show readings on the Modulation Analyzer when in both the FM and ΦM measurement modes. When in FM, the quantity being measured is the peak frequency deviation, which is the maximum frequency excursion from the average carrier frequency. When measuring ΦM, the peak phase deviation is measured, which is the maximum phase excursion from the average carrier phase. Phase and frequency have the relationship that phase is the integral of the frequency or frequency is the derivative of the phase. In fact, the Modulation Analyzer demodulates ΦM by integrating the demodulated FM.

This relationship is most easily visualized by some examples. Look at Figure 1-7. The first baseband signal shown is a square wave. The three waveforms under it are the result of applying this signal to an FM, ΦM, and AM modulator respectively. (The AM waveform is included only for reference.) It is assumed that the phase modulator doesn't produce AM—only ΦM. The FM waveform is as expected. The frequency goes up on the positive peak of the baseband signal and down on the negative peak. The phase modulated signal, however, is peculiar. The frequency is generally constant throughout except for a discontinuity where the baseband signal switches amplitude. The waveform of the figure was contrived so that a 180° phase shift occurred exactly at a zero crossing of the carrier. In general, a discontinuity will occur when the baseband signal switches amplitude, but the phase shift is not necessarily 180° and does not need to occur at a zero crossing of the carrier. Mathematically, the derivative of a square wave is the constant zero except for a positive spike (impulse) where the baseband signal switches positive and a negative spike where the square wave switches negative.

Now look at the triangle wave. The frequency modulator produces a continually increasing frequency as the baseband signal slopes upward and a continually decreasing frequency as the signal slopes downward. The phase modulator produces a signal that resembles the signal from the frequency modulator for the square wave baseband signal. This is because the derivative of a constant slope is a constant. When the slope is positive, the phase shift is continually increasing, thus producing a uniform frequency shift upward. When the slope is negative, the phase shift is continually decreasing and produces a downward frequency shift. For the triangle wave baseband signal, the shift in frequency when the slope changes is proportional to the change in slope.

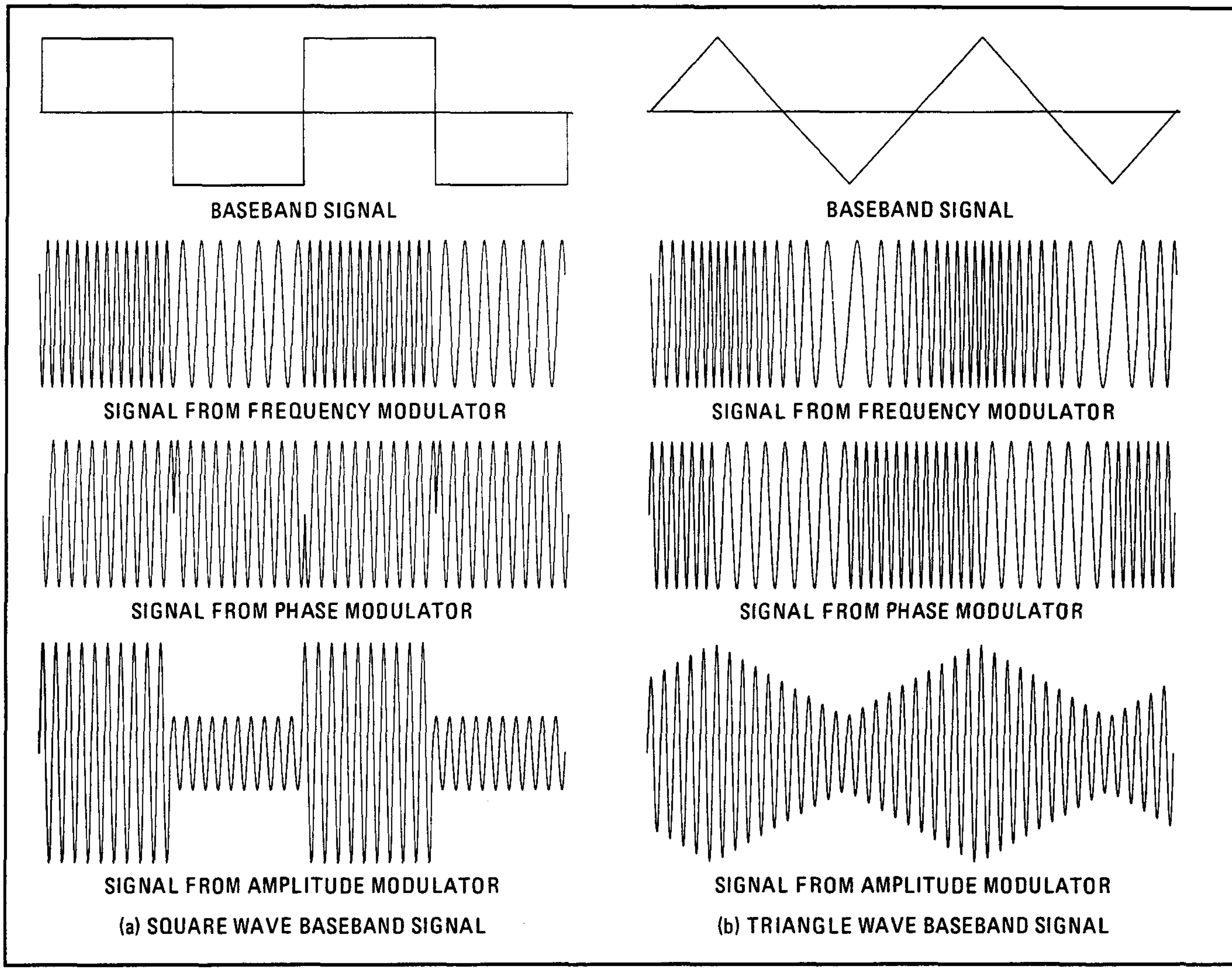
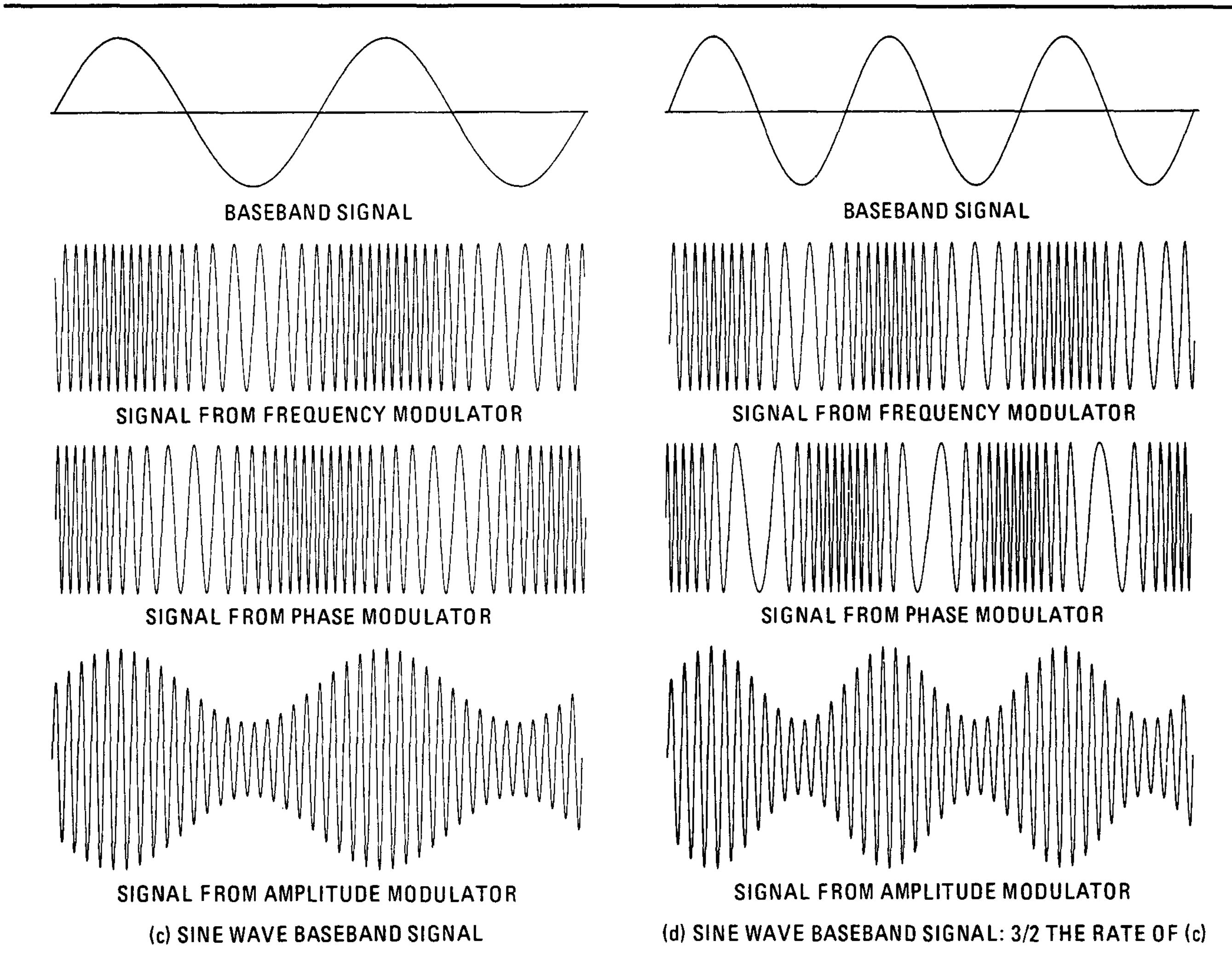


Figure 1-7. *Signals from Frequency, Phase, and*

Now note the sine wave of Figure 1-7(c). The signals from the frequency and phase modulators look the same except for the 90° phase shift between the two. For the frequency modulated signal, the frequency is highest when the baseband signal is most positive and lowest when most negative. For the phase modulated signal, the frequency is highest when the slope of the baseband signal is steepest in a positive direction. This occurs at the positive-going zero crossing. Similarly, the frequency is lowest when the slope is most negative.

If in the last example, the rate, but not the amplitude, of the baseband signal is increased, the highest and lowest frequencies of the signal from the frequency modulator stay the same—they just occur more often. However, for the signal from the phase modulator, not only do the frequency peaks occur more often, but the excursions are large because the slopes of the baseband signal are steeper at the zero crossings. See Figure 1-7(d).

The maximum frequency deviation which can be measured is 400 kHz. The maximum phase deviation is 400 rad or 400 kHz divided by the modulation rate, whichever is smaller. As with AM, an asymmetrical baseband waveform will result in different readings in PEAK+ than PEAK−.



Amplitude Modulators for Various Baseband Signals

Other Considerations

In practice, it is difficult to produce an FM or ΦM signal which does not also have a small amount of AM—called incidental AM or AM-on-FM. Likewise, an AM signal usually contains a small amount of incidental FM and ΦM. In order to accurately measure this incidental modulation, the Modulation Analyzer itself must not contribute to it. This contribution is specified as AM rejection and FM rejection.

A typical CW signal also contains a small amount of residual AM, FM, and ΦM. The residual modulation is generated by such things as line hum, noise, and microphonics. The residual AM and FM specifications quantify the residual modulation internal to the Modulation Analyzer.

Residual modulation affects the modulation readings in a manner which depends on the detector used, the nature of the residuals, and the signal-to-noise ratio. If the residual is predominately noise, when the peak detector is used, the residuals add in a way that is statistically related to the signal-to-noise ratio. This is discussed under *Residual Noise Effects* in the *Detailed Operating Instructions* in Section 3. When the average detector is used, the residuals add approximately in an rms manner, that is, the square root of the sum of the squares of the noise and the signal. The effect of this noise becomes insignificant, however, when the signal-to-noise ratio rises above a few dB. Noise can be further reduced by filtering the demodulated signal.

Table 1-1. Specifications (1 of 6)

RF Power

The HP 8901B Modulation Analyzer, with HP 11722A Sensor Module, performs RF Power Measurements from −20 dBm (10 μW) to +30 dBm (1W) at frequencies from 100 kHz to 2.6 GHz. The 8901B can be used with any of the HP 8480 series power sensors (8481A/1B/1H/2A/2B/2H/3A/4A/5A) to make power measurements from −70 dBm (10 pW) to +44 dBm (25W) at frequencies from 100 kHz to 26.5 GHz. The 8480 series sensors also work with the HP 435A and HP 436A Power Meters. Unless otherwise specified, the specifications shown below refer to the 8901B only. A detailed explanation of how the uncertainty specifications provided below affect the absolute power measurement accuracy of the 8901B is provided in Application Note 64-1.

RF POWER RESOLUTION[1]:
0.1% of full scale in watts or volts mode.
0.01 dB in dBm or $dB_{relative}$ mode.

LINEARITY (includes sensor non-linearity):
RF range linearity ± RF range-to-range change error.

RF RANGE LINEARITY (using Recorder Output)[2]:
±0.02 dB, RF ranges 2—5.
±0.03 dB, RF range 1.
Using front-panel display add ±1 count of least-significant digit.

RF RANGE-TO-RANGE CHANGE ERROR:
±0.02 dB/RF Range Change from reference range.

INPUT SWR: <1.15, using 11722A Sensor Module.

ZERO SET (DIGITAL SETTABILITY OF ZERO):
±0.07% of full scale of lowest range.
Decrease by a factor of 10 for each higher range.

Supplemental Characteristics:

ZERO DRIFT OF METER:
±0.03% of full scale/°C of lowest range.

NOISE (at constant temperature, peak change over any one-minute interval for the 11722A Sensor Module and 8481A/1B/1H/2A/2B/2H/3A/5A Sensors):
0.4% of full scale on range 1 (lowest range).
0.13% of full scale on range 2.
0.013% of full scale on range 3.
0.0013% of full scale on range 4.
0.00013% of full scale on range 5.
For HP 8484A Sensor multiply noise by five on all ranges.

[1] *The 8901B fundamental RF Power measurement units are watts. Further internal processing is done on this number to display all other units.*

[2] *When using 8484A sensor the noise specification may mask the linearity specification and become the predominant error. When operating on the top RF power range, add the Power Sensor Linearity percentages found in the power sensor specifications.*

ZERO DRIFT OF SENSORS (1 HOUR, AT CONSTANT TEMPERATURE AFTER 24-HOUR WARM-UP):
±0.1% of full scale of lowest range for 11722A Sensor Module and 8481A/1B/1H/2A/2B/2H/3A/5A sensors.
±2.0% of full scale of lowest range for 8484A sensor.
Decrease by a factor of 10 for each higher range.

RF POWER RANGES OF 8901B MODULATION ANALYZER WITH 11722A SENSOR MODULE:
−20 dBm to −10 dBm (10 μW to 100 μW), range 1.
−10 dBm to +0 dBm (100 μW to 1 mW), range 2.
+0 dBm to +10 dBm (1 mW to 10 mW), range 3.
+10 dBm to +20 dBm (10 mW to 100 mW), range 4.
+20 dBm to +30 dBm (100 mW to 1W), range 5.

RESPONSE TIME (0 to 99% OF READING):
<10 seconds, range 1.
<1 second, range 2.
<100 milliseconds, ranges 3-5.

DISPLAYED UNITS:
watts, dBm, $dB_{relative}$, $\%_{relative}$, volts, mV, μV, dB V, dB mV, dB μV.

INTERNAL NON-VOLATILE CAL-FACTOR TABLES (user-modifiable using special functions):

MAXIMUM NUMBER OF CAL FACTOR/FREQUENCY ENTRIES:
Table #1 (Primary): *16 pairs plus Reference Cal Factor.*
Table #2 (Frequency Offset): *22 pairs plus Reference Cal Factor.*

MAXIMUM ALLOWED FREQUENCY ENTRY:
200 GHz.

FREQUENCY ENTRY RESOLUTION: *50 kHz.*

CAL FACTOR RANGE: *40 to 120%.*

CAL FACTOR RESOLUTION: *0.1%.*

Power Reference

POWER OUTPUT:
1.00 mW. Factory set to ±0.7%, traceable to the U.S. National Bureau of Standards.

ACCURACY: ±1.2% worst case (±0.9% rss) for one year (0°C to 55°C).

Supplemental Characteristics:

FREQUENCY: *50 MHz nominal.*

SWR: *1.05 nominal.*

FRONT PANEL CONNECTOR: *Type-N female.*

All parameters describe performance in automatic operation or properly set manual conditions. **Specifications** describe the instrument's warranted performance. ***Supplemental Characteristics*** (shown in *italics*) are intended to provide information useful in applying the instrument by giving typical, but non-warranted, performance parameters.

Amplitude Modulation

RATES:

20 Hz to 10 kHz, 150 kHz $\leq f_c <$ 10 MHz.
20 Hz to 100 kHz, 10 MHz $\leq f_c \leq$ 1300 MHz.

DEPTH: to 99%.

ACCURACY[3, 4, 5]:

AM Accuracy	Frequency Range	Rates	Depths
±2% of reading ±1 digit	150 kHz-10 MHz	50 Hz-10 kHz	5%-99%
±3% of reading ±1 digit	150 kHz-10 MHz	20 Hz-10 kHz	to 99%
±1% of reading ±1 digit	10 MHz-1300 MHz	50 Hz-50 kHz	5%-99%
±3% of reading ±1 digit	10 MHz-1300 MHz	20 Hz-100 kHz	to 99%

For rms detector add ± 3% of reading.

FLATNESS[6, 7]:

Flatness	Frequency Range	Rates	Depths
±0.3% of reading ±1 digit	10 MHz-1300 MHz	90 Hz-10 kHz	20%-80%

DEMODULATED OUTPUT DISTORTION:

<0.3% THD for ≤50% depth.
<0.6% THD for ≤95% depth.

FM REJECTION (50 Hz TO 3 kHz BW)[4]:

FM Rejection	Frequency Range	Rates	FM Deviations
<0.2% AM	250 kHz-10 MHz	400 Hz or 1 kHz	$<5\ kHz_{peak}$
<0.2% AM	10 MHz-1300 MHz	400 Hz or 1 kHz	$<50\ kHz_{peak}$

RESIDUAL AM (50 Hz to 3 kHz BW): $<0.01\%_{rms}$.

Supplemental Characteristics:

DETECTORS: *+peak, −peak, ±peak/2, peak hold, average (rms sinewave calibrated), rms.*

MAXIMUM DEPTH, RESOLUTION, AND MAXIMUM DEMODULATED OUTPUT SENSITIVITY ACROSS AN OPEN CIRCUIT (600Ω OUTPUT IMPEDANCE)[7]:

Maximum Resolution	Maximum Demodulated Output Sensitivity	Depths
0.1%	0.01 V/percent	$AM_{peak} \geq 40.0\%$
0.01%	0.1 V/percent	$AM_{peak} < 40.0\%$
0.001% (rms detector only)	0.1 V/percent	$AM_{rms} < 3.0\%$

[3] *But not to exceed: 50 Hz to 40 kHz rates for stated accuracy with rms detector.*

[4] *Peak residuals must be accounted for in peak readings.*

[5] *For peak measurements only: AM accuracy may be affected by distortion generated by the Analyzer. In the worst case this distortion can decrease accuracy by 0.1% of reading for each 0.1% of distortion.*

[6] *Flatness is the variation in indicated AM depth for constant depth on input signal.*

[7] *For optimum flatness, cables should be terminated with their characteristic impedance.*

Frequency Modulation

RATES[8]:

20 Hz to 10 kHz, 150 kHz $\leq f_c <$ 10 MHz.
20 Hz to 200 kHz, 10 MHz $\leq f_c \leq$ 1300 MHz.

DEVIATIONS[8]:

$40\ kHz_{peak}$ maximum, 150 kHz $\leq f_c <$ 10 MHz.
$400\ kHz_{peak}$ maximum, 10 MHz $\leq f_c \leq$ 1300 MHz.

ACCURACY[3, 4, 8]:

FM Accuracy	Frequency Range	Rates	Deviations
±2% of reading ±1 digit	250 kHz-10 MHz	20 Hz-10 kHz	$\leq 40\ kHz_{peak}$
±1% of reading ±1 digit	10 MHz-1300 MHz	50 Hz-100 kHz	$\leq 400\ kHz_{peak}$
±5% of reading ±1 digit	10 MHz-1300 MHz	20 Hz-200 kHz	$\leq 400\ kHz_{peak}$

For rms detector add ±3% of reading.

DEMODULATED OUTPUT DISTORTION[8, 9]:

THD	Frequency Range	Rates	Deviations
<0.1%	400 kHz-10 MHz	20 Hz-10 kHz	<10 kHz
<0.1%	10 MHz-1300 MHz	20 Hz-100 kHz	<100 kHz

AM REJECTION (50 Hz TO 3 kHz BW)[4]:

AM Rejection	Frequency Range	Rates	AM Depths
<20 Hz peak deviation	150 kHz-1300 MHz	400 Hz or 1 kHz	≤50%

RESIDUAL FM (50 Hz to 3 kHz BW):

$<8\ Hz_{rms}$ at 1300 MHz, decreasing linearly with frequency to $<1\ Hz_{rms}$ for 100 MHz and below.

Supplemental Characteristics:

MAXIMUM FM DEVIATION, RESOLUTION, AND MAXIMUM DEMODULATED OUTPUT SENSITIVITY ACROSS AN OPEN CIRCUIT (600Ω OUTPUT IMPEDANCE)[7]:

Maximum Resolution	Maximum Demodulated Output Sensitivity	Deviations (ΔF)
100 Hz	0.01 mV/Hz	$\Delta F_{peak} \geq 40$ kHz
10 Hz	0.1 mV/Hz	4.0 kHz $\leq \Delta F_{peak} < 40$ kHz
1 Hz	1.0 mV/Hz	$\Delta F_{peak} < 4$ kHz
0.1 Hz (rms detector only)	1.0 mV/Hz	$\Delta F_{rms} < 0.3$ kHz

Resolution is increased one digit with 750 µs de-emphasis and pre-display on.

The demodulated output signal present at the Modulation Out/Audio In connector is increased in amplitude by a factor of 10 with 750 µs de-emphasis.

[8] *But not to exceed: 20 kHz rates and 40 kHz peak deviations with 750 µs de-emphasis filter.*

[9] *With 750 µs de-emphasis and pre-display "off," distortion is not specified for modulation outputs >4V peak. This condition can occur near maximum deviation for a measurement range, at rates <2 kHz.*

Table 1-1. *Specifications (3 of 6)*

DEMODULATED OUTPUT DISTORTION:

THD	Frequency Range	Rates	Deviations
<0.3%	150 kHz–400 kHz	20 Hz–10 kHz	<10 kHz

DETECTORS: *+peak, −peak, ±peak/2, peak hold, average (rms sinewave calibrated), rms.*

STEREO SEPARATION (50 Hz to 15 kHz): *>47 dB.*

Phase Modulation

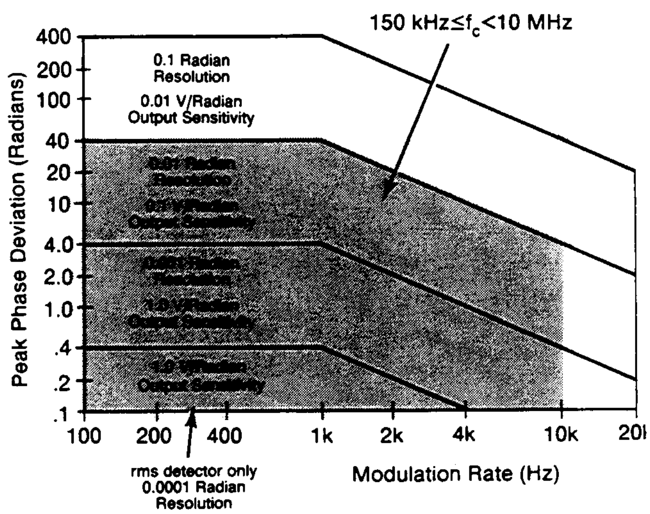
RATES:
200 Hz to 10 kHz, 150 kHz$\le f_c <$ 10 MHz.
200 Hz to 20 kHz, 10 MHz$\le f_c \le$ 1300 MHz.

ACCURACY[4]**:**
±4% of reading ±1 digit, 150 kHz$\le f_c <$ 10 MHz.
±3% of reading ±1 digit, 10 MHz$\le f_c \le$ 1300 MHz.
For rms detector add ±3% of reading.

DEMODULATED OUTPUT DISTORTION: <0.1% THD.

AM REJECTION (FOR 50% AM AT 1 kHz RATES)[4]**:**
<0.03 radians peak (50 Hz to 3 kHz BW).

MAXIMUM DEVIATION, RESOLUTION, AND MAXIMUM DEMODULATED OUTPUT SENSITIVITY ACROSS AN OPEN CIRCUIT (600Ω OUTPUT IMPEDANCE)[7]**:**



Supplemental Characteristics:

MODULATION RATES: *usable from 20 Hz to 100 kHz with degraded performance.*

DETECTORS: *+peak, −peak, ±peak/2, peak hold, average (rms sinewave calibrated), rms.*

Modulation Reference

AM CALIBRATOR DEPTH AND ACCURACY:
33.33% depth nominal, internally calibrated to an accuracy of ±0.1%.

FM CALIBRATOR DEVIATION AND ACCURACY:
34 kHz_{peak} deviation nominal, internally calibrated to an accuracy of ±0.1%.

Supplemental Characteristics:

CARRIER FREQUENCY: *10.1 MHz.*

MODULATION RATE: *10 kHz.*

OUTPUT LEVEL: *−25 dBm.*

Frequency Counter

RANGE: 150 kHz to 1300 MHz.

MAXIMUM RESOLUTION: 1 Hz.[10]

ACCURACY:
± reference accuracy ±3 counts of least-significant digit, f_c <100 MHz.
± reference accuracy ±3 counts of least-significant digit or 30 Hz, whichever is larger, $f_c \ge$ 100 MHz.

Supplemental Characteristics:

MODES:
Frequency and Frequency Error (displays the difference between the frequency entered via the keyboard and the actual RF input frequency).

SENSITIVITY IN MANUAL TUNING MODE:
0.22 mV_{rms} (−60 dBm). (Approximate frequency must be entered from keyboard.)

Internal Reference

FREQUENCY: 10 MHz.

AGING RATE:
<1 × 10^{-6}/month.
<1 × 10^{-9}/day (Option 002).[11]

Supplemental Characteristics:

INTERNAL REFERENCE ACCURACY:
Overall accuracy is a function of time base calibration ± aging rate ± temperature effects ± line voltage effects ± short-term stability.

	Standard	Option 002
Aging Rate	<1 × 10^{-6}/mo.	<1 × 10^{-9}/day
Temperature Effects	<2 × 10^{-7}/ °C	<2 × 10^{-10}/ °C
Line Voltage Effects (+5%, −10% Line Voltage Change)	<1 × 10^{-6}	<6 × 10^{-10}
Short Term Stability	—	<1 × 10^{-9} for 1 s average

[10] 10 Hz for instruments with firmware date codes 234.1985 and below. (To display the firmware date code, select 42.0 SPCL.) To order a ROM set that contains this capability, contact the nearest HP sales office.
[11] After 30-day warmup.

Table 1–1. Specifications (4 of 6)

Audio Frequency Counter

FREQUENCY RANGE:
20 Hz to 250 kHz. *(Usable to 600 kHz.)*

MAXIMUM EXTERNAL INPUT VOLTAGE: $3V_{rms}$.

Accuracy (For Demodulated Signals):[12]

Accuracy	Frequency	Modulation (Peak)
±3 counts of least-significant digit ±Internal Reference Accuracy	>1 kHz	AM ≥10% FM ≥1.0 kHz ϕM ≥ 1.5 radians
±0.02 Hz ±Internal Reference Accuracy	≤1 kHz	AM ≥10% FM ≥ 1.0 kHz ϕM ≥1.5 radians
±0.2 Hz ±Internal Reference Accuracy (3 kHz low-pass filter inserted)	≤3 kHz	1.5% ≤ AM < 10% 0.15 kHz ≤ FM < 1.0 kHz 0.15 radian ≤ ϕM < 1.5 radians

Accuracy (For External Signals):[11]

Accuracy	Frequency	Level
±3 counts of least-significant digit ±Internal Reference	>1 kHz	≥100 mV_{rms}
±0.02 Hz ±Internal Reference Accuracy	≤1 kHz	≥100 mV_{rms}

Supplemental Characteristics:

DISPLAYED RESOLUTION: *6 digits.*

MEASUREMENT RATE: *2 readings/s.*

COUNTING TECHNIQUE:
Reciprocal with internal 10 MHz time base.

AUDIO INPUT IMPEDANCE: *100 kΩ nominal.*

Audio Distortion

FUNDAMENTAL FREQUENCIES:
400 Hz ± 5% and 1 kHz ±5%.

MAXIMUM EXTERNAL INPUT VOLTAGE: 3V.

DISPLAY RANGE:
0.01% to 100.0% (−80.00 dB to 0.00 dB).

DISPLAYED RESOLUTION: 0.01% or 0.01 dB.

ACCURACY: ±1 dB of reading.

SENSITIVITY:
Modulation: 0.15 kHz peak FM. 1.5% peak AM or 0.6 radian peak ϕM.
External: 100 mV_{rms}.

RESIDUAL NOISE AND DISTORTION[13]**:**
0.3% (−50 dB). temperature <40°C.

Supplemental Characteristics:

MEASUREMENT 3 dB BANDWIDTH: *20 Hz to 50 kHz.*

DETECTION: *True rms.*

MEASUREMENT RATE: *1 reading/s.*

AUDIO INPUT IMPEDANCE: *100 kΩ nominal.*

Audio RMS Level

FREQUENCY RANGE: 50 Hz to 40 kHz.

VOLTAGE RANGE: 100 mV to 3V.

ACCURACY: ± 4.0% of reading.

Supplemental Characteristics:

FULL RANGE DISPLAY: *.3000V, 4.000V.*

AC CONVERTER: *true-rms responding for signals with crest factor of ≤3.*

MEASUREMENT RATE: *2 readings/s.*

AUDIO INPUT IMPEDANCE: *100 kΩ nominal.*

Audio Filters

DE-EMPHASIS FILTERS: 25 μs, 50 μs, 75 μs, and 750 μs. De-emphasis filters are single-pole, low-pass filters with 3 dB frequencies of: 6366 Hz for 25 μs, 3183 Hz for 50 μs, 2122 Hz for 75 μs, and 212 Hz for 750 μs.

50 Hz HIGH-PASS FILTER (2 POLE):
Flatness: <1% at rates≥ 200 Hz.

300 Hz HIGH-PASS FILTER (2 POLE):
Flatness: <1% at rates≥ 1 kHz.

3 kHz LOW-PASS FILTER (5 POLE):
Flatness: <1% at rates ≤1 kHz.

15 kHz LOW-PASS FILTER (5 POLE):
Flatness: <1% at rates ≤10 kHz.

>20 kHz LOW-PASS FILTER (9 POLE BESSEL)[14]**:**
Flatness: <1% at rates ≤10 kHz.

Supplemental Characteristics:

DE-EMPHASIS FILTER TIME CONSTANT ACCURACY: *±3%.*

HIGH PASS AND LOW PASS FILTER 3 dB FREQUENCY ACCURACY: *±3%.*

>20 kHz LOW PASS FILTER:
3 dB Cutoff Frequency: 100 kHz nominal.

OVERSHOOT ON SQUARE WAVE MODULATION[14]***:***
<1%.

12 *With the low-pass and high-pass audio filters used to stabilize frequency readings.*

13 *For demodulated signals, the residual noise generated by the 8901B must be accounted for in distortion measurements (i.e. residual AM, FM or ϕM.)*

14 *The >20 kHz low-pass filter is intended for minimum overshoot with squarewave modulation.*

RF Input

FREQUENCY RANGE: 150 kHz to 1300 MHz.

OPERATING LEVEL:

Minimum Operating Level	Maximum Operating Level	Frequency Range
12 mV_{rms} (−25 dBm)	7 V_{rms} ($1W_{peak}$) Source SWR <4	150 kHz-650 MHz
22 mV_{rms} (−20 dBm)	7 V_{rms} ($1W_{peak}$) Source SWR <4	650 MHz-1300 MHz

Supplemental Characteristics:

TUNING:

Normal Mode: *Automatic and manual frequency entry.*

Track Mode: *Automatic and manual frequency entry, $f_c \geq 10$ MHz.*

Acquisition Time (automatic operation): *~1.5 seconds.*

INPUT IMPEDANCE: *50Ω nominal.*

MAXIMUM SAFE DC INPUT LEVEL: *5V.*

General Specifications

TEMPERATURE: **Operating:** 0°C to 55°C.
Storage: −55°C to 75°C.

REMOTE OPERATION: HP-IB; all functions except the line switch are remotely controllable.

HP-IB COMPATIBILITY (defined in IEEE 488-1978): SH1, AH1, T5, TE0, L3, LE0, SR1, RL1, PP0, DC1, DT1, C0, E1.

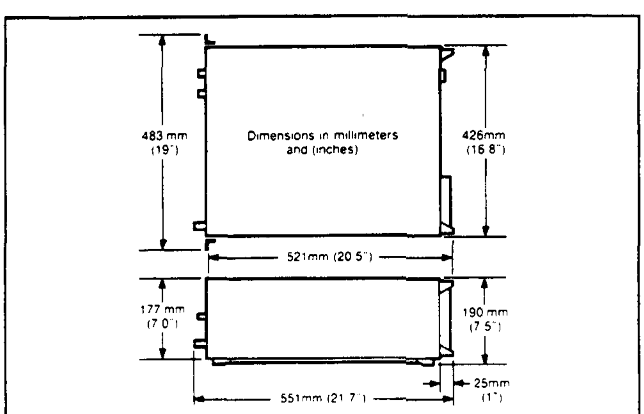
EMI: Conducted and radiated interference is within the requirements of VDE 0871 (Level B), and CISPR publication 11.

POWER: 100, 120, 220, or 240V (+5%, −10%); 48–66 Hz; 200 VA maximum.

WEIGHT: Net 23.4 kg. (51.5 lb.); Shipping 31.1 kg (68.5 lb).

DIMENSIONS: 190 mm. H × 426 mm. W × 551 mm. D (7.5" × 16.8" × 21.7").

HP SYSTEM II MODULE SIZE: 177.0 H × 1 MW × 497.8 D.



HP 8901B Rear Panel Inputs/Outputs

Supplemental Characteristics:

FM OUTPUT: *10 kΩ impedance, −9V to 6V into an open circuit: ~6V/MHz, dc coupled, 16 kHz bandwidth (one pole).*

AM OUTPUT: *10 kΩ impedance, −4V to 0V into an open circuit, ~8 mV/%, dc coupled, 16 kHz bandwidth (one pole).*

RECORDER OUTPUT: *DC voltage proportional to the measured results, 1 kΩ impedance, 0V to 4V for each resolution range into an open circuit.*

IF OUTPUT: *50Ω impedance, 150 kHz to 2.5 MHz, −27 dBm to −3 dBm.*

10 MHz REFERENCE OUTPUT: *50Ω impedance, TTL levels (0V to >2.2V into an open circuit). Available only with Option 002 1×10^{-9}/day internal reference.*

10 MHz REFERENCE INPUT[15] *>500Ω impedance, $0.5V_{peak\text{-}to\text{-}peak}$ minimum input level.*

LO INPUT (Option 003): *50Ω impedance, ~1.27 MHz to 1301.5 MHz, 0 dBm nominal.*

RF SWITCH REMOTE CONTROL OUTPUT: *Provides output signals necessary to remotely control either an HP 33311B/C Option 011 or an HP 8761A RF switch.*

FREQUENCY OFFSET MODE REMOTE CONTROL OUTPUT: *TTL high output if in frequency offset mode (Special Function 27.1 or 27.3) with an external LO frequency >0, TTL low output for all other cases.*

[15] External reference accuracy affects accuracy of all measurements.

Table 1-1. Specifications (6 of 6)

Carrier Noise (Options 030-037)

FREQUENCY RANGE: 10 MHz to 1300 MHz.

CARRIER POWER RANGE: +30 dBm to −20 dBm; 12.5 kHz, 25 kHz and 30 kHz filters.
+30 dBm to −10 dBm; carrier noise filter.

DYNAMIC RANGE: 115 dB.

CARRIER REJECTION (temp. ≤35°C): >90 dB; for offsets of at least 1 channel spacing or 5 kHz, whichever is greater.

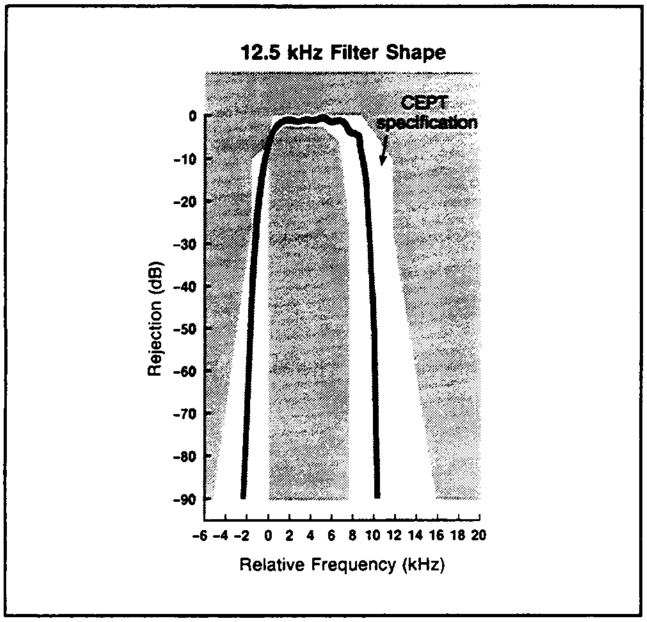
RELATIVE MEASUREMENT ACCURACY: ±0.5 dB; levels ≥−95 dBc; 12.5 kHz, 25 kHz and 30 kHz filters.
±0.5 dB; levels ≥−129 dBc/Hz; carrier noise filter.

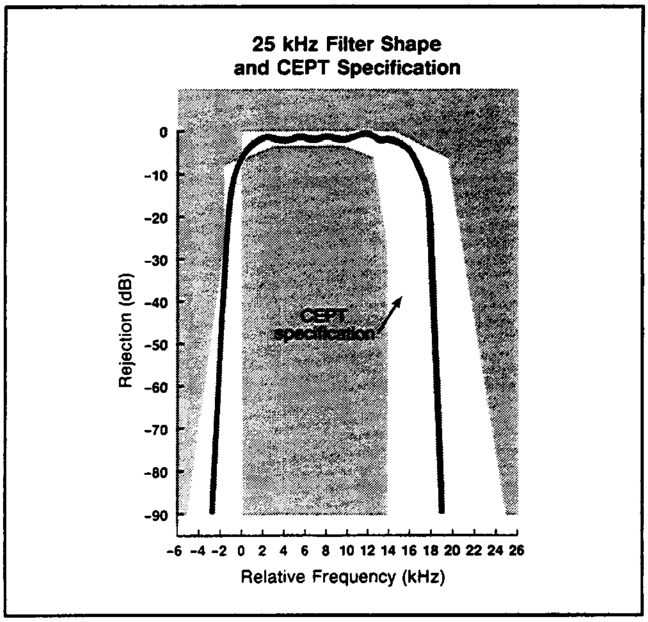
CARRIER NOISE FILTER:
Filter Noise Bandwidth: 2.5 kHz nominal.
Noise Bandwidth Correction Accuracy (stored in non-volatile memory): ±0.2 dB.

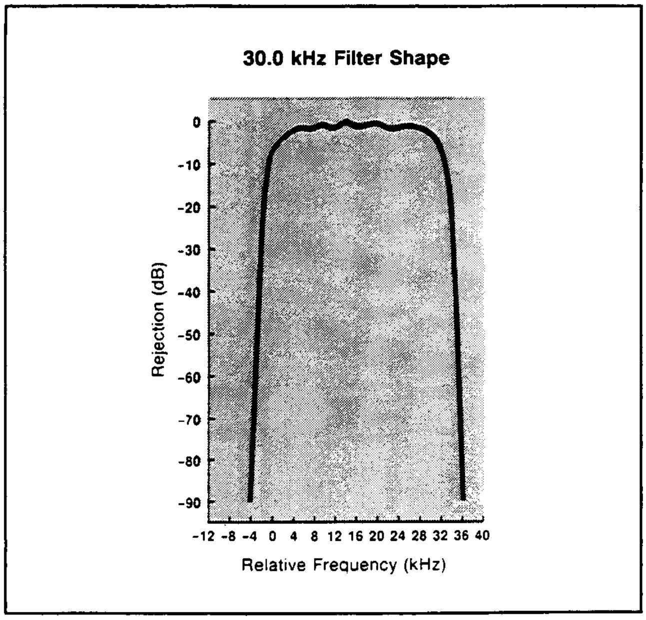
Supplemental Characteristics:

ADJACENT/ALTERNATE CHANNEL FILTERS:
6 dB Filter Bandwidth:
8.5 kHz, 12.5 kHz adjacent-channel filter.
16.0 kHz, 25 kHz adjacent-channel filter.
30.0 kHz, 30 kHz (cellular radio) alternate-channel filter.

TYPICAL NOISE FLOOR: *−150 dBc/Hz, 0 dBm carrier power level. For System noise performance add LO contribution.*







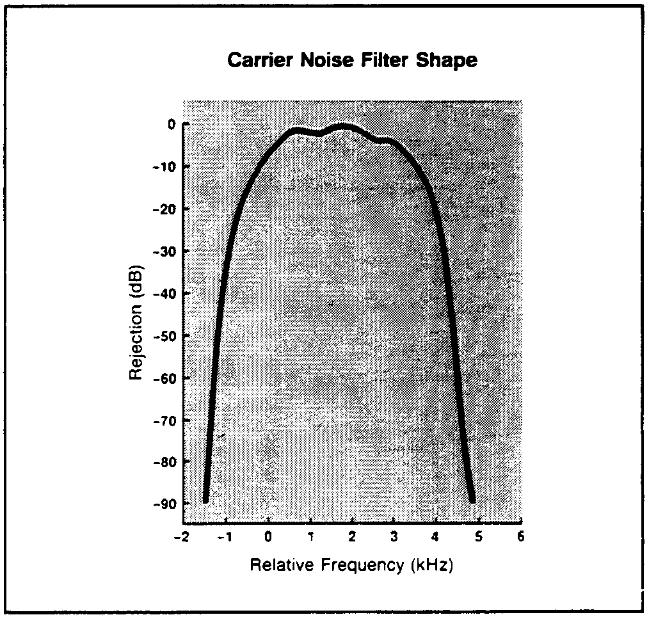


Table 1–2. *Recommended Test Equipment (1 of 4)*

Instrument Type	Critical Specifications	Suggested Model	Use*
AM/FM Test Source	Carrier Frequency: within range 10 to 1300 MHz Output Level: > −20 dBm FM Deviation: 400 kHz peak maximum FM Distortion: < −72 dB at 12.5 MHz carrier with 12.5 kHz deviation and <10 kHz rate < −72 dB at 400 MHz carrier and 400 kHz deviation at <100 kHz rate FM Flatness: ±0.1% from 20 Hz to 100 kHz rates ±0.25% to 200 kHz rates CW Residual FM: <3 Hz rms in a 50 Hz to 3 kHz bandwidth at 560 MHz Incidental AM: <0.08% AM at 100 MHz with <50 kHz peak deviation and 1 kHz rate in a 50 Hz to 3 kHz bandwidth AM Depth: 5% to 99% AM Distortion: < −66 dB at <50% AM at 20 Hz to 100 kHz rates < −60 dB at <95% AM at 20 Hz to 100 kHz rates AM Flatness: ±0.1% from 50 Hz to 50 kHz ±0.25% from 20 Hz to 100 kHz Incidental ΦM: <0.008 rad peak at 12.5 MHz with 50% AM at a 1 kHz rate in a 50 Hz to 3 kHz bandwidth Residual AM: <0.01% rms in a 50 Hz to 3 kHz bandwidth AM Linearity: ±0.1% at <95% AM ±0.2% at <99% AM	HP 11715A	P,A,T
Attenuator, 3 dB (2 required)	Frequency: 30 MHz SWR Maximum: 1.2 (Used as alternate equipment.)	HP 8491A Option 03	P
Attenuator, 6 dB	Frequency Range: 0.15 to 1300 MHz SWR Maximum: 1.2 Attenuation Accuracy: ±0.4 dB	HP 8491A Option 06	P
Audio Analyzer	Fundamental Frequency Range: 20 Hz to 100 kHz Distortion Range: −70 dB minimum Distortion Accuracy: ±2 dB Low-Pass Filters: 30 and 80 kHz Oscillator Level: 3V maximum into 600Ω Oscillator Distortion: < −70 dB Oscillator Frequency Accuracy: ±2%	HP 8903B	P,A,T

*C=Operator's Checks; P=Performance Tests; A=Adjustments; T=Troubleshooting

Table 1–2. Recommended Test Equipment (2 of 4)

Instrument Type	Critical Specifications	Suggested Model	Use*
Audio Synthesizer	Frequency Range: 20 Hz to 400 kHz Output Level: +16 dBm (50Ω) maximum Frequency Accuracy: ±0.1% Attenuator Accuracy: ±0.1 dB from 0 to 20 dB Level Flatness: ±0.015 dB from 90 Hz to 10 kHz ±0.3 dB from 50 Hz to 100 kHz ±0.07 dB from 20 Hz to 200 kHz Distortion: < −50 dB from 20 Hz to 200 kHz	HP 3336C Option 005	P,A,T
Computing Controller	HP-IB compatibility as defined by IEEE Std 488 and the identical ANSI Std MC1.1: SH1, AH1, T2, TE0, L2, LE0, SR0, PP0, DC0, DT0, and C1, 2, 3, 4, 5.	HP 9825A and HP 98034A and HP 98213A or HP 85B Option 007	C,P,T
Digital Multimeter	DC Range: 0 to 50V DC Accuracy: ±0.01% at 1V AC Range: 0 to 100V AC Accuracy: ±0.01% at 2V and 2 kHz Ohms Range: 0 to 1 MΩ Ohms Accuracy: ±1%	HP 3455A	P,A,T
Divider Probe (2 required)	Divider Ratio: 10:1 Input Impedance: 1 MΩ Input Capacitance: <10 pF	HP 10040A	A,T
Extender Cable	No substitution is recommended.	HP 08901-60179	A,T
Frequency Standard	Accuracy: ±0.1 ppm recommended	House Standard	A
Oscilloscope	Bandwidth: less than 3 dB down 0 to 100 MHz Sensitivity: 5 mV per division minimum Input Impedance: 10 MΩ and 50Ω Triggering: External and Internal	HP 1740A	C,A,T

*C=Operator's Checks; P=Performance Tests; A=Adjustments; T=Troubleshooting

Table 1–2. Recommended Test Equipment (3 of 4)

Instrument Type	Critical Specifications	Suggested Model	Use*
Power Meter	Power Range: 1 mW Transfer Accuracy (input-to-output): 0.2%	HP 432A	P,A
Thermistor Mount	SWR: 1.05, 50 MHz Accuracy: ± 0.5% at 50 MHz	HP 478A-H75** or HP 478A-H76***	P,A
Power Reference	Power Output: 1.00 mW, factory set to ±0.7%, NBS calibrated Accuracy: ±(1.2% worst case +0.9% rss) for one year; 0 to 50° C	HP 435A Option K05	
Power Supply	Output Range: 0 to 25 Vdc	HP 6215A	T
Range Calibrator	Calibration Functions: outputs corresponding to power displays of 10 μW, 100 μW, 1 mW, 10 mW, and 100 mW Calibration Uncertainty: ±0.25% in all ranges	HP 11683A	P,A,T
RF Spectrum Analyzer	Frequency Range: 0 to 2 GHz Input Level: ±10 dBm maximum Display Range: 60 dB	HP 8559A and HP 182T	A,T
Sensor Module	Compatible with HP 8901B Input SWR: <1.3, at RF Input, RF Ranges 1 and 2 <1.5, at RF Input, RF Range 3 <1.3, at RF Input, RF Range 3 with Modulation Analyzer's Special Function 1.9	HP 11722A	P,A,T
Service Accessory Kit	No substitution recommended.	HP 08901-60287	T
Signal Generator	Frequency Range: 0.5 to 1100 MHz Output Level: +19 dBm maximum to 500 MHz +13 dBm maximum to 1100 MHz Output Level Accuracy: ±1 dB Frequency Accuracy: ±1% Frequency Resolution: 1 kHz Modulation Capability: AM and FM AM Depth: 0 to 95% AM Accuracy: ±10% FM Range: 0 to 400 kHz peak deviation FM Accuracy: ±10%	HP 8640B Options 001 and 002	C,P,A T

*C=Operator's Checks; P=Performance Tests; A=Adjustments; T=Troubleshooting
**HP 478A-H75 must be calibrated at the National Bureau of Standards (NBS) for this accuracy.
***HP 478A-H76 includes HP standards lab calibration to ±0.58% at 50 MHz (traceable to NBS).