HEWLETT® PACKARD

HP 8901A Modulation Analyzer

150 kHz to 1300 MHz

Product Overview

Outstanding signal characterization

Measurements*

Frequency

Range: 150 kHz to 1300 MHz

Resolution:
10 Hz below 1000 MHz,
100 Hz above 1000 MHz

Input Level:
Automatic Mode: –20 dBm to +30 dBm
Manual Mode: Typically –60 dBm to +30 dBm

Power

Display: Peak envelope power

Range: 1 milliwatt to 1 watt

Accuracy: *Typically ±1.5 dB*

Input Power Protection:
>25 watts

Modulation

Frequency Modulation

Rates: 20 Hz to 200 kHz

Deviations: to 400 kHz

Accuracy: ±1% of reading ±1 digit for rates 30 Hz to 100 kHz

Amplitude Modulation

Rates: 20 Hz to 100 kHz

Depths: to 99%

Accuracy: ±1% of reading ±1 digit for rates 50 Hz to 50 kHz and depths >5%

Phase Modulation

Rates: 200 Hz to 20 kHz

Deviations: to 400 radians

Accuracy: ±3% of reading ±1 digit

Applications

Mobile Radio

The HP 8901A Modulation Analyzer combines all the capabilities necessary for making accurate transmitter measurements. It can be used in making all the tests listed below. It can also be used to test modules and subassemblies from either the transmitter or receiver. For reliability, input power protection reduces the chance of accidentally damaging the modulation analyzer by connecting it directly to a high power transmitter.

- Carrier power
- Carrier frequency and stability
- AM depth
- FM deviation
- Hum and noise
- Incidental AM or FM
- Modulation limiting
  - Instantaneous
  - Steady state
- Audio frequency response

Maintenance and Metrology

Accurately measuring modulation has long been a problem for metrology laboratories. The HP 8901A Modulation Analyzer helps solve this problem two ways. First, it provides an extremely accurate method of measuring AM depth and FM deviation, and it recovers the modulation with little degradation for making measurements such as modulation distortion. Second, the optional calibrators provide a precise modulation source for calibration. There are many metrology and maintenance uses for the modulation analyzer. They include:

- Signal generator calibration
- Modulation calibration standard
- VCO and VCXO characterization

*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.

Applications, *cont.*

Research and Development

The accuracy and versatility of the modulation analyzer make it a very useful laboratory instrument for characterizing a wide variety of devices and assemblies. When used with a modulated signal source the modulation analyzer can make stimulus-response measurements for direct measurement of a device's effects on such signals. Because of its wide frequency range, it can measure the performance of both RF and IF assemblies. Characterizing modulated sources for sensitivity, distortion, and incidentals, and measuring the noise performance of local oscillators is also possible.

- Mixer and Amplifier compression
- Local oscillator residual FM
- Modulator characterization
- Incidental AM or FM
- RF and IF characterization

Features

Complete Signal Characterization

The HP 8901A Modulation Analyzer brings together in one instrument several RF signal measurement capabilities. It is more than just a high quality modulation meter. It accurately measures carrier frequency and peak input power in addition to completely characterizing modulation. This unique combination of capabilities makes the HP 8901A Modulation Analyzer an extremely powerful tool for analyzing signals. In normal use it eliminates the need to frequently connect and disconnect several instruments, such as counters and power meters. The modulation analyzer is fully programmable and can be used as part of an automatic system to make all these measurements under remote control.

Single Key Measurements

The HP 8901A Modulation Analyzer features easy to use controls. In automatic operation, all major functions are selected by pushing a single key. No manual tuning or range selection is needed. The modulation analyzer automatically tunes to the input signal, adjusts for proper signal level, selects the appropriate measurement range, makes the measurement, and displays the result.

For certain measurements manual operation may be more desirable. When selecting a specific signal in the presence of others or for special applications, the operator can easily use the modulation analyzer's keyboard to set any or all measurement parameters. Functions not selected manually remain in automatic mode. This greatly increases the modulation analyzer's versatility.

High Performance

The HP 8901A Modulation Analyzer offers a significant advancement in modulation measurements. Modulation depth and deviation are measured with unprecedented 1 percent accuracy. To complement this capability, optional calibrators with 0.1 percent depth or deviation accuracy can be included in the analyzer.

A significant improvement has also been made in the area of residual noise. The extremely low internal noise of the modulation analyzer makes possible residual AM and FM measurements even on very stable signals. Accurate measurement of signals with small incidental AM or FM modulation are now easily performed. Residual AM in a 50 Hz to 3 kHz bandwidth is <0.02 percent, and residual FM in the same bandwidth is <8 Hz at 1300 MHz decreasing to <1 Hz below 100 MHz.

The HP 8901A Modulation Analyzer is a complete measurement system for accurately characterizing signals in the 150 kHz to 1300 MHz frequency range.

It can make more than just a single form of measurement; it combines the capabilities of three separate instruments. The HP 8901A Modulation Analyzer has the capability of a frequency counter for measuring carrier frequency. It can measure RF peak power with typical measurement accuracy of ±1.5 dB. It can also accurately measure modulation and recover the modulating signal. This allows the user to make those measurements most commonly needed to totally characterize a signal. The modulation analyzer can measure a signal's frequency, frequency drift, peak power level, AM, FM, or ϕM, and AM and FM noise components. It recovers the modulating signal with very low added distortion for audio analysis.

Besides combining several measurements in one instrument the HP 8901A Modulation Analyzer makes a second contribution to signal analysis—extremely precise modulation measurements. Its ability to make highly precise depth and deviation measurements coupled with very low internal noise enables the analyzer to characterize very accurate signal sources. Modulation depth or deviation accuracy is generally <1 percent of reading. Residual noise in a 50 Hz to 3 kHz bandwidth is 0.02 percent for AM and <8 Hz for FM at 1300 MHz carrier frequencies, decreasing to <1 Hz below 100 MHz.

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 measurements can be easily controlled remotely and data transferred via the Hewlett-Packard Interface Bus (HP-IB).*

Frequency Measurements

In automatic operation the HP 8901A Modulation Analyzer has the performance of a high quality 150 kHz to 1300 MHz frequency counter. Resolution is 10 Hz below 1000 MHz and 100 Hz above 1000 MHz. Sensitivity is –25 dBm (12 mVrms) below 650 MHz and –20 dBm (22 mVrms) above 650 MHz.

Besides normal frequency measurement capabilities the analyzer's counter has several additional capabilities. Like most frequency counters it will measure signals over a wide dynamic range, >50 dB (22 mVrms to 7 Vrms), and is protected from damage for signals up to 35 Vrms. Unlike many frequency counters, however, it automatically adjusts itself as the input level changes. There is no need to manually set or adjust any input attenuator. Because the modulation analyzer is usually used to measure modulated signals, its frequency counter accurately measures signals with significant levels of AM modulation.

The modulation analyzer uses an indirect technique for measuring RF frequencies. Instead of counting directly, the input signal is down-converted to an interme diate frequency (IF) using a mixer and a local oscillator (LO). By counting the frequency of both the IF and LO and calculating their difference, the modulation analyzer can determine the frequency of the input signal. In automatic operation the analyzer automatically tunes to the largest input signal and measures its frequency.

In manual operation the user determines the frequency to which the modulation analyzer tunes. When more than one signal is present it is thus normally possible to select which signal is counted. Entering the approximate frequency on the keyboard causes the IF filter to eliminate all but very close interfering signals. This allows the modulation analyzer to selectively count signals other than the largest. Also, because of the large IF gain of the modulation analyzer, it is possible to measure very low-level signals. In manual operation the modulation analyzer has sensitivity of 0.22 mV_{rms}, and dynamic range of >90 dB (0.22 mV_{rms} to 7 V_{rms}).

* HP-IB is Hewlett-Packard's implementation of IEEE standard 488.

RF Power Measurements

The HP 8901A Modulation Analyzer uses a diode detection circuit to measure RF input power. This technique measures peak voltage and is calibrated from 1 mW to 1 W for sine wave inputs. In the case of amplitude modulated signals, the modulation analyzer measures the peak envelope power with ±1.5 dB accuracy, thus eliminating the need for a power meter in most applications.

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, such as the modulation analyzer, used to measure transmitters. The modulation analyzer is tested for inputs up to 25 watts. Protection is provided by limiting diodes and an RF relay. When excessive power is applied the relay opens and protects sensitive components, and the analyzer displays an error message. The circuit automatically resets whenever a key is depressed. This technique is superior to fuses which in many cases are too slow for adequate protection and require replacement each time an overload occurs.

In addition to normal RF level measurements made directly on the input signal, the modulation analyzer can measure the signal level in the constant-gain IF filter pass band. This is the Tuned RF Level function. In this mode the analyzer accuracy is degraded from normal RF measurements, but relative power measurements at a single frequency can be made with increased resolution. Because the IF filter allows some selectivity, one signal can be measured even when others are present.

Modulation Measurements

In AM, high accuracy and low noise are coupled with resolution of 0.01 percent below 40 percent depth and 0.1 percent resolution to over 100 percent. AM signals at rates up to 100 kHz can be measured and the modulation accurately recovered. AM signals with significant levels of FM can be measured because of excellent FM rejection.

Most AM depth measurements can be made with accuracies better than 1 percent of reading. This is made possible by very linear amplifiers and detectors. Because these amplifiers and detectors are also low noise, residual AM in a 50 Hz to 3 kHz bandwidth is <0.02 percent rms.

FM deviation can be measured with accuracy of 1 percent and displayed with resolution ranging from 1 Hz for deviations below 4 kHz, to 100 Hz for deviations greater than 40 kHz. Modulation is recovered with less than 0.1 percent distortion, and most AM is rejected.

The ability to measure low residual FM is one of the key contributions of the modulation analyzer. A low noise local oscillator in combination with a low noise discriminator allows residual FM measurements of <8 Hz at 1300 MHz and <1 Hz below 100 MHz. This is low enough to allow the direct measurement of residual FM of such low noise sources as crystal oscillators.

For all AM depth and FM deviation measurements the user can select from three detectors. Both positive and negative peak (trough for AM) can be measured. The modulation analyzer also has an average-responding detector which is RMS sine wave calibrated. This type of detector is useful for determining the residual noise on a signal where the RMS value and not the peak is generally the desired measurement.

The modulation analyzer also has a Peak Hold function that is used with either the positive or negative peak detectors. This function captures and displays the maximum peak modulation of a signal and is ideal for making measurements such as modulation limiting on mobile radios. Peak Hold can capture even very short transients and display their peak value indefinitely. Measurements can be made for any length of time and either the largest positive or negative peak that occurs will be measured. Pushing the Peak Hold key resets the display and initiates a new measurement cycle.

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 cut-off 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.

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. The user can select whether or not the de-emphasis network affects the deviation measured and indicated by the display. 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. By ordering Option 010 a precise AM and FM modulation standard is included in the HP 8901A modulation analyzer.

The AM standard is generated by summing two identical 10 MHz signals. When one of the signals is switched on and off at a 10 kHz rate, the result is 33.33 percent AM depth. By internally measuring any slight difference in the levels of the 10 MHz signals the analyzer is able to determine the actual depth to ±0.1 percent accuracy. To further improve the modulation envelope the rise and fall transitions are smoothed to eliminate ringing that might otherwise occur when this signal is measured.

The FM standard is generated by square-wave modulating a VCO with a nominal 33 kHz peak deviation. By using the internal counter to measure the upper and lower frequency of this signal, the actual peak deviation is determined to ±0.1 percent accuracy. To prevent ringing, the square wave is modified to a round edge trapezoid.

Because the modulation standards are internal to the analyzer, there is little need for metrology laboratories to purchase separate calibration standards. Also, because of the technique used, it is easy to verify that the calibrators are operating properly.

Operation

Often instruments with state-of-the-art accuracy require tedious setup or highly skilled operators in order to be used. This is not the case with the HP 8901A Modulation Analyzer. It provides excellent accuracy while remaining easy to use. The front panel is simple, uncluttered, and easy to understand.

The user need only select the measurement to be made. There is no need to tune, adjust levels, or select the appropriate range; the internal microprocessor does all this quickly. Because the microprocessor determines the best instrument settings, most measurements require only a single keystroke.

For those applications requiring tuning to a specific frequency, automatic tuning may be overridden. This feature allows a single signal to be selected in the presence of others but retains the speed and convenience of the rest of the automatic functions.

The user can also make measurements relative to either a measured value or one entered from the keyboard by using the ratio keys. Relative measurements can be expressed in either dB or percent. This means that when testing FM mobile transmitters a user could enter 3 (kHz), depress the dB key, and make measurements in dB relative to 3 kHz deviation. Similarly, in broadcast FM applications, deviation could be displayed in percent relative to 75 kHz deviation where 75 kHz is defined as 100 percent. The user can also enter a measurement limit on the keyboard which will cause the modulation analyzer to signal whenever the measured value exceeds the value entered as a limit.

Special Functions

The modulation analyzer can do more than is apparent from the front panel. This capability is accessed by using the data keys and a special function key or remotely via HP-IB. They fall into three categories: manual control of instrument functions, instrument operation verification, and service aids.

An example of the type of special function found in the manual control category is the auto tune-track mode. This mode is accessed by entering 4.1, then pressing the special key. Once the modulation analyzer has been placed in track mode the analyzer will continuously track the signal as it changes frequency. This eliminates the delays caused by the analyzer searching for the signal each time the signal's frequency changes. Using this special function, a user could continuously monitor modulation accuracy on a signal generator while tuning across the signal generator's frequency band. Auto tune-track makes it possible to tune the analyzer three ways: automatically, manually by entering the frequency on the keyboard, and track mode.

Special functions can also be used to set any measurement range or instrument function. They can be used to select either of two internal IF's, the one normally used for frequencies above 10 MHz or a narrow IF where rates and deviations are more restricted but selectivity is increased. All instrument functions not set using these special functions remain in automatic mode. This allows the user to select any combination of manual or automatic operation. By depressing the special key, the display shows an eight-digit number that indicates 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 functions used in diagnosing and repairing the analyzer, make repairs much faster and easier. An additional service aid is the built-in ability to use HP signature analysis instrumentation. This allows a technician with little knowledge of digital circuits to rapidly troubleshoot a failure in the digital portion of the instrument.

Those special functions that are most commonly used in operating the analyzer are described on the pullout information card under the front panel.

Programmability

The HP 8901A Modulation Analyzer is completely programmable via the Hewlett-Packard Interface Bus (HP-IB). This, coupled with the ability of the modulation analyzer to make several measurements, the speed with which these measurements can be made, and the flexibility of the special functions, makes the modulation analyzer 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 analyzer is in remote, the front panel annunciators make it very easy to determine what state the analyzer is in.

Applications

The HP 8901A Modulation Analyzer is a useful tool for analyzing many types of signals. Often it can provide needed information that has been difficult to obtain such as incidental FM or residual FM. It can replace large, complex test systems, and speed and simplify measurements. The modulation analyzer is superbly capable of measuring transmitters used in mobile communications. This single instrument can be used in making most of the measurements made on transmitters.

The modulation analyzer can be equally useful for other types of transmitters. For avionics applications it can be very useful in measuring navigation signals. In testing ILS transmitters the analyzer can be used to very accurately measure depth of modulation. For broadcast AM and FM it can be used to measure AM depth or FM deviation, and it can accurately recover the modulation for making measurements such as stereo separation.

With its accuracy the modulation analyzer makes an excellent addition to a metrology laboratory. An example of its usefulness is in calibrating signal generators.

The modulation analyzer's capabilities exceed those required to verify many signal generator specifications. Besides improving the accuracy of these measurements it greatly reduces the time involved in making measurements. Also, the optional calibrators provide a new level of modulation standard accuracy and help ensure accurate measurements. They also enhance the calibration of the modulation analyzer itself .

Because the modulation analyzer is useful for characterizing all types of signals in general, it is very useful in research and development laboratories. It can be used for characterizing VCO's, measuring residual noise on crystal oscillators, measuring incidental modulation, measuring frequency on low level signals, etc. When used with a signal source it can be used to characterize RF and IF designs, evaluate modulators, and test individual IC's or modules.

Options

HP 8901A Modulation Analyzer

Option 001: Rear panel instead of front panel connections for input, modulation output, calibrators.

Option 002: $1x10^{-9}$/day internal reference oscillator.

Option 003: Rear panel connections which allow use with an external local oscillator.

Option 004: Operation from 48 to 440 Hz power line.

Option 010: AM and FM calibrators.

Option 907: Front panel handle kit.

Option 908: Rack mounting flange kit.

Option 909: Front panel handle plus rack mounting flange kit.

Option 910: Extra manual.

Option 915: Service manual.

Related Literature:

Technical Specifications 5968-1286E

Price List 5968-1285EUS

HEWLETT® PACKARD

For more information about Hewlett-Packard test and measurement products, applications, services, and a current sales office listing, visit our web site: http://www.hp.com/go/tmdir

You can also contact one of the following centers and ask for a test and measurement sales representative.

United States:
Hewlett-Packard Company
Test and Measurement Call Center
P.O. Box 4026
Englewood, CO 80155-4026
(tel) 1 800 452 4844

Canada:
Hewlett-Packard Canada Ltd.
5150 Spectrum Way
Mississauga, Ontario
L4W 5G1
(tel) (905) 206 4725

Europe:
Hewlett-Packard
European Marketing Centre
P.O. Box 999
1180 AZ Amstelveen
The Netherlands
(tel) (31 20) 547 9900

Japan:
Hewlett-Packard Japan Ltd.
Measurement Assistance Center
9-1, Takakura-Cho, Hachioji-Shi,
Tokyo 192-8510, Japan
(tel) (81) 426 56 7832
(fax) (81) 426 56 7840

Latin America:
Hewlett-Packard
Latin American Region Headquarters
5200 Blue Lagoon Drive, 9th Floor
Miami, Florida 33126
U.S.A.
(tel) (305) 267-4245
(tel) (305) 267-4220
(fax) (305) 267-4288

Australia/New Zealand:
Hewlett-Packard Australia Ltd.
31-41 Joseph Street
Blackburn, Victoria 3130
Australia
(tel) 1 800 629 485 (Australia)
(tel) 0800 738 378 (New Zealand)
(fax) (61 3) 9210 5489

Asia Pacific:
Hewlett-Packard Asia Pacific Ltd.
17-21/F Shell Tower, Times Square,
1 Matheson Street, Causeway Bay,
Hong Kong
(tel) (852) 2599 7777
(fax) (852) 2506 9285

Printed in U.S.A. 7/98
5968-1287E