Debugging Asynchronous Interrupts

Sequence Mode Characterizes Interrupt Timing

Interrupts allow microprocessor based electronic systems to interface with external events, which may not be synchronous with systems timing. LeCroy oscilloscopes incorporate a number of tools for effectively measuring and characterizing interrupt driven digital processes. This type of measurement requires long memory to acquire a full cycle of the interrupt event while maintaining a high sampling rate to analyze timing waveforms with sub-nanosecond precision

Consider the interrupt timing shown in figure 1. This is the interrupt timing for the roll mode acquisition in a LeCroy oscilloscope. In this acquisition mode waveform samples are written to the display in real time as they become available. The timebase generates an interrupt (top trace) every eight samples, an event period of 800 us. The scope's processor responds by enabling write operations to the display memory. Trace 3 shows this signal which consists of 4 groups (one per channel) of eight pulses each. In this example the time from the leading edge of the interrupt to the first write enable pulse in the burst is being measured along with the period of the interrupts. Note that the timing resolution of the meas-

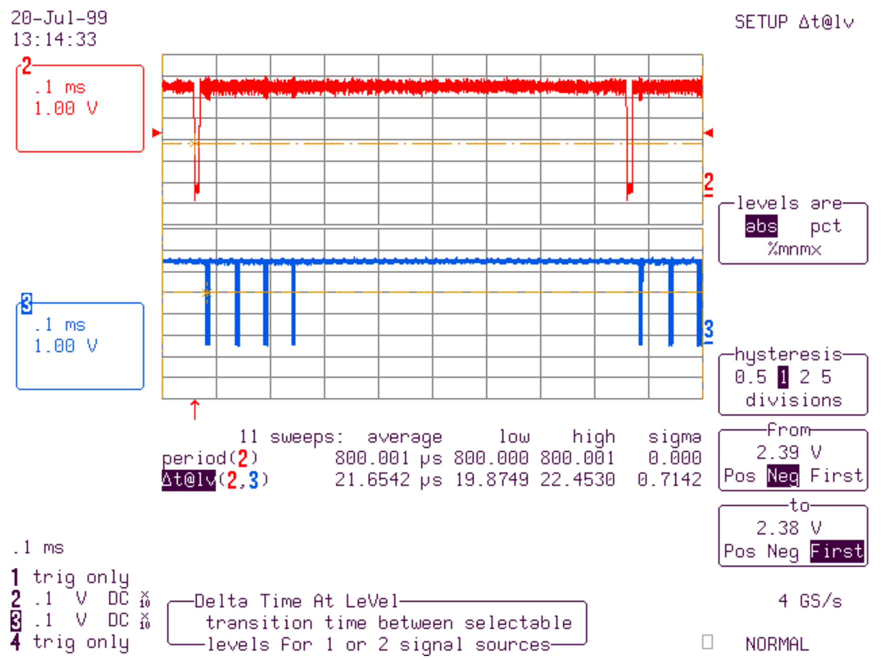


Figure 1– A system interrupt (top trace) and the response to it (lower trace)

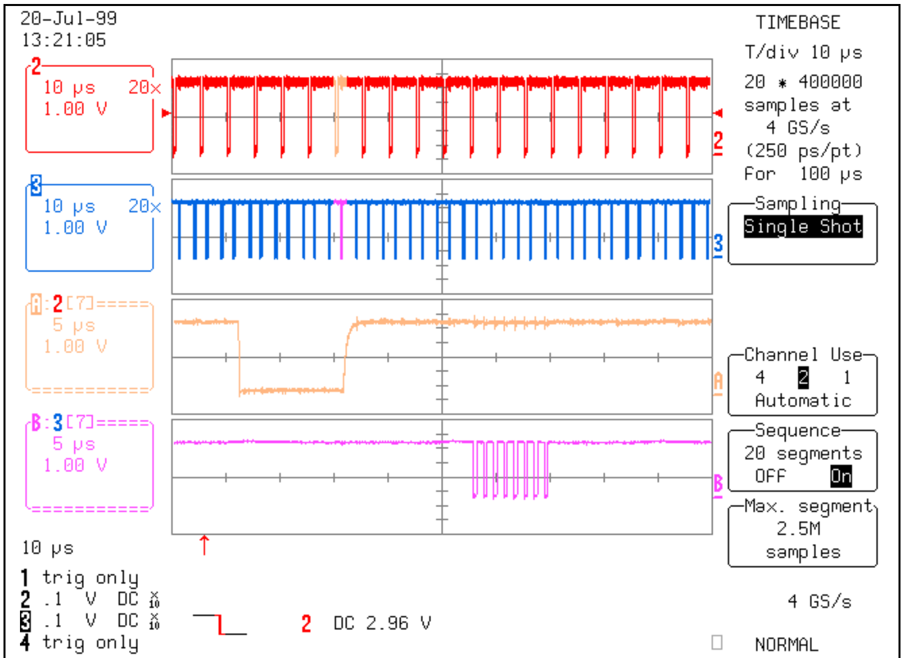


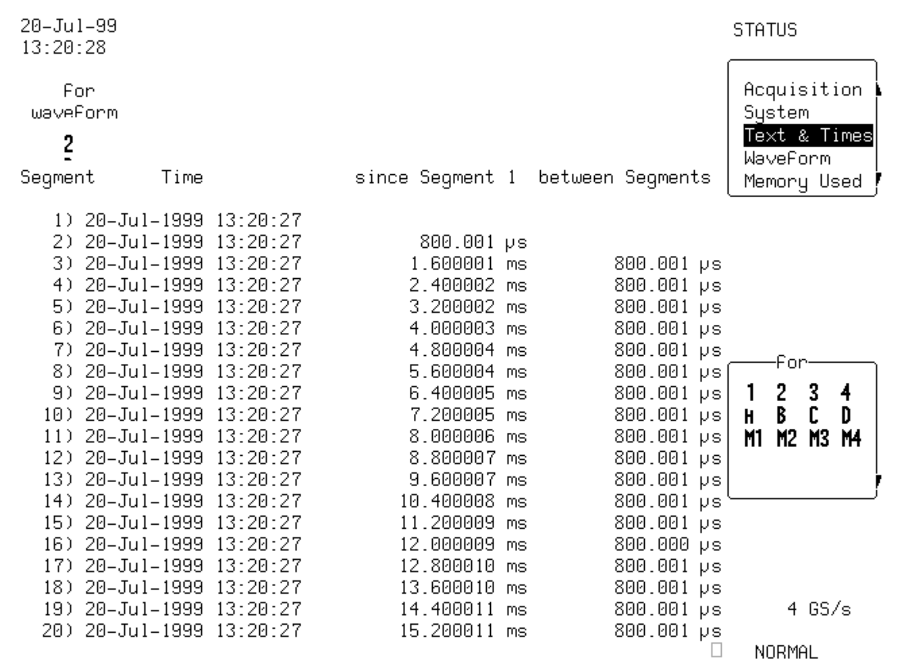
Figure 2 – Using sequence mode to segment acquisition memory

urements is being maintained because the long memory (16 Mb) of the scope keeps the sample rate at 4 GS/s even at 0.1 ms/division. This allows timing measurements with 100 ps average time resolution.

These measurements characterize the timing of the response to the interrupt. The period measurement provides average timing information for the occurrence of the interrupt.

Figure 2 shows the setup for using sequence mode which segments the acquisition memory to capture and time stamp the interrupts. In sequence mode the acquisition memory is segmented into as many as 4000 segments. Each of the segments can be viewed individually using the zoom display. Multi-zoom locks the horizontal zoom position and gain so that two or more zoom traces track as the operator scans across all the segments. The lower two traces in figure 2 are zooms of channel 2 and 3, showing segment 7 of the acquired waveforms.

The scope acquires and time stamps each trigger event as shown in figure 3. Time stamps show absolute time, time since first trigger, and time between triggers. The sequence mode acquisition updates within as little as 25 us depending on the model of oscilloscope.



Segment	Time	since Segment 1	between Segments
1)	20-Jul-1999 13:20:27		
2)	20-Jul-1999 13:20:27	800.001 µs	
3)	20-Jul-1999 13:20:27	1.600001 ms	800.001 µs
4)	20-Jul-1999 13:20:27	2.400002 ms	800.001 µs
5)	20-Jul-1999 13:20:27	3.200002 ms	800.001 µs
6)	20-Jul-1999 13:20:27	4.000003 ms	800.001 µs
7)	20-Jul-1999 13:20:27	4.800004 ms	800.001 µs
8)	20-Jul-1999 13:20:27	5.600004 ms	800.001 µs
9)	20-Jul-1999 13:20:27	6.400005 ms	800.001 µs
10)	20-Jul-1999 13:20:27	7.200005 ms	800.001 µs
11)	20-Jul-1999 13:20:27	8.000006 ms	800.001 µs
12)	20-Jul-1999 13:20:27	8.800007 ms	800.001 µs
13)	20-Jul-1999 13:20:27	9.600007 ms	800.001 µs
14)	20-Jul-1999 13:20:27	10.400008 ms	800.001 µs
15)	20-Jul-1999 13:20:27	11.200009 ms	800.001 µs
16)	20-Jul-1999 13:20:27	12.000009 ms	800.000 µs
17)	20-Jul-1999 13:20:27	12.800010 ms	800.001 µs
18)	20-Jul-1999 13:20:27	13.600010 ms	800.001 µs
19)	20-Jul-1999 13:20:27	14.400011 ms	800.001 µs
20)	20-Jul-1999 13:20:27	15.200011 ms	800.001 µs

Figure 3 – Time stamps measure time between interrupts with 1 ns precision

The use of sequence mode provides a means for determining and logging the timing of multiple interrupt events while not compromising the timing resolution for the response measurements.

This technique can also be applied to related measurements such as packet collision studies in local area networks and bus contention in multi-processor based digital systems. In each of these applications, random, low duty cycle events need to be analyzed with high timing precision. This combination requires an oscilloscope with long memory, stable timebase, and sequence mode acquisition capability.