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 Measuring Receiver'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 Measuring Receiver automatically tunes to the input signal and measures it.

In manual operation, you can determine the frequency to which the Measuring Receiver tunes. Entering the approximate frequency on the keyboard causes all but very close interfering signals to be eliminated. This allows the Measuring Receiver 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 Measuring Receiver offers numerous data-display formats. For example, RF power and tuned RF level 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 Measuring Receiver 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 Measuring Receiver faster and easier.

Those Special Functions that are most commonly used in operating the Measuring Receiver 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 Measuring Receiver's front panel. When the external LO frequency must be changed, the Measuring Receiver 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 Measuring Receiver is completely programmable via the Hewlett-Packard Interface Bus (HP-IB). This, coupled with the diversity of measurements the Measuring Receiver 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 Measuring Receiver is in remote, the front-panel annunicators 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 Measuring Receiver 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 Measuring Receiver 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 Measuring Receiver, 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)),
- RF power level measurements on tuned signals to −127 dBm (0.1 μV),
- relative RF level measurements on out-of-channel signals to −129 dBc (Option Series 030),
- 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 conector of the Measuring Receiver. 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 8902A Measuring Receiver with HP 11722A Sensor Module, for information on maximum operating levels.

The broadband, low-noise RF Amplifier improves the sensitivity of the Tuned RF Level measurement. The amplifier is normally bypassed in the other measurement modes.

CAUTION

An RF detector in the RF Amplifier (not shown in Figure 1–2) causes the RF Amplifier to be bypassed when an overload occurs. However, because of the relatively long switching time (approximately 30 ms), the RF Amplifier can be damaged by a large overload. Refer to Table 1–1, under RF Input, Operating Level, 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 and for the Tuned RF Level measurement at all frequencies. Below 2.5 MHz, the input passes directly through the Input Mixer without down-conversion. (The Tuned RF Level measurement is invalid below 2.5 MHz.)

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 except for the Tuned RF Level measurement mode (described below). The IF Filters determine the frequency response of the IF. The IF Filters can be manually selected with Special Function 3 as described in the following table. 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) except for the Tuned RF Level measurement mode where the Narrow 455 kHz Bandpass (with a bandwidth of 30 kHz) is also inserted. (Other exceptions are noted in the following table.)

Frequency Range	Special Function	
	Tuned RF Level	All Others
10 to 1300 MHz	3.6	3.2
2.5 to 10 MHz	3.5	3.1
150 kHz to 2.5 MHz	–	3.2

In the Tuned RF Level measurement mode, the signal (after amplification by IF Amplifier, which is now a precision, variable-gain amplifier) is detected by the IF Synchronous Detector, which phase locks to and tracks the IF signal. The narrow bandwidth of the phase lock loop (150 Hz) makes it possible for the detector to measure the signal level even when the signal is buried in noise.

To enhance the accuracy of this low-level measurement, the operator must first provide a high-level signal at the desired frequency. (The range of acceptable levels depends on the type of Power Sensor used.) The level is measured by both the Power Meter (which is assumed to be the calibration standard) and the IF Synchronous Detector. From the two power measurements, the Controller computes a calibration factor, which corrects subsequent level measurements made at the same frequency.

Another way of making a tuned RF level measurement is with the IF Average Detector (accessed with Special Function 4), which is part of the AM Demodulator. (Refer to *Tuned RF Level* in the *Detailed Operating Instructions* of Section 3 in this *Operating Information* manual.) Although somewhat less sensitive than the IF Synchronous Detector, the IF Average Detector has a wider bandwidth, which gives it the ability to make measurements on signals with higher residual FM.

In instruments with Option Series 030, the IF signal is further processed by the Channel Filters (which also includes a precision, variable-gain amplifier) and detected by the IF RMS Detector. The Channel Filters set the IF bandwidth and gain for the Adjacent Channel 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.

1-11. MODULATION BASICS

The Measuring Receiver 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 Measuring Receiver 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

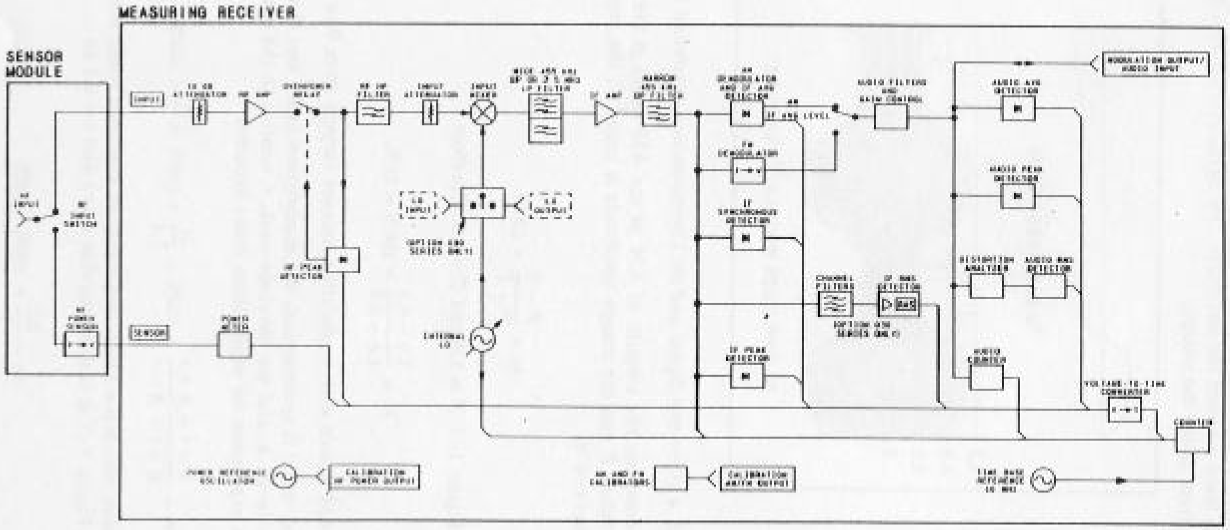
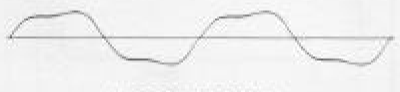
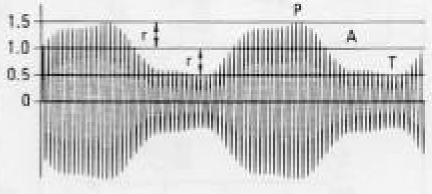


Figure 1–2. HP 8902A Measuring Receiver Simplified Block Diagram

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) BASEBAND SIGNAL



(b) AMPLITUDE MODULATED CARRIER

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

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%.

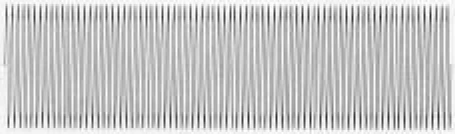
When the baseband signal is symmetrical, the modulation index can also be expressed in terms of the average carrier level, A, and the envelope peak, r, relative to the carrier. Then $P = A + r$, and $T = A - r$, and the expression for modulation index becomes

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

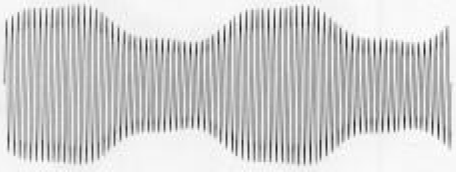
This is the expression which the Measuring Receiver evaluates when making an AM measurement. Referring back to Figure 1–3, it is apparent that $A = 1$ and $r = 0.5$ so

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

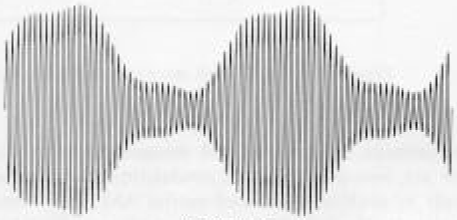
as before.



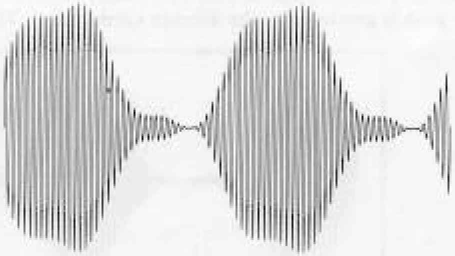
(a) 0% AM (CW)



(b) 30% AM



(c) 70% AM



(d) 100% AM

Figure 1–4. AM for Various Depths

The Measuring Receiver 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 Measuring Receiver 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–.

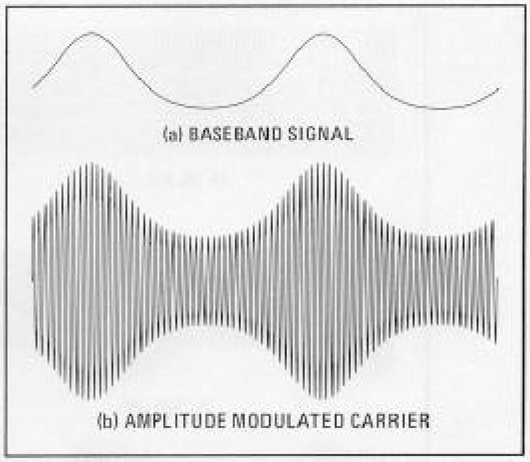


Figure 1–5. *AM with an Asymmetrical Baseband Signal*

The range of modulation indexes for AM measurements by the Measuring Receiver 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 Measuring Receiver is not intended for measuring such signals. Nevertheless, there are cases, when the Measuring Receiver 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.

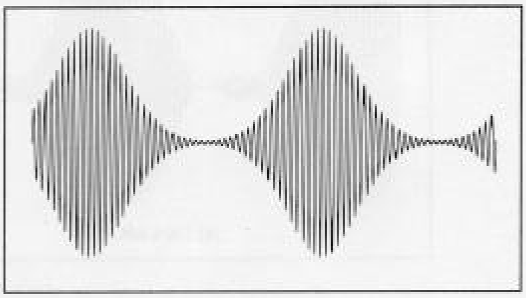


Figure 1–6. *AM with Modulation Exceeding 100% as Measured by the PEAK+ Detector*

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 Measuring Receiver 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 Measuring Receiver 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.

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.

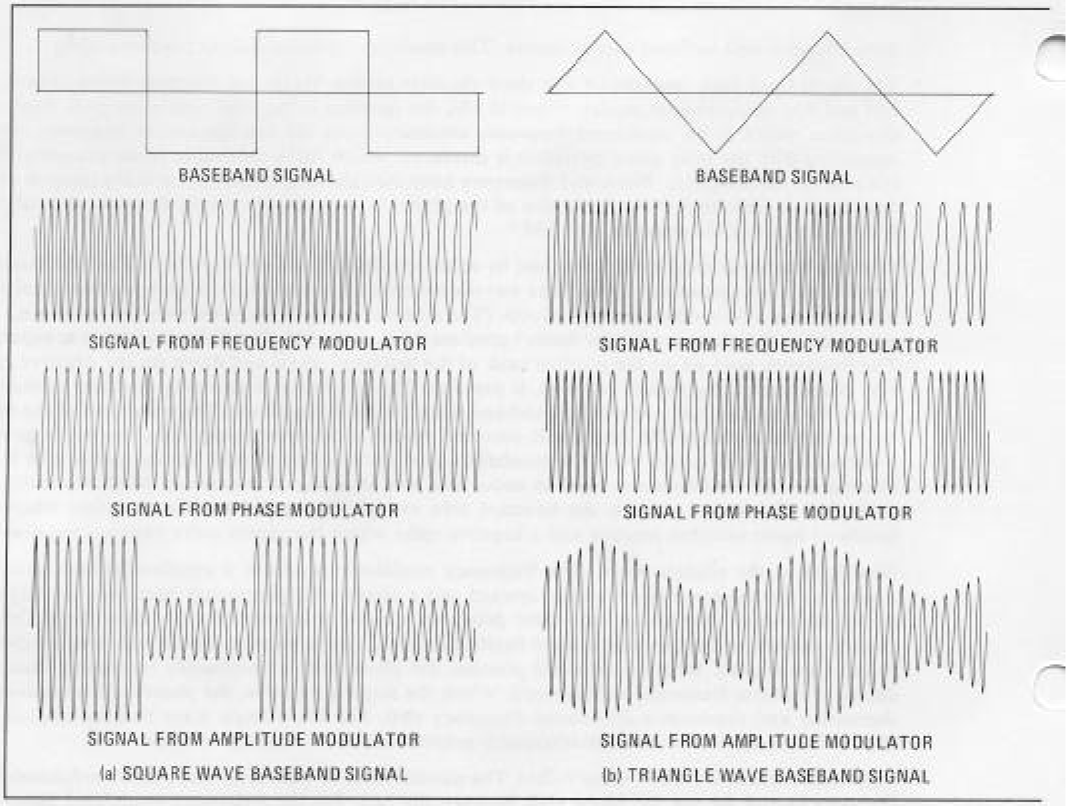
If in the last example, the rate, but not the amplitude, of the baseband signal is increased, the highest and lowest frequencies of the signal from the frequency modulator stay the same—they just occur more often. However, for the signal from the phase modulator, not only do the frequency peaks occur 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–.

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 Measuring Receiver 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



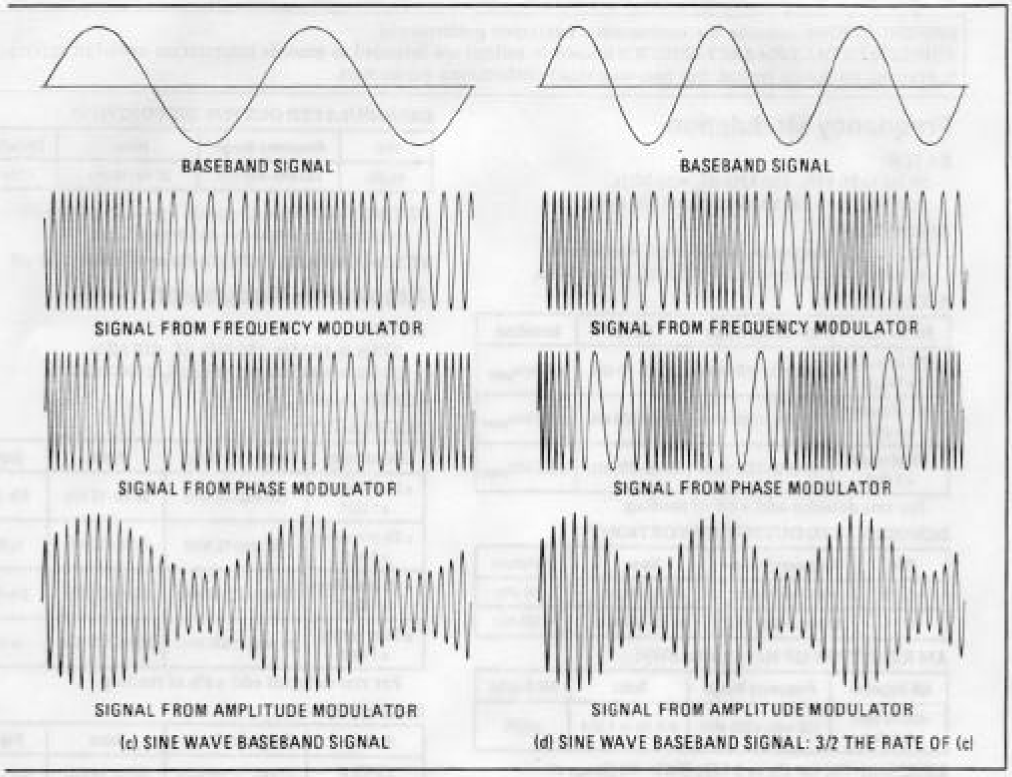
(a) SQUARE WAVE BASEBAND SIGNAL (b) TRIANGLE WAVE BASEBAND SIGNAL

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

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 Measuring Receiver.

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.

In FM broadcasting and communications, the signal-to-noise ratio is improved by giving the baseband signal a high-frequency boost before applying it to the modulator. This is called pre-emphasis. The boost is a simple 6 dB per octave with the 3 dB corner specified by a time constant; for example, 75 μs (which corresponds to a 3 dB corner of 2.12 kHz) for commercial broadcast FM. If desired, the demodulated FM can be de-emphasized to equalize the signal at the modulation output and at the display.



Amplitude Modulators for Various Baseband Signals

Table 1–1. *Specifications (1 of 7)*

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.

Frequency Modulation

RATES[6]:
20 Hz to 10 kHz, 150 kHz $\le f_c <$ 10 MHz.
20 Hz to 200 kHz, 10 MHz $\le f_c \le$ 1300 MHz.

DEVIATIONS[6]:
40 kHz_{peak} maximum, 150 kHz $\le f_c <$ 10 MHz.
400 kHz_{peak} maximum, 10 MHz $\le f_c \le$ 1300 MHz.

ACCURACY[1,2,6]:

FM Accuracy	Frequency Range	Rates	Deviations
±2% of reading ±1 digit	150 kHz–10 MHz	20 Hz–10 kHz	≤40 kHz_{peak}
±1% of reading ±1 digit	10 MHz–1300 MHz	50 Hz–100 kHz	≤400 kHz_{peak}
±5% of reading ±1 digit	10 MHz–1300 MHz	20 Hz–200 kHz	≤400 kHz_{peak}

For rms detector add ±3% of reading.

DEMODULATED OUTPUT DISTORTION[6,7]:

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)[2]:

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)[5]:

Maximum Resolution	*Maximum Demodulated Output Sensitivity*	*Deviations (ΔF)*
100 Hz	*0.01 mV/Hz*	$\Delta F_{peak} \ge 40$ kHz
10 Hz	*0.1 mV/Hz*	$4.0 \text{ kHz} \le \Delta F_{peak} < 40$ 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.

DEMODULATED OUTPUT DISTORTION[7]:

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.*

Amplitude Modulation

RATES:
20 Hz to 10 kHz, 150 kHz $\le f_c <$ 10 MHz.
20 Hz to 100 kHz, 10 MHz $\le f_c \le$ 1300 MHz.

DEPTH: to 99%.

ACCURACY[1,2,3]:

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[4,5]:

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)[2]:

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$\%_{rms}$.

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[1] Not to exceed for stated accuracy: 50 Hz to 40 kHz rates with rms detector.

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

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

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

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

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

[7] 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 (2 of 7)

Amplitude Modulation, continued

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)[5]*:*

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	$AM_{rms} < 3.0\%$

Phase Modulation

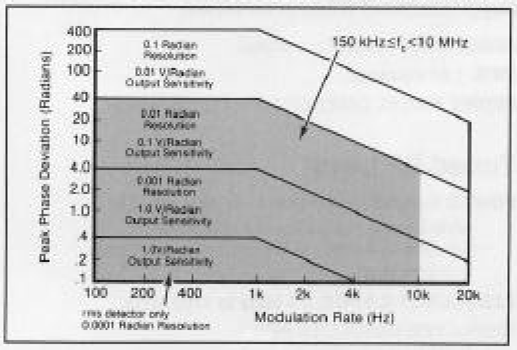
RATES:
200 Hz to 10 kHz, 150 kHz $\leq f_c <$ 10 MHz.
200 Hz to 20 kHz, 10 MHz $\leq f_c \leq$ 1300 MHz.

ACCURACY[2]**:**
±4% of reading ±1 digit, 150 kHz $\leq f_c <$ 10 MHz.
±3% of reading ±1 digit, 10 MHz $\leq f_c \leq$ 1300 MHz.
For rms detector add ±3% of reading.

DEMODULATED OUTPUT DISTORTION: <0.1% THD.

AM REJECTION (for 50% AM at 1 kHz rate)[2]**:**
<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)[5]**:**



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.

SENSITIVITY:
12 mV_{rms} (−25 dBm), 150 kHz $\leq f_c \leq$ 650 MHz.
22 mV_{rms} (−20 dBm), 650 MHz $< f_c \leq$ 1300 MHz.

MAXIMUM RESOLUTION: 1 Hz.

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, $f_c \geq$ 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: *Approximate frequency must be entered from keyboard. 0.22 mV_{rms} (−60 dBm).*

Using the RF amplifier and the IF amplifiers, sensitivity can be increased to approximately −100 dBm.

Internal Time Base Reference

FREQUENCY: 10 MHz.

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

Supplemental Characteristics:

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

	Standard	Option 002
Aging Rate	$<1 \times 10^{-6}$/mo.	$<1 \times 10^{-9}$/day
Temperature Effects	$<2 \times 10^{-7}$/°C	$<2 \times 10^{-10}$/°C
Line Voltage Effects (+5%, −10% Line Voltage Change)	$<1 \times 10^{-8}$	$<5 \times 10^{-10}$
Short-Term Stability	—	$<1 \times 10^{-9}$ for 1 sec. average

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

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

[6] After 30-day warm-up.

Table 1–1. *Specifications (3 of 7)*

RF Power

The HP 8902A Measuring Receiver, 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 HP 8902A can be used with the HP 11792A Sensor Module and any of the HP 8480 series Power Sensors (HP 8481A/1B/1H/2A/2B/2H/3A/4A/5A/6A) to make power measurements from −70 dBm (10 pW) to +44 dBm (25W) at frequencies from 100 kHz to 50 GHz. The HP 8480 Series Sensors also work with the HP 435A, HP 436A and HP 438A Power Meters. Unless otherwise specified, the specifications shown below refer to the HP 8902A only. A detailed explanation of how the uncertainty specifications provided below affect the absolute power measurement accuracy of the HP 8902A is provided in Application Note 64-1.

RF POWER RESOLUTION[9]:
0.01% 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)[10]:
±0.02 dB, RF ranges 2 through 5.
±0.03 dB, RF range 1.
Using front-panel display add ±1 count of least-significant digit.

RF RANGE-TO-RANGE CHANGE ERROR (using Recorder Output): ±0.02 dB/RF range change from reference range. Using front-panel display add ±1 count of least-significant digit.

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

ZERO SET (digital settability of zero): ±0.5% ~~±0.07%~~ of full scale on lowest range. Decrease by a factor of 10 for each higher range.

Supplemental Characteristics:

ZERO DRIFT OF METER: *±0.03% of full scale/°C on lowest range. Decrease by a factor of 10 for each higher range.*

NOISE (at constant temperature, peak change over any 1-minute interval for the HP 11722A Sensor Module and HP 8481A/1B/1H/2A/2B/2H/3A/5A/6A 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 5 on all ranges.

ZERO DRIFT OF SENSORS (1 hour, at constant temperature after 24-hour warm-up):
±0.1% of full scale on lowest range for HP 11722A Sensor Module and HP 8481A/1B/1H/2A/2B/2H/3A/5A/6A Sensors.
±2.0% of full scale on lowest range for HP 8484A Sensor. Decrease by a factor of 10 for each higher range.

RF POWER RANGES OF HP 8902A MEASURING RECEIVER WITH HP 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 through 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.*

Tuned RF Level

POWER RANGE: −127 dBm to 0 dBm, using IF synchronous detector (200 Hz BW).
−100 dBm to 0 dBm, using IF average detector (30 kHz BW).

FREQUENCY RANGE: 2.5 MHz to 1300 MHz.

DISPLAYED RESOLUTION[11]:
4 digits in watts or volts mode.
0.01 dB or 0.001 dB in dBm or $dB_{relative}$ mode.

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[9] The HP 8902A fundamental RF Power measurement units are watts. Further internal processing is done on this number to display all other units.

[10] When using HP 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.

[11] The HP 8902A fundamental Tuned RF Level measurement units are volts. Further internal processing is done on this number to display all other units.

Table 1–1. Specifications (4 of 7)

Tuned RF Level, continued

RELATIVE MEASUREMENT ACCURACY (at constant temperature and after RF range calibration is completed)[12]: Detector linearity + IF range-to-range error + RF range-to-range error + frequency drift error + noise error ± 1 digit.

DETECTOR LINEARITY:

For IF Synchronous Detector:

±0.007 dB/dB change, but not more than ±0.02 dB/10 dB change.

Typically <±0.004 dB/dB change and <±0.01 dB/10 dB change.

For IF Average Detector (0°C to +35°C):

±0.013 dB/dB change, but not more than ±0.04 dB/10 dB change.

Typically <±0.008 dB/dB change and <±0.02 dB/10 dB change.

IF RANGE-TO-RANGE ERROR (see Tuned RF Level range plot)[13]:

±0.02 dB/IF range change, IF ranges 1 through 5.

±0.05 dB/IF range change, IF ranges 6 and 7.

RF RANGE-TO-RANGE ERROR:

±0.04 dB/RF range change (Tuned RF Level only).

±0.06 dB/RF range change, RF Power to Tuned RF Level.

FREQUENCY DRIFT ERROR: ±0.05 dB/kHz frequency drift from center of IF (using IF synchronous detector).

NOISE ERROR: ±0.18 dB for levels <−120 dBm, or for levels <−110 dBm if Special Function 1.9 is selected.

INPUT SWR:

<1.18, at HP 8902A RF input, RF range 1 and 2.

<1.40, at HP 8902A RF input, RF range 3.

<1.33, at HP 11722A RF input, RF range 1 and 2.

<1.50, at HP 11722A RF input, RF range 3.

<1.33, at HP 11722A RF input, RF range 3 with Special Function 1.9.

Supplemental Characteristics:

ABSOLUTE LEVEL MEASUREMENT ACCURACY AT LOW LEVELS (at constant temperature and after RF range calibration is completed)[12]:

Absolute level measurement accuracy is a function of the RF Power and Tuned RF Level measurement accuracy. Product Note 8902A-1 explains how both of these measurements affect absolute level measurement accuracy. For a source with an output SWR of 1.7 and level of −110 dBm the typical absolute level measurement accuracy is 0.46 dB rss and 1.02 dB worst case.

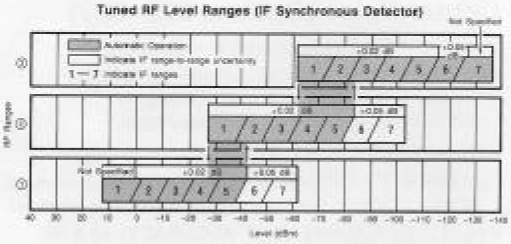
IF FREQUENCY: 455 kHz.

ACQUISITION TIME: *<4 seconds, ≥−110 dBm.*
<10 seconds, ≥−127 dBm.

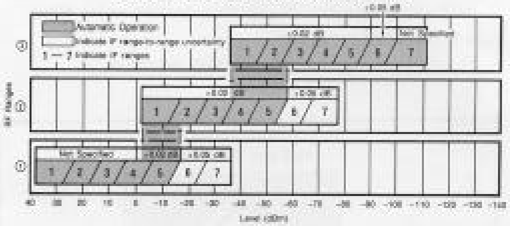
RESPONSE TIME (responding to changes in level of an acquired signal): *<2 seconds, ≥−110 dBm.*
<5 seconds, ≥−127 dBm.

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

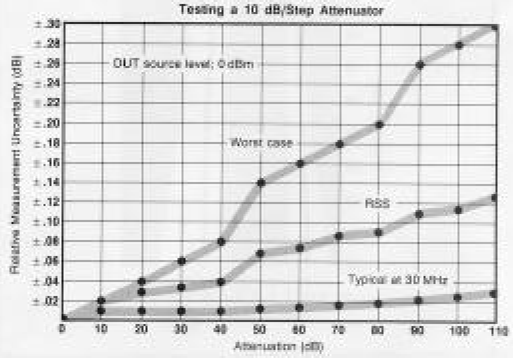
Tuned RF Level Ranges (IF Synchronous Detector)



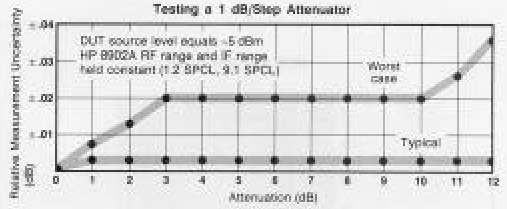
Tuned RF Level Ranges (IF Average Detector)



Testing a 10 dB/Step Attenuator



Testing a 1 dB/Step Attenuator



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[11] The HP 8902A fundamental Tuned RF Level measurement units are volts. Further internal processing is done on this number to display all other units.

[12] Tuned RF Level accuracy will be affected by residual FM of the source-under-test. If the residual FM_{peak} is >50 Hz measured over a 30 second period in a 3 kHz BW, Tuned RF Level measurements should be made using the IF average detector (30 kHz BW) by using Special Function 4.4. The Tuned RF Level measurement sensitivity when using the IF average detector is −100 dBm.

[13] IF Ranges 6 and 7 (see Tuned RF Level range plots) are only used in automatic operation for Tuned RF Level measurements below approximately −110 dBm for the IF synchronous detector, and below approximately −85 dBm for the IF average detector.

Table 1–1. *Specifications (5 of 7)*

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.

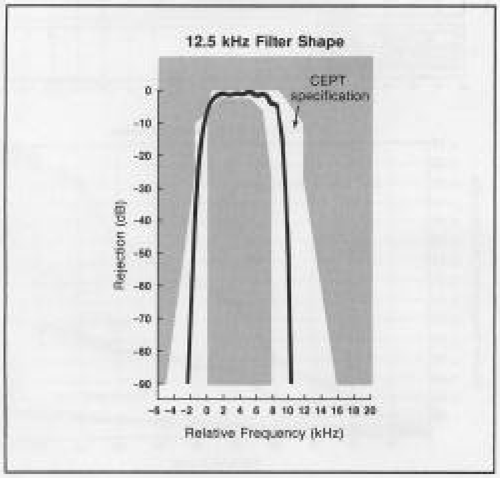
CARRIER NOISE FILTER:
Filter Noise Bandwidth: 2.5 kHz nominal.

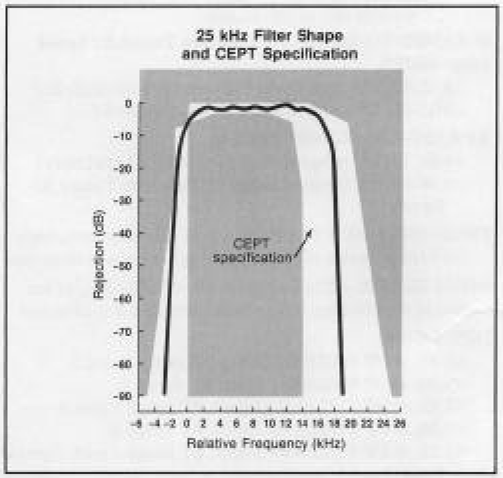
Noise Bandwidth Correction Accuracy (stored in non-volatile memory): ±0.2 dB.

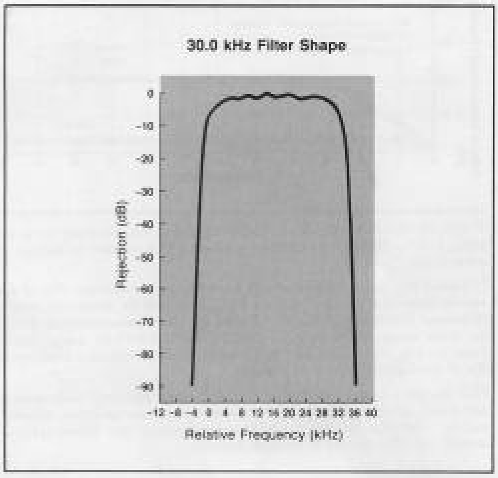
Supplemental Characteristics:

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.*







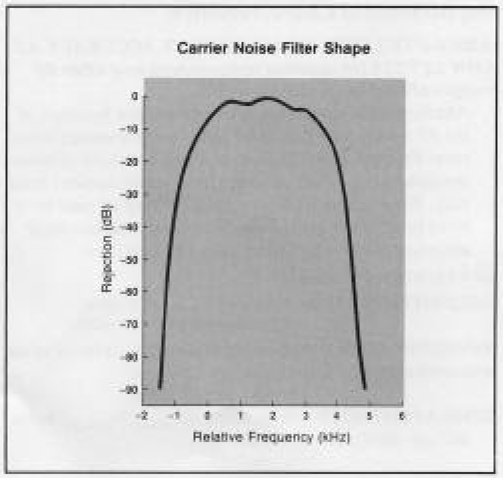


Table 1-1. *Specifications (5 of 7)*

Increased Power Measurement Accuracy (Option 050)

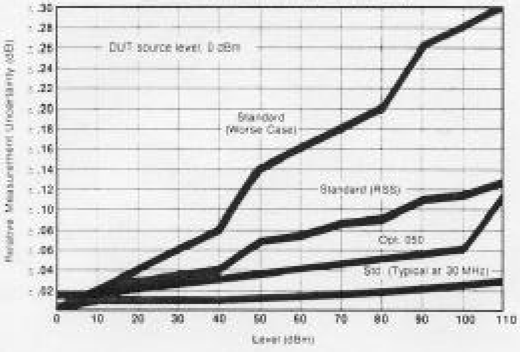
POWER RANGE: −120 to 0 dBm

FREQUENCY RANGE: 2.5 MHz to 1300 MHz

MEASUREMENT ACCURACY[14,15]:

Measurement	Range	Accuracy
Absolute (Using an HP 11722A Sensor Module)	0 dBm to −100 dBm	±0.005 dB/10 dB step ±0.120 dB ± 1 digit
	−100.001 dBm to −120.000 dBm	±0.050 dB/10 dB step ±0.120 dB ± 1 digit
Relative	0 dBm to −100 dBm	±0.005 dB/10 dB step ±0.015 dB ± 1 digit
	−100.001 dBm to −120.000 dBm	±0.050 dB/10 dB step ±0.015 dB ± 1 digit

Standard vs. Option 050 Measurement Uncertainty



(See Tuned RF Level for other specifications.)

Supplemental Characteristics:

MEASUREMENT TIME: 10 to 30 seconds.

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[14] Option 050 specifications are warranted when using a Hewlett-Packard synthesized source with less than 100 Hz peak residual FM measured in a 3 kHz post-detection bandwidth over a 30 second period.

[15] Accuracy specifications do not include mismatch uncertainty.

Table 1-1. Specifications (6 of 7)

Audio Frequency Counter

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

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

ACCURACY (for demodulated signals)[16]:

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)[16]:

Accuracy	Frequency	Level
±3 counts of least-significant digit ±Internal Reference Accuracy	>1 kHz	$\geq 100\ mV_{rms}$
±0.02 Hz ±Internal Reference Accuracy	<1 kHz	$\geq 100\ mV_{rms}$

Supplemental Characteristics:

DISPLAYED RESOLUTION: *6 digits.*

MEASUREMENT RATE: *2 readings per second.*

COUNTING TECHNIQUE: *Reciprocal with internal 10 MHz time base.*

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 per second.*

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[17]: 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 per second.*

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)[18]:

Flatness: <1% at rates ≤10 kHz.

Supplemental Characteristics:

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

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

>20 kHz LOW PASS FILTER 3 dB CUTOFF FREQUENCY: *100 kHz nominal.*

OVERSHOOT ON SQUARE WAVE MODULATION[18]: *<1%.*

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[16] With the low-pass and high-pass audio filters used to stabilize frequency readings.

[17] For demodulated signals, the residual noise generated by the HP 8902A must be accounted for in distortion measurements (i.e., residual AM, FM or φM.)

[18] The >20 kHz low-pass filter is intended for minimum overshoot with square wave modulation.

Table 1-1. Specifications (7 of 7)

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.

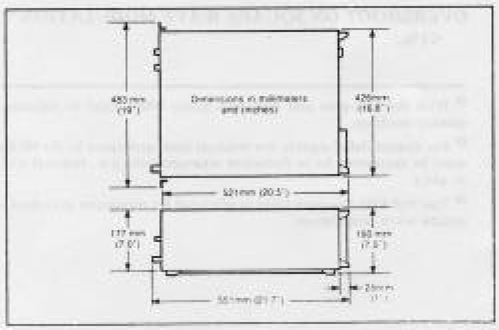
EMI: Conducted and radiated interference is within the requirements of VDE 0871 (Level B), and CISPR publication 11.

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

WEIGHT: Net 23.6 kg. (52 lb.); Shipping 31.4 kg (69 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 8902A 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[19]*: >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.*

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

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: ±0.07 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
Piston Attenuator	Accuracy: ±(0.005 dB/10 dB + 0.03 dB) at 30 MHz (Used as alternate equipment.)	Eaton Type 32	P

*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***	
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 8902A 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 Measuring Receiver's Special Function 1.9	HP 11722A	P,A,T
Service Accessory Kit	No substitution recommended.	HP 08901-60287	T

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

** HP 476A-H75 must be calibrated a the National Bureau of Standards (NBS) for this accuracy.

*** HP 478-H76 includes HP standards lab calibration to ±0.58% at 50 MHz (traceable to NBS)

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

Instrument Type	Critical Specifications	Suggested Model	Use*
Signature Analyzer	External Count Range: to 15 MHz Because the signatures documented are unique to a given signature analyzer, no substitution is recommended.	HP 5005A	T
Step Attenuator	Step Accuracy: ±0.01 dB between 10 and 20 dB at 50 MHz	HP 355D Option J25	P
SWR Bridge	Frequency Range: 150 kHz to 1300 MHz Impedance: 50Ω Directivity: >40 dB Connectors: Type-N	Wiltron 60N50	P

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

Table 1-3. Recommended Test Accesories

Accessory Type*	Recommended Part
Adapter (Type N Male to BNC Female connectors)	HP 1250-0067
Capacitor, 620 pF	HP 0160-3536
IC Extender Clip, 16 Pin	HP 1400-0734
Resistor, 909Ω1% 1/4W	HP 0757-0422
Resistor, 1210Ω1% 1/4W	HP 0757-0274
Resistor, 2150Ω1% 1/4W	HP 0698-0084
Resistor, 4640Ω1% 1/4W	HP 0698-3155
Tee (Coaxial, BNC, one Male and two Female connectors)	HP 1250-0781
50ΩLoad (Male, BNC, coaxial)	HP 1250-0207
Adjustment Tool	HP 8710-0772

*Accessories listed in this table are only those not already contained in the Service Accessory Kit HP 08901-60287