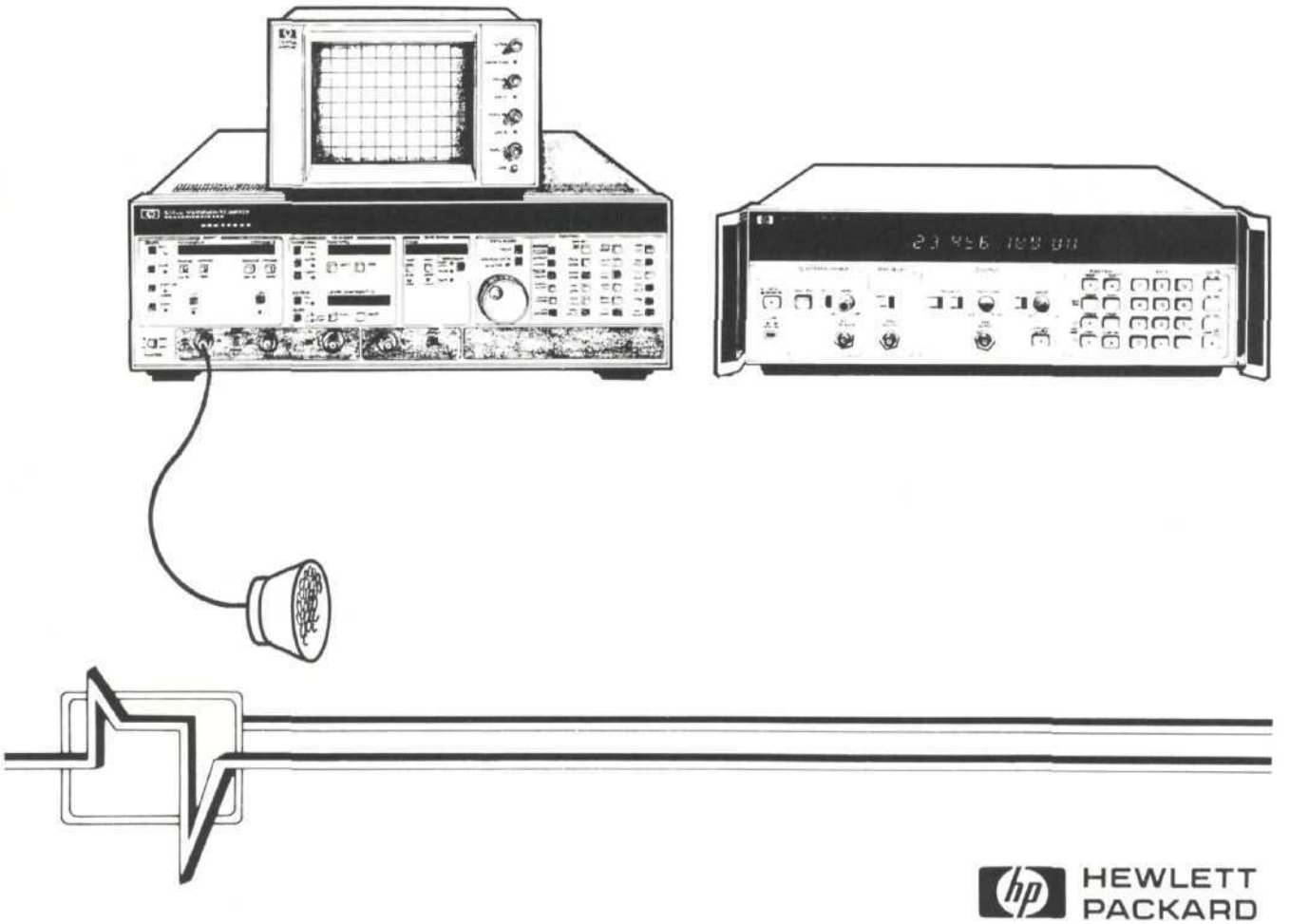
Application Note 313-6

Recording Sonar and Other Signals Using the 5180A's Toggle Mode



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Introduction

If you need to record two windows of data, separated by a time interval with little information content, the 5180A Waveform Recorder provides a recording mode for just this purpose. The 5180A will sample at a high rate during the windows of data at the beginning and end of the waveform, providing high resolution where it is needed. During the dead time between data windows, the sampling rate is much lower, to avoid wasting memory space where detailed information is not required.

For example, a transmitted sonar pulse and the received return pulse have a high information content and need to be recorded using a high sampling rate. The interval between the pulses, on the other hand, may be sampled at a relatively slow rate without loss of valuable information. The 5180A provides an ideal method of recording such a signal, using its "toggle" timebase mode.

Operation of the Toggle Mode

The 5180A's toggle timebase mode divides each memory record into three sections, as shown in Figure 1. The first and last sections contain equal numbers of waveform samples, which are taken using the sampling rate of the main timebase. The second section of each memory record is recorded at the delay timebase sampling rate. After selecting toggle mode recording, you can specify the percentage of memory (or total time) to be allocated to the second section. The 5180A then automatically divides the remaining portion of memory between the first and last sections, centering the second section in the record.

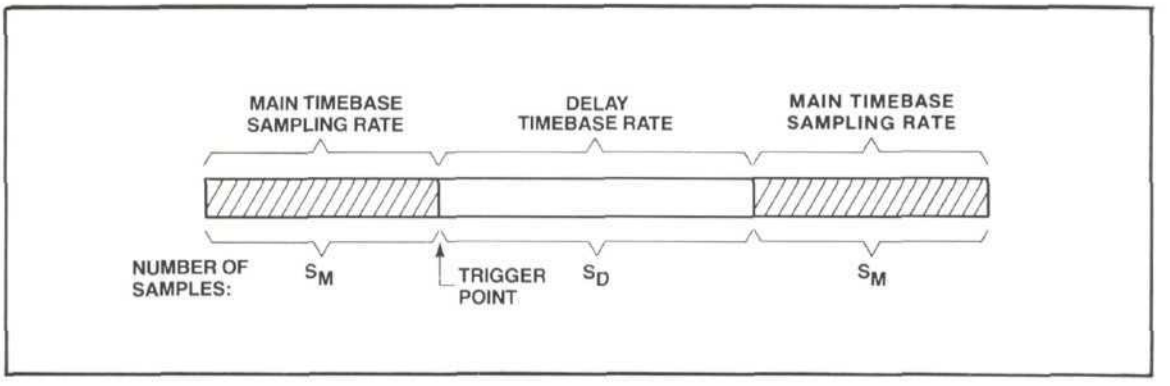


Figure 1. In toggle mode, each memory record is divided into three sections.

When recording in toggle mode, the 5180A requires a trigger at the end of the first data window, when the timebase changes from main to delay. Because of this requirement, the portion of the waveform to be recorded initially using the main timebase must be received by the 5180A before the trigger occurs. After the trigger point, the 5180A samples at the delay timebase rate for the selected period, then returns to the main timebase rate to fill the third section of memory. If you select the length of the second section of memory to be equal to the dead time between data windows, the 5180A's return to main timebase sampling rate should coincide with the beginning of the second data window on the incoming waveform.

Setup for Toggle Mode Recording

To record a waveform using toggle mode, you'll need to provide an appropriate trigger signal (if internal triggering is not used), and also select a few front panel function values. This section describes a method of calculating optimal front panel function values for a waveform similar to that shown in Figure 2.

You'll need to know the approximate duration of the data windows and the time delay separating them to use this procedure. It is possible to record a signal which has data windows of two different durations, by selecting the longer of the two times as the length of both windows. In addition, this method of determining the front panel setup allows you to select both the sampling rate to be used during the data windows (main timebase rate), and the memory record length. If you select a 16K record length, maximum resolution will be available in recording the signal.

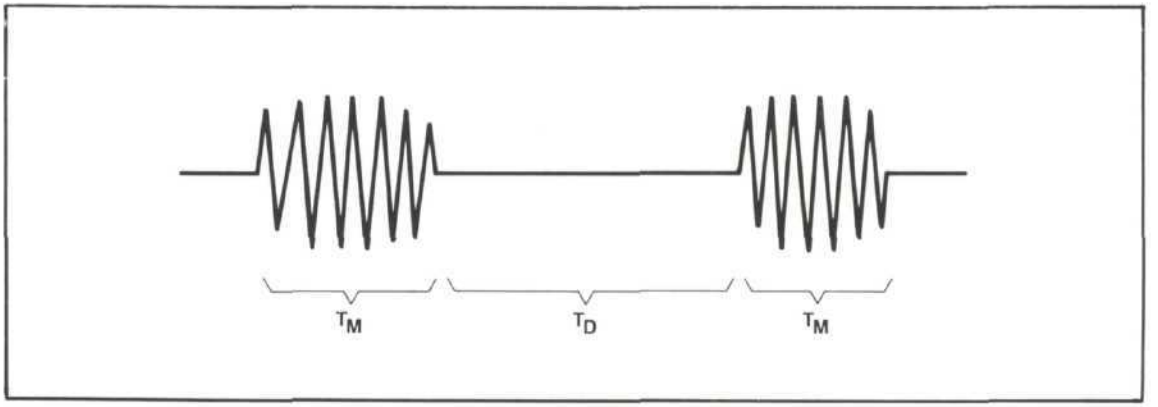


Figure 2. Waveform contains two windows of data, separated by a "deadtime" with little information content.

The notation which is used in this procedure is summarized in Table 1. After selecting the values for T_M, T_D, R_M, and L, you will be able to calculate the optimal delay timebase sampling rate, R_D, and trigger position setting.

Table 1. Notation Used for this Procedure

T_M = Duration of each data window (recorded using main timebase)
T_D = Duration of time interval between data windows (recorded using delay timebase)
R_M = Sampling rate assigned to main timebase
R_D = Sampling rate assigned to delay timebase
S_M = Number of samples assigned to main timebase
S_D = Number of samples assigned to delay timebase
L = Memory record length

Calculation Procedure:

1) In order to leave a sufficient portion of each memory record for recording data windows, a certain minimum sample time may be used during the dead time. This theoretical minimum rate $R_D(min)$ is given by:

$$R_D(min) = T_D/(L-2\ (T_M/R_M))$$

2) Since the delay timebase sampling rate must be selected from available values, the actual delay timebase rate, R_D, should be assigned equal to the next available sample time greater than or equal to $R_D(min)$:

$$R_D \geq R_D(min)$$

3) When R_D has been selected, you can use it to determine the number of samples in each section of memory:

For the dead time: $S_D=T_D/R_D$
For each data window: $S_M=(L-S_D)/2$

4) Using the values which you have selected and calculated so far, the following front panel settings should be used:

Main Timebase Sampling Rate = R_M
Delay Timebase Sampling Rate = R_D
Trigger Position = $-R_DS_D$ given in time
= $-S_D/L$ given in %

Example of Toggle Mode Application

As an example of the use of toggle mode recording and the front panel function values calculated using this procedure, a sonar burst and return signal (of the form shown in Figure 2) were recorded. An HP 5359A Time Synthesizer was used to provide an external trigger signal for the 5180A. The 5359A measured a precise delay after the beginning of the transmitted sonar burst, and sent a trigger to the 5180A at the end of the transmitted burst. (See Figure 3)

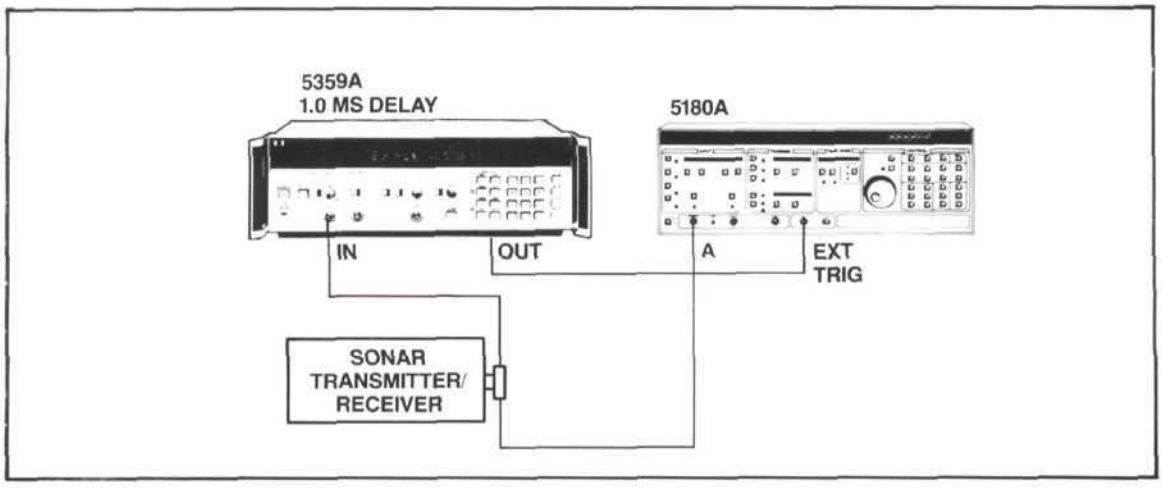


Figure 3. Equipment set-up for recording sonar signal.

For front panel function settings, the values which were selected and calculated are given in Table 2. These values were obtained using the Calculation Procedure as follows:

1) $R_D(min) = T_D/[L-2(T_M/R_M)] = 12.4$ ms/[8192–2(1.0 ms/500 ns)] = 2.96 μs/sample
2) $R_D \geq 2.96$ μs/sample; select $R_D = 5$ μs/sample
3) $S_D = T_D/R_D = 12.4$ ms/(5 μs/sample) = 2480 samples/dead time
   $S_M = (L-S_D)/2 = (8192-2480)/2 = 2856$ samples/data window
4) Trigger position % = $-S_D/L = -2480/8192 = -30\%$

Using the front panel function values calculated here and the setup described, the sonar signal and echo were recorded. A display of the digitized waveform appears in Figure 4.

Table 2. Values Assumed and Calculated in this Application

Assumed:
$T_M \geq 1.0$ ms
$T_D = 12.4$ ms
$R_M = 500$ ns/sample
L = 8192 samples
Calculated:
$R_D = 5$ μs/sample
Trigger Position = –30%

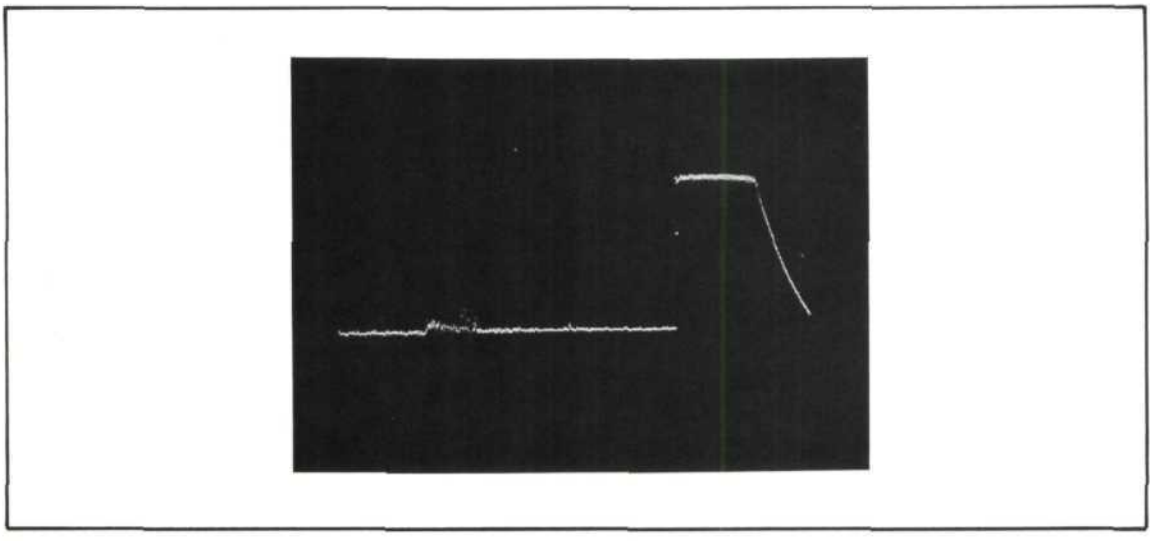


Figure 4. Recorded sonar burst and return signal.

Appendix: How the Formulas Were Derived

The key to the calculation procedure described is the formula for determing the optimal delay timebase sampling rate. It's not easy to find a sampling rate which will give the right delay time (without using too many or too few samples) by trial-and-error. The derivation of this formula for determining a sampling rate follows:

Calculation Procedure:

1) Calculate the minimum number of samples, $S_M(min)$, required to sample one of the data windows, by dividing the minimum time, T_M, by the sampling rate, R_M.

$$S_M(min) = T_M/R_M$$

2) From this, the minimum number of samples assigned to the main timebase, which is used to record both data windows, is $2 \times S_M(min)$.

3) Calculate the minimum portion of memory, $P_M(min)$, assigned to the main timebase, by dividing the minimum number of samples assigned to the main timebase by the total number of samples in one memory record.

$$P_M(min) = [2S_M(min)/L]$$

4) Calculate the maximum portion of memory, $P_D(max)$, which may be assigned to the delay timebase, leaving the required minimum portion of memory for the main timebase.

$$P_D(max) = 1 - P_M(min)$$

5) From this, the maximum number of samples assigned to the delay timebase, $S_D(max)$, is $(L)P_D(max)$.

6) Calculate the minimum sample time for the delay timebase, $R_D(min)$, by dividing the duration of the dead time between pulses by the maximum number of samples to be recorded using the delay timebase.

$$R_D(min) = T_D/S_D(max)$$

7) From steps 5 and 6, then: $R_D(min) = T_D/[(L)P_D(max)]$
   Using step 4: $R_D(min) = T_D/(L[1-P_M(min)])$
   Then from step 3: $R_D(min) = T_D/[L-2S_M(min)]$
   Finally, using step 1: $R_D(min) = T_D/[L-2(T_M/R_M)]$

The last step results in the desired formula for the minimum sample rate.



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