Capture More with Less using Oscilloscope Segmented Memory Acquisition

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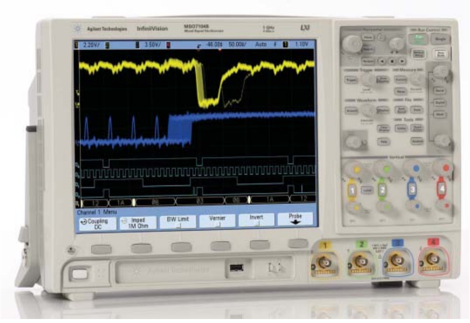


Introduction

If the signals that you need to capture on an oscilloscope have relatively long idle times between low duty cycle pulses or bursts of signal activity, such as packetized serial data, then using a scope with segmented memory acquisition can effectively extend the amount of time and the number of serial packets that can be captured at a higher sample rate.

All oscilloscopes have a limited amount of acquisition memory. And you should be aware that a scope's memory depth determines the amount of waveform time and the number of serial packets the scope can capture at a particular sample rate. Although you can easily set a scope's timebase to a very slow time/div setting in order to capture very long time-spans and lots of serial packets, scopes will automatically reduce their sample rates once the maximum time-span at the scope's maximum sample rate has been exceeded. When a scope's sample rate is reduced, it can no longer provide precision horizontal and vertical waveform detail (based on the scope's specified bandwidth and maximum sample rate).

In the case of Agilent's InfiniiVision series scopes, the maximum memory depth is 8 Mega points and the maximum sample rate is 4 GSa/s. This means that the maximum amount of continuous time that the scope can capture while still sampling at the scope's maximum sample rate of 4 GSa/s is 2 milliseconds (Acquisition time = memory depth/sample rate). Figure 1 shows an example where just three narrow pulses can be captured at the scope's maximum sample rate. But what if you needed to capture and compare 100 consecutive pulses or bursts of signal activity… or perhaps even 1000 consecutive pulses or serial packets?

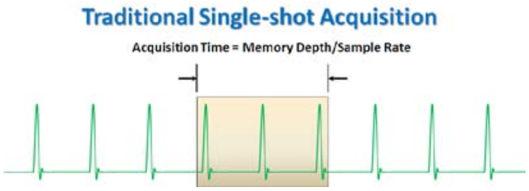


Figure 1: Continuous acquisition time is a function of a scope's memory depth and sample rate.

If you need to capture a longer time-span and more serial packets while still digitizing at a high sample rate, then one option is to simply purchase an oscilloscope with deeper memory. Unfortunately, purchasing a scope with Giga bytes of acquisition memory can be a costly option. But if the signals that you need to capture exhibit long signal dead-times between important waveform segments, such as low duty cycle pulses or bursts of serial data packets, then using a scope with segmented memory acquisition can be a more economical solution.

Segmented Memory acquisition can effectively extend the scope's total acquisition time by dividing the scope's available acquisition memory into smaller memory segments. The scope then selectively digitizes just the important portions of the waveform under test at a high sample rate as illustrated in Figure 2. This enables your scope to capture many successive single-shot waveforms with a very fast re-arm time — without missing important signal information.

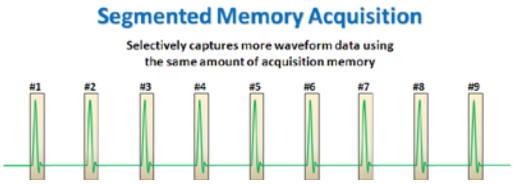


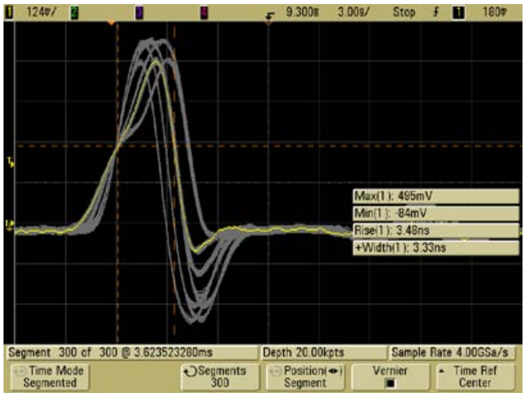
Figure 2: Segmented memory optimizes capture time by dividing the scope's available acquisition memory into smaller segments.

After a segmented memory acquisition is performed, you can then easily view all captured waveforms overlaid in an infinite-persistence display, as well as quickly scroll through each individual waveform segment. And in the case of serial bus applications, the scope also automatically provides protocol decode of each captured packet/segment. Although most of the signal dead/idle-time between each segment is not captured, the scope provides a time-tag for each segment so that you know the precise time between each pulse, each burst, or each serial packet captured.

Common measurement applications for this type of oscilloscope acquisition include high energy physics measurements, laser pulse measurements, radar burst measurements, and packetized serial bus measurements. We will first show two "classical" examples of using segmented memory acquisition to capture a series of very low duty cycle laser pulses, as well as radar bursts. We will then show an example of "a new kid on the block" and what should be considered a more common — but less understood — segmented memory acquisition application of capturing consecutive and selective packets of serial bus activity.

High Energy Physics and Laser Pulse Applications

One of the more traditional applications for segmented memory acquisition in an oscilloscope is to capture electrical pulses generated by high energy physics (HEP) experiments, such as capturing and analyzing laser pulses.



Max(1): 495mV
Min(1): -84mV
Rise(1): 3.48ns
+Width(1): 3.33ns
Segment 300 of 300 @ 3.623523280ms
Depth 20.00kpts
Sample Rate 4.00GSa/s

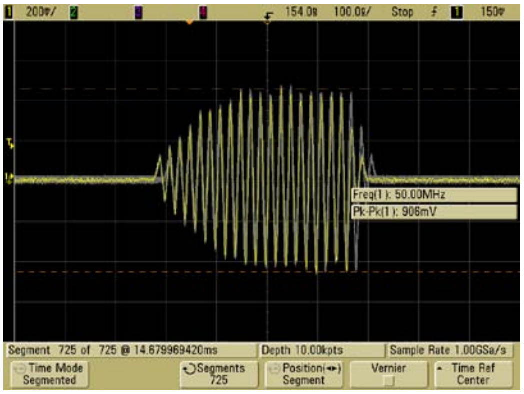
Figure 3: Segmented memory acquisition captures 300 consecutive laser pulses for analysis.

Figure 3 shows a segmented memory acquisition of 300 consecutive laser pulses with an approximate pulse width of 3.3 ns and a pulse separation time of approximately 12 µs. All 300 captured pulses are displayed in the infinite-persistence gray color, while the current selected segment is shown in the channel's assigned color (yellow for channel-1). Note that the 300th captured pulse occurred exactly 3.62352380 ms after the 1st captured pulse as indicated by the segment time-tag shown in the lower left-hand region of the scope's display. With the scope sampling at 4 GSa/s, capturing this amount of time would have required over 14 Mega points of conventional acquisition memory. But if these laser pulses were separated by 12 ms, then the amount of conventional acquisition memory to capture 3.6 seconds of continuous acquisition time (300 x 12 ms = 3.6 sec) would be over 14 Giga points. Unfortunately, there are no oscilloscopes on the market today that have this much acquisition memory. And if you could find one, beware of the price tag! But since segmented memory only captures a small and selective segment of time around each pulse, while shutting down the scope's digitizers during signal idle time, Agilent's InfiniiVision scopes can easily capture this much information using just 8 Mega points of memory, and at a much more reasonable price-point.

Another similar high energy physics application involves the measurement of energy and pulse shapes of signals generated from sub-atomic particles flying around an accelerator ring (particle physics). Assuming that sub-atomic particles have been slung around a 3 km accelerator ring at a speed approaching the speed of light (299,792,458 meters/sec), electrical pulses generated at a single detector at one location along the 3 km ring would occur approximately every 10 µs. With segmented memory acquisition, successive pulses generated by the sub-atomic particles could be easily captured, compared, and analyzed with precise time-tagging.

Radar and Sonar Burst Applications

Another application that often requires segmented memory acquisition in an oscilloscope is measuring radar and/or sonar bursts. Figure 4 shows an example of capturing 725 consecutive 50-MHz RF burst signals. It is often necessary to not only compare sent and received signals, but also to compare signal degradation from echo signals. In addition, these types of RF burst applications also require precise time-tagging in order to accurately compute distances. Distance and time between bursts can often be very long, such as when analyzing satellite communications. If a satellite is located 100 miles in space away from an Earth transmitter/receiver station, a radar echo time (over 200 miles round trip) would be approximately 1.07 milliseconds.



Freq(1): 50.00MHz
Pk-Pk(1): 906mV
Segment 725 of 725 @ 14.679969420ms
Depth 10.00kpts
Sample Rate 1.00GSa/s

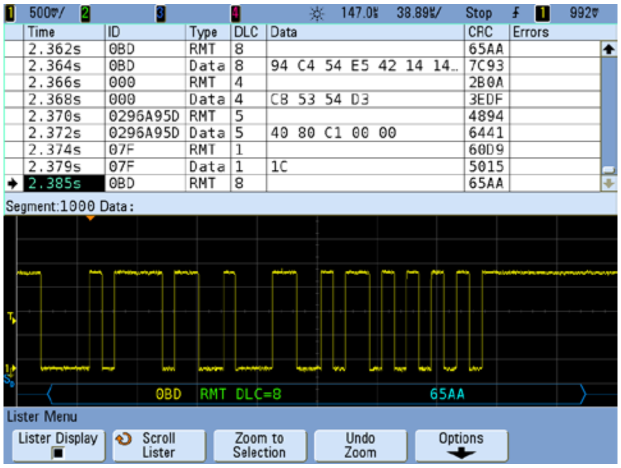
Figure 4: Capturing consecutive RF bursts with precise time-tagging using segmented memory.

Using the 50-MHz RF burst shown in Figure 4 as example, 725 consecutive bursts separated by 1.07 ms could easily be captured using segmented memory. Capturing this much time (775 ms) using conventional oscilloscope acquisition at 1 GSa/s would require nearly 1 Giga points of acquisition memory.

Serial Bus Applications

Although perhaps not considered before, packetized serial bus measurements are another application area where segmented memory acquisition can optimize the number of serial packets/frames that can be captured consecutively by selectively ignoring (not digitizing) unimportant idle time between packets. Segmented memory can also be used to capture just selected packet/frames with a particular ID or address, and ignore all other packets and signal idle time. Common serial buses where segmented memory can be used to optimize the number of packets/frames that can be captured include I^{2}C, SPI, RS-232/UART, CAN, LIN, FlexRay, I^{2}S, and MIL-STD 1553.

To illustrate how segmented memory acquisition can enhance serial bus measurements, we will examine an automotive CAN bus measurement application on an Agilent InfiniiVision 7000B series oscilloscope. Figure 5 shows a CAN bus measurement with the scope setup to trigger on every start-of-frame (SOF) condition. Using this triggering condition with the segmented memory acquisition mode turned on, the scope easily captures 1000 consecutive CAN frames for a total acquisition time of 2.385 seconds. After acquiring the 1000 segments/CAN frames, we can then easily scroll through all frames individually to look for any anomalies or errors. In addition, we can easily make latency timing measurements between frames using the segmented memory's time-tagging.

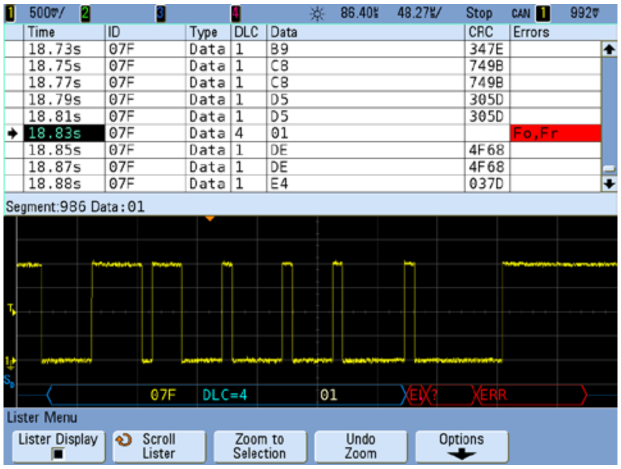


Time	ID	Type	DLC	Data	CRC	Errors
2.362s	0BD	RMT	8		65AA	
2.364s	0BD	Data	8	94 C4 54 E5 42 14 14..	7C93	
2.366s	000	RMT	4		2B0A	
2.368s	000	Data	4	CB 53 54 D3	3EDF	
2.370s	0296A95D	RMT	5		4894	
2.372s	0296A95D	Data	5	40 80 C1 00 00	6441	
2.374s	07F	RMT	1		60D9	
2.379s	07F	Data	1	1C	5015	
2.385s	0BD	RMT	8		65AA	

Segment:1000 Data:

Figure 5: Capturing 1000 consecutive decoded CAN frames using segmented memory on Agilent's 7000B series oscilloscope.

After capturing 1000 consecutive CAN frames based on a start-of-frame (SOF) triggering condition, perhaps we notice something peculiar about one specific frame ID, such as data frame 07F, and we now want to further analyze our CAN serial bus activity, but only when data frame 07F is generated. We could change the scope's trigger condition from triggering on SOF to trigger on ID: 07F in order to selectively capture 1000 consecutive occurrences of just frame ID 07F as shown in Figure 6. In this example, the scope captured nearly a 20 seconds time span. Notice in the scope's protocol lister/table display, each captured frame has the same frame ID (07F). Also notice that the scope captured an error frame (highlighted in red) during segment #986, which occurred 18.83 seconds after the first captured frame/segment.



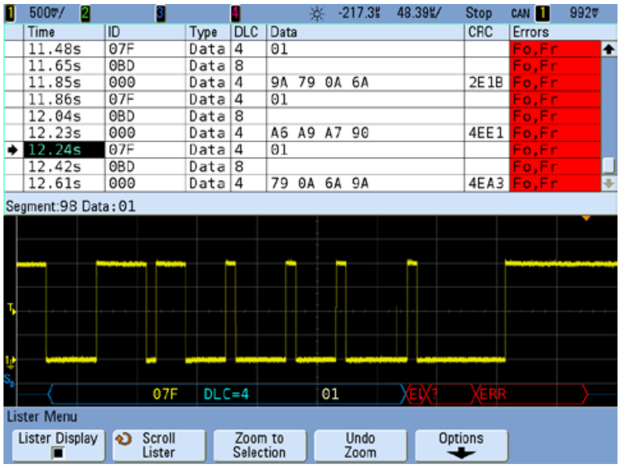
Time	ID	Type	DLC	Data	CRC	Errors
18.73s	07F	Data	1	B9	347E	
18.75s	07F	Data	1	C8	749B	
18.77s	07F	Data	1	C8	749B	
18.79s	07F	Data	1	D5	305D	
18.81s	07F	Data	1	D5	305D	
18.83s	07F	Data	4	01		Fo,Fr
18.85s	07F	Data	1	DE	4F68	
18.87s	07F	Data	1	DE	4F68	
18.88s	07F	Data	1	E4	037D	

Segment:986 Data:01

Figure 6: Capturing 1000 consecutive occurrences of just data frame ID: 07F.

The next step in this CAN serial bus debug process while using segmented memory acquisition might be to then setup the scope to selectively capture consecutive occurrences of all flagged error frames, regardless of the frame ID. To do this we would change the scope's trigger condition from triggering on data frame ID: 07F to trigger on Error Frames. But since error frames occur very infrequently, we will change the number of segments to capture from 1000 segments to just 100 segments.

In Figure 7 we can see that the scope captured 100 consecutive CAN error frames over an approximate 12.5 second time-span. We can see from the protocol lister that error frames appear to be occurring during just frame IDs 07F, 0BD, 000. Also notice that segment #98, which is frame ID: 07F and is shown in the zoomed waveform display, contains a narrow glitch near the end of the frame. Perhaps this glitch is the culprit that is causing error frames to sometimes occur during frame ID: 07F.



	Time	ID	Type	DLC	Data	CRC	Errors
	11.48s	07F	Data	4	01		Fo,Fr
	11.65s	0BD	Data	8			Fo,Fr
	11.85s	000	Data	4	9A 79 0A 6A	2E1B	Fo,Fr
	11.86s	07F	Data	4	01		Fo,Fr
	12.04s	0BD	Data	8			Fo,Fr
	12.23s	000	Data	4	A6 A9 A7 90	4EE1	Fo,Fr
➔	12.24s	07F	Data	4	01		Fo,Fr
	12.42s	0BD	Data	8			Fo,Fr
	12.61s	000	Data	4	79 0A 6A 9A	4EA3	Fo,Fr

Segment:98 Data:01

Figure 7: Capturing 100 consecutive occurrences of CAN Error Frames reveals a glitch in frame ID: 07F.

Summary

Segmented Memory acquisition should no longer be considered a special oscilloscope function relegated to special applications such as high energy physics experiments. Segmented memory acquisition is now available in many of today's digital storage oscilloscopes. Segmented memory acquisition optimizes a scope's available acquisition memory to effectively extend the time-span that the scope can capture in a single-shot. And when combined with serial bus protocol decoding and triggering, this acquisition mode can be used to more effectively debug your serial bus application.

About the Author

Johnnie Hancock is a Product Manager at Agilent Technologies Digital Test Division. He began his career with Hewlett-Packard (now Agilent Technologies) in 1979 as an oscilloscope hardware analog/digital circuit designer, and holds a patent for digital oscilloscope amplifier calibration. Johnnie is currently responsible for worldwide application support activities that promote Agilent's digitizing oscilloscopes and he regularly speaks at technical conferences worldwide. Johnnie graduated from the University of South Florida with a degree in electrical engineering. In his spare time, he enjoys spending time with his four grandchildren and restoring his 116-year-old Victorian home located in Colorado Springs, Colorado USA.