



PART TWO

LOOKING DEEPER

Part Two of the manual covers the Waverunner features you'll use for more advanced waveform operations: RIS and sequence sampling, SMART Trigger, Advanced waveform processing. It also looks deeper into operations already covered in Part One.

Use Part Two as an advanced guide and a reference for understanding important functions of your digital oscilloscope.

CHAPTER SEVEN : *A Question of Timebase*

In Part One you saw how to adjust and set up timebase. Next, take a closer look at the Waverunner timebase sampling modes.

In this chapter, see how

To choose a sampling mode

To use single-shot or RIS modes

To use sequence mode

To sample externally

Choose a Sampling Mode

Depending on your timebase, you can choose any of three sampling modes: single-shot, RIS (Random Interleaved Sampling), or roll mode. In addition, on timebases suited to single-shot and roll, the acquisition memory can be subdivided into user-defined segments to give sequence mode.

SINGLE-SHOT — WAVERUNNER'S BASIC CAPTURE TECHNIQUE

A single-shot acquisition is a series of digitized voltage values sampled on the input signal at a uniform rate. It is also a series of measured data values associated with a single trigger event. The acquisition is typically stopped a defined number of samples after this event occurs: a number determined by the selected trigger delay and measured by the timebase. The waveform's horizontal position — and waveform display in general — is determined using the trigger event as the definition of time zero.

You can choose either a pre- or post-trigger delay. Pre-trigger delay is the time from the left-hand edge of the Waverunner grid *forward* to the trigger event, while post-trigger delay is the time *back* to the event. You can sample the waveform in a range starting well before the trigger event up to the moment the event occurs. This is 100% pre-trigger, and it allows you to see the waveform leading up to the point at which the trigger condition was met and the trigger occurred. (Waverunner offers up to one million points of pre-trigger information.) Post-trigger delay, on the other hand, allows you to sample the waveform starting at the equivalent of 10 000 divisions after the event occurred.

Because each Waverunner input channel has a dedicated ADC (Analog-to-Digital Converter), the voltage on each is sampled and measured at the same instant. This allows very reliable time measurements between the channels.

On fast timebase settings, the maximum single-shot sampling rate is used. But for slower timebases, the sampling rate is decreased and the number of data samples maintained.

The relationship between Waverunner sample rate, memory and time can be simply defined as:

$$\text{Capture time} = \frac{1}{\text{Sample Rate}} \times \text{Memory},$$

and

$$\frac{\text{Capture time}}{10} = \text{Time/Division}.$$

RIS — FOR HIGHER SAMPLE RATES

RIS (Random Interleaved Sampling) is an acquisition technique that allows effective sampling rates higher than the maximum single-shot sampling rate. It is used on repetitive waveforms with a stable trigger. The maximum effective Waverunner sampling rate of 25 GS/s can be achieved with RIS by making 50 single-shot acquisitions at 500 MS/s or 200 MS/s, depending on model. The bins thus acquired are positioned approximately 40 ps apart. The process of acquiring these bins and satisfying the time constraint is a random one. The relative time between ADC sampling instants and the event trigger provides the necessary variation, measured by the timebase to 5 ps resolution.

It takes Waverunner 30 trigger events to complete a 1 GS/s RIS acquisition, and 230 events for a 25 GS/s acquisition. But sometimes the scope needs many more than this. It then interleaves these segments (Fig. 1) to provide a waveform covering a time interval that is a multiple of the maximum single-shot sampling rate. However, the real-time interval over which Waverunner collects the waveform data is much longer, and depends on the trigger rate and the amount of interleaving required. The oscilloscope is capable of acquiring approximately 40 000 RIS segments per second.

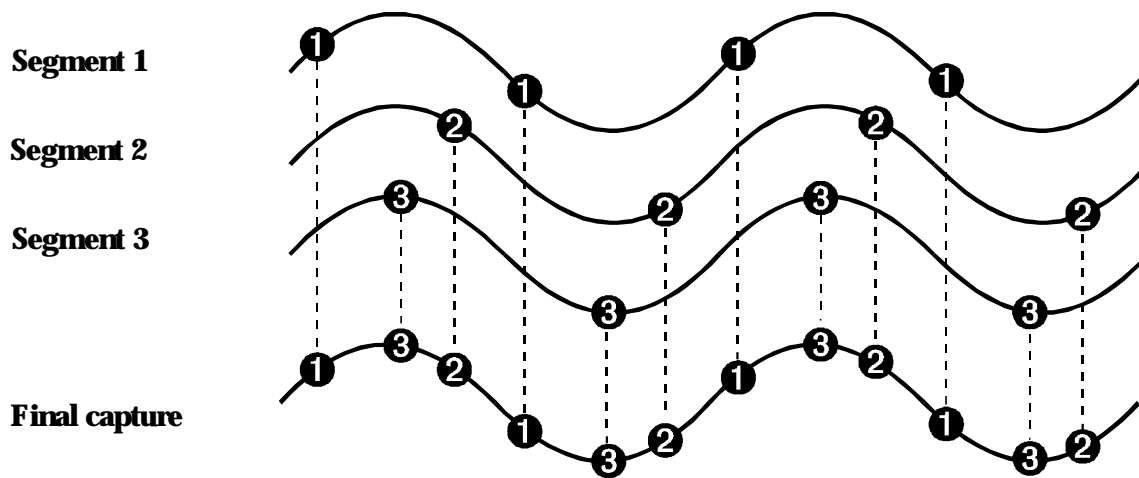


Figure 1. Buildup of an RIS waveform.

ROLL — DISPLAY IN REAL-TIME

Waverunner roll mode displays in real time incoming points in single-shot acquisitions that have a sufficiently low data rate. At timebase settings of ≥ 0.5 s/div the oscilloscope rolls the incoming data continuously across the screen until a trigger event is detected and the acquisition is complete. Even when real-time display is not possible, the data will continue to be acquired. This works in the same way as a strip-chart recorder: the latest data is used to update the trace display. Waveform math and parameter calculations are performed on the completed waveforms, after the real-time display has stopped.

SEQUENCE — WORKING WITH SEGMENTS

In sequence mode, the complete waveform consists of a number of fixed-size segments (Fig 2) acquired in single-shot mode (see Waverunner specifications for the limits). You select the number of segments to be captured, and can then select each segment, individually, and use it for processing with Math and Measure tools.

Sequence offers a number of unique capabilities. With it, you can limit dead time between trigger events for consecutive segments. Waverunner can capture in fine detail complicated sequences of events over large time intervals, while ignoring the uninteresting periods between the events. You can also make time measurements between events on selected segments using the full precision of the acquisition timebase.

Trigger time stamps of 1 ns resolution are given for each of the segments in the Text & Times Status menu. Each individual segment can be zoomed or used as input to math functions.

Waverunner uses the sequence timebase setting to determine the capture duration of each segment: 10 x time/div. The oscilloscope uses this setting — with the desired number of segments, maximum segment length and total available memory — to determine the actual number of samples or segments, and time or points. However, the display of the complete waveform with all its segments may not entirely fill the screen.

Sequence mode can also be used in remote operation to take full advantage of Waverunner's high data transfer capability (see Chapter 12, "Use Waverunner with PC," and the *Remote Control Manual*).

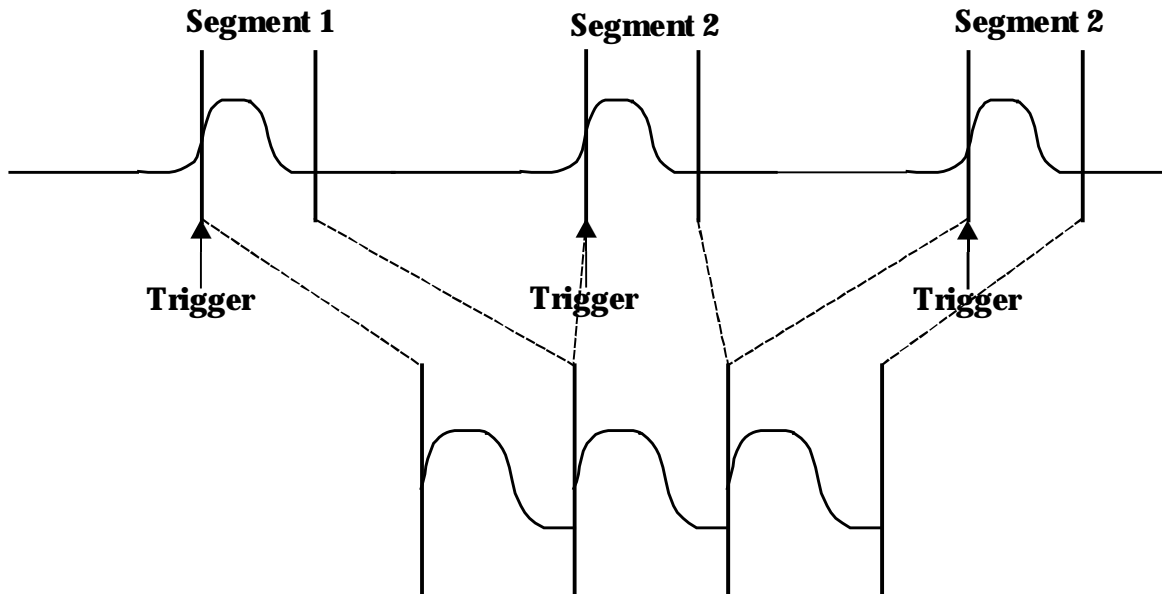


Figure 2. How Waverunner captures segments. See page 83 for how to obtain a sequence status summary.

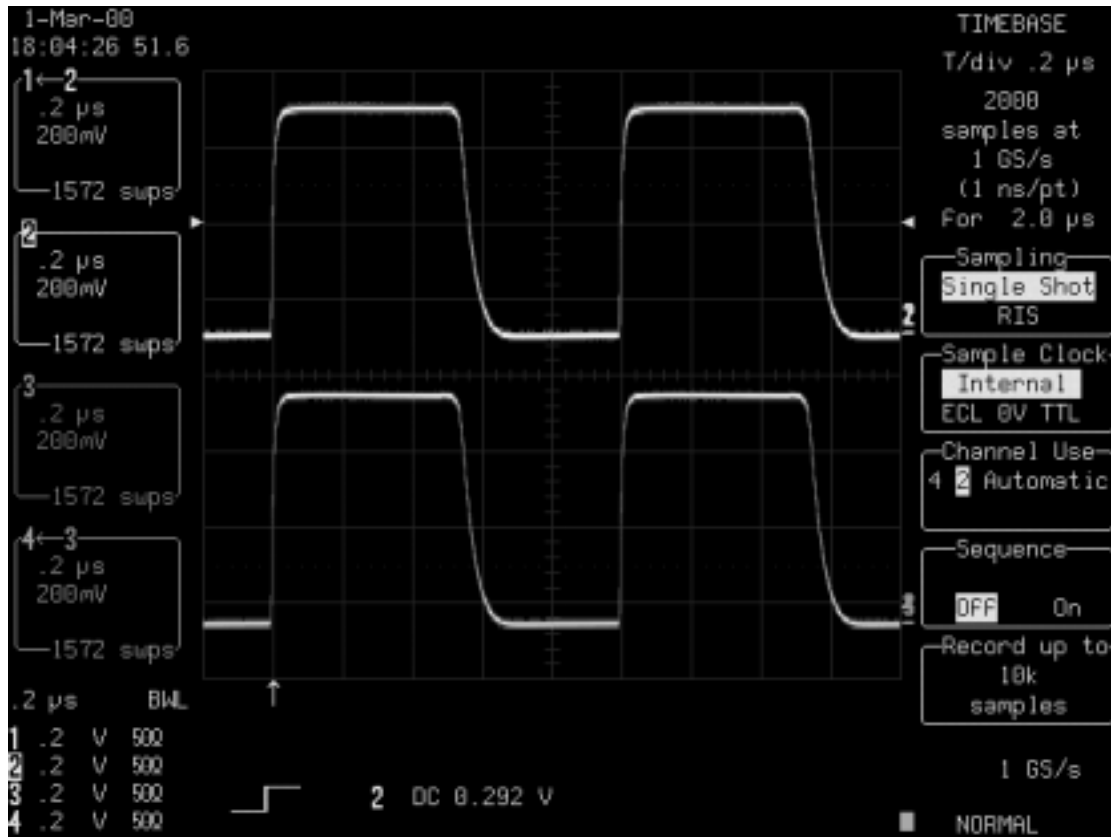
PART TWO: LOOKING DEEPER

PAIRING CHANNELS (LT364 SERIES ONLY)

A pair of channels can be combined on channel 2 or 3, with channels 1 and 4 disabled or available only for triggering. On these paired channels the maximum sampling rate is doubled and the record length is increased by two times.

Channels are combined to increase sample rate or memory size or both in order to capture and view a signal in all its detail. When combined, the channels (like the EXT BNC input) that are not involved in the combination remain available for triggering, even though they are not displayed. It is preferable to select "Automatic" to combine channels and have the remaining acquisition channels available for triggering. The channels available for triggering only would be indicated by "trig only" in the Acquisition Summary Field.


Refer to the "Acquisition Modes" table in Appendix A for maximum sample rates.

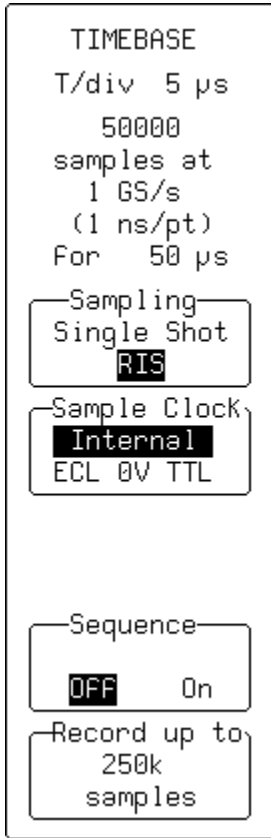


Combining of Channels

Use a Sampling Mode

SET UP FOR SINGLE-SHOT OR RIS

1. Press  and access the TIMEBASE SETUP menus.

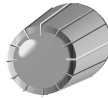


2. Use these menus to set up the Waverunner timebase for Single-Shot or RIS.

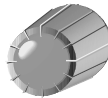


To select **Single-Shot** for display of data collected during successive single-shot acquisitions from the input channels, or **RIS** for a higher sampling rate with a repetitive input signal and stable trigger.

To select from an internal or external clock source. See page 83 for external clock.



To switch Sequence mode **On** or **Off**. Use the knob to choose the number of segments. See next page.



To select the maximum number of samples to be acquired, using the menu knob.

SET UP FOR SEQUENCE CAPTURE

TIMEBASE
T/div 2 μ s
50 * 5000
samples at
250 MS/s
(4 ns/pt)
For 20 μ s

Sampling
Single Shot


Sample Clock
Internal
ECL OV TTL

Sequence
50 segments
OFF **On**



Max. segment
500K
samples


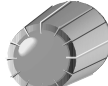
3. Activate sequence mode using the Sequence menu and then use these menus to do sequence sampling


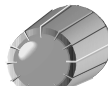
SCOPE STATUS

TIP: Press  and select "Text and Times" to obtain a status report on a trace or memory's sequence segment range.

 To select **Single-Shot** for sequence sampling.

 To select **Internal** or external — **ECL, OV, TTL** — clock modes. Select internal unless using an external clock signal (see next page).
 You can select a time-out for sequence mode using the UTILITIES, Special Modes, and Timebase Trigger menu.


  To turn Sequence **On** or **Off**.

  To select with the knob the maximum record length, in samples, for each sequence segment.


NOTE: In sequence mode: Press the **SINGLE** button and Waverunner will fill the chosen number of segments and then stop capturing. But if there are not enough trigger events to fill the segments, Waverunner will not stop capturing until you press **STOP**. If you press **NORMAL** the segments will be filled and the data processed and displayed. Then, if more trigger events occur, Waverunner will restart capturing from the first segment. When you press **AUTO**, capturing will also be restarted from the first segment, if the time between two consecutive triggers exceeds a selected time-out. However, avoid any unnecessary button pushing and knob turning in Sequence mode.

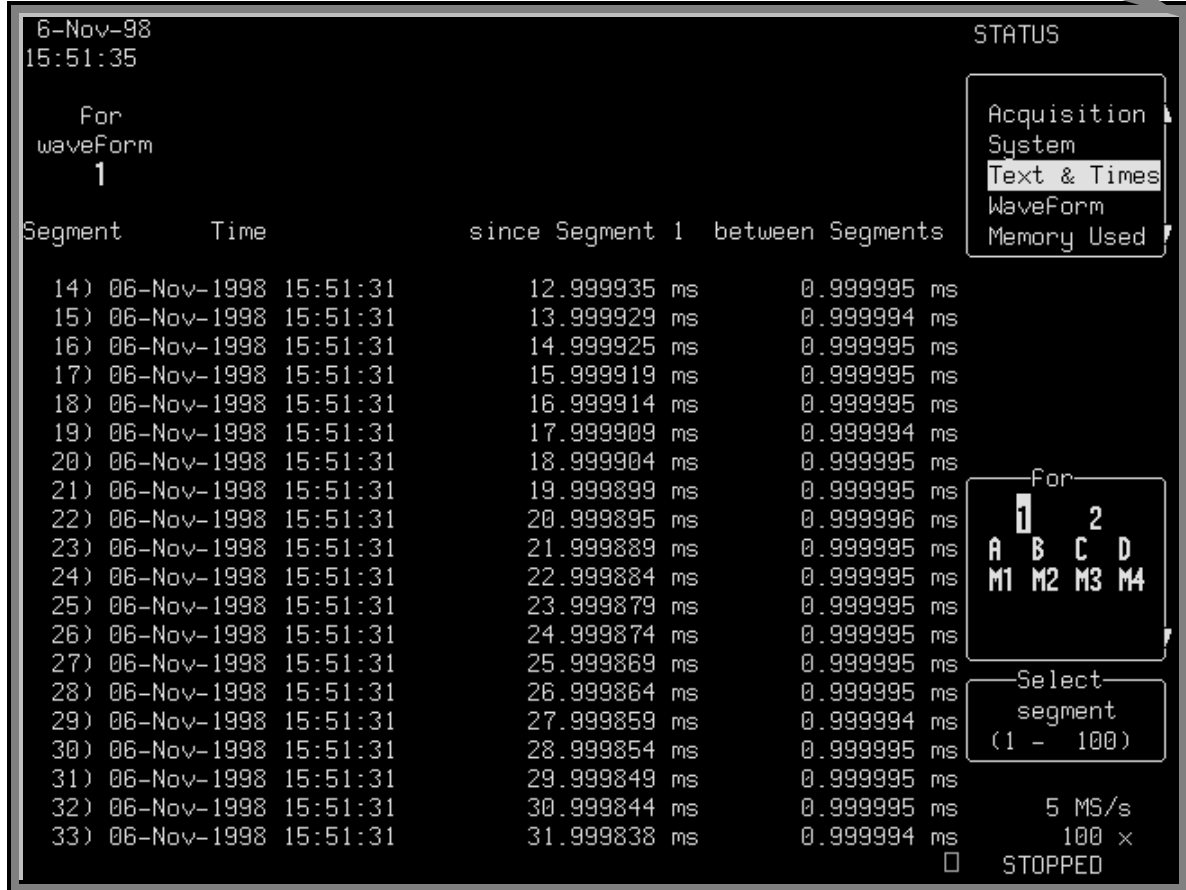
OBTAIN A SEQUENCE STATUS SUMMARY

Display a summary of the status of your sequence acquisition.

4. Press  to show the STATUS menus.
5. Press the button to select **Text & Times**.

PRINT
SCREEN

TIP: Press  to document your status summary and make a hard copy. Printing (and storage) operations will include undisplayed text.



6-Nov-98
15:51:35

For waveForm 1

Segment	Time	since Segment 1	between Segments
14)	06-Nov-1998 15:51:31	12.999935 ms	0.999995 ms
15)	06-Nov-1998 15:51:31	13.999929 ms	0.999994 ms
16)	06-Nov-1998 15:51:31	14.999925 ms	0.999995 ms
17)	06-Nov-1998 15:51:31	15.999919 ms	0.999995 ms
18)	06-Nov-1998 15:51:31	16.999914 ms	0.999995 ms
19)	06-Nov-1998 15:51:31	17.999909 ms	0.999994 ms
20)	06-Nov-1998 15:51:31	18.999904 ms	0.999995 ms
21)	06-Nov-1998 15:51:31	19.999899 ms	0.999995 ms
22)	06-Nov-1998 15:51:31	20.999895 ms	0.999996 ms
23)	06-Nov-1998 15:51:31	21.999889 ms	0.999995 ms
24)	06-Nov-1998 15:51:31	22.999884 ms	0.999995 ms
25)	06-Nov-1998 15:51:31	23.999879 ms	0.999995 ms
26)	06-Nov-1998 15:51:31	24.999874 ms	0.999995 ms
27)	06-Nov-1998 15:51:31	25.999869 ms	0.999995 ms
28)	06-Nov-1998 15:51:31	26.999864 ms	0.999995 ms
29)	06-Nov-1998 15:51:31	27.999859 ms	0.999994 ms
30)	06-Nov-1998 15:51:31	28.999854 ms	0.999995 ms
31)	06-Nov-1998 15:51:31	29.999849 ms	0.999995 ms
32)	06-Nov-1998 15:51:31	30.999844 ms	0.999995 ms
33)	06-Nov-1998 15:51:31	31.999838 ms	0.999994 ms

STATUS

- Acquisition System
- Text & Times**
- WaveForm
- Memory Used

For

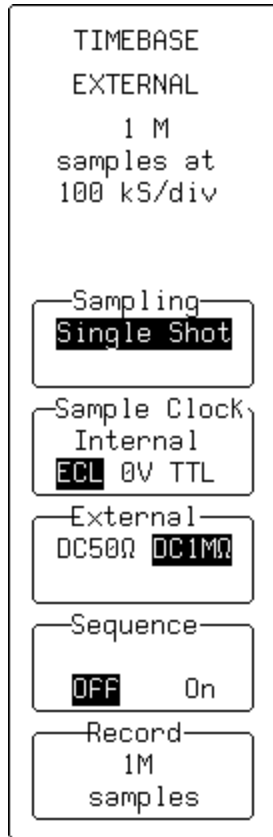
1	2		
A	B	C	D
M1	M2	M3	M4

Select segment (1 - 100)

5 MS/s
100 x
STOPPED

Press the *SCOPE STATUS* button for a full status summary of your sequence acquisition. Use the *Select segment* menu and its button and knob to scroll down the segment list.

OR SAMPLE EXTERNALLY



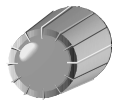
Use an external clock at a fixed frequency (see Appendix) to control and synchronize the sampling with an external signal source connected to the Waverunner rear EXT signal input.



This menu is inactive when the external sample clock is being used. **Single-Shot** is selected by default.



To specify the effective threshold for sampling the EXT input: 1.3 V with **ECL**, 0.0 V with **0V**, or +1.5 V with **TTL** selected.



To turn Sequence **On** or **Off**. Use the knob to set the number of segments.



To select with the knob the maximum record length, in samples, for each segment.

NOTE: External clock modes are available only if the EXT trigger is NOT the trigger source. Trigger time stamps and the AUTO sequence time-out feature are unavailable when you use an external clock signal. And inter-segment dead time is NOT guaranteed.

External clock time/div is expressed in samples per division, as is the trigger delay, which can be adjusted normally. No attempt is made to measure the time difference between the trigger and the external clock, so successive acquisitions of the same signal can appear to jitter on the screen. Waverunner requires a number of pulses to recognize the external clock signal. It stops capturing only when the trigger conditions have been satisfied and the appropriate number of data points have been accumulated. Any adjustment to the TIME/DIV knob automatically returns the scope to normal (internal) clock operation.



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