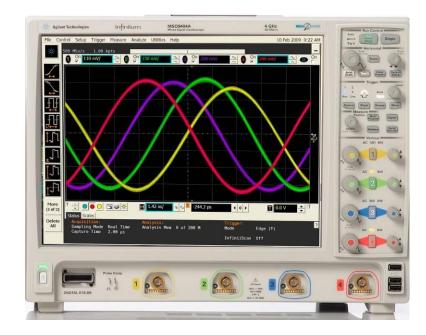
# Advanced Troubleshooting with Oscilloscopes

9000 Scope Hands-on Labs





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# Scope-based Protocol Analysis Start lab 1 here.

Scope-based Protocol Analysis Lab:

Background

Serial bus interfaces are widely used today in electronic designs. In many designs, these buses provide a content-rich point for debug and test. However, since these protocols transfer packets serially, using a traditional oscilloscope has limitations. Manually converting captured 1's and 0's to protocol requires significant effort, can't be done in real-time, and includes potential for human error. In addition, traditional scope triggers are not sufficient for specifying protocol-level conditions. Agilent's scope-based protocol applications make it easy to debug and test designs that include serial buses.

Agilent scopes support a wide variety of scope-based protocol analysis applications for:

- I<sup>2</sup>C
- SPI
- RS-232/UART
- CAN
- LIN
- FlexRay

- JTAG
  - (IEEE1149.1)
- USB 2.0
- USB 3.0
- MIPI D-Phy
- PCle
- SATA

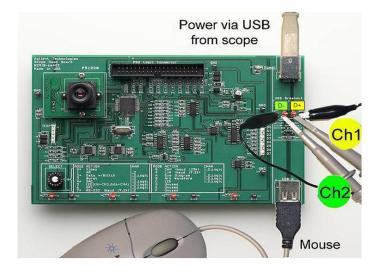
- 8B/10B
- Mil Std 1553 (InfiniiVision only)
- I<sup>2</sup>S (InfiniiVision only)

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	Byte 0 110 110 110 110 110 110 110 110 110
States	
Protocol viewer and waveforms.	Additional packet detail

#### **Become Familiar with Infiniium Protocol Analysis**

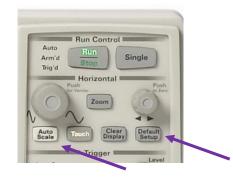
#### **Connect to target system:**

- 1. **Power the demo board via USB** from the scope.
- Connect scope channel 1 to D+ and channel 2 to D-. (Be careful not to ground D+ or D-...if you do, just unplug the mouse and plug it back in.)
- 3. Connect a USB mouse to the demo board.



- 4. Press **Default Setup** button on Front Panel (Restores to factory default)
- 5. Press **Auto Scale** button on Front Panel (Automatically scales voltage and time)
- 6. Push the "**Serial Decode**" button on the front of the scope then **Setup**

Or, access the decode setup dialog from Setup → Serial Decode





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		2 Ch	annel 2		Ctrl+2	
7		3 Ch	annel 3		Ctrl+3	
4		4 Ch	annel 4		Ctrl+4	
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$\rightarrow$	_	Pr	obes		Alt+P	
	ГШ	Se	rial Decod	e	Alt+S	
		Se	rial Search			

7. Select USB 2.0 and Low-speed (1.5 Mb/s)

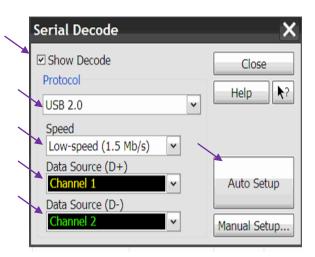
8. Assign Channel 1 to D+ and Channel 2 to D-

9. Check the "Show Decode" button.

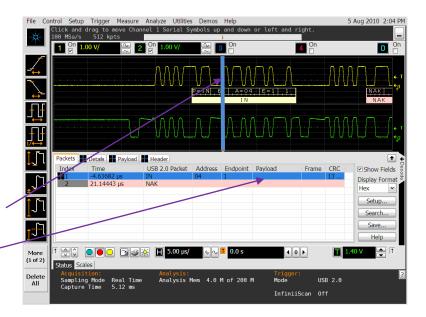
10. Press **Auto Setup** (this is an Agilent exclusive feature that is protocol smart. Auto Setup automatically sets measurement thresholds, sample rate, and adjust timebase for specified protocol eliminating time required for manual setup.)

11. Close the serial decode dialog and press the **RUN** button

- You should now see USB traffic generated by the USB mouse communicating with the PC host.
- Infinitum displays serial packet decode below signal waveforms and additionally in a protocol viewer.
- The line shaded in blue on the protocol viewer is time correlated with the blue bar on the waveform area and if you double click on a new packet, the blue marker in the waveform area tracks automatically.

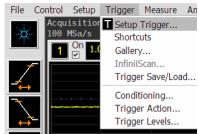






#### Triggering on data packets

• The protocol viewer includes a multi-tab packet viewer. Let's see how this works featuring some more interesting USB traffic.

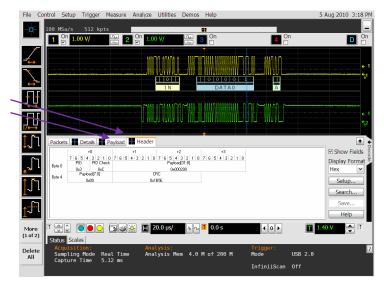


12. Set the scope to trigger on USB data packets. Trigger Setup Trigger Serial, Type = Data

Trigger Setup	×
■ InfiniiScan Edge Edge Transition Serial Edge Then Edge Glitch Pulse Width Protocol USB 2.0 Setup	Close Help R? Conditioning Trigger Action Thresholds Sweep Auto
Type Data	<ul> <li>● Triggered</li> </ul>
Any Data	<ul> <li>✓</li> <li>✓ Clear Trigger Settings</li> </ul>
View as Bits	Save/Load Trigger Setup

13. **Move the mouse** to generate USB data packets that contain XY coordinates).

• The scope now only triggers when data packets are transmitted.



#### **USB Protocol Lab**

- Measure the enumeration time for a USB optical mouse when connected to your scope (Measure from first SETUP packet to last SETUP packet when the USB mouse is plugged in. Each setup is separated by several ms).
- Set the scope to trigger on a USB Setup token (Trigger → Setup Trigger)

Trigger Setup	×
Trigger Setup InfiniiScan Edge Edge Transition Serial Edge Then Edge Glitch Pulse Width Protocol USB 2.0 Setup Type Token View as Bits	Close Help ? Conditioning Trigger Action Thresholds Sweep O Auto Triggered Clear Trigger Settings Save/Load Trigger Setup

- 2. Unplug the mouse from the target board.
- 3. Press Single button on the scope front panel to begin looking for the SETUP token trigger condition.
- Plug the mouse USB connector into the demo board to start the enumeration process.

#### <u>Info</u>

• The enumeration starts by sending a reset signal to the USB device.

• After reset, the USB device's information is read by the host and the device is assigned a unique 7-bit address.

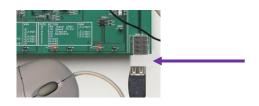
• If the device is supported by the host, the device drivers needed for communicating with the device are loaded and the device is set to a configured state.

• If the USB host is restarted, the enumeration process is repeated for all connected devices.

• "Setup" packets are exclusively used during the enumeration process.

#### **USB** device enumeration sequence

- Device attach low speed device pulls up Dto ~3.3V.
- Host bus reset. Host drives both D- and D+ to zero.
- Host reads device descriptor







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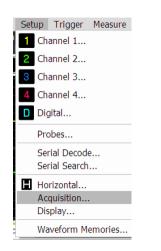
- We've now triggered on a Setup packet, but there may be more Setup packets. We don't know how many Setup packets will occur.
- Different USB devices require varying numbers of Setup packets (ie a USB keyboard or higher speed USB device will have a different number of Setup packets before enumeration is complete.)
- We could increase memory depth to capture more Setup packets, but can't guarantee that we'll have enough memory to capture them all.
- We'll employ segmented memory to capture all Setup

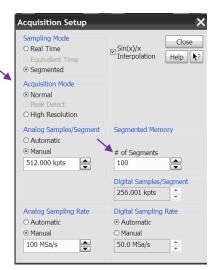
- Change the acquisition type to segmented memory (Setup→Acquisition).
   We'll choose 100 segments as this number is well above the number of Setup packets needed for enumeration.
- 6. Disconnect the mouse
- Press Single button on the scope front panel to begin looking for the Setup packet.
- 8. Plug mouse into target.

The acquired segment count is located in the upper right corner of the display.

We've set the scope to acquire up to 100 segments, but this number of segments did not occur before enumeration was complete. The scope is still looking for additional Setup packets, but isn't seeing any more of them.

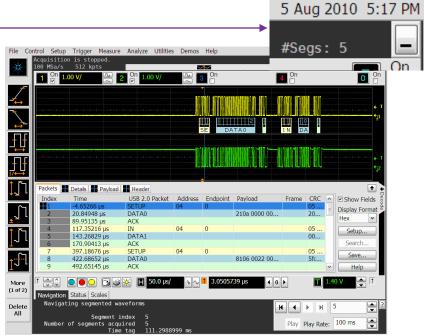
9. Press the **Stop** button on the front of the scope.











10. **Scroll** through each segment using the software controls on the — lower right part of the display.

Each segment includes a Setup packet (trigger condition) and the amount of time between segments is shown at the bottom of the display.

For the mouse used in this example, it took 5 Setup packets and 111ms for enumeration to complete.

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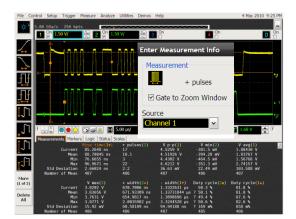
# Measurements and Analysis Start lab 2 here.

## Advanced Measurements and Analysis

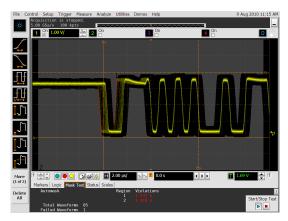
## Background

Infiniium oscilloscopes include a rich set of measurement and analysis capabilities.

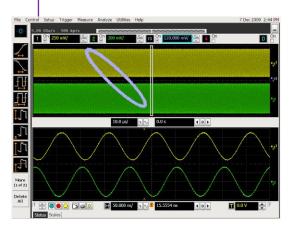
- Standard Infiniium features
  - **56 built-in measurements** with statistics (up to 10 can be displayed simultaneously)
  - o 35 built-in functions (math, FFTs, low-pass filters, Versus (XY), etc)
  - o Histograms (can be made on any signal, measurement, or function)
  - Mask and limit testing
- Optional applications
  - $\circ$  ~ Use SDA (serial data analysis) for clock recovery and eye analysis
  - Add additional functions created in **MATLAB** (import .m file) using User-Definable Function (UDF) application
  - Analyze high-speed signals using serial data analysis (clock recovery and eye diagrams) and **EZJit/EZJit+** for jitter analysis.
  - o Automated testing and reporting with User-Definable Application (UDA)



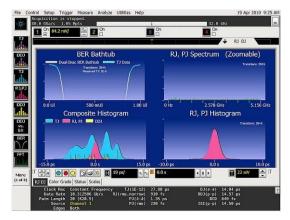
Measurements with statistics



Mask testing



#### Functions

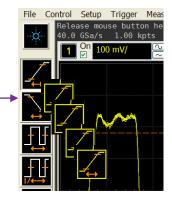


Jitter applications

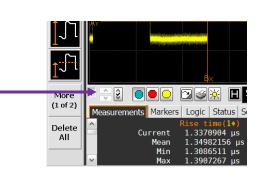
#### **Become Familiar with Infiniium Measurement and Analysis**

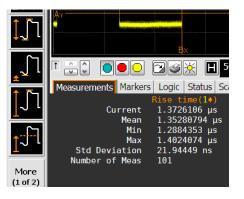
- Connect Channel 1 to the Probe Comp signal on the front of scope and disconnect all other probes and unplug MSO cable if plugged into target system..
- 2. Press **Default Setup** button on Front Panel (Restores to factory default)
- 3. Press **Auto Scale** button on Front Panel (Automatically scales voltage and time)
- 4. Drag and drop a **rise time measurement** on a rising edge of the waveform.



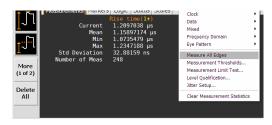


6. **Expand measurement window** to show up to 10 simultaneous measurements with statistics.





 Right click in the measurement window and select "Measure All Edges...."

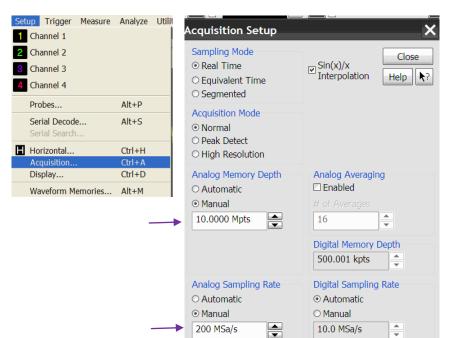


#### Effectively use memory for measurements.

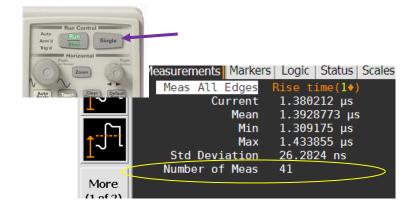
 Scopes generally make one measurement per acquisition. Often, users mistakenly think that more memory will equal more measurements. For most scopes, more memory just equals more test time.

Infiniium offers a feature to make measurements across the entire acquisition. "**Measure All Edges...**" creates an edge database for the Infiniium measurement system. What happens if we use more memory?

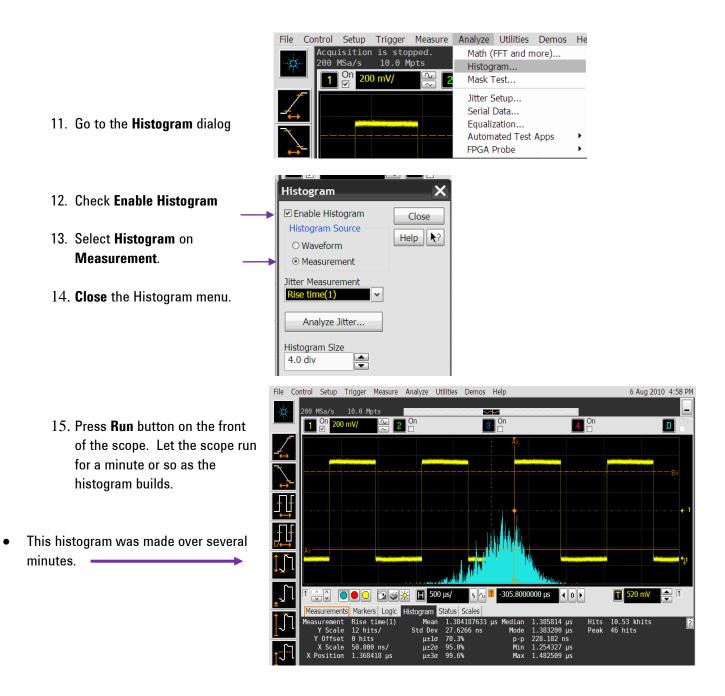
- 8. In Analog Memory Depth, select manual and increase acquisition memory to 10 Mpts.
- 9. In Analog Sampling Rate fix sample rate to 200 MSa/s. (Agilent Infiniium scopes are the only scopes in their class that allow users to independently select sample rate and memory depth.)



10. Press the **Single** button on the front panel of the scope and see how many risetime measurements were taken in a single acquisition (41).



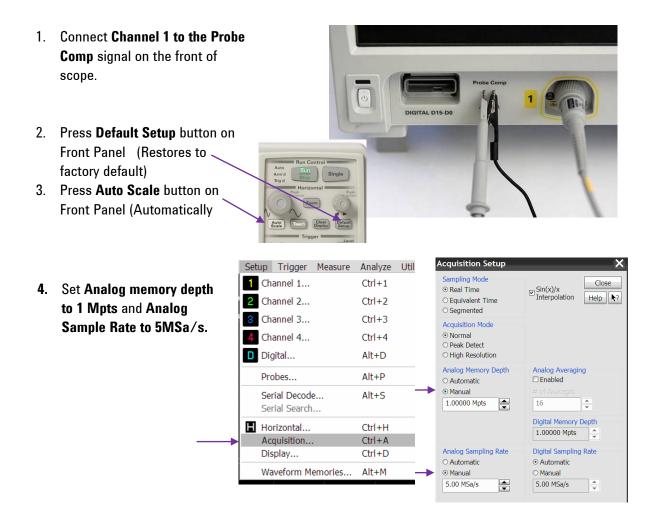
- We are using our memory effectively we are getting a lot of statistics.
- By default the Measurements results tab has the Current Value, Mean, Minimum, Maximum, Range, Standard Deviation, and Number of Measurements.
- Infinitum provides the ability to create **histograms** with waveforms, functions, and measurements. We will create a histogram with our Rise Time measurement.



#### Analysis Lab

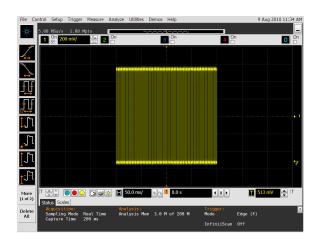
Many times it's useful to measure the FFT of a signal to analyze its frequency and power characteristics. This can be an effective way to see frequency cross-coupling from a power supply, view harmonics, look at filters, see broadband signals, and determine if you need more precise measurements with a spectrum analyzer.

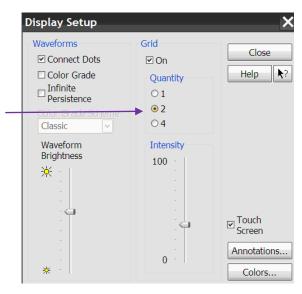
Measure the instantaneous power of the 5<sup>th</sup> harmonic on the scope CAL signal. The CAL signal has a fundamental frequency of 810 Hz (5<sup>th</sup> harmonic will be 4.05 kHz).



 Turn horizontal knob to adjust timebase to 50 ms/div Displaying all acquired data on screen will provide a more accurate FFT measurement as FFTs operate exclusively on on-screen data.

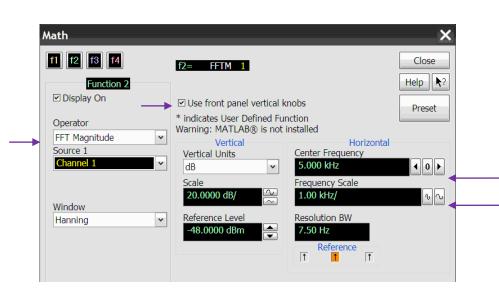




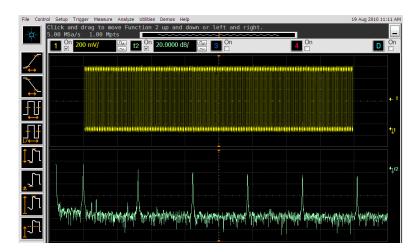


6. Setup display for **2 grids**.

- Analyze Utilities Demos Help Math (FFT and more)... Histogram...  $\sim$ n Mask Test... 7. Select the Math(FFT Jitter Setup... and more) dialog. Serial Data... Equalization... Automated Test Apps FPGA Probe 8. Select "f2" and check Math the "Display On" field. f1 f2 f3 f4 f2= Function 2 Display On **⊠** 5 Operator \* ir Magnify ~ Wa Source 1 Channel 1 ۲ С
  - 9. Change the function to "FFT magnitude" and set the **Center Frequency**, **Frequency Scale**, and **Vertical Units** fields as shown.
  - 10. Check the box "**Use front panel vertical knobs**" which will allow us to use the Ch2 offset and scale knobs to control the FFT magnitude display.



- 11. Drag the green f2 FFT function to the lower grid using the mouse.
- 12. Press the **Single** button on the scope front panel. You should have a display that looks like the following image.

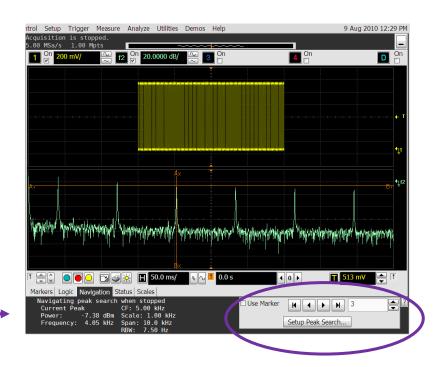


We will use the Navigation window to show us power levels of each harmonic

**13.** Set the markers to **FFT Navigation**.



File	Control	Setup	Trigger	Measure	Analyze
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15. Use the "**Setup Peak Search**..." control to move to the 5<sup>d</sup> harmonic (3<sup>rd</sup> peak)

The frequency and power readings will be found in the bottom right of the Navigation pane.

 We could make power and frequency measurement by adding markers
 (Measure→markers→Manual

Placement→Function 2")

The scope would show marker

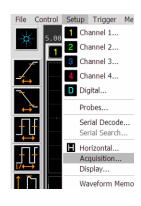
horizontal frequency values in

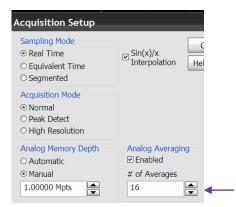
dB.

Hertz and vertical power values in



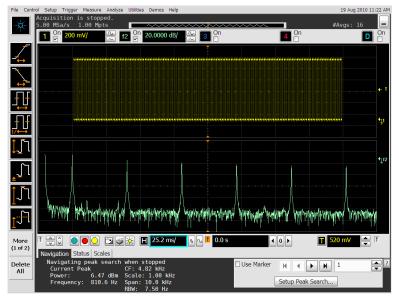
16. To reduce noise, **turn on analog averaging** 





17. Press the **Single** button on the front of the scope to take 16 acquisitions and average them.





# InfiniiScan Start lab 3 here.

InfiniiScan Graphical Triggering Application Lab:

Background:

All digital scopes use hardware-based triggering. Trigger circuitry inside the scope inspects incoming signals in real-time and when the trigger condition is seen in hardware, the scope captures the signal, displays it, and then begins looking for the next trigger condition. Users select from a wide range of parameterized hardware-based triggers.

Trigger Setup	×	Trigger Setup	×
InfiniiScan Runt Timeout Pattern/State Setup And Hold Window Video  Source Level Channel 1  O.0 V  C C AND (Qualifier)	Close Help Conditioning Trigger Action Thresholds Sweep ⊙ Auto ○ Triggered Clear Trigger Settings Save/Load Trigger Setup	□ InfiniiScan         Runt Pattern/State       Shortcuts         Setup And Hold       Gallery         Window       Gallery         Mode       < Setup	Close Help ₹? Conditioning Trigger Action Thresholds Sweep Auto Triggered Clear Trigger Settings Save/Load Trigger Setup
		AND (Qualifier)	

Hardware based triggers excel at finding events in real-time, but don't have flexibility to add new types of events.

#### InfiniiScan Software-based Triggering (N5415B)

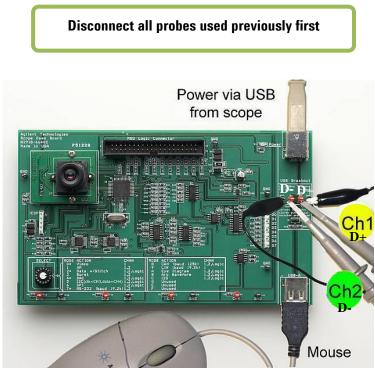
- User graphically describes a trigger condition by **drawing a zone** in the scope waveform area. Have you ever been able to visually see what you want to trigger on, but unable to set it up in the vast complement of standard scope triggers?
- InfiniiScan will look through each acquisition and if the specified event occurs, it will display the acquisition. If the specified event does not occur, the scope will discard the acquisition and will look for the specified event on the next acquisition.
- InfiniiScan zone-qualified triggers slow scope update rate.
- InfiniiScan zone-qualified triggering can be combined with hardware-triggers to create multi-stage triggers.
- InfiniiScan zone qualified triggers can seek out "must intersect" conditions or "must NOT intersect" conditions. And... switch back and forth quickly between the must/must-not intersect conditions on already defined zone boundaries. This is particularly useful for executing forms of trigger filtering (example in lab to follow).

The following lab highlights some applications where the 9000 series oscilloscope's built in protocol triggering could be used to accomplish <u>some</u> of the same tasks. But, keep in mind several important differences... First, these labs demonstrate methods for general analog debug and could

apply equally as well for different signal shapes (other than digital) or protocols that are not directly supported with the built in protocol analyzer (it just so happens these labs target digital protocols available on the 9000 series demo board). Furthermore, in cases where serious enough signaling problems at the physical layer prevent protocol decode from working (can't stay synchronized with the packets), InfiniiScan doesn't rely on protocol correctness.

#### InfiniiScan Lab 1 – Isolating USB Data Packets:

In this lab, your task will be to use InfiniiScan zone triggering to isolate USB packets which contain XY coordinate data transmitted from a USB mouse. You will then make some measurements on the data bits using drag and drop measurements.



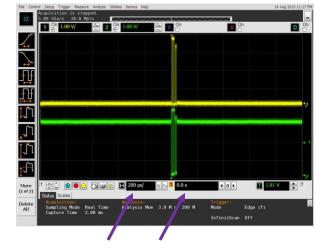
- 1. Power the demo board via USB from the scope.
- 2. Connect scope channel 1 and channel 2 as shown.
- 3. Connect a USB mouse to the demo board.

Setup:

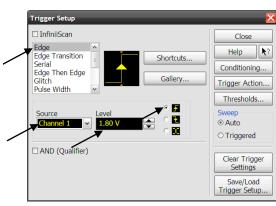
- 4. Press Default Setup Button on Front Panel (Restores to factory default)
- 5. Press Auto Scale Button on Front Panel (Automatically scales voltage and time)

After Default Setup and Auto Scale:

6. Adjust time/div to 10µs/div. Also set horizontal delay to 38µs.



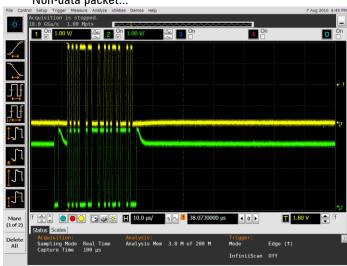
🗆 InfiniiScan 7. (Menu) Trigger...Setup Trigger Edge Edge Transition  $\rightarrow$  Set trigger to **1.8V** on **rising** Serial Edge Then Edge edge of channel 1 (D+) which is Glitch Pulse Width approx. middle of the Vpp amplitude of channel 1. Source Channel 1 Note: Triggering on channel 1 AND (Qualifier) instead of channel 2 avoids periodic low-speed "keep alive" pulses you see on ch 2 (not every packet).



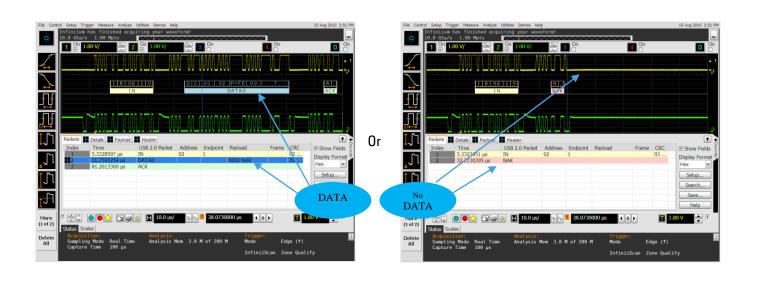
You will now either see packets with data or without data (move mouse around as scope is running to see the difference):



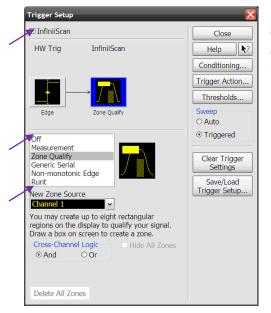




#### (ILLUSTRATION) Here is what you would see if you set up protocol decode for USB:



Continuing on with using InfiniiScan to isolate data packets...



8. Using InfiniiScan zone qualification, set a trigger to find only packets containing XY coordinate mouse data. Start by going to ...

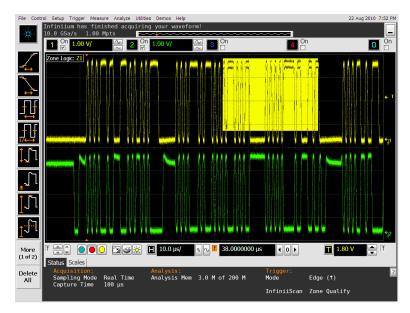
- A. (Menu) **Trigger**... **Setup Trigger** and enabling InfiniiScan by **checking the "InfiniiScan" box** in the top left.
- B. Next select Zone Qualify in the middle selection list.
- C. Use Channel 1 as the New Zone Source.
- D. Once you have made these selections, press "Close".

9. Now back at the main scope graticule display, use your mouse to drag and drop a zone rectangle in the area where you see data bits (see below). The rectangle can be placed just to the right of center screen in the yellow (Channel 1) area with a width of a few

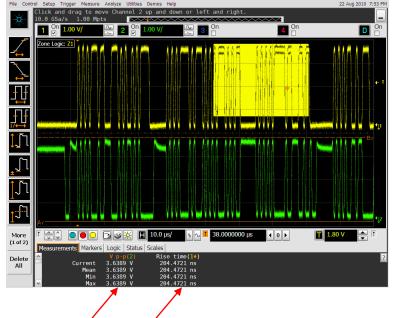
 $\mu$ s (just wide enough to catch a transition or two is fine). It is also important that the zone be above the baseline (not overlapping the OV level of channel 1 – otherwise you will get false triggers).



10. After the zone is placed, while running the scope you only see trigger events corresponding to data packets (when you move the mouse). If you don't move the mouse, the scope will be waiting for a trigger (Arm'd illuminated and no flash on Trig'd). Press the "Single" key on the front panel and move the mouse to catch a single data packet.



11. Now that you have captured a data packet, feel free to use the quick measure toolbar at the left column to drag and drop measurements like "Rise Time" or "Peak Voltage" onto either the D+ (ch 1) or D- (ch 2) waveforms.



Here is an isolated data packet with measurements on ch 1 (D+) and ch 2 (D-) :

InfiniiScan Lab 2 – RS-232 Protocol Debug:

In the RS-232 lab, you will investigate the physical layer signal timing on Tx which leads to a parity error. Then you will use InfiniiScan to filter out all trigger events with a parity error (ignore the messages with parity error).

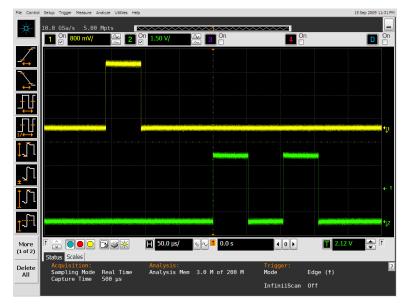
Setup:



- 1. Connect Rx Channel 1 probe to Test Point labeled CH1 on Training Bd Connect Tx Channel 2 probe to Test Point labeled CH2 on Training Bd Turn Selector Knob on Demo Board to 7- RS-232 (baud 19.2k)
- 2. Press **Default Setup** Button on Front Panel (Restores to factory default). Press **Auto Scale** Button on Front Panel.

(Automatically scales voltage, time, and trigger)

a. In this case, the default trigger is always edge and the trigger source will be the highest number channel selected (channel 2 - 50% threshold).



Auto Scale displays the Rx on Channel 1 and Tx on Channel 2

3. Change Horizontal Time/Div scale to 1 ms/div, Trigger Delay to 455 us



- 4. The trigger is set to rising edge on channel 2. Because of the multiple pulses in bursts on channel 2, the trigger is not perfectly stable. You will use <u>trigger hold-off</u> to lock the trigger on the rising edge of the first burst. Notice the red arrow added to the screen shot below. This arrow shows the minimum time you would want to use for trigger hold-off (enough to avoid triggering on any other rising edge in a message burst). To set the trigger hold-off,
  - a. Go to (Menu) Trigger  $\rightarrow$  Conditioning
  - b. Here you can **set a fixed trigger** hold-off of **5ms** to produce a more stable trigger.



## Setup Serial Decode Display:

- 1. Push **Serial Decode** Button on Front Panel
- 2. Select Setup → RS-232 Protocol
  - a. Word Size = 8
    - b. Parity = Odd
    - c. Baud = 19.2 kbp/s
    - d. Idle Polarity = Low
    - e. Bit Order = LSB
    - f. Press "Close"

#### **Do Not Press Auto Setup** (will reset trigger condition)

File Control Setup Trigger Measure Analyze U		15 Aug 2010 6:39 PM
100 MSa/s 1.00 Mpts ■ On 800 mV/ 2	On 1.50 V/ ☆ 3 On	
Serial Decode		
Show Decode	Close	1
RS-232/UART	Help <b>k</b> ?	<u>.52</u> <u>.52</u>
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Rx Source		
Tx Source	40 53 447	
↓↓↓ Channel 2 Word Size	Tx S	iource  Display Format
Parity		Hex V
Odd 🗸		Setup
Baud 19.200 kb/s	4D	Save
Idle Polarity	40 53 4F	Help
Bit Order		✓ 0 µs (0) 1.92 V ▲ ↑
(1 of 2) End of Frame Word	Auto Setup	00 µs    0 ►    1.92 ∨    1
Delete XX Hex v	Manual Setup 3.0 M of 200 M	Trigger: Mode Edge (†)
Capture lime 10.0 ms		InfiniiScan Off

#### 3. Change **Display Format** from Hex to **ASCII**

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Index 1 2 3	-3.93971132 ms	A	Tx Source		Display Format
1 2	-3.93971132 ms -3.36559132 ms	A g	Tx Source		Display Format ASCII
1 2 3	-3.93971132 ms -3.36559132 ms -2.79087132 ms	A g i	Tx Source		Display Format ASCII
1 2 3 4 5	-3.93971132 ms -3.36559132 ms -2.79087132 ms -2.21615132 ms -1.64143132 ms	A g i l e	Tx Source		Display Format ASCII
1 2 3 4	-3.93971132 ms -3.36559132 ms -2.79087132 ms -2.21615132 ms -1.64143132 ms -1.06671132 ms	A g i l e n	Tx Source		Display Format     ASCII     Setup     Search
1 2 3 4 5 6 7	-3.93971132 ms -3.36559132 ms -2.79087132 ms -2.21615132 ms -1.64143132 ms -1.06671132 ms -491.98132 μs	A g i l e			Display Format ASCII
1 2 3 4 5 6 7 8	-3.93971132 ms -3.36559132 ms -2.79087132 ms -2.21615132 ms -1.64143132 ms -1.06671132 ms -491.98132 µs 83.33870 µs	A g i l e n	М		Bisplay Format
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1 2 3 4 5 6 7 8 9 10 10 10 10 \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$	-3.93971132 ms -3.36559132 ms -2.79087132 ms -2.27087132 ms -1.64143132 ms -1.6471132 ms -1.06671132 ms -3.33870 µs 658.05870 µs 1.23277870 ms	A g i e n t t	м s o л. <b>1</b> 455.1000000 µs		Display Format ASCII Search Save Help
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1 2 3 4 5 6 7 8 9 10 10 10 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5	-3.93971132 ms -3.36559132 ms -2.79087132 ms -2.21615132 ms -1.64143132 ms -1.06671132 ms -1.06671132 ms -1.06671132 ms -0.580.5870 µs -0.580.5870 µs -0.5207870 µs -0.520	A g i i e n t t <b>1.00 ms/</b>	M S O 11 455.1000000 µs 16 M of 200 M No	igger:	Display Format ASCII Search Save Help

Setup File = RS-232\_ProtocolStep1.set

4. Notice that there is an occasional parity error (shown in red)...? First, how can you filter out parity errors (or effectively, trigger when the error <u>doesn't</u> occur)? Second, how can you investigate the timing of this parity error? In this particular example, the 9000 series protocol decode is smart enough to identify a RS-232 parity error (so it would initially seem InfiniiScan may not be necessary). But, protocol triggering can't help us filter out parity errors nor can it be used in other protocol scenarios where either protocol support isn't built-in or a physical layer signal timing violation throws off the protocol decode algorithms completely (i.e. protocol decode is no longer sync'd up).

Let's take a closer look at the parity error. First, adjust horizontal **Time/Div** scale to **200 µs/div** and **Trigger Delay** to **4.8 ms**.



Then open the trigger dialog Trigger...Setup Trigger...

File Control Setup Trigger Measure Analyze Utilitie	s Demos Help		15 Aug 2010 6:50 PM
Trigger Setup	×		
⊡ InfiniiScan	Close 3	On a O	
HW Trig InfiniiScan	Help R? Conditioning		· · · · · · · · · · · · · · · · · · ·
Edge Zone Qualify	Trigger Action Thresholds Sweep O Auto		
Off Measurent Zone Qualify Generic Serial Non-monotonic Edge Runt New Zone Source Channel Z You may create up to eight rectangular regions on the display to qualify your signal. Draw a box on screen to create a zone. Cross-Channel Logic © And O Or	Triggered     Clear Trigger     Settings     Save/Load     Trigger Setup	Tx Source # 1	Display Format ASCII w Search Save Help
	1	4.800000000 ms	1.92 V 💽 T
Delete All Zones	ма	Trigger: of 200 M Mode	Edge (†)
Capture Time 2.00 ms		InfiniiScan	Zone Qualify

5. Check InfiniiScan in the top left of the dialog and configure the Zone settings as above. First, you will use a zone on Channel 2 (Tx) to filter parity errors. Once the settings for the trigger are configured, press Close button to shut the Trigger Setup dialog.

Then, **draw a zone** that will catch the falling edge of the last bit on ch 2 Tx (parity bit) when it is wide enough to not cause a parity error (use "AND Must Intersect"):

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Index       Time       Rx Source       Allo Must Not Intersect       Zone 2         Index	<u>↓</u> ↓					7000.1	← T
Alex	<u>↑</u> 「~						
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(1 of 2)     Status Scales       Delete All     Acquisition:     Analysis:       Trigger:     Analysis Mem 3.0 M of 200 M       Node     Edge (†)	More	t 🖻 🗅		🔆 🖪 200 us/	1 A. 1 4.800000000 ms		2 V 🔄 T
Delete All         Acquisition:         Analysis:         Trigger:           Sampling Mode         Real Time         Analysis Mem         3.0 M of 200 M         Mode         Edge (†)         2           Capture Time         2.00 ms         Sampling Mode         Edge (†)         Sampling Mode         Edge	(1 of 2)						
Capture Time 2.00 ms	Delete	Acquisi	tion:	Analysis:	Tr 3.0.M.of 200.M. Mo	igger: de Edge (†)	?
InfiniiScan Zone Qualify	All			- Andreys13 Helli			
					In	ifiniiScan Zone Quali	fy

Notice how while the oscilloscope is running you have now have messages completely free of parity errors? Are there cases where you have asked "How do I trigger when an event doesn't happen?" That is what is illustrated here.

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<u></u> • <u>↓</u> ,	4	-2.21615448 ms	1			=	Setup
<u> </u>	5	-1.64142448 ms	e				Search
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Ľ	7	-491.98448 µs 83.33553 µs	t	М			Save
<u>^</u>	9	658.05553 µs		S			Help
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More			🔆 🖪 1.00 ms/	n n <b>1 455.0000</b>	00 µs 🛛 0 🕨	T 1.92	
(1 of 2)	Status Sca						
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All	Samplin	g Mode Real Tim		n 3.0 M of 200 M	Mode	Edge (†)	
	Capture	Time 10.0 ms			InfiniiScan	Zone Qualif	y

6. And with a simple change, we can switch the condition to trigger on all messages with parity errors. Right click on the zone that you set before and change the condition from "And Must Intersect" to "And Must Not Intersect". By reverse logic, if the parity bit is not wide enough to cross through the InfiniiScan zone, it must be failing the parity

error condition (there were only two modes you observed earlier when looking at the occasional parity error)...

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<u> </u>		64142925 ms	e			<ul> <li>Channel 2</li> </ul>	
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	apture lim	19.9 ms			InfiniiSc	an Zone Qualify	

Now the messages with parity errors are what we always see:

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	7	-491.98683 µs 83.33318 µs	t		М		Display Format
	9	658.05318 µs			S		ASCII
<b>≙</b> <sup>™</sup>	10	1.23278318 ms			0		Setup
	11	1.80750318 ms	_		S		Search
	12	2.38282317 ms	R				Jearch
Ľ	13 14	2.95694317 ms 3.53106317 ms	R			=	Save
<u>^</u>	14	4.10578318 ms	ĸ		#		Help
î,j-t	16	4.67990318 ms			# 1		
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More	T AÇ		🔆 Η 1.00 ms	5/ N N 1 455.00	000000 µs 🛛 ( ) )	<b>T</b> 1.9	2 V 📮 🕅
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# MSO Lab:

## Background

Infinitum 9000 Series models are available in either DSO or MSO (mixed signal oscilloscopes) models. MSOs offer 16 integrated digital channels in addition to the standard analog channels found on DSOs. MSO digital channels can be combined with analog channels for more effective debug of FPGAs, serial buses, microcontrollers, microprocessors, or state machines. Infinitum MSOs sample up to 2 GSa/s and come standard with 128 Mpts/channel of memory. The MSOs use accessories that are common to Agilent logic analyzers including:

- Flying leads probing
- Mictor connectors probing

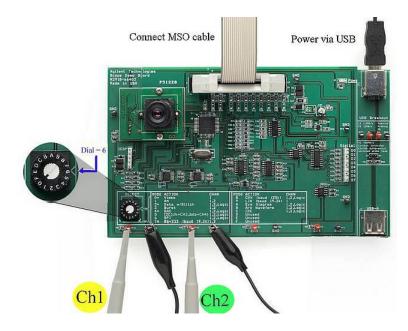
- Samtec connector probing
- Softtouch connectorless probing



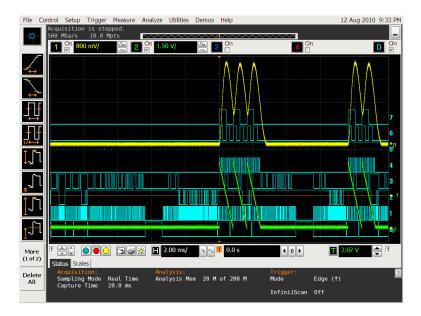


Sample MSO Screenshot

#### Become Familiar with Infiniium MSOs



- 1. Connect Channel 1 & 2 probes and MSO cable probes as shown above.
- 2. Turn Selector Knob on demo board to "6."
- 3. Press Default Setup Button on Front Panel (Restores to factory default)
- Press Auto Scale Button on Front Panel (Automatically scales voltage, time, and trigger for both analog and digital channels. Many other vendor's MSOs don't autoscale on MSO digital channels.)



You will see a combination of analog and digital signals on the display. Don't worry about what the signals are for right now. We'll use them to get some familiarity with the MSO settings.

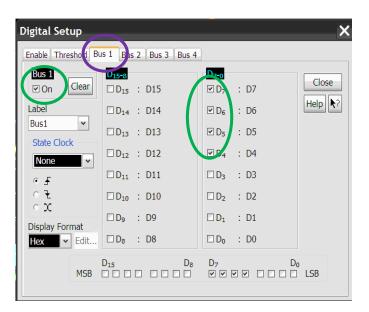
#### Set up display of analog and digital channels

File Control	Setup	Trigger	Measure	Analyze	Utilit
Infi 100	1 Ch	annel 1		Ctrl+1	
	2 Ch	annel 2		Ctrl+2	
	3 Ch	annel 3		Ctrl+3	
	4 Ch	annel 4		Ctrl+4	
	D Dig	gital		Alt+D	
	Dro	nhae		Δl++D	

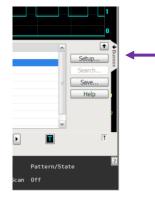
5. **Turn off** the display of D7, D6, D5, and D4.

Digital Setup	Bus 1 Bus 2 Bus 3 Bus 4	
	D <sub>15-8</sub>	Select All Close
Labels		_abels Help R?
□ On Separate	$\square$	▼
Auto Resize D <sub>15</sub> D <sub>0</sub>	$\Box_{13} D13 \checkmark \Box_{5} D5$ $\Box_{12} D12 \checkmark \Box_{4} D4$	✓
D0 D15		<b>~</b>
Size	$\square D_{10}  D10  \checkmark  \blacksquare D_2  D2$ $\square D_9  D9  \checkmark  \blacksquare D_1  D1$	✓
	$\Box D_8  D8  \blacksquare  D_0  D0$	~

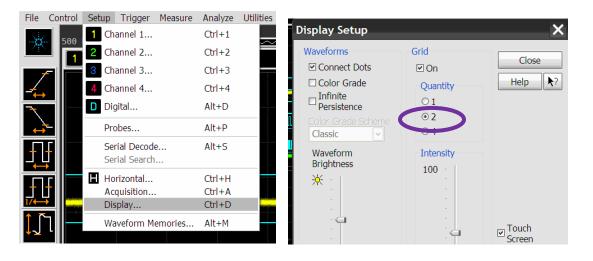
7. Select the Bus1 tab, and **group** MSO channels D7, D6, D5, D4 in a bus (Bus 1)



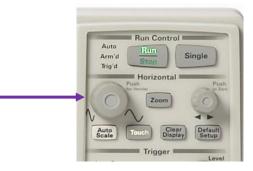
8. **Minimize the lister** so that only waveforms are displayed.

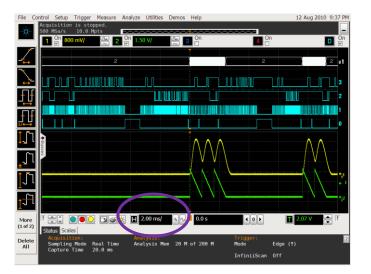


9. Set up a two grid display.



- 7. **Drag** analog channels C1 and C2 to the lower grid using the mouse. Arrange the digital channels evenly on the upper grid.
- 8. Adjust the timebase to 2 ms/div





12. See bus values in both lister and on waveform display by opening the lister.

13. Expand the lister to full screen. Turn the horizontal knob on the front panel to10 ms/div to increase memory depth and see more bus values.

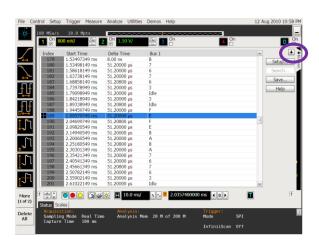


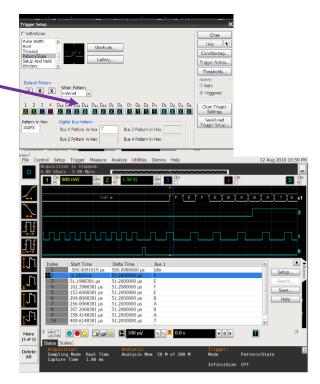
Turn the timebase back to 100 uS/div

14. **Minimize the lister** and show exclusively bus value waveforms.

13. Setup pattern trigger when Bus1 has F (hex) on it. (Trigger→Setup→Pattern/State (about ¾ of the way down the list)

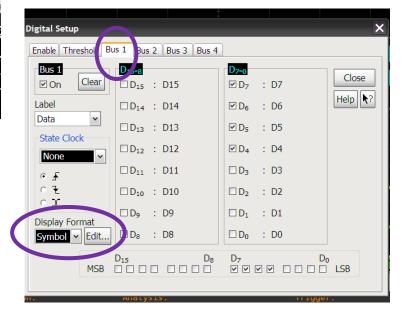






Bus1 is a 4-bit data bus. Agilent MSOs include the ability of displaying symbols instead of binary or hex digits. We are going to load a symbol file for Bus1 so it displays "Idle" whenever the 02 Hex value is captured.

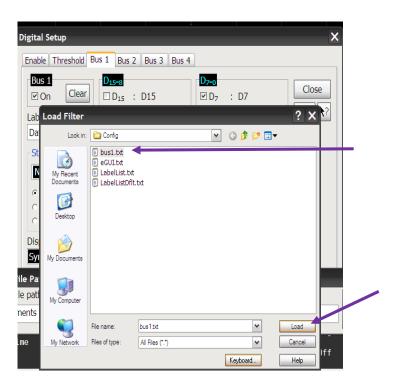
File	Control	Setup	Trigger	Measure	Analyze	Utilitie
	Acqu 500	1 Ch	annel 1		Ctrl+1	
		2 Ch	annel 2		Ctrl+2	Ě
1	╕╢╞╧	3 Ch	annel 3		Ctrl+3	
4		4 Ch	annel 4		Ctrl+4	
$\overline{\mathbf{x}}$		D Dig	gital		Alt+D	
		Pro	obes		Alt+P	



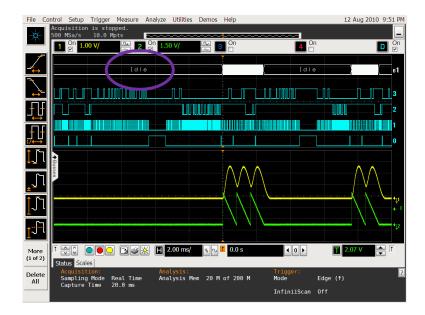
14. Change display format to **"Symbol"** and press "Edit" to specify the location of the symbol file.

15. **Choose bus1.txt** which was previously created. (Should be the default location and file). The symbol file is a simple text file whose contents are:

Idle 02 Hex End 0000 binary



Bus1 values of 02(Hex) are now displayed as the symbol "Idle." We could add more symbols to the bus1.txt file to make reading the bus readout easier.



## MSO Lab

The system we are debugging includes a SPI bus. Shortly after the SPI bus carries certain values, the system should output the following: Verify that the system is working as expected.

#### • Shortly after SPI data = 03 06 XX XX (hex)

- 3 analog pulses are output
- $\circ$   $\,$  Digital bus emits traffic while pulses are generated -

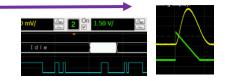
#### • Shortly after SPI data = 03 10 XX XX (hex)

- 2 analog pulses are output
- Digital bus emits traffic while pulses are generated





- Shortly after SPI data = 03 20 XX XX (hex)
  - 1 analog pulse is output
  - Digital bus emits traffic while pulses are generated —

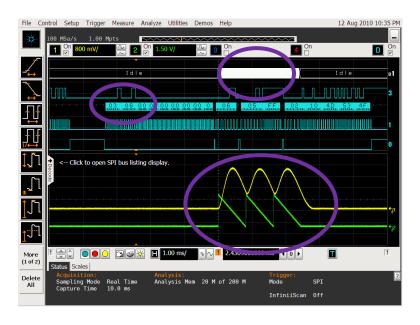


- 1. Use following setup file.
  - a. Load MSO\_SPI\_lab.set from TWO folder on the desktop

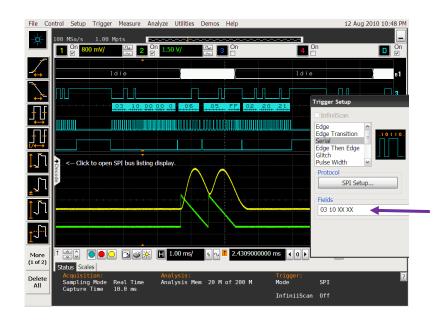
The setup file includes the work we just did, plus includes a SPI protocol setup with SPI Data on MSO channel 3, SPI clock on MSO channel 1, and SPI Chip Select on MSO channel 0. We'll minimize the SPI decode window and view SPI decode exclusively below MSO channel D3 waveform.

- Setup SPI trigger for 03 06 XX. (Trigger→Setup→Serial then click in the "Fields area" and change the 1<sup>st</sup> word to 06. Press "OK" to close menu.)
- 3. Verify that 3 analog pulses are present and that there's traffic on bus1.

100 MSa/s 1.00 Mpts	Enter Values Size Format 4 → Clear All
InfiniiScan Edge Edge Transition Serial Edge Then Edge Glitch Pulse Width Protocol SPI Setup Fields 03 06 XX XX Hex v	0 1 2 3 4 5 6 0 1 2 3 4 5 6 10 XX XX 0 E F - A B C CLR 7 8 9 4 5 6 FF 1 2 3 00 0 X XX OK Cancel Help



- 4. Setup SPI trigger for 03 10 XX.
- 5. Verify that 2 analog pulses are present and that there's traffic on bus1.



- 6. Setup SPI trigger for 03 20 XX.
- 7. **Verify** that 1 analog pulse is present and that there's traffic on bus1.



#### **Key Learning:**

- MSO channels can be used to capture signals in combination with analog channels.
- Pattern triggering enables triggering across digital and/or analog channels.
- MSO channels can be grouped into buses and displayed with user-defined symbols.
- MSO channels can be used for serial protocol triggering and decode, preserving analog channels for other system activity