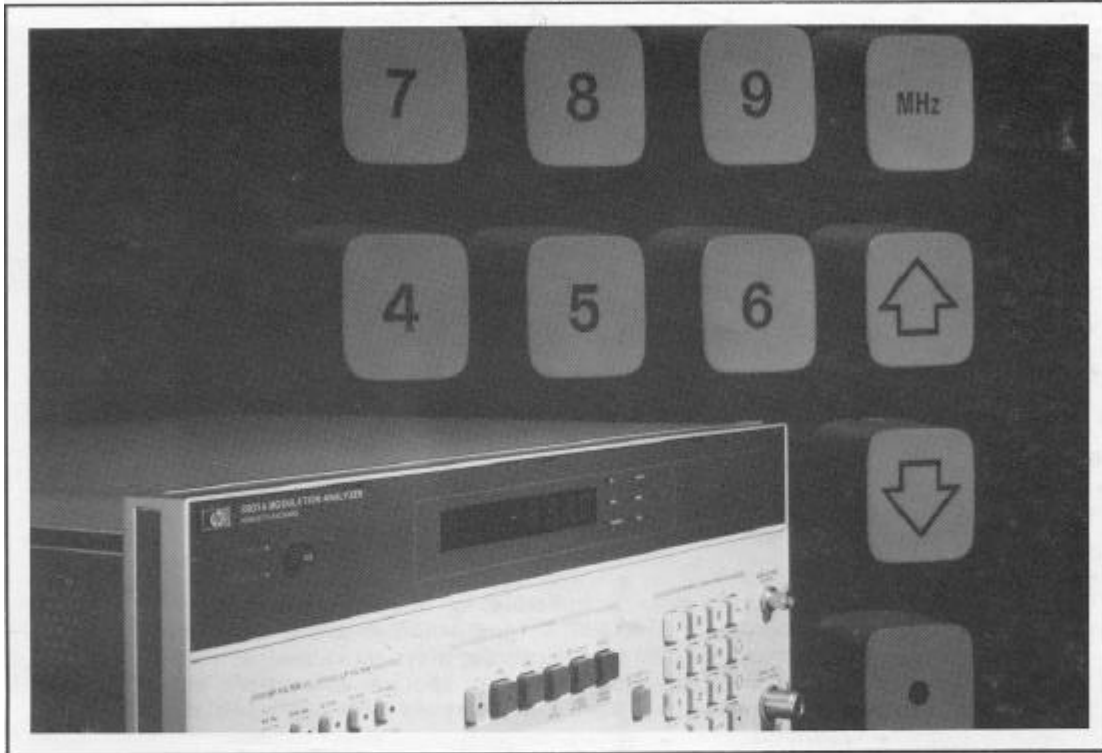


FIELD REFERENCE NOTE



8901A MODULATION ANALYZER

- APPLICATIONS
- EXTENDING THE MEASUREMENT CAPABILITIES
- LITERATURE
- APPLICATION SOFTWARE
- SPECIALS
- RETROFIT KITS

JUNE 1982

 **HEWLETT
PACKARD**

This Field Reference Note is intended to bring the most important information about the 8901A Modulation Analyzer into one document. It contains 8901A applications, ways to extend its measurement capabilities, literature, software, specials and retrofit kits. Though meant for field engineers, this Reference Note may be helpful to your customers.

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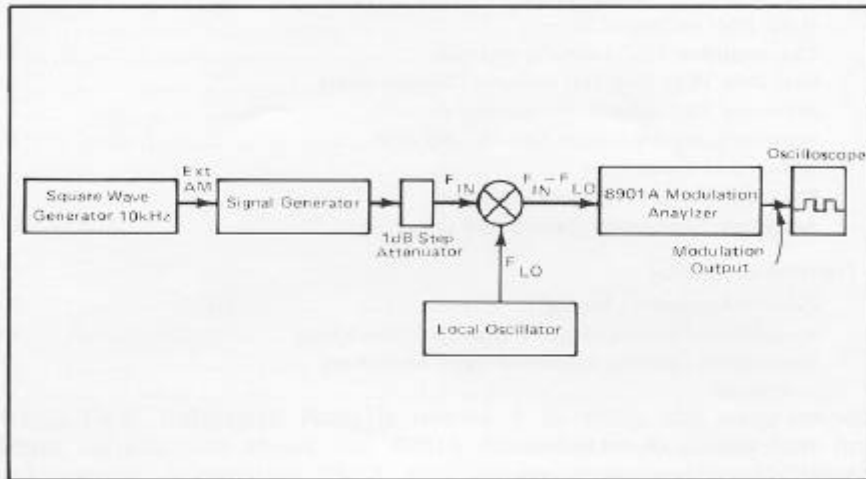
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APPLICATIONS

General

MIXER/AMPLIFIER COMPRESSION MEASUREMENTS



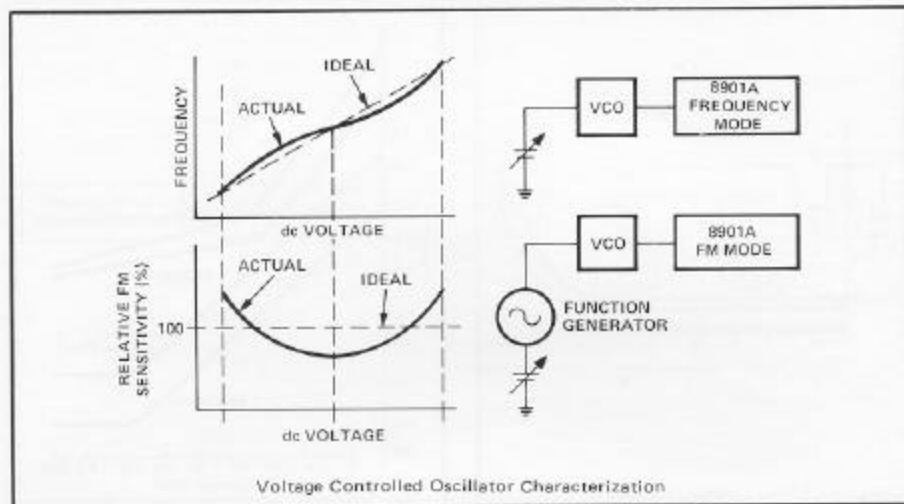
For measuring mixer or amplifier compression the 8901A Modulation Analyzer yields better accuracy, sensitivity, and repeatability than obtainable with power meters or spectrum analyzers. The method is based in principle on amplitude-modulating the mixer input signal with a squarewave, thereby dynamically switching the mixer between two operating levels. The resulting modulation measurement is made very accurately by the 8901A.

More information is contained in *Application Note 286-2, "Accurate Mixer/Amplifier Compression Measurement Using the 8901A Modulation Analyzer"*, and *RF and Microwave Symposium Paper, "A Powerful New General-Purpose Measurement Tool for the RF Design Bench, the Modulation Analyzer."*

COMPUTER DISC MEASUREMENTS

Computer disc drives are complex systems. Because they are mechanical they induce errors on the clock, data and servo feedback signals recorded on the disc. The 8901A can be used to help analyze such systems. First a repetitive 1/0 data stream is recorded on the disc. Mechanical phase jitter is then measured by measuring the ϕM or FM of the data stream read back off the disc. Head tracking errors and medium variations can be analyzed by measuring the AM of the signal. The 8901A is also useful for making sure there are no phase glitches at the point a track starts and ends.

CHARACTERIZING VCO LINEARITY AND GAIN



Voltage-controlled oscillator (VCO) linearity can be measured very simply by varying the dc input voltage to the VCO while counting the frequency (f). By plotting the results you also obtain the VCO's transfer characteristic.

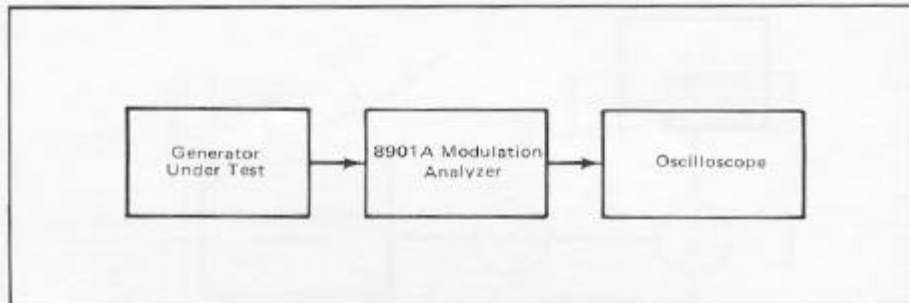
Often a plot of VCO gain is more useful. VCO gain (or VCO modulation sensitivity) is defined as $(\Delta f / \Delta V)$, as a function of the control voltage (V). Because VCO gain is a measure of small changes in frequency for small changes in input level, it is really just an FM measurement. The 8901A is ideal for measuring modulation sensitivity because it measures very small amounts of FM deviation accurately. To make the measurement use the procedure listed below.

Procedure:

1. 8901A: RF Frequency
2. function generator: adjust the function generator dc offset to set the VCO to its center frequency; set the function generator for a 10 kHz sine wave; adjust amplitude for a small VCO deviation.
3. 8901A: FM, 300 Hz high-pass and 15 kHz lowpass filters on, track mode (4.1 SPCL), average detector, % or dB ratio
4. function generator: vary the dc offset until the VCO has covered the full frequency range of interest.

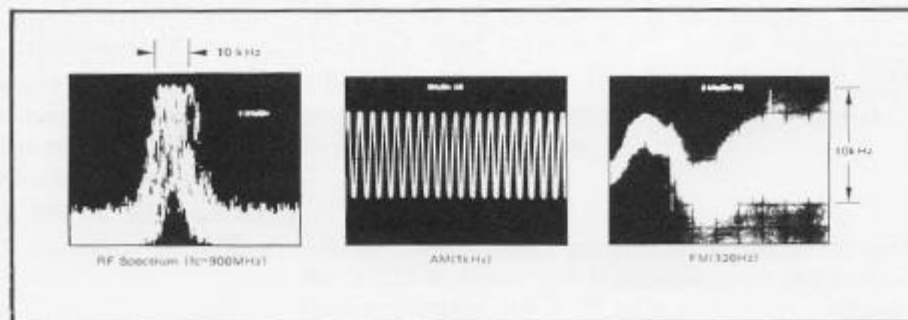
For more information on VCO testing see *Application Note 286-1, "Application and Operation of the 8901A Modulation Analyzer"*, page 11, and the *RF and Microwave Measurement Symposium paper, "A Powerful New General-Purpose Measurement Tool for the RF Design Bench, the Modulation Analyzer."*

NOISE AND MICROPHONIC MEASUREMENTS



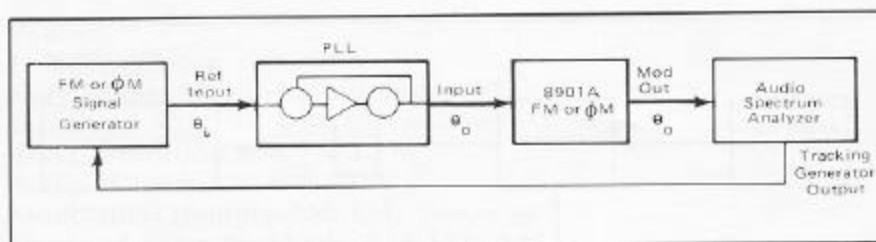
Minimizing microphonic susceptibility is important to designers of all types of transmitters. The 8901A's low internal noise makes it possible to measure the residual FM on signals due to noise and microphonics of even very stable transmitters. The set-up shown was used to measure microphonics and noise on a high performance manual signal generator, the HP 8640B. After reducing the generator microphonic vibrations, an improvement of approximately 13 dB was achieved in the residual FM noise output of the generator.

SEPARATING AND MEASURING AM, FM & ϕ M



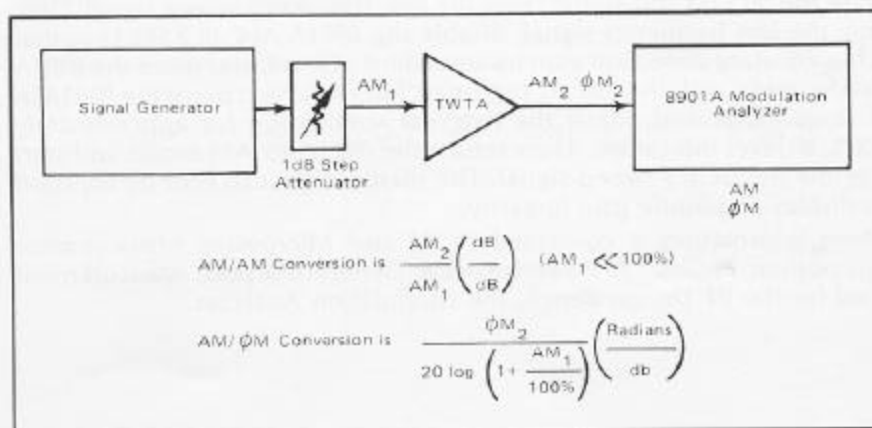
Separating AM and ϕ M in AM stereo, measuring the AM, FM and ϕ M components of satellite signals, or incidental AM on FM transmitters, are all ideal applications for the 8901A. The 8901A has excellent isolation between AM and FM, very linear demodulators and accurate detectors for demodulating and measuring signals with simultaneous AM, FM or ϕ M. In the example shown here, undesired FM is caused by power supply ripple, from a faulty signal generator power supply. The problem was quickly diagnosed by looking at the demodulated FM.

PHASE-LOCK LOOP FREQUENCY RESPONSE



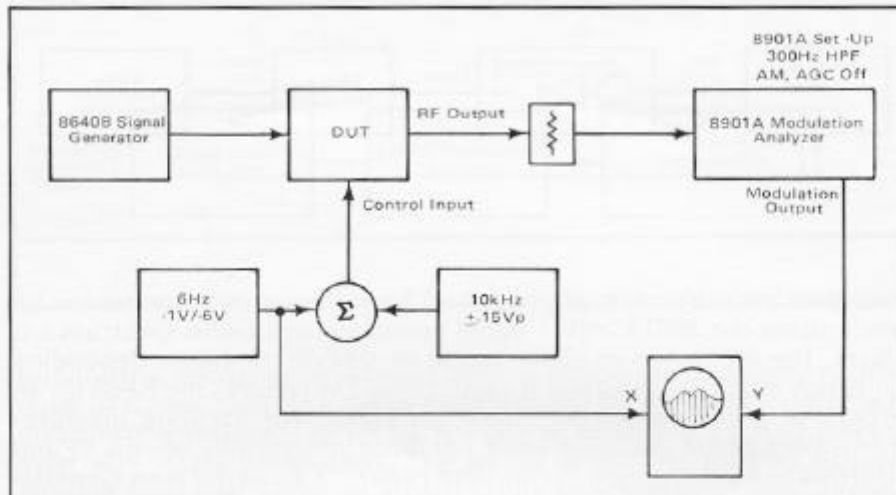
Real-time measurements of phase-lock loop frequency response can be made using the 8901A with a signal generator and audio spectrum analyzer. The 8901A acts as either an FM or ϕ M discriminator depending on which modulation format is used. Using FM reduces the need for an expensive phase-modulated signal generator. For accurate measurements keep phase deviation small. For more information, see the *RF and Microwave Measurement Symposium Paper*, "A Powerful New General-Purpose Measurement Tool for the RF Design Bench, the Modulation Analyzer."

AM TO ϕ M CONVERSION



The 8901A is an excellent tool for designers and manufacturers of a variety of phase and amplitude sensitive devices such as bandpass filters and multiple channel receivers, because of its incidental modulation rejection. Accurate AM to ϕ M and AM to AM conversion measurements can be made as shown in the TWT amplifier example.

AMPLITUDE MODULATOR LINEARITY AND GAIN



Making real time amplitude modulator linearity and gain measurements is simple with the 8901A Modulation Analyzer as shown above. The key to this measurement process is the ability of the 8901A to accurately separate the 10 kHz test signal from the low frequency sweep signal. First, stop the low frequency signal, disable the 8901A ALC (6.2 SPCL) so that it has constant detection gain independent of level, and place the 8901A in AM mode with the 300 Hz high-pass filter on. Next place the 8901A in IF level mode and adjust the external attenuation for approximately 100% IF level indication. Then return the 8901A to AM mode and start the low frequency sweep signal. The oscilloscope can now be adjusted to display amplitude gain linearity.

More information is contained in *RF and Microwave Measurement Symposium Paper, "A Powerful New General-Purpose Measurement Tool for the RF Design Bench, the Modulation Analyzer."*

GENERAL TRANSMITTER TESTING

Power

Frequency Error

Microphone Sensitivity AM, FM, ϕ M

Incidental AM, FM, ϕ M

Audio Distortion AM, FM, ϕ M

Audio Flatness AM, FM, ϕ M

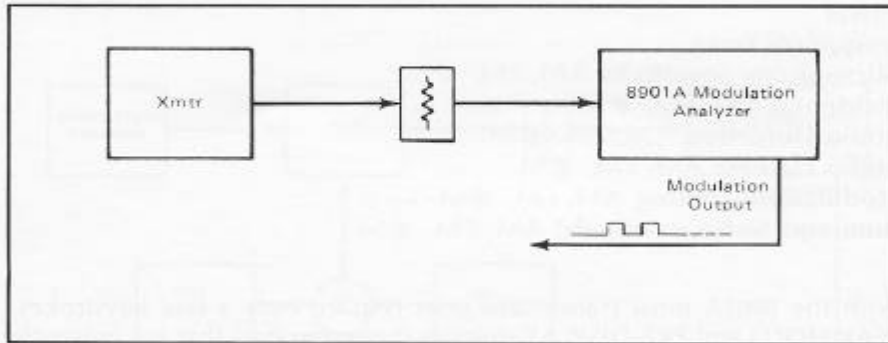
Modulation Limiting AM, FM, ϕ M

Hum and Noise (residuals) AM, FM, ϕ M

With the 8901A most transmitter tests require only a few keystrokes. PEAK HOLD and PRE-DISPLAY simplify measurements that are presently difficult or tedious to perform. The percent and dB ratio modes allow the 8901A to display measurement results in the units that are most often used. For example, FM hum and noise can be displayed in dB down from a user-entered reference deviation. Using the 8903A Audio Analyzer as a companion instrument, measurements like audio distortion are added to the 8901A's long list of capabilities.

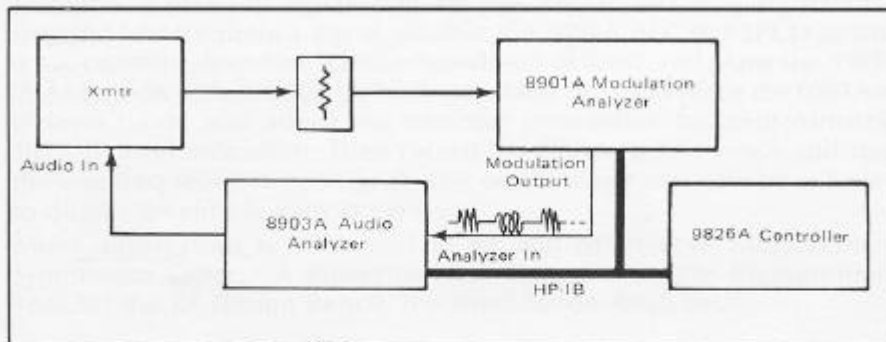
More information is contained in *Application Note 286-1, "Applications and Operation of the 8901A Modulation Analyzer,"* the *8901A Operating Manual*, *Application Note 300, "High Performance Semi-Automatic Transceiver Testing,"* and the *8953A Transceiver Test Set Operating Manual*.

TRANSMITTERS UTILIZING DIGITAL PRIVATE LINE SQUELCHING



The 8901A's lower audio cut-off frequency of .2Hz allows demodulation of Digital Private Line codes. These serial codes can be as low as 5.8 Hz, requiring detection equipment to have a 3 dB roll-off of less than .3 Hz.

TRANSMITTERS UTILIZING SEQUENTIAL TONE SQUELCHING



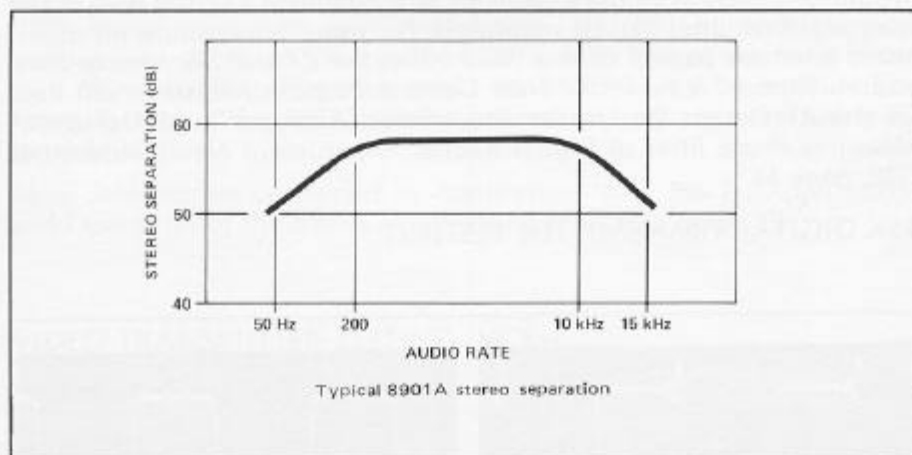
The 8901A can be used in analyzing the signaling tones generated by a transmitter when it is first keyed. The 18.NN special function on the 8901A inserts a variable time delay between detecting a carrier and turning on the MODULATION OUTPUT. Delays of 1 to 99 msec are available where NN represents the delay. The 8903A Audio Analyzer, under remote control, will measure the duration and frequency of these tones as the 8901A demodulates them.

More information is contained in the *8901A Operating Manual*, Page 3-132, and in *Product Note 8903A-2*, "High-Speed Tone Generation and Analysis Using the 8903A Audio Analyzer." 5952-8249.

AM STEREO

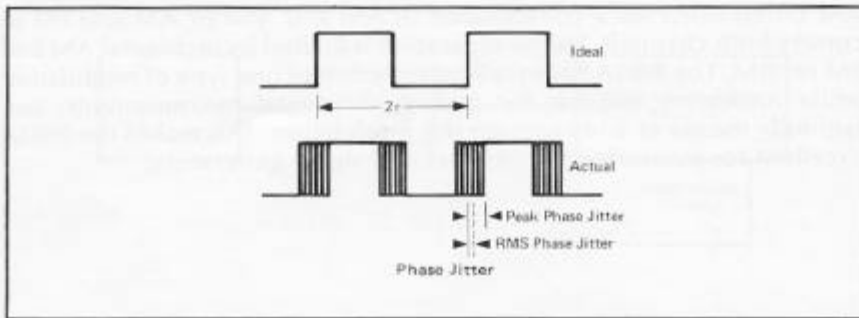
AM stereo relies on a combination of AM and ϕ M or AM and FM to convey both channels. Stereo separation is limited by incidental AM and FM or ϕ M. The 8901A has excellent rejection of one type of modulation while measuring another for making incidental measurements, and faithfully measures and recovers the modulation. This makes the 8901A excellent for measuring transmitters and signal generators.

FM STEREO



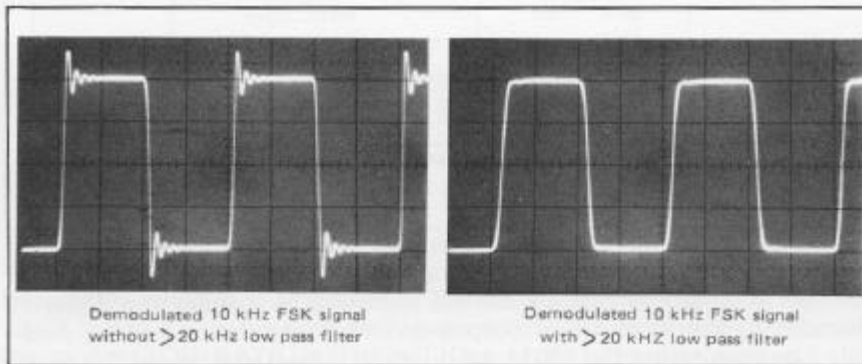
The 8901A accurately recovers FM stereo modulation for making measurements such as stereo separation. The left and right channels of stereo FM broadcast signals can be obtained by connecting a stereo decoder to the modulation output or stereo separation can be measured by monitoring the 8901A modulation output with an oscilloscope.

PHASE JITTER ON DIGITAL RADIOS



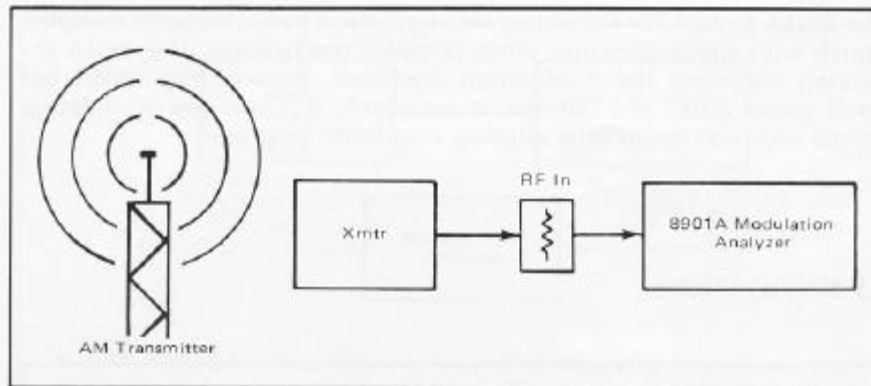
Multiplexing many digital channels and bit stuffing can cause phase jitter on multi-channel digital radios. This can cause data errors as jitter is added by each radio on a long-haul system. This requires that the radios be designed to minimize jitter and this jitter reduction is often specified. By tuning the 8901A to the frequency of a repetitive 1/0 data stream and selecting ϕM , jitter can be measured. For more information on digital phase jitter see page 2 of this Field Note, the *RF and Microwave Symposium Paper*, "A Powerful New General-Purpose Measurement Tool for the RF Design Bench, the Modulation Analyzer" and "HP 8901A Measures Phase Jitter of Digital Radios," *Instrument News*, November 1980, page 44.

FSK DIGITAL TRANSMITTER TESTING



Frequency-shift keying (FSK) is a popular digital modulation format used with FM transmitters. The 8901A contains a special post detection filter for accurately measuring FSK modulation. The >20 kHz filter is a nine pole Bessel low-pass filter. Square-wave overshoot is typically less than 1%. This filter is ideal for all types of transient modulation measurements.

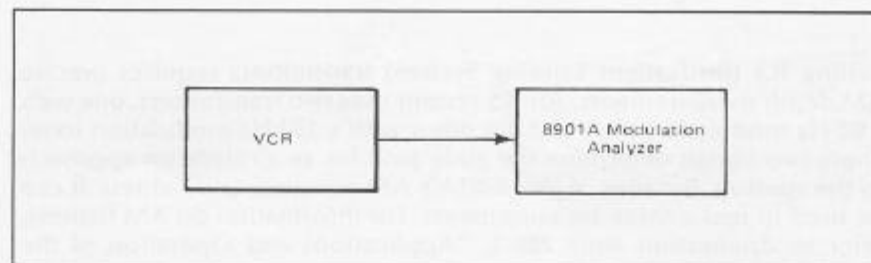
AM BROADCAST



Often it is desired to measure percent AM for depths greater than 100%, as in the case of AM Broadcast. Peak positive depths greater than 100% occur whenever over modulating. The 8901A measures peak positive AM depth to greater than 300% with typical accuracy better than 3% of reading. Negative peaks up to 100% can be measured by manually tuning the 8901A to the proper RF frequency and using 8.7 special function.

More information contained in *Application Note 286-1, "Applications and Operation of the 8901A Modulation Analyzer,"* page 19.

VIDEO TRANSMITTER TESTING (VCRs)

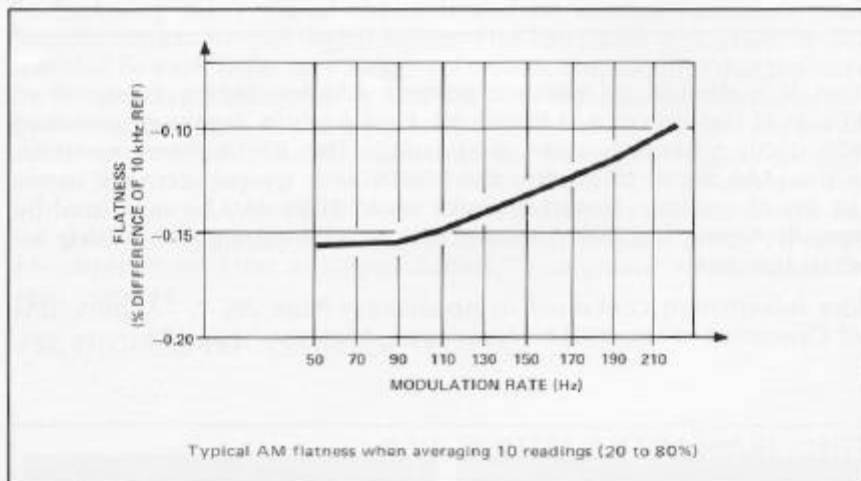


The 8901A Modulation Analyzer with modification H08 measures AM depth of video modulated signals. This extended measurement capability is now being used in the automatic testing of video cassette recorders (VCRs). Modification H08 changes the AM 250 kHz lowpass filter to a 750 kHz lowpass filter, and changes the > 20 kHz filter 3 dB point from approximately 100 kHz to 300 kHz.

SONOBUOY TESTING

The 8901A is used for sonobuoy testing. These buoys transmit complex signals with subcarriers and other complex modulation. The 8901A accurately measures the modulation deviation. Because the 8901A has good group delay and flatness, it accurately recovers the modulating signals without significantly altering amplitude or phase.

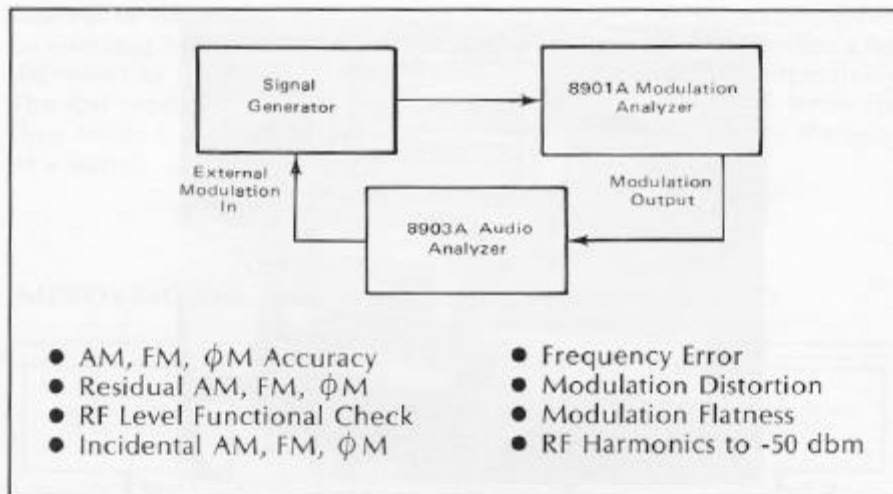
ILS NAVIGATION



Testing ILS (Instrument Landing System) transmitters requires precise AM depth measurements. An ILS system uses two transmitters, one with a 90 Hz modulation tone and the other with a 150 Hz modulation tone. These two signals determine the glide path for an airplane on approach to the runway. Because of the 8901A's AM accuracy and flatness, it can be used to make these measurements. For information on AM flatness, refer to *Application Note 286-1, "Applications and Operation of the 8901A Analyzer,"* page 19.

Signal Generator Testing

SIGNAL GENERATOR CALIBRATION



The 8901A is a calibrated receiver capable of testing high performance signal generators. Outstanding modulation accuracy and low residual noise enable the 8901A to perform the most demanding modulation tests.

More information is contained in *Application Note 286-1, "Applications and Operation of the 8901A Modulation Analyzer,"* page 7.

EXTENDING THE MEASUREMENT CAPABILITIES

Extended Applications

RF TROUBLE-SHOOTING USING THE 8901A WITH A 500 MHz POWER PROBE



The 8901A is an excellent trouble-shooting tool when used with a high impedance probe such as the HP 1120A 500 MHz active probe. It can monitor signals at various points of a device. At each point, the residual noise, AM content, FM content, distortion and signal level can be checked. In this way, any element that creates AM to FM conversion, additional noise, or additional distortion can be isolated.

MEASURING HIGHER RATE SIGNALS ON CARRIERS < 2 MHz

It is possible to accurately measure signals with modulation rates greater than 10 kHz at carrier frequencies less than 2 MHz even though 10 kHz is the specification and the 15 kHz Low-pass Filter comes on. The procedure for removing the 15 kHz low-pass filter for carrier frequencies < 2 MHz is:

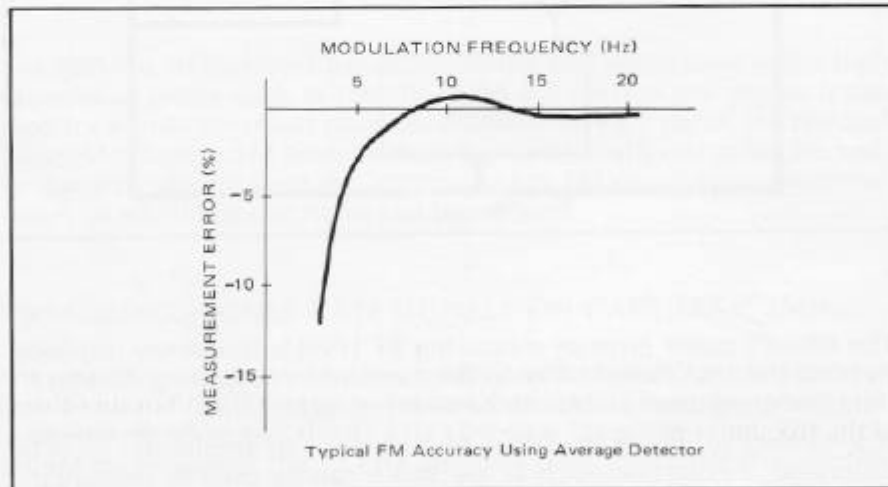
- (1) Tune the 8901A to 100 MHz.
- (2) Disable tuning errors with 8.1 SPCL (special function).
- (3) Make the modulation measurement. Modulation accuracy is typically 1% of reading. To measure frequency, use 10. SPCL which counts the IF frequency.

Extended Applications

TRACK AND MEASURE AM OR ϕ M OF SIGNALS WITH LOW RATE, HIGH DEVIATION FM

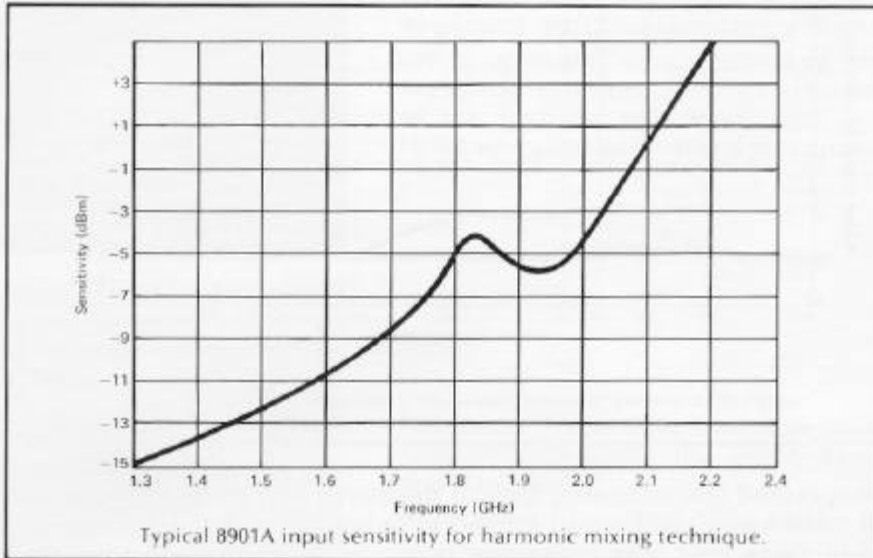
If you want to measure AM or ϕ M of a signal with low rate, high deviation FM, what do you do? You use the 8901A automatic tuning track mode to track the signal. The automatic track mode (4.1 special function) enables the analyzer to continuously track a signal that is varying in frequency.

More information describing applications of the track mode special function is provided in *Application Note 286-1, "Applications and Operation of the 8901A Modulation Analyzer,"* pages 24 and 25.

FREQUENCY MODULATION AT RATES LESS THAN 20 Hz

The 8901A modulation output is ac coupled with a 3 dB cut-off of about 0.2 Hz. This allows it to accurately recover modulation with low frequency components such as Digital Private Line (DPL). For measuring deviation the peak detectors can be used down to about 10 Hz and the average detector down to about 5 Hz with a typical error of about 5%.

EXTENDING THE FREQUENCY RANGE TO MICROWAVE FREQUENCIES

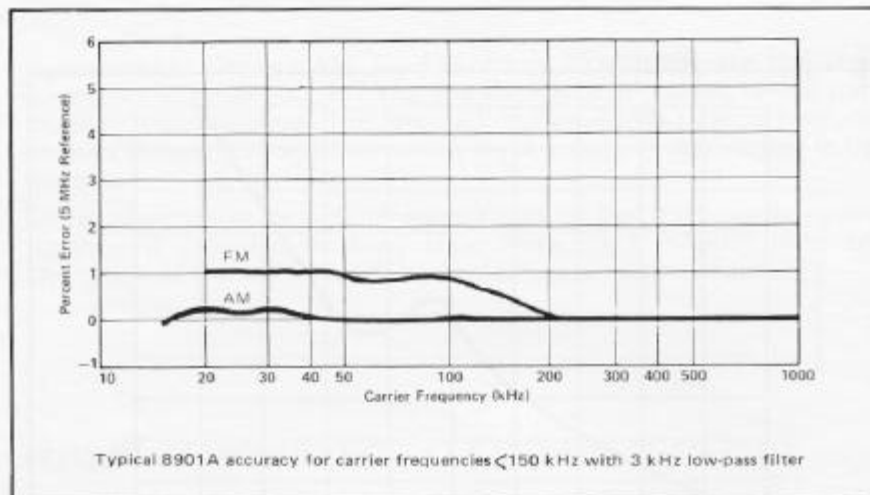


There are three techniques for extending the 8901A frequency range above 1300 MHz: internal harmonic mixing, external local oscillator-mixer down-conversion, and down-conversion with a spectrum analyzer. All three techniques extend the excellent AM, FM, and ϕ M measurement capabilities of the 8901A to microwave carrier frequencies.

Between 1.3 and 2.2 GHz the harmonic mixing technique is ideal because it requires no additional equipment. This technique uses the third harmonic of the 8901A's internal local oscillator (LO) to down convert signals. Just manually tune the Analyzer 1 MHz lower than one-third of the frequency of the signal to be measured. For example, to tune to a 2100 MHz signal, manually tune the Analyzer to 699 MHz. Modulation accuracy is typically 1% of reading, but sensitivity is reduced. For more information on extending the frequency of the 8901A Modulation Analyzer to microwave frequencies see *Product Note 8901A-1, "Extending the Frequency Range of the 8901A Modulation Analyzer."*

Extended Applications

EXTENDING OPERATION BELOW 150 kHz



The specified low frequency limit of the 8901A is 150 kHz. However, it will make meaningful measurements to below 50 kHz by using the special function keys. The procedure is simple. First, manually tune the 8901A to 100 MHz and override error "E01" by entering 8.1 SPCL (special function). This enables the input signal to pass directly through the input mixer without frequency conversion. Next, suppress IF feedthrough by selecting the 3 kHz or 15 kHz lowpass filter. The analyzer is now ready to make modulation measurements. You can count the input signal frequency by using 10. SPCL (special function). For more information on extending operation below 150 kHz see *Product Note 8901A-1*, "Extending the Frequency Range of the 8901A Modulation Analyzer."

8901A AS A COMPANION TO THE 8568A SPECTRUM ANALYZER

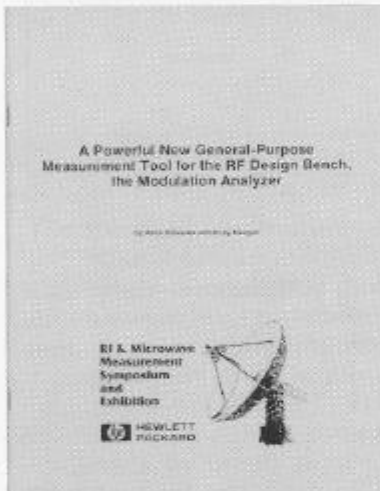
An example of the 8901A helping in a typical RF application is spectrum surveillance. The 8568A Spectrum Analyzer, with its excellent gain and variable bandwidth, receives the RF signal. After identifying a signal, the spectrum analyzer is fixed tuned and its IF output is connected to the 8901A. Measurements such as modulation can now be made very accurately. The MODULATION OUTPUT of the 8901A can be utilized for further analysis of the recovered audio.

More information is contained in the February, 1981 *Instrument News* article "Modulation and Spectrum Analyzers Team-Up for Spectrum Surveillance," page 44.



Hewlett-Packard Journal, November 1979,
Volume 30, Number 11

A thorough description of the 8901A Modulation Analyzer and some applications.



“A Powerful New General-Purpose Measurement Tool for the RF Design Bench, the Modulation Analyzer.”

RF & Microwave Symposium Paper, 1981

This paper describes many practical measurement applications of the 8901A Modulation Analyzer.



“High Performance Semi-Automatic Transceiver Testing”

Application Note 300 (5952-8241)

This application note describes a transceiver test set for automatic testing of AM and FM communication transmitters and receivers. The 8901A is one of the 3 basic measurement instruments used in the test set. Included in the application note is a description of software for remotely programming the 8901A using the HP 85F Desktop Computer System.



8953A Transceiver Test Set Data Sheet (5953-8370)

The 8901A Modulation Analyzer with its companion instrument the 8903A Audio Analyzer perform automatic AM and FM transmitter testing in the 8953A Transceiver Test Set.



8901A Modulation Analyzer Operating Manual (08901-90031)



8901A Modulation Analyzer Service Manual (08901-90032)

