HEWLETT PACKARD

Product Note 8901A-1

Extending the Frequency Range of the 8901A Modulation Analyzer

Introduction

The specified frequency range of the 8901A Modulation Analyzer is 150 kHz to 1.3 GHz. This product note describes how to extend the frequency range down to 15 kHz and up to 2.2 GHz. It also explains how to extend the frequency range even further (>2.2 GHz and <15 kHz) with additional equipment.

Extending Operation Above 1300 MHz

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.

Between 1.3 and 2.2 GHz there are many applications that require accurate modulation measurements and have modulation rates, AM depths, and FM deviations within the range of the 8901A. The harmonic mixing technique is ideal for these applications because it requires no additional equipment.

Above 2.2 GHz down-conversion to the range of the 8901A with an external local oscillator or spectrum analyzer is necessary. If the external LO or spectrum analyzer has low phase-noise, the 8901A can measure residual FM of microwave sources.

All three techniques extend the excellent AM, FM, and ΦM measurement capabilities of the 8901A to microwave carrier frequencies.

Harmonic Mixing Technique

In normal operation the 8901A uses only the fundamental component of the internal local oscillator (LO). However, the input mixer operates up to 2.2 GHz without excessive losses. As a result, it is possible to use the third harmonic of the LO to measure signals up to 2.2 GHz. Just manually tune the Analyzer 1 MHz lower than one-third of the

frequency of the signal to be measured:

$$F_{ent} = \frac{F_{in}}{3} - 1$$

where F_{in} = frequency of input signal (MHz)

F_{ent} = frequency entered on 8901A keyboard (MHz).

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 (Figure 1).

External Local Oscillator and Mixer Technique

Above 2.2 GHz an external mixer and local oscillator (LO) can be used to heterodyne the input signal to the range of the 8901A (Figure 2). Generally, the local oscillator should be set 10 to 100 MHz above or below the frequency of the input signal because the 8901A has lowest residual FM and largest modulation range selection over this frequency range.

AM MEASUREMENTS. When measuring amplitude modulation with this technique there are three important considerations: LO level, mixer input level vs. LO level, and mixer output level into the 8901A. First, the local oscillator should be set to the level specified for the mixer. Then, to minimize distortion due to mixer compression, the input signal level should be at least 10 dB below the LO level, preferably 20 dB. Finally, the average mixer output level must be high enough to result in at least —25 dBm into the 8901A. For example, with an LO level of +10 dBm, a typical mixer conversion loss of 8 dB, and the input signal at –10 dBm (20 dB below the LO), the level into the 8901A is –18 dBm, well within the –25 dBm specification. With this technique residual AM is basically unaffected because the mixer removes any small amounts of AM on the LO.

FM MEASUREMENTS. With FM measurements, residual FM has the greatest effect on accuracy, and in this system the main sources of residual FM are the external LO and the 8901A itself. However, because the 8901A has very low noise, the residual FM is usually determined by the local oscillator. Therefore, for best results, the LO should have low noise (the HP 8672A Synthesized Signal Generator for example). There is one other consideration. If the LO frequency is higher than the input signal, the positive and negative peaks of the recovered modulation are reversed.

SHORT-TERM FREQUENCY STABILITY MEASUREMENTS. This external LO and mixer technique is very useful for measuring short-term frequency stability (residual FM) of microwave sources. Measuring phase noise characteristics of microwave oscillators is difficult because it requires phase locking a low-noise reference oscillator to the source under test to heterodyne the test signal to dc with a quadrature detector. Often this is not practical. However, if the exact spectral characteristics of the phase noise curve are not important, residual FM may be just as valid a measure of short-term frequency stability. If this is the case, using the 8901A is quicker, more convenient, and doesn't require phase locking the source under test.

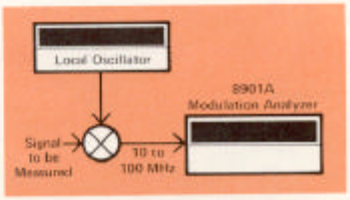

Figure 2. Extending the 8901A frequency range with an external local oscillator and mixer.

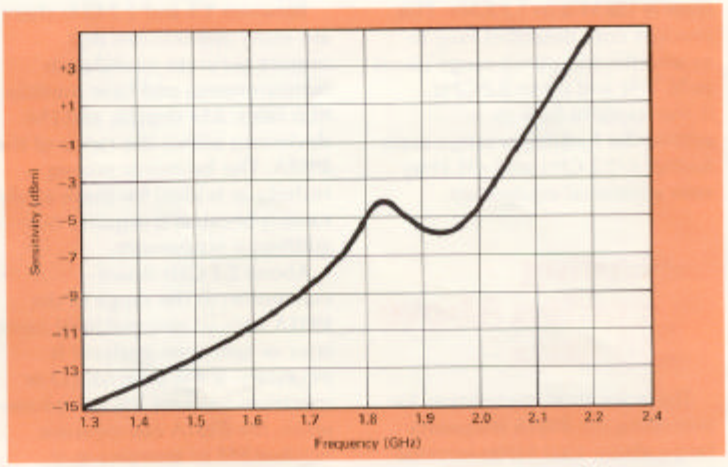

Figure 1. Typical 8901A input sensitivity for harmonic mixing technique.

Spectrum Analyzer Technique

Another way to down-convert the input signal to the range of the 8901A is to use a microwave spectrum analyzer that has an IF output such as the HP 8559A, 8565A, 8569A or 8566A (Figure 3). The measurement procedure is

1. Tune the spectrum analyzer center frequency to the frequency of interest, and put the analyzer in zero span mode with linear detection. Use any resolution bandwidth that is wide enough to pass the input signal of interest.
2. Adjust the spectrum analyzer fine frequency control to peak the signal on the display.
3. Connect the spectrum analyzer IF output to the 8901A input, and adjust the spectrum analyzer reference level so that the 8901A automatically acquires and displays the IF frequency.
4. The Modulation Analyzer can now be used to accurately measure the modulation characteristics of the signal at the spectrum analyzer input.

This combination of a spectrum analyzer and the Modulation Analyzer is ideal for monitoring off-the-air signals. The spectrum analyzer provides a visual display of the activity over a broad range of frequencies and the 8901A accurately measures and recovers the modulation on a particular signal of interest. The variable gain and selectivity of the spectrum analyzer make it easy to preselect and down-convert the signal of interest to the range of the 8901A. The 8901A then recovers the audio information for listening or analysis.

Extending Operation Below 150 kHz

The specified low frequency limit of the 8901A is 150 kHz. However, it is possible to make meaningful measurements to below 50 kHz. In normal operation, below 2.5 MHz the Analyzer sets the LO to 101.5 MHz and the input signal passes directly through the mixer to the IF without frequency conversion (Figure 4). For inputs below 150 kHz the Analyzer displays error "E10" (input frequency out of range) as it attempts to retune to obtain an IF greater than 150 kHz. To overcome this error display and make measurements

1. Stop the Analyzer from autotuning by manually tuning to 100 MHz (or any frequency well above the signal of interest).
2. Override error "E01" (signal out of IF range) by entering 8.1 SPCL on the 8901A keyboard.
3. Suppress IF feedthrough by selecting the 3 or 15 kHz lowpass filter. The 3 kHz filter is preferred if the modulation rate is 1 kHz or less. The analyzer is now ready to make modulation measurements.

Figures 5 and 6 show typical accuracy. The degradation in accuracy is primarily due to IF feedthrough. The 3 kHz filter removes most of this feedthrough, permitting measurements down to 15 kHz. Distortion also degrades as the input frequency decreases. Typical distortion is <1% at 100 kHz, <1.5% at 50 kHz, and <2.5% at 30 kHz.

You can count the input signal using 10. SPCL. This special function counts the intermediate frequency (IF), which is the input frequency in this mode.

Using an HP 3585A Spectrum

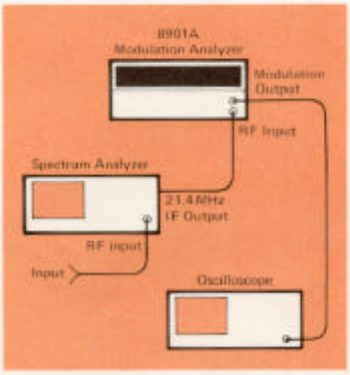

Figure 3. Spectrum analyzer technique for extending the frequency range of the 8901A.

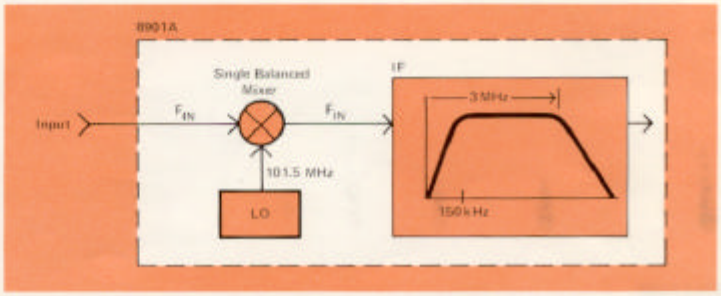

Figure 4. Input Signals below 2.5 MHz pass through mixer without down-conversion.

Analyzer as an up-converter, it is possible to make frequency modulation measurements well below 15 kHz. The measurement procedure is similar to the procedure for using a spectrum analyzer described above, except that the 3585A IF is 350 kHz. Choose a resolution bandwidth that is wide enough for the modulation rates of interest and narrow enough to avoid local oscillator feedthrough from the spectrum analyzer. This technique is particularly effective for measuring residual FM signals as low as 10 Hz.

Other Application Information for the 8901A

Application Note 286-1: Applications and Operation of the 8901A Modulation Analyzer.

Application Note 286-2: Accurate Mixer/Amplifier Compression Measurement Using the 8901A Modulation Analyzer.

Application Note 300: High Performance Semi-Automatic Transceiver Testing.

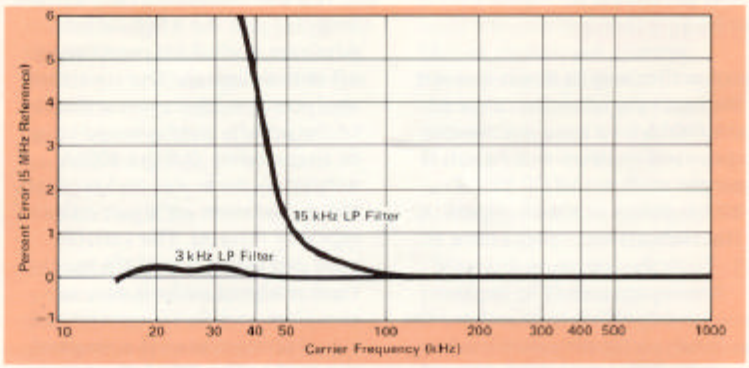

Figure 5. Typical 8901A AM accuracy for carrier frequencies <150 kHz.

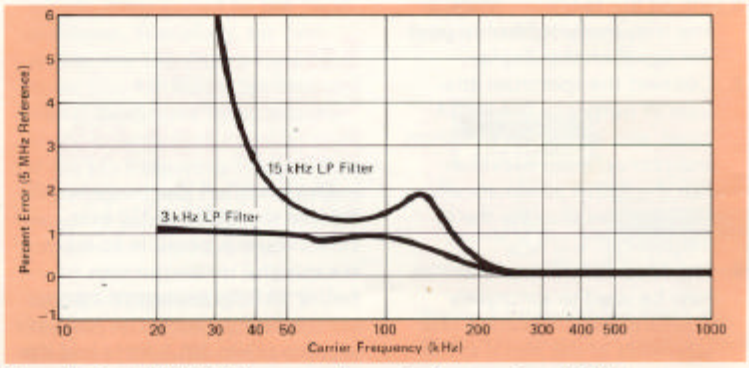

Figure 6. Typical 8901A FM accuracy for carrier frequencies <150 kHz.

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