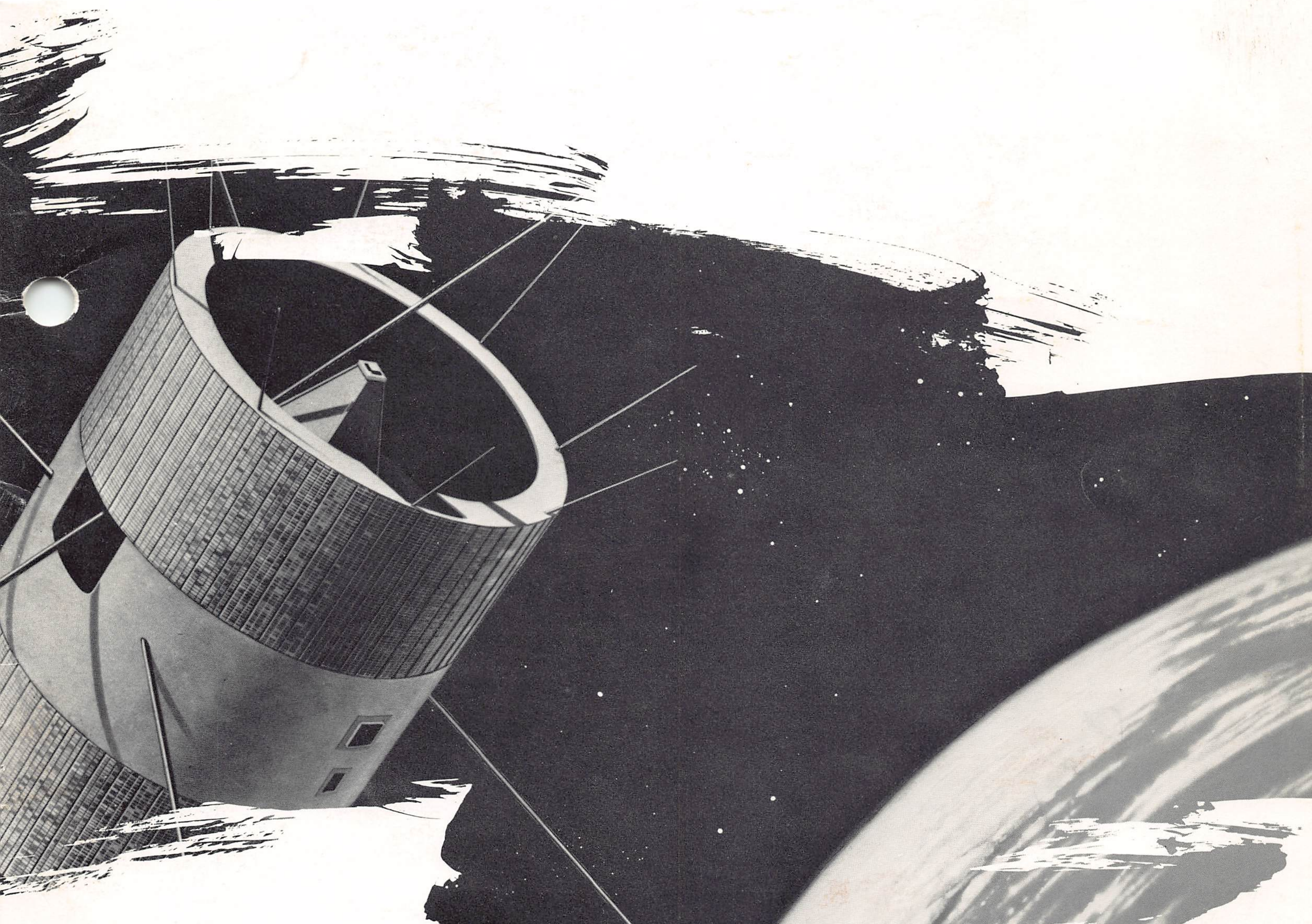
~~David M. Rowe~~

# AM, FM MEASUREMENTS WITH THE TRANSFER OSCILLATOR

## Application Note 141



# AM, FM MEASUREMENTS WITH THE TRANSFER OSCILLATOR
## Application Note 141

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*HEWLETT hp PACKARD*

# INTRODUCTION

In addition to the CW and pulsed RF frequency measurements made by conventional transfer oscillators, the HP 5257A uniquely and economically solves a host of more difficult measurement problems. These unique abilities stem from its excellence as a down converter. The RF input signal, down converted in frequency, is available at the PULSED RF OUTput and contains all the modulation, noise, and real time information of the input but is within the range of low frequency measuring devices. Thus, when this signal is applied to such instruments as the 180A Oscilloscope, the 5210A FM Discriminator with filter kit, the 310A Wave Analyzer, or the 333A Distortion Analyzer, many valuable measurements are possible. Measurements over the full range of 50 MHz to 18 GHz, can now be made with a single set of instruments and the range can be extended to 40 GHz using the E80-5245L Measurement System.

Modulation meters and frequency tuning dials of signal generators can be easily calibrated. The AM and FM characteristics of RF signals can be measured. Broadcast frequencies and station accuracy can be verified. These measurements and many more can be made using the techniques described in this note by combining low frequency measuring devices with the HP 5257A Transfer Oscillator.

The HP 5345A Counter with 5354A Frequency Converter will automatically make any CW or pulsed RF measurements up to 4 GHz. This is extended up thru 18 GHz using the manually tuned 5257A Transfer Oscillator. Even at frequencies below 4 GHz the 5257A can be helpful when measuring noisy CW signals as it serves as a tracking filter when operated in the APC mode. As an example, the 5257A can be tuned to lock either to the picture carrier or the aural carrier on the antenna feed line of a TV transmitter carrying full program information. In this way accurate frequency measurements can be made without interrupting the program.

## SPECIFICATIONS*

**FREQUENCY RANGE:** 50 MHz to 18 GHz.

**INPUT SIGNAL CAPABILITY:** CW Signals, Pulsed RF Signals. Signals with high FM content.

**CW MEASUREMENT ACCURACY:** Retains counter accuracy in APC mode.

**INPUT SENSITIVITY:** 100 mV rms (-7 dBm) for input frequencies of 50 MHz to 15 GHz. 140 mV rms (-4 dBm) for input frequencies of 15 to 18 GHz and VFO FREQUENCY of 125-133.3 MHz.

**INPUT IMPEDANCE:** 50 ohms nominal.

**MAXIMUM INPUT:** +10 dBm for CW Signals. 2 volts P-P for Pulsed RF Signals.

**APC LOCK RANGE:** Approximately ±0.2% of input frequency.

**METER:** APC MODE—Indicates loop phase error under locked conditions. PULSED RM MODE—Zero beat indicator.

**PULSED RF OUT:** For external oscilloscope, 0.5 volt P-P.

**PULSE CARRIER FREQUENCY MEASUREMENTS:** Minimum pulse width—0.5 μsec. Minimum repetition rate —10 pulses per sec. Accuracy—0.01 cycle per pulse width (typical error: ±20 kHz or less for pulse width >2 μs; ±50 kHz <2 μs).

**VFO: Frequency Range** — 66.7 to 133.3 MHz.

**Drift** — (With constant temperature in operational range of 0° to 55°C) typically ±2 parts in $10^5$ per minute immediately after turn on. Typically ±1 part in $10^7$ per minute after 2 hours of operation. **Temperature Variation**—Typically 1 part in $10^4$ per degree C.

**INPUT CONNECTOR:** Precision Type N female.

**OPTION 01:** Precision Type APC-7 input connector.

**WEIGHT:** Net, 7¼ lb (3,3 kg). Shipping, 8 lb (3,7 kg).

**When used with HP Electronic Counters: 5245L (serial no. prefix below 402 requires modification), 5245M, M54-5245L/M, 5246L, 5247M, 5248L/M, M54-5248L/M, 5345A with 10590A Plug-in Adapter or 5360A with 10536A Plug-in Adapter.*

# GENERAL THEORY AND OPERATING PROCEDURES

## OPERATING PROCEDURES

With greater simplicity and accuracy than conventional transfer oscillators, the HP 5257A gives the user the ability to measure signals over the entire range of 50 MHz to 18 GHz. Tuning of the extremely stable local oscillator (±1 part in $10^7$) is accomplished with a single dual speed dial whose superb anti-backlash makes accurate, repeatable measurements simple. The high input sensitivity (-7 dBm to 15 GHz and -4 dBm to 18 GHz), wide range (+10 dBm max.), direct readout, simple tuning meter which replaces conventional and more complicated oscilloscopes to indicate zero beats, and wide capture and phase lock (± 0.2% of input frequency) when in A.P.C. mode combine to place a variety of measurements at the fingertips of the user. These measurements can be made in six simple steps. Refer to Figure 1 for a front panel diagram.

1. Being sure to observe the +10 dBm input overload limit, apply the signal to be measured to the RF INPUT.

2. Set the appropriate frequency range on the RANGE SWITCH, as determined by the CW or pulsed RF carrier signal to be measured.

3. Set the MODE switch to PULSED RF, tune the FREQUENCY dial for a maximum indication on the meter, then adjust the LEVEL ADJ until the meter reads .9 of full scale, indicated by the red level mark.

4. For CW measurements turn the MODE switch to APC and tune the FREQUENCY dial to get a counter reading other than all zeros. In the APC mode, the counter is blanked while not in phase lock.

5. Determine the harmonic number (see below).

6. Set the harmonic number on the thumbswitches and read directly the frequency on the counter display. It is a good practice to press the RESET button on the counter mainframe after setting the harmonic number to avoid delay before the first reading.

Determining the harmonic number is easy if the input frequency is known to within the sampling frequency of the 5257A (i.e. 16.7 to 33.3 MHz in the .05 to 0.2 GHz range and 66.7 to 133.3 MHz in the 0.2 to 18 GHz range). After following steps 1. to 6. above with the harmonic number thumbswitches set to 001, the counter displays $F_{LO}$, the frequency of the local oscillator which is harmonically related to the input. The harmonic number N can now be calculated as, $N = F_{INPUT} / F_{LO}$ where $F_{INPUT}$ is the approximate input frequency. By tuning the frequency of the local oscillator to around 100 MHz, determining the harmonic number will be further simplified.

If the input frequency is not known to within the sampling frequency of the 5257A, the harmonic number can be determined in four steps.

1. Set the harmonic number thumbswitches to 001.

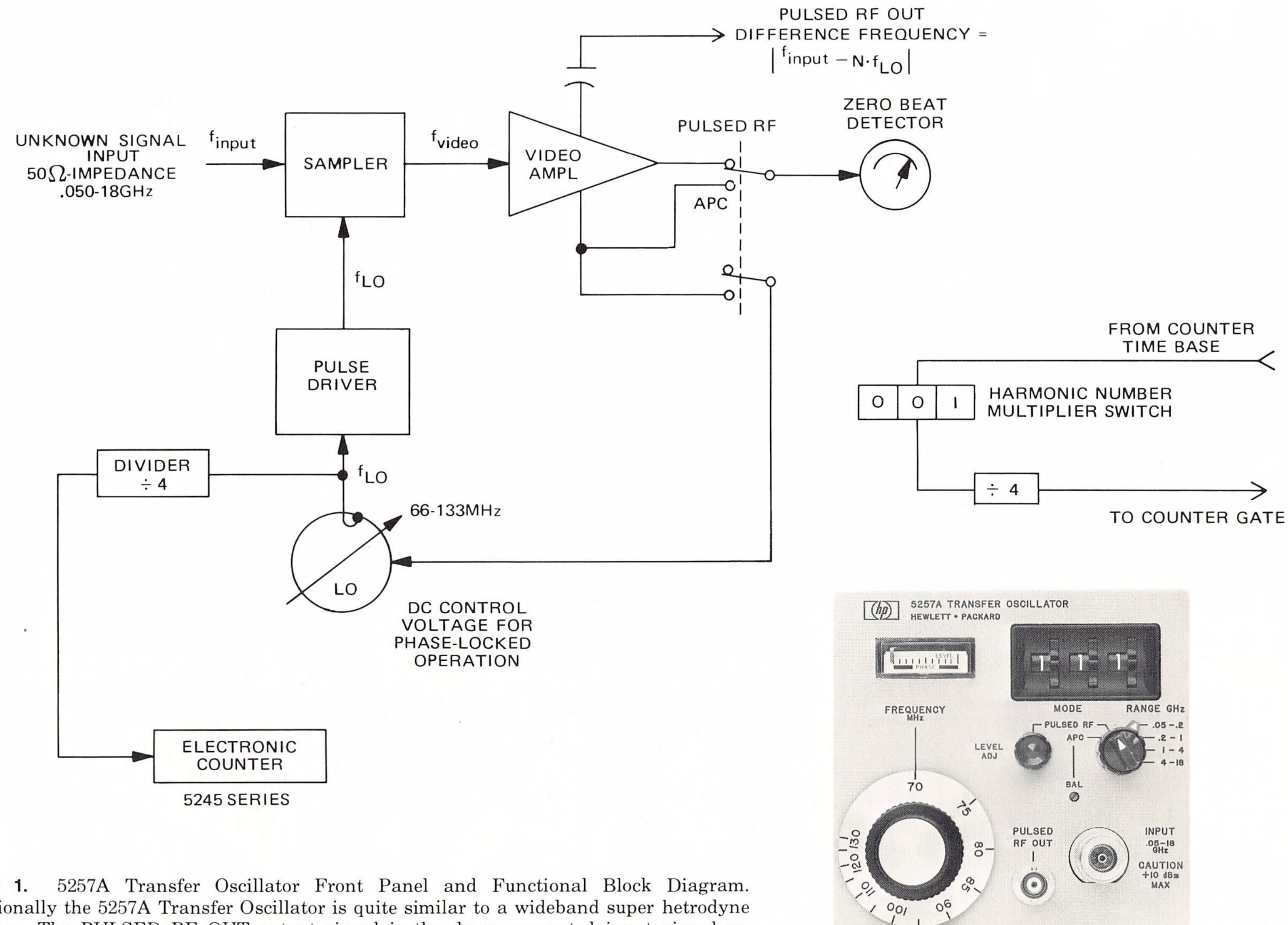



**Figure 1.** 5257A Transfer Oscillator Front Panel and Functional Block Diagram. Functionally the 5257A Transfer Oscillator is quite similar to a wideband super hetrodyne receiver. The PULSED RF OUT output signal is the down converted input signal retaining all the modulation, noise, and real time information of the input. It is this signal which makes possible many valuable measurements with low frequency instruments.

2. Follow steps 1. to 6. described above to determine one harmonic of the input, $F_{S1}$.

3. Tune the FREQUENCY dial either up or down to find the *next* higher or lower harmonic frequency, $F_{S2}$. It is important not to skip a harmonic.

4. The harmonic number N is now determined by

$$N = \frac{F_{S1}}{|F_{S1} - F_{S2}|}$$

As the input frequency increases, separation between harmonics decreases. For this reason, extra care should be taken in determining the harmonic number of higher input frequencies. It is a good practice to check the harmonic number after calculating it. This can be done by increasing or decreasing the FREQUENCY dial to obtain an *adjacent* zero beat. If the harmonic number thumbswitch is now decreased or increased by one, the counter reading should be within 10 kHz of the first reading, providing the signal source is stable.

## THEORY OF OPERATION

The basic operating principle of the 5257A is quite simple (see Figure 1 for a functional block diagram). To down convert the frequency of the input signal to the range of low frequency measuring devices while retaining all of the signal's modulation, noise, and real time information, the 5257A uses a technique quite similar to a wideband super hetrodyne receiver. By sampling the input signal, $F_{INPUT}$, with harmonics of a very stable tunable local oscillator, $F_{LO}$, and filtering the resulting signal through a video amplifier with a bandwidth of 1 MHz, a difference frequency signal $F_{INPUT}-N(F_{LO})$ is obtained. If the local oscillator is tuned to zero beat with the input, then $F_{INPUT}$ will equal $N(F_{LO})$. Thus, $F_{INPUT}$ can be measured, by measuring $F_{LO}$ and multiplying by N. The multiplication is done by extending the counter gate time so that the counter displays directly $F_{INPUT}$.

The accuracy of the measurement is determined by how well a zero beat can be obtained. In PULSED RF MODE, if a perfect zero beat were obtained, the difference frequency signal observed at the PULSED RF OUT output would be DC and would thus appear as horizontal lines if viewed on an oscilloscope (see Figure 2). In general, this signal is not perfectly horizontal but rather has a slight slope to it. The specification that a zero beat can be obtained to within 1/100 of a cycle per pulse width refers to how well the slope of this signal can be detected. On very long pulses, a slight slope will be much more noticeable then on a very short pulse, thus the accuracy of zero beat tuning is greater for the longer pulse. For example, on a 1 $\mu$sec pulse the error is 1 cycle per 100 $\mu$sec, or 10 kHz. On a 10 $\mu$sec pulse the error is 1 cycle per 1000 $\mu$sec or 1 kHz. For CW signals the effective pulse width is very large and thus, on stable signals great accuracy can be obtained. See Figure 3 for a plot of this error.

For CW signals, the 5257A gives the user the advantage of operating in APC MODE thus eliminating the error due to tuning for a zero beat. The wide

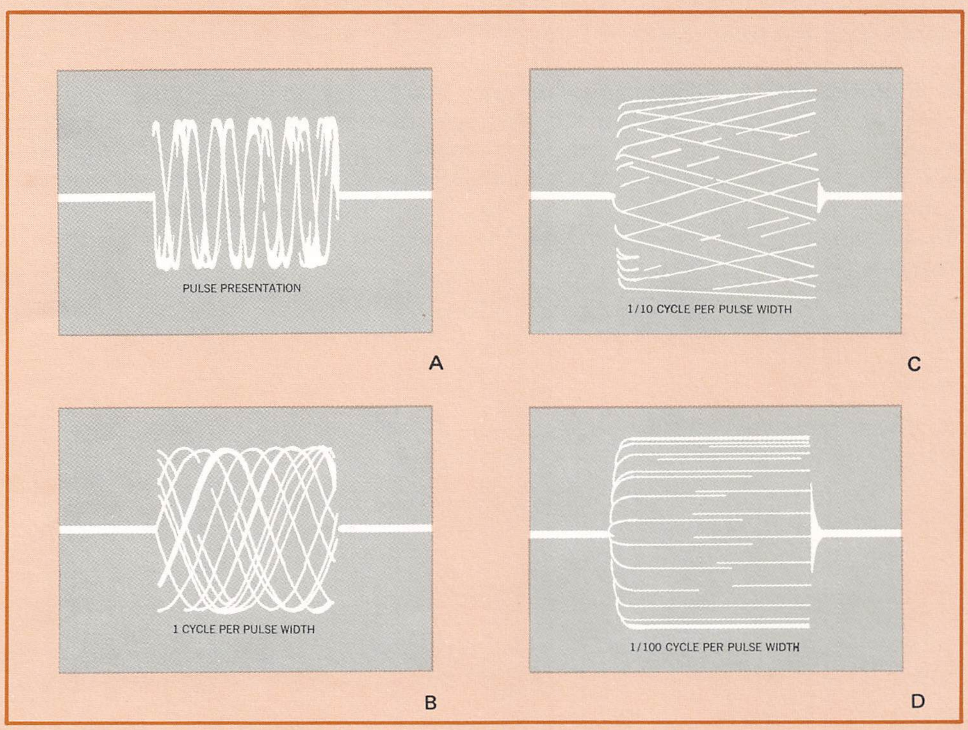



**Figure 2.** Typical PULSED RF OUT Output Signals. A—D shows a difference frequency signal resulting from a pulsed RF input as the local oscillator is successively tuned closer to zero beat with the input the carrier frequency. As zero beat is approached, the difference frequency goes to zero as indicated by horizontal lines in the observed signal. The degree of accuracy in obtaining a zero beat is determined by how close the observed signal approaches horizontal lines, and by the stability of the local oscillator.

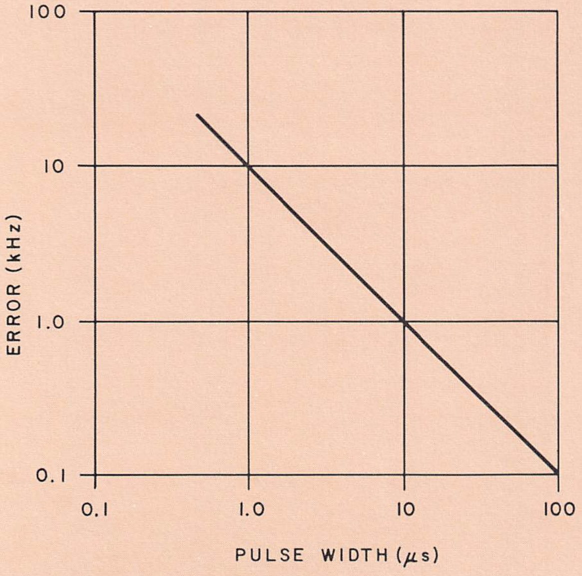



**Figure 3.** Approximate Error in PULSED RF Measurements. In PULSED RF MODE, the accuracy of any measurement is determined by how accurate a zero beat can be tuned. The specification that a zero beat can be obtained to within 1/100 of a cycle per pulse width is shown in this plot.

phase lock range (± 0.2% of input frequency) allows automatic measurement of signals with FM components.

In PULSED RF MODE the difference frequency signal, ($F_{INPUT}$-$NF_{LO}$), contains all the modulation, noise, and real time information of the input but is within the range of low frequency measuring devices. Thus, when this signal, which is obtainable at the PULSED RF OUT output, is applied to instruments such as the 180A Oscilloscope, the 5210A FM Discriminator with filter kit, the 310A Wave Analyzer, or the 333A Distortion Analyzer, many useful measurements are possible.

## PULSED RF

CARRIER FREQUENCY
PULSE WIDTH
PULSE REPETITION RATE
LOW LEVEL (-50 to -60 dBm)

Preservation of the input signal's real time information by the difference frequency signal makes measurement of pulse width and repetition rate on pulsed RF signals possible. These parameters are easily viewed on a general purpose lab oscilloscope, such as the 180A or the 181A. See Figure 4 for a typical instrument configuration. After following the procedure for measuring pulsed RF carrier frequencies outlined in the General Operation section of this note, the difference frequency signal at the PULSED RF OUT output will be a down converted version of the input. Figures 5; A, B, and C, show a typical difference frequency signal resulting from a 4 GHz pulsed RF input. In these figures the pulse repetition rate and pulse width are easily measured. In Figure 5B the local oscillator signal is tuned slightly off zero beat giving a carrier frequency of several hundred cycles. In Figure 5C, the local oscillator is tuned much closer to zero beat giving a carrier frequency of only a few cycles. In both cases the real time information is preserved showing that this information is not affected by the tuned difference frequency.

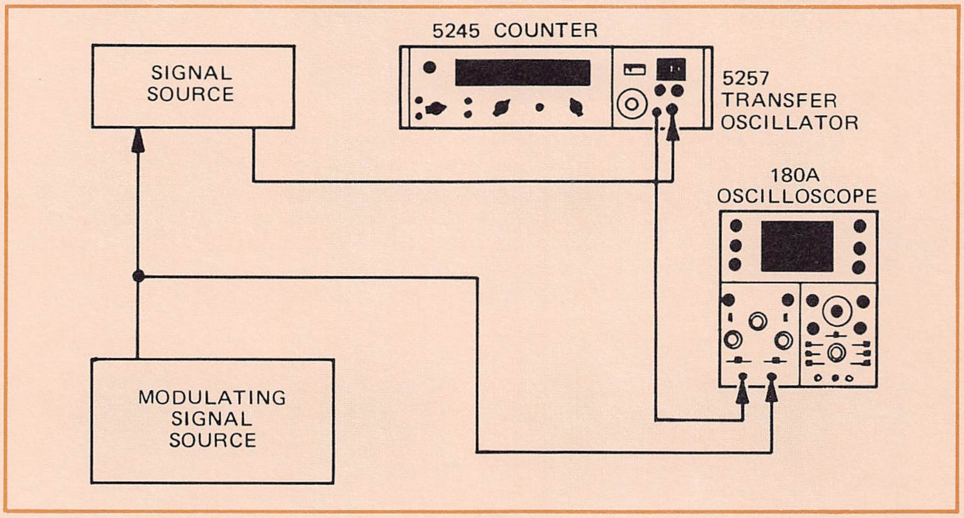



**Figure 4.** Basic Instrument Set Up to Observe the Down Converted Input Signal. This set up is useful to observe real time pulse information and amplitude modulation characteristics.

### LOW LEVEL MEASUREMENTS

With the ability to observe the down converted input signal, very low level pulsed RF signals can be measured. Levels as low as *-50 to -60 dBm* are typical. Figures 6A and 6B show the result of a -55 dBm pulsed RF input signal. While noise is quite visible, the real time variables are still measurable. A zero beat is also detectable and usable at these levels, thus allowing frequencies to be measured on signals too small to give a meter indication.

These techniques apply to pulses as narrow as 1 $\mu$sec and repetition rates as low as 10 pulses per second. At the lower pulse repetition rates a variable persistance oscilloscope such as the 181A or 141A must be used.

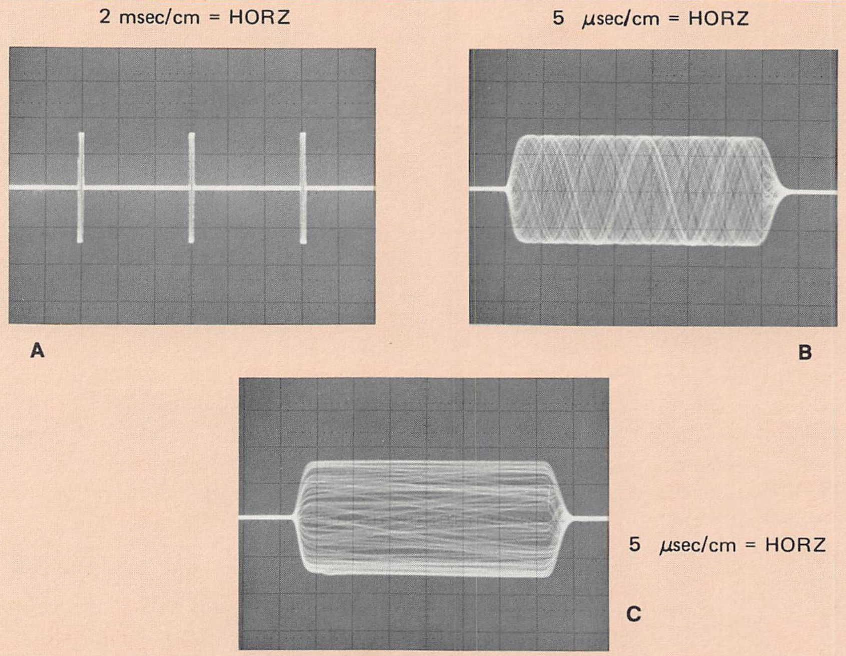



**Figure 5.** The HP 5257A Transfer Oscillator preserves real time information while down converting the carrier frequency of pulsed RF signals. In 5A the pulse repetition rate is easily measured. Expanding the time scale, the pulse width is also easily viewed in 5B and 5C. 5C is tuned close to zero beat for the measurement of carrier frequency while 5B is not. The real time information is not affected by the tuned difference frequency. The input is a 4 GHz pulsed RF signal.

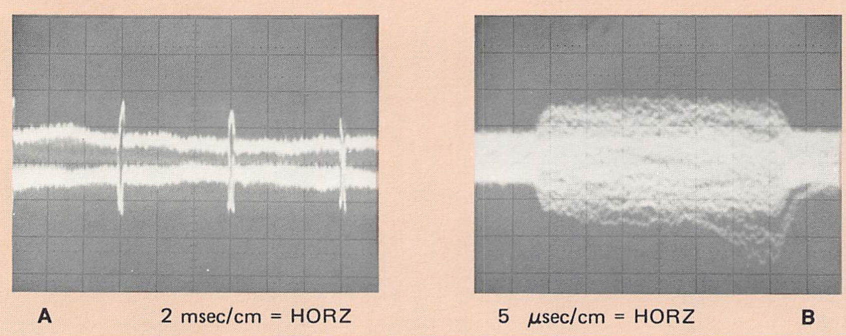



**Figure 6.** Down converted pulsed RF signals as low as -50 to -60 dBm are observable at the PULSED RF OUT output of the 5257A. While noise is visible, it is possible to measure the inputs real time parameters and to detect zero beats making very low level measurements possible. The input observed in A and B was a -55 dBm pulsed RF signal with a 4 GHz carrier frequency.

## AM MEASUREMENTS

PERCENTAGE MODULATION
CARRIER FREQUENCY
PHASE DISTORTION

Using the 5257A as an accurate down converter preserves the AM characteristics of the input in the difference frequency signal. Operating in PULSED RF MODE and following the steps outlined in the General Operating section, a difference frequency signal with a carrier frequency less than 1 MHz can be generated. Thus the percentage modulation, defined as (P-T)/(P+T) × 100 where P = peak value and T = trough value is easily measured using a low frequency oscilloscope to observe the 5257A PULSED RF OUT output (see Figure 7A).

Figure 7A shows a difference frequency signal resulting from a 4 GHz amplitude modulated signal. The upper trace represents the audio modulating signal. The signal is tuned slightly off zero beat giving a carrier frequency of several kHz. With this signal the percentage modulation can be easily measured. In Figure 7B, the same signal is tuned much closer to zero beat and the audio modulating signal is superimposed upon the difference frequency signal to show that the AM characteristics are not affected by the tuned difference frequency.

This technique works for signals whose peak amplitude is less than +10 dBm, the input limit, and whose minimum amplitude does not fall below the sensitivity of the input. With these restrictions, the 5257A can measure signals with as much as 90% modulation.

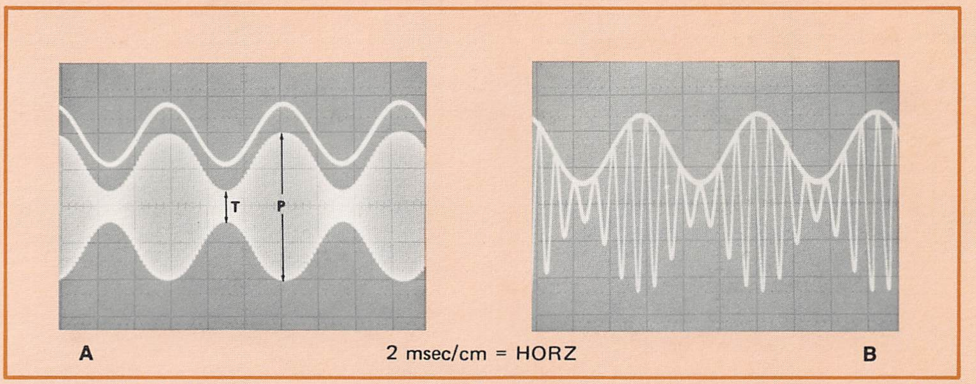



**Figure 7.** While down converting RF signals, the 5257A preserves the input's amplitude modulation and noise thus making measurements of these parameters with low frequency instruments possible. The upper trace in A is the audio modulating signal. The input was a 4 GHz signal and the difference frequency signal (the lower trace) was tuned off zero beat. In B, this signal was tuned much closer to zero beat and the modulating signal was superimposed showing that the modulation information is not effected by the tuned difference frequency.

Using the HP 8471A RF Detector to detect the PULSED RF OUT signal, phase distortion of modulating circuits can also be measured. Figure 8 shows a typical instrument set up to make this measurement.

In order for the AM characteristics, such as percent modulation, to be measured accurately, the input signal must not have large (>500 kHz) amounts of incidental FM. Incidental FM causes the difference frequency to be frequency modulated. Since the output amplifier bandwidth is approximately 1 MHz, any incidental FM which causes the difference frequency to approach this limit will cause amplitude distortion on the down converted signal.

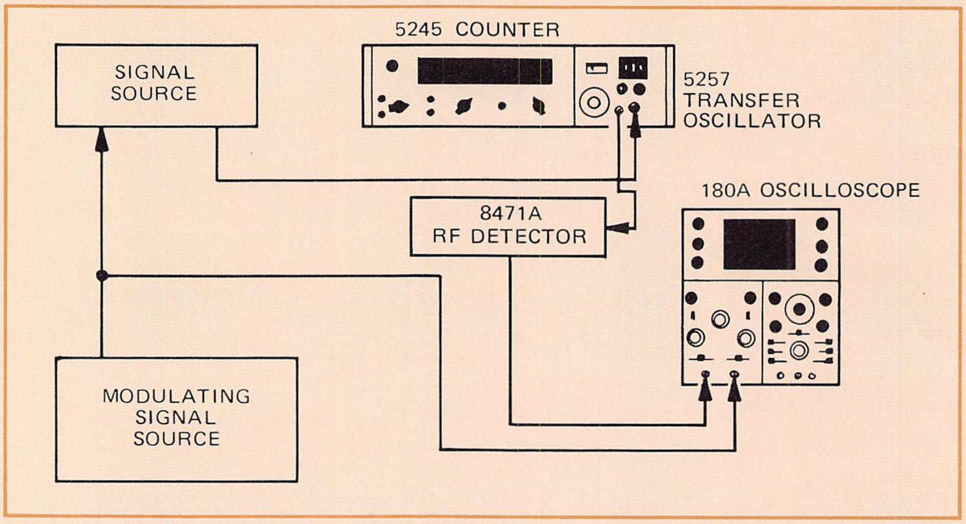



**Figure 8.** By detecting the down converted input signal, phase distortion of modulating circuits can be measured.

# FM DEVIATION AND INCIDENTAL FM

PEAK TO PEAK FM DEVIATION
RMS FM DEVIATION
PERCENTAGE MODULATION
INCIDENTAL FM
CARRIER FREQUENCY

It is often necessary to measure the amount of FM on an RF signal. When the FM is desired and controlled, this measurement is called FM deviation. When the FM occurs as noise, it is called incidental FM.

With the aid of a low frequency oscilloscope, 5210A FM Discriminator, 310A Wave Analyzer, and other low frequency instruments as shown in Figure 9, the 5257A makes these measurements and many others possible.

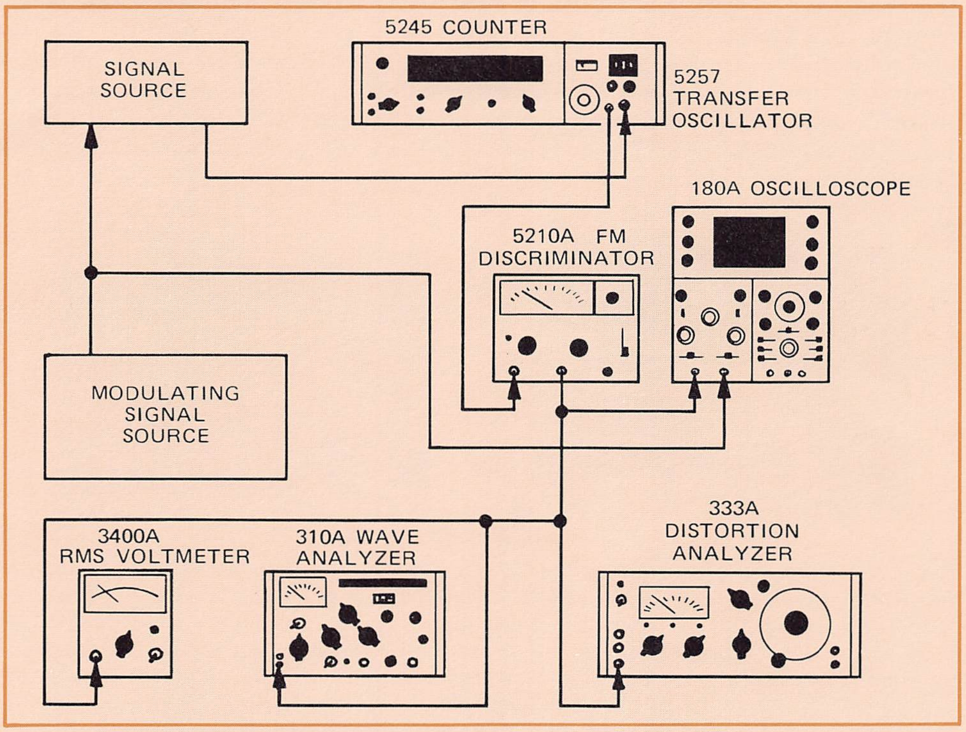



**Figure 9.** The FM characteristics of RF signals can be measured with this simple instrument set up.

## FM DEVIATION

To see how FM deviation is measured, consider Figure 10A. The staircase signal was used to FM modulate an RF signal generator. By following steps 1. to 6. of the GENERAL OPERATION section of this note, a difference frequency signal was obtained at the PULSED RF OUT output and the harmonic number of the RF carrier was determined and set into the thumbswitches. The difference signal is also shown in Figure 10A. By tuning the FREQUENCY dial across the range of the FM, zero beats are obtained. In Figure 10A, the dial has been tuned to give a zero beat, indicated by the straight line, on the fifth step of the staircase modulating signal. To measure the FM deviation of this signal, the

FREQUENCY dial is decreased until no zero beat patterns exist. The dial is then carefully increased until the first zero beat pattern is obtained on the first step of the staircase. The counter reading is then recorded, this is the lower limit of the frequency deviation. To obtain the other limit, the FREQUENCY dial is tuned until the zero beat patterns once again disappear. At this point, the dial is carefully tuned back to obtain a zero beat pattern on the top step of the staircase. The counter reading then corresponds to the other limit of the deviation. The difference between these two limits is the peak to peak frequency deviation of the RF signal.

The audio modulating signal can also be recovered from the down converted signal by applying the PULSED RF OUT output to an FM discriminator such as the 5210A with a filter kit. The upper trace of Figure 10B shows the staircase modulating signal used in Figure 10A. The lower trace shows the recovered signal when an HP 5210A FM Discriminator with 10531 Filter Kit with a 10 kHz cut off was used. From this, any phase distortion in the modulating circuits can also be measured. In this example the difference frequency was adjusted to approximately 800 kHz. By applying this recovered signal to a true RMS voltmeter such as the HP 3400A, RMS deviation can also be easily measured. In Figure 10, a staircase modulating signal was used because of its non-symmetrical form in time.

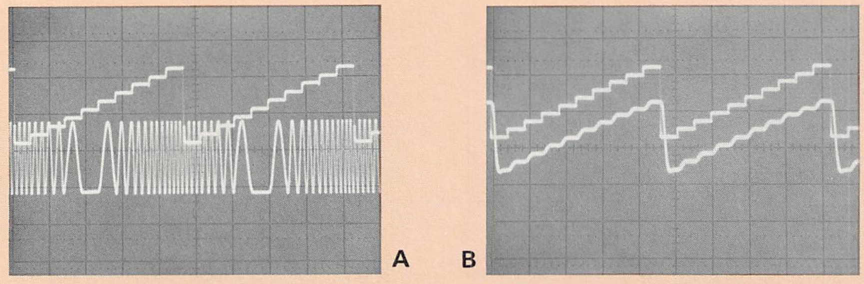



**Figure 10.** A shows a staircase signal used to frequency modulate a 4 GHz RF signal. The lower trace is the difference frequency signal tuned to zero beat with the frequency of the fifth step of the staircase modulating signal. To measure FM deviation the local oscillator is tuned to zero beat with the lower limit, corresponding to the first step and the counter reading is recorded. The local oscillator is then tuned to zero beat with the upper limit corresponding to the tenth step. The difference between these limits is FM deviation. In B the modulating signal was recovered (the lower trace) using a 5210A Discriminator with 10531A Filter Kit. The upper trace is the original signal.

Figures 11A—E illustrate another example. In these figures the upper trace represents the modulating signal and the lower trace the difference frequency observed at the PULSED RF OUT output. In Figure 11A, the FREQUENCY dial was tuned upward in frequency until no zero beat patterns were visible and then carefully tuned back until the first zero beat pattern was seen. As can be seen, this corresponds to the upper limit of the modulating signal. The counter reading was observed at this time.

As the dial was further decreased these patterns split as seen in Figure 11B. This corresponds to the two points on the modulating signal corresponding to the zero beat set by the FREQUENCY dial. In Figure 11C, the spacing of the zero beat patterns is equal, indicating, for a sinusoidal modulating signal, the RF carrier. Figure 11D shows the patterns coming together again as the dial is tuned closer to the lower limit. In Figure 11E the dial was tuned until no patterns were visible and then tuned back to obtain the lower limit of the modulating signal. The counter reading was observed at this time. The peak-to-peak FM deviation was then calculated as the first reading minus the second reading. Knowing the peak-to-peak deviation now enables the modulation meter on signal generators to be simply calibrated. Note that modulation meters usually indicate peak deviation which is half the peak-to-peak value measured.

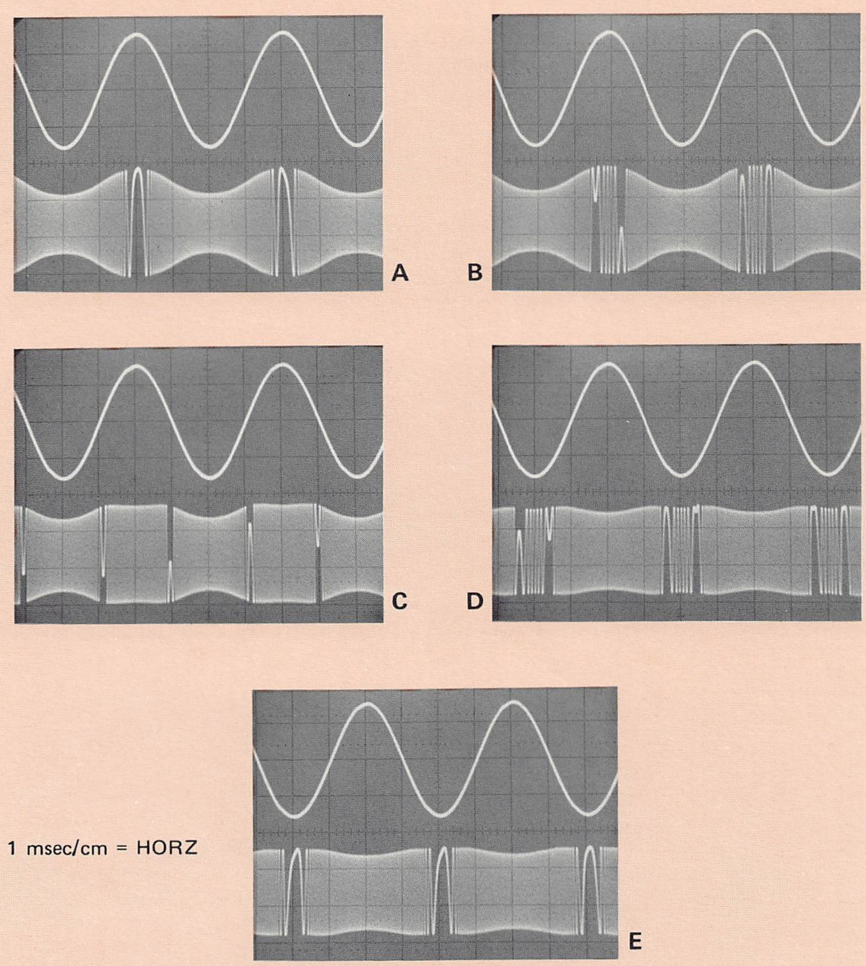



**Figure 11.** A—E shows an audio modulating signal (the upper trace) used to frequency modulate an RF signal generator and (the lower trace) the difference frequency signal. In A—E the local oscillator is tuned across the FM range of the input resulting in a movement of the zero beat pattern from corresponding to a maximum in A to a minimum in E. Recording the counter reading in A where zero beat patterns just begin to appear, and in E where they begin to disappear, and taking the difference between these recordings gives peak-to-peak FM deviation.

In Figure 11A—E, the observed difference frequency appears to have an AM component. This is not the case. The dip in amplitude is caused by the bandwidth limitation of the output video amplifier of the 5257A (3 dB down at 1 MHz). As the difference frequency approaches the 1 MHz band limit, the output signal's amplitude decreases. That is, as the FM deviation about the tuned zero beat approaches 1 MHz the amplitude of the signal decreases but this does not effect the FM deviation measurement. While the difference frequency may not be observable when the FM has gone 1 MHz beyond the tuned zero beat, all zero beat patterns can at all times be observed. The upper limit on the amount of FM deviation measurable is the frequency of the local oscillator when it is zero beat with the input. If the FM deviation is greater than this frequency (16.7 to 33.3 MHz on the .05 to 0.2 GHz range or 66.6 to 133.3 MHz on the 0.2 to 18 GHz range) multiple zero beat patterns will occur confusing the observer. For maximum deviation measurements the higher end of the FREQUENCY dial should be used.

## INCIDENTAL FM

Incidental FM measurements are usually made on signals with a low amount of unwanted FM. The fact that incidental FM exists on a signal is indicated by the difficulty of obtaining a perfect zero beat pattern. Figures 12A and B show a signal with incidental FM. The upper trace is a frequency modulating signal applied to an RF signal generator. If the upper level of this signal was DC, the generator output would be a constant frequency during this time. The difference frequency, the lower trace in these figures, would exhibit a clean zero beat pattern during this same interval of time. But as can be seen in Figure 16, while a zero beat is attainable at the beginning of the time interval, it does not exist at the end of the time interval. This indicates that some FM exists on the signal. This problem of being able to get a zero beat at some points and not at others is the indication that some incidental FM exists. This applies for any signal AM, pulsed RF, etc.

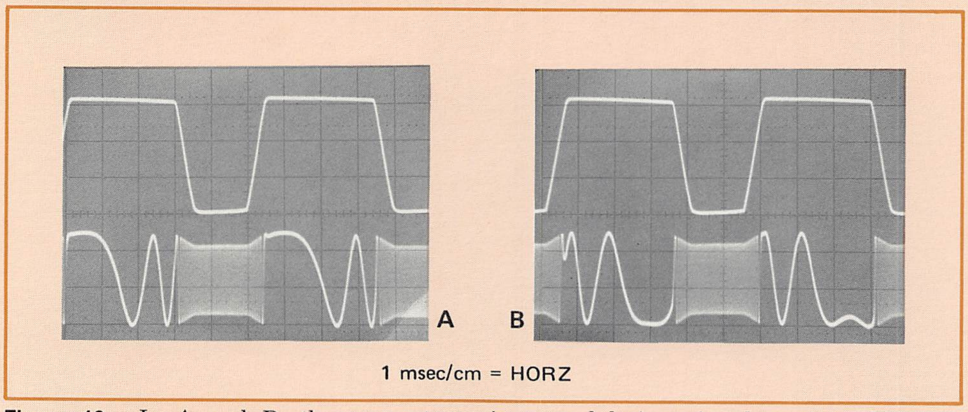
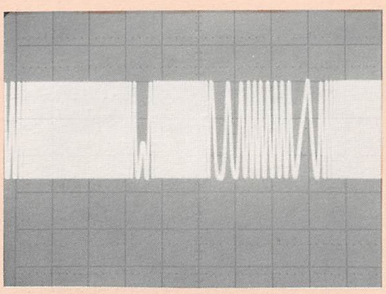



**Figure 12.** In A and B, the upper trace is a modulating signal used to frequency modulate a 4 GHz signal. The lower trace is the difference frequency signal tuned to zero beat with the maximum level of the modulating signal. In A, a zero beat is obtained at the beginning of the interval but not at the end. In B the opposite is true. This difficulty in obtaining a zero beat across the entire interval indicates the presence of incidental FM.

Figure 13 shows another common difference frequency signal with incidental FM characteristics. In this example, zero beats occur randomly indicating a random FM content on the RF input. The measurement of peak-to-peak incidental FM is the same as peak-to-peak FM deviation. The only difference being that the zero beats do not occur evenly displaced in time.

To measure peak-to-peak incidental FM, first follow steps 1. through 6. in the General Operation section of this note to obtain a zero beat pattern at the PULSED RF OUT output and to determine the harmonic number of the RF signal. Observing the difference frequency signal on an oscilloscope, tune the FREQUENCY dial until no zero beat patterns are observable. The 5257A is now tuned outside the incidental FM limits. Slowly tune the FREQUENCY dial until the first zero beat pattern occurs. This point corresponds to one limit of the incidental FM and should be recorded. Continually tuning the FREQUENCY dial until no zero beat patterns are observed, puts the 5257A outside the other limit. Slowly tune the dial back until a pattern again appears. This point corresponds to the second limit. The difference between the two counter readings is peak-to-peak incidental FM. Due to the randomness of incidental FM, an RMS measure may be of more value. This can be accomplished by connecting the PULSED RF OUT signal to an HP 5210A FM Discriminator and measuring the discriminator output with a true RMS voltmeter such as the HP 3400A.



1 msec/cm = HORZ

**Figure 13.** A typical indication of incidental FM is random zero beat patterns as observed in this difference frequency signal. To measure incidental FM, the local oscillator is tuned to the point where zero beat patterns first appear. This corresponds to one limit. It is then tuned to the point where all zero beat patterns begin to disappear. This is the other limit. The difference between the limits is the incidental FM.

## RF COMB GENERATOR

Much increased accuracy in measuring frequency components viewed on spectrum analyzers, such as the HP 8555A or 8552A can be achieved when the 5257A is used as an RF comb generator. A signal containing all harmonic components of the local oscillator frequency from 50 MHz to 18 GHz is available at the RF INPUT. The amplitude of this signal is constant (approximately -65 dBm) over the frequency range. When applied to the input of a spectrum analyzer along with the RF signal being analyzed (see Figure 14), the 5257A and counter combination becomes a precise tuning dial for measuring the desired frequency. By selecting the appropriate comb pulse, adjusting the comb pulse by the FREQUENCY tuning dial of the 5257A until it coincides with the desired frequency component, and by setting the appropriate harmonic number on the thumbswitches of the 5257A, the counter will read directly the desired frequency. The accuracy in this measurement is determined by how well the user can adjust the comb pulse to coincide with the desired frequency component viewed on the spectrum analyzer. For narrow windows, the accuracy can be within a few kHz. This technique is extremely valuable for very low level signals (down to -100 dBm typically).

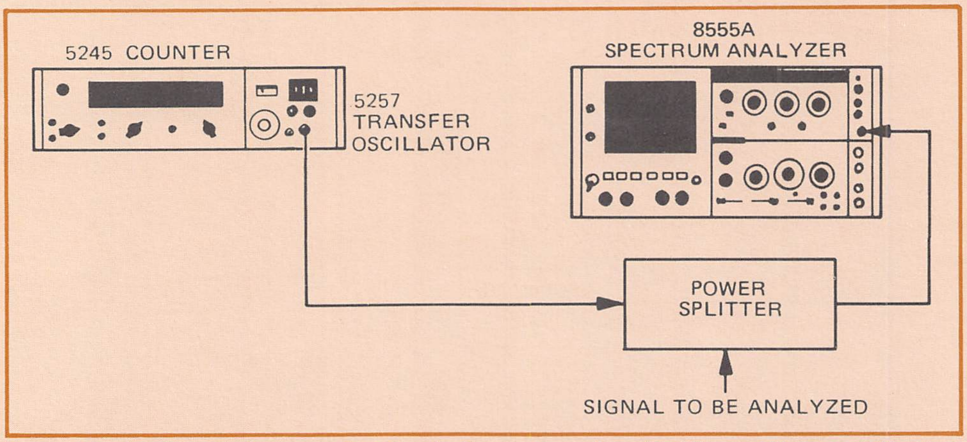



**Figure 14.** 5257A Used as an RF Comb Generator. The 5257A provides an RF comb signal containing all harmonics of the tuned local oscillator frequency over the range of 50 MHz to 18 GHz. This signal where used with a spectrum analyzer allows very accurate measurement of desired frequency components.

## DIAL CALIBRATION

Another very useful application, particularly at instrument service facilities, is for rapid calibration of the frequency dial of a high-frequency signal generator. To do this, the LO of the transfer oscillator is tuned to exactly 100 MHz as indicated by the electronic counter (the N switch on the transfer oscillator is set to 001). Connect the signal generator to be calibrated to the transfer oscillator "INPUT". Begin at one end of the signal generator tuning range and tune to the other. Each time the output frequency of the generator is an exact multiple of 100 MHz, zero beat will occur. The operator has only to glance at the generator dial to see if it is on a multiple of 100 MHz or note the error if it is not. In this manner a signal generator dial can be checked from one end of the tuning range to the other in just a few minutes. Any other LO frequency in the tuning range of the transfer oscillator LO could be used in a like manner however only frequencies of 75 MHz, 100 MHz or 125 MHz are easily related to the signal generator dial markings. An external oscilloscope connected to the pulsed rf output BNC is useful for speeding up this calibration procedure as the larger zero beat display is easier to see than the zero beat meter of the 5257A. This technique works equally well for cw or pulsed-modulated generators.

## E80-5245L MEASUREMENT SYSTEM (18—40 GHz)

The technique described in this note can be easily extended to 40 GHz signals with the use of the E80-5245L Measurement System. This system uses a double transfer oscillator technique. (See Figure 15 for a functional block diagram.) The 8620A Sweep Oscillator acts as a 2—4 GHz local oscillator for the first stage transfer oscillator. This signal is mixed with the input signal in the 11517A mixer. The resulting difference frequency signal is available at the output of a Microlab type HW-30N Monitor Tee. This signal may be viewed on a 140A Oscilloscope for zero beat tuning or applied to an 8709A Synchronizer for phase locking to the 8620A Sweep Oscillator. When tuned to or near a zero beat, this signal can be used with other low frequency measurement instruments as described earlier in this note.

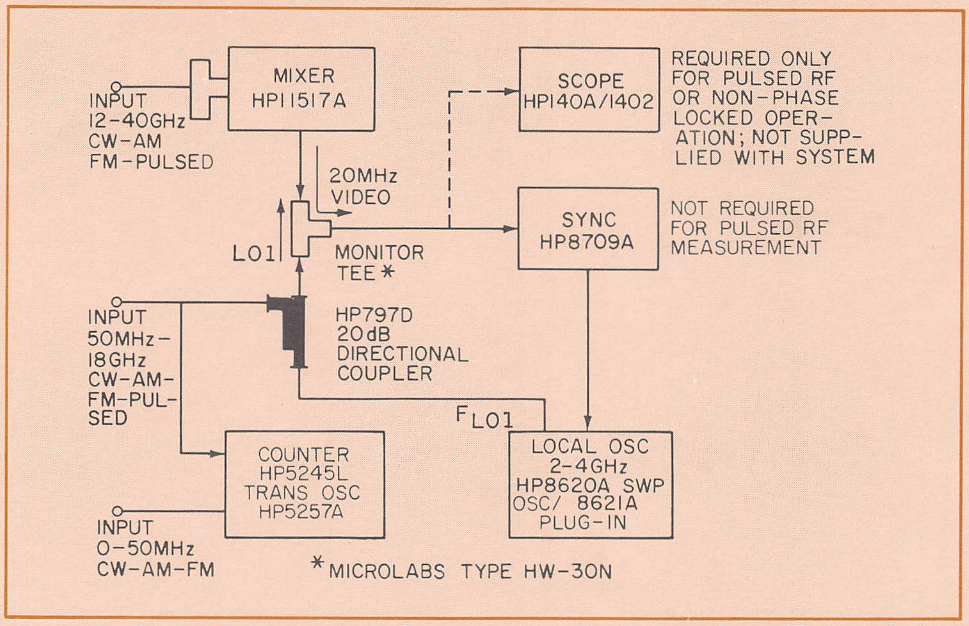



**Figure 15.** E80-5245L Measurement System using a double transfer oscillator technique. The E80-5245L System extends the measurements discussed in this note to 40 GHz. The 5257A is the second transfer oscillator stage of this system.

The 5257A is the second stage of the double transfer oscillator. If a zero beat has been obtained with the 8620A Sweep Oscillator, the relation $F_{INPUT} = N_1(F_{LO1})$ exists. $F_{LO1}$ is now a 2—4 GHz signal and can be measured with the 5257A and 5245L combination using the technique described in the General Operation section of this note. The counter will display $F_{LO1}$ and it is necessary for the user to multiply by $N_1$. $N_1$ can be determined by the same procedure used with the 5257A. For convenience, $F_{LO1}$ is usually set so that $N_1$ is 10 or some other convenient number.

When the 8709A Synchronizer is used, an IF frequency of 20 MHz must be added to the results.

The important feature of this system is that the difference frequency signal at the Microlabs type HW-30N Monitor Tee contains all the modulation, noise, and real time information of the input and is within the range of low frequency measurement devices. So like the PULSED RF OUT output of the 5257A, this signal has many interesting and valuable applications.

*HEWLETT·PACKARD*

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