HEWLETT PACKARD

APPLICATION NOTE 44A

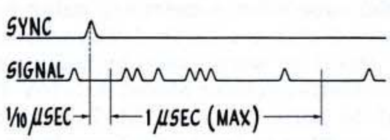
SYNCHRONIZING THE ⓗⓟ 185A OSCILLOSCOPE

SINCE ITS INTRODUCTION IN AUGUST 1959, THE HEWLETT-PACKARD MODEL 185A 800 MC OSCILLOSCOPE HAS OPENED AN IMPORTANT NEW AREA OF THE ELECTROMAGNETIC SPECTRUM TO THE TECHNIQUE OF OSCILLOGRAPHIC ANALYSIS. REVERSING A TREND TOWARD LOWER SENSITIVITIES AND SMALLER DISPLAYS PREVIOUSLY ASSOCIATED WITH WIDE BAND OSCILLOSCOPES, THE 185A HAS THE HIGH SENSITIVITY, LARGE DISPLAY SIZE AND BRILLIANT TRACE FORMERLY FOUND ONLY IN LOW FREQUENCY OSCILLOSCOPES. THESE AND OTHER NOVEL FEATURES HAVE LED TO VERY WIDE ACCEPTANCE OF THIS INSTRUMENT FOR A VARIETY OF CIRCUIT AND COMPONENT TESTING APPLICATIONS.

TO ACQUAINT YOU WITH SOME OF THE USEFUL APPLICATIONS OF THE 185A AND TO KEEP YOU UP TO DATE ON NEW ACCESSORIES THAT ARE BEING DEVELOPED TO INCREASE THE USEFULNESS OF THE 185A, WE ARE PUBLISHING A SERIES OF APPLICATION NOTES. THIS APPLICATION NOTE IS THE FIRST OF THE SERIES. THE SECOND NOTE, NUMBER 44B, "WAVEFORM ANALYSIS WITH THE 185A OSCILLOSCOPE" WILL BE AVAILABLE SOON FROM ⓗⓟ OR YOUR ⓗⓟ ENGINEERING REPRESENTATIVE.

AVAILABLE RIGHT NOW ARE APPLICATION NOTE 36, "SAMPLING OSCILLOGRAPHY" AND ⓗⓟ JOURNAL VOLUME 11, NUMBER 5-7, "A VERSATILE NEW DC-500 MC OSCILLOSCOPE WITH HIGH SENSITIVITY AND DUAL CHANNEL DISPLAY" - George Fredrick, Application Engineer.

All sampling oscilloscopes require external synchronization because the actual test signal is sampled at the input to the two probes and is not available internally for use in synchronization. For this reason ⓗⓟ has designed several accessories and synchronizing methods to enhance the compatability of the ⓗⓟ 185A with your system. This Application Note describes several useful synchronizing methods.



BASIC TIME "WINDOW" OF 185A SAMPLING OSCILLOSCOPE

Figure 1.

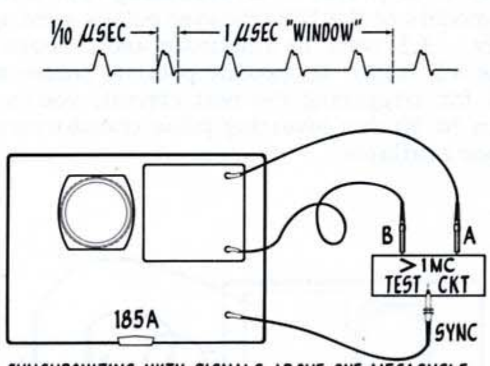
The basic capability of the 185A for viewing signals is illustrated in Figure 1. After the synchronizing signal appears at the Sync Input jack there is a period of approximately 1/10 microsecond of "dead time" while the scope sweep is being energized.

After this 1/10μsec. interval, there is a maximum period of 1 microsecond during which you can view signals. This period corresponds to the slowest sweep speed of 100 nanoseconds (millimicroseconds) per centimeter for the full 10 centimeters of the trace. For faster sweep speeds of course, the "window" becomes proportionally narrower. At any of the sweep time settings you can use the sweep magnifier to obtain up to 100 times magnification. After magnification, you can bring any magnified portion of the original unmagnified trace into view on screen with the Delay Control.

METHODS OF SYNCHRONIZATION

Signal Repetition Rate Greater than 1 mc

Early Model 185A's would synchronize on signals, including sine waves, up to 50 mc. Improvements in the sync circuits have now increased this maximum frequency to 100 mc. The oscilloscope itself has a maximum triggering recurrence rate of 100kc. Above 100 kc a circuit causes the oscilloscope to select only a fraction of the input trigger signals. At 100 mc, for example, this "count down" circuit allows only one in every thousand inputs to pass through and energize the sweep circuits.



SYNCHRONIZING WITH SIGNALS ABOVE ONE MEGACYCLE

Figure 2.

This simplest method of synchronizing the 185A is to trigger on one pulse in a train and to view several succeeding pulses on the screen. This method is illustrated in Figure 2 and can be used when the repetition rate of the signal is above one megacycle because the signal occurs frequently enough to fall within the 1 μsec time window shown in Figure 1.

Signal Repetition Rate Less than 1 mc

When the signal repetition rate is below one megacycle, the signal does not occur frequently enough to fall within the 1 µsec time window. However, you may trigger the oscilloscope just ahead of an input pulse to allow it to fall in the time window. Three methods are available.

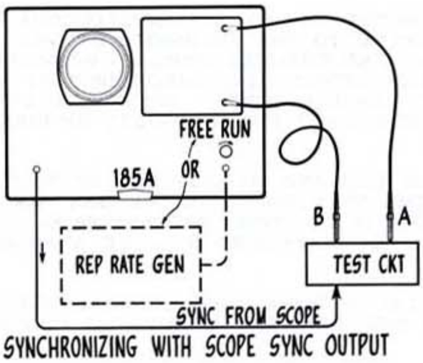


Figure 3.

1) Figure 3 illustrates the use of the Sync Output signal from the oscilloscope for triggering the test circuit. This signal is a fast rise pulse that is suitably delayed from the triggering of the oscilloscope sweep. If you place the Mode Control in the "Free Run" position, the sync pulse will reoccur at approximately a 100 kc rate. If you cannot drive the test circuit at this rate, you can use a repetition rate generator such as a ⓗ Model 211A Square Wave Generator to trigger the 185A at any rate between 50 cps and 100 kc to produce corresponding sync pulses. In early models of the 185A the sync pulses were approximately - 1.5 volts in amplitude and in more recent models +3 volts. If opposite polarity pulses are required for triggering the test circuit, you can use a 50 ohm to 50 ohm inverting pulse transformer if you have one available.

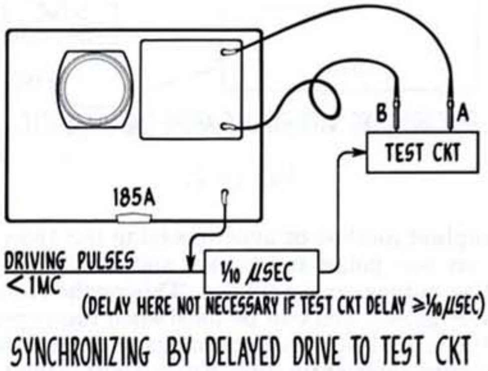


Figure 4.

2) When you excite the test circuit from a separate source, a convenient means of synchronizing is to delay the drive to the test circuit. This method is illustrated in Figure 4. An important consideration here is that it is often possible to tolerate some deterioration of the driving pulses by the delay line or delay circuit since these pulses serve only to trigger the test circuit. As long as the drive pulses arrive at the test circuit with sufficiently fast rise time to provide reliable triggering, there is no loss of information on the signals presented to the oscilloscope.

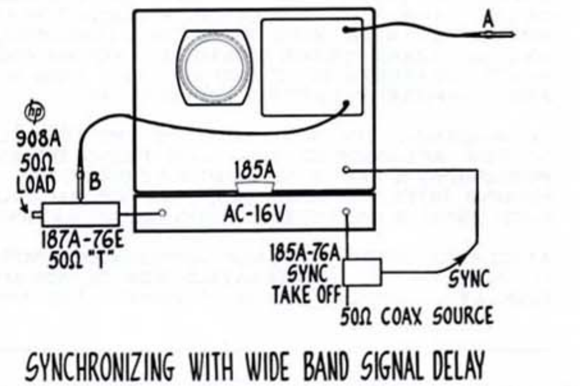


Figure 5.

3) There are occasions when the test circuit operates at repetition rates under one megacycle and cannot be driven by any type of sync pulses. This is typically the case when a mercury pulse generator is used. Figure 5 shows a method of synchronizing from the signal itself in such cases by delaying the signal with the Hewlett-Packard Model AC-16V Delay Line. The signal is split by the 185A-76A Sync Take-Off "T" and a portion is fed to the Sync Input jack of the oscilloscope. After a delay of 120 nanoseconds, the signal appears at the Delay Line output where it is applied to the probe input to the oscilloscope. Since in the usual case, it is desirable to terminate the signal in 50 ohms, you should place a regular 50-ohm load on the end of the "T". The 185A-76A Sync Take-Off attenuates the signal by 6 db so the amplitude of the signal on the oscilloscope should be multiplied by a factor of 2. Because the signal itself must pass through the Delay Line, it is desirable that the line have as much bandwidth as possible. The ⓗ AC-16V has a pass band of approximately 1 kmc which is sufficient for most signals. If still wider bandwidth is desired, you can use a coil of 3/4 in. or larger Styroflex cable approximately 105 feet long to provide about 120 nanoseconds delay.

Synchronizing on High Frequency Signals Above 100 mc

For triggering on signals above 100 mc, a Synchronizing Trigger Unit, the H01 184A, is available. This unit performs a preliminary count down on the rf waveform and provides a trigger wave train at a sub-multiple of the signal frequency in the 10 mc region. This output is then fed to the oscilloscope

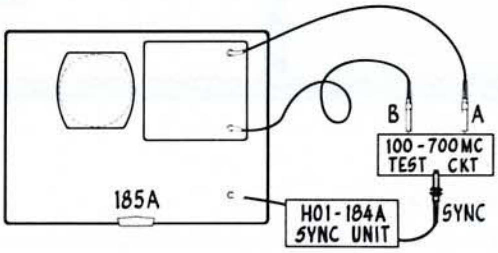


Figure 6.

synchronizing circuit which, in turn, selects approximately 1 out of each 100 triggers as it operates in the 100 kc region. Figure 6 shows a typical application of the H01 184A. With the H01 184A, you can obtain stable synchronization on signals to over 700 mc.

When you synchronize with the H01 184A, you can use the 185A to view directly signals including sine waves in the uhf - vhf ranges and above. You can estimate distortion on such signals from the oscilloscope presentation. This presentation is useful in adjusting a multiplier circuit, for example. If viewing two signals from the same basic source on Channels A and B, you can measure the phase shift between the two signals. It is important, when you measure phase shift, to remember that there may be up to 0.1 nanoseconds difference in delay between Channels A and B because of slightly different lengths of cable between the sampling pulse generator and the sampling diodes in the probes. At 100 mc, 1° = .028 nanoseconds, and thus 0.1 nanosecond time difference will introduce 3° phase shift. If this becomes a problem, you can feed the same signal through a signal splitter to the two probes, measure the time or phase difference, and use this difference as a correction factor.

Effects of FM and Jitter

When the repetition rate of the input signal is below 100 kc, the 185A samples the signal on a pulse by pulse basis and is not affected by fm or jitter on the pulse train. Above 100 kc the hold-off circuit operates and the effects of fm and jitter on the pulse become progressively more severe as the frequency is increased. For the hold-off circuit to operate properly, the period of the input signal should not change by more than 1/2 of its average period during the normal 185A 10 microsecond hold-off time which occurs before the next sample. As a rough guide, the maximum present fm or jitter that can be present without affecting the trigger circuit can be expressed as follows:

$$\text{Max. \% fm} = \frac{5}{f}$$

where f = frequency in megacycles

At 1 mc this indicates a maximum deviation of 5%, at 100 mc, .05%.

Above 100 mc, when the H01 184A is being used, the situation becomes more complex because two "count down" circuits, each with somewhat different characteristics, are operating in series. Experimental results indicate reliable triggering with up to 0.05% fm in the 100-200 mc region and correspondingly less at higher frequencies. In any case, the allowable fm is considerably greater than is found on most good signal generators and other rf signal sources.