



# **Agilent InfiniiVision 7000B Series Oscilloscopes**

## **Evaluation Guide**



**Agilent Technologies**

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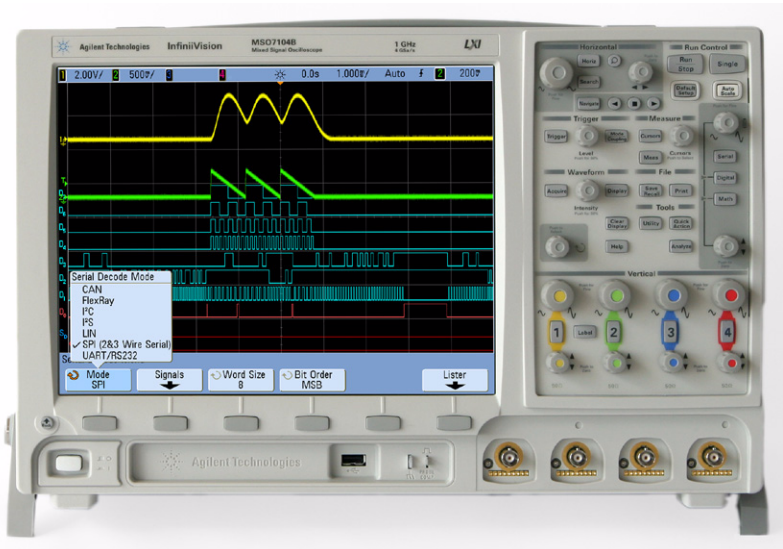
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# Agilent InfiniiVision 7000B Series Oscilloscopes

Agilent's InfiniiVision 7000 Series is the only oscilloscope in its class engineered to provide maximum signal visibility. The InfiniiVision 7000 Series shows jitter, infrequent events, and subtle signal detail that other oscilloscopes miss.

**The InfiniiVision 7000B Series oscilloscopes offer bandwidths up to 1 GHz. Each model, equipped with a large 12.1" XGA LCD display, comes in an extremely quiet package that is just 6.5" deep and weighs only 13 pounds. Agilent engineers architected the InfiniiVision 7000 Series oscilloscopes with technology to provide the industry's best signal visibility.**



## 1. ATTRACTIVE — Big Display. Small Footprint.

Bigger displays have become increasingly important as general purpose oscilloscopes need more space to display digital and serial signals in addition to traditional oscilloscope channels. The increased display size helps users who need to display up to 20 channels simultaneously with serial protocol.

## 2. FAST — 100,000 Waveforms Per Second.

Have you turned your oscilloscope's deep memory on only to have the controls become sluggish and unresponsive? If so, you've experienced the impact of architecture on performance. While it may be annoying to wait for new settings to take effect on your oscilloscope, this same architecture limitation has a more significant impact. While processing and drawing waveforms the oscilloscope is blind to target signal changes. Infrequent anomalies and critical signal detail are likely to be missed.

Patented MegaZoom III technology provides up to 100,000 waveforms (acquisitions) per second with responsive deep memory always available. See a display more representative of the actual signals under test than with any other oscilloscope. Turn knobs and the instrument responds instantly and effortlessly. Decoding serial packets? Unlike other oscilloscopes that become less responsive and are blind to target signal changes while employing software-based serial decode, Agilent's hardware-accelerated decode allows the product to stay responsive and does not compromise update rate.

## 3. SMART — Insightful Applications.

Upgrade your general purpose oscilloscope with a wide range of application packages provide meaningful insight into application-specific problems. These include:

- Mask Testing.
- Segmented memory.
- Serial triggering with hardware-accelerated decode for: I<sup>2</sup>C, SPI, RS-232/UART, CAN, LIN, FlexRay, I<sup>2</sup>S, and MIL-STD 1553.
- Core-assisted FPGA debug for Altera and Xilinx devices.
- PC-based offline analysis of previously acquired DSO/MSO data.
- Power measurements.

## Demo Equipment and Set Up

### Required Equipment

- Agilent InfiniiVision 7000B Series oscilloscope.
- Two passive probes.
- Demo kit with demo board, USB cable, and MSO Demo board cable.

### Demo Board Set Up

- 1 To power the demo board, connect the oscilloscope's MSO cable to the demo board's 40-pin connector. You can also power the demo board by



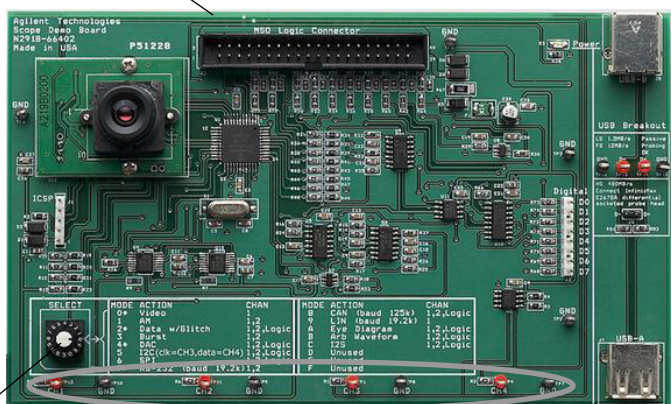
connecting a USB cable between it and the Agilent InfiniiVision 7000B Series oscilloscope.

- 2 Connect the oscilloscope channel 1 probe to demo board CH1 and GND. Connect the oscilloscope channel 2 probe to demo board CH2 and GND.
- 3 Connect the MSO ribbon cable to the back of the oscilloscope as shown below.
- 4 Plug the other end into the demo board as shown below.



MSO Cable Connection  
(Digital Inputs)

Power is provided via  
MSO or USB cable.



MODE Action  
Select Knob

Oscilloscope Probe Connections

## In This Guide

If you are experiencing the InfiniiVision 7000 Series oscilloscope for the first time, begin with [Demo Board Getting Started Guide](#). If you have a basic knowledge of the InfiniiVision 7000 Series oscilloscope's front-panel controls, begin with Lab 1.

	Topic	Page	Time Allowance
	<a href="#">Demo Board Getting Started Guide</a>	7	10 min.
Lab 1:	<a href="#">Capturing and Viewing Complex Signals with MegaZoom Technology</a>	14	10 min.
Lab 2:	<a href="#">Using Auto Scale, Cursors, Measurements, and Waveform Math</a>	18	10 min.
Lab 3:	<a href="#">Discovering an Infrequent Glitch with Fast Waveform Update Rates</a>	24	10 min.
Lab 4:	<a href="#">Using Pass/Fail Mask Testing to Discover a Signal Violation</a>	27	10 min.
Lab 5:	<a href="#">Viewing Multiple Signals in an MCU-based Design with an MSO</a>	30	10 min.
Lab 6:	<a href="#">Verifying I<sup>2</sup>C Serial Bus Communication</a>	34	10 min.
Lab 7:	<a href="#">Verifying SPI Serial Bus Communication</a>	39	10 min.
Lab 8:	<a href="#">Verifying RS-232/UART Serial Bus Communication</a>	43	10 min.
Lab 9:	<a href="#">Verifying CAN Serial Bus Communication</a>	48	10 min.
Lab 10:	<a href="#">Verifying LIN Serial Bus Communication</a>	54	10 min.
Lab 11:	<a href="#">Verifying I<sup>2</sup>S Serial Bus Communication</a>	58	10 min.
Lab 12:	<a href="#">Using Segmented Memory Acquisition to Capture More Data</a>	61	10 min.
Lab 13:	<a href="#">Using Serial Search and Navigation</a>	67	10 min.
Appendix A:	<a href="#">Using Trigger Holdoff to Synchronize Acquisitions/Display on Complex Signals</a>	71	10 min.

## Conventions

In this guide's descriptions:

- Front panel keys are in brackets and bold, for example **[Run/Stop]**.
- Softkeys and selected values are in bold, for example **Settings** and **D15**.
- Knobs are described by name/function, for example "Trigger Level knob".



## Demo Board Getting Started Guide

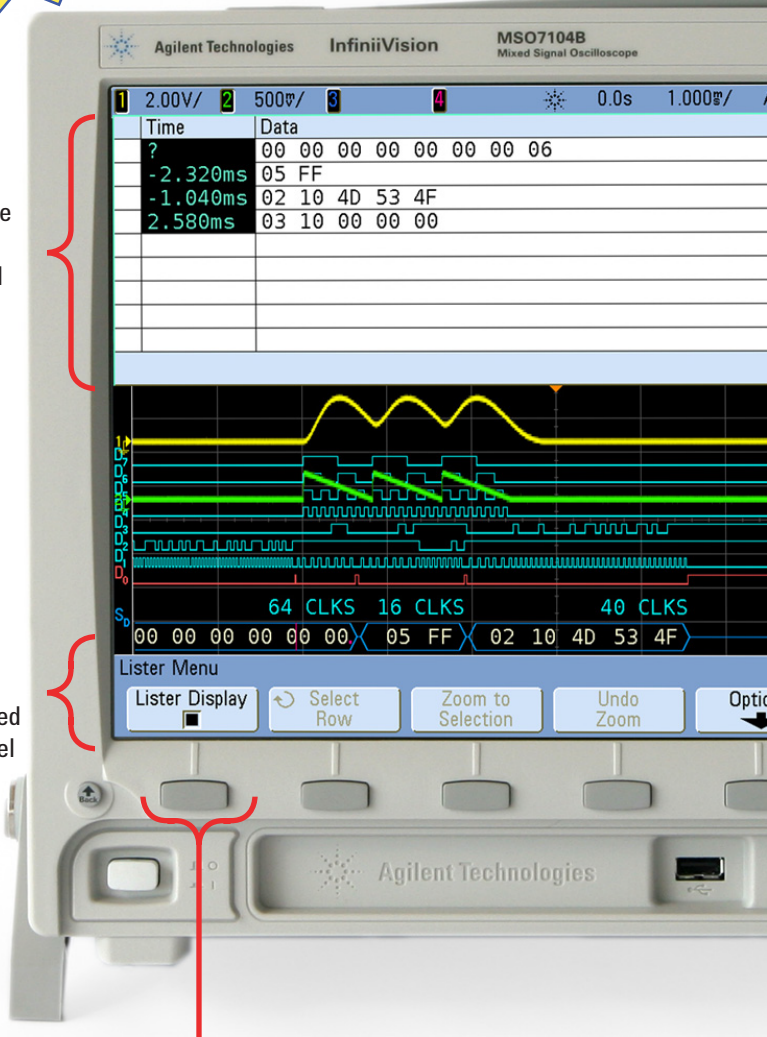
If you are not familiar with the Agilent InfiniiVision 7000B Series oscilloscopes, please first look over the main sections of the front panel as illustrated in this guide.



Dedicated front panel keys and pushable knobs

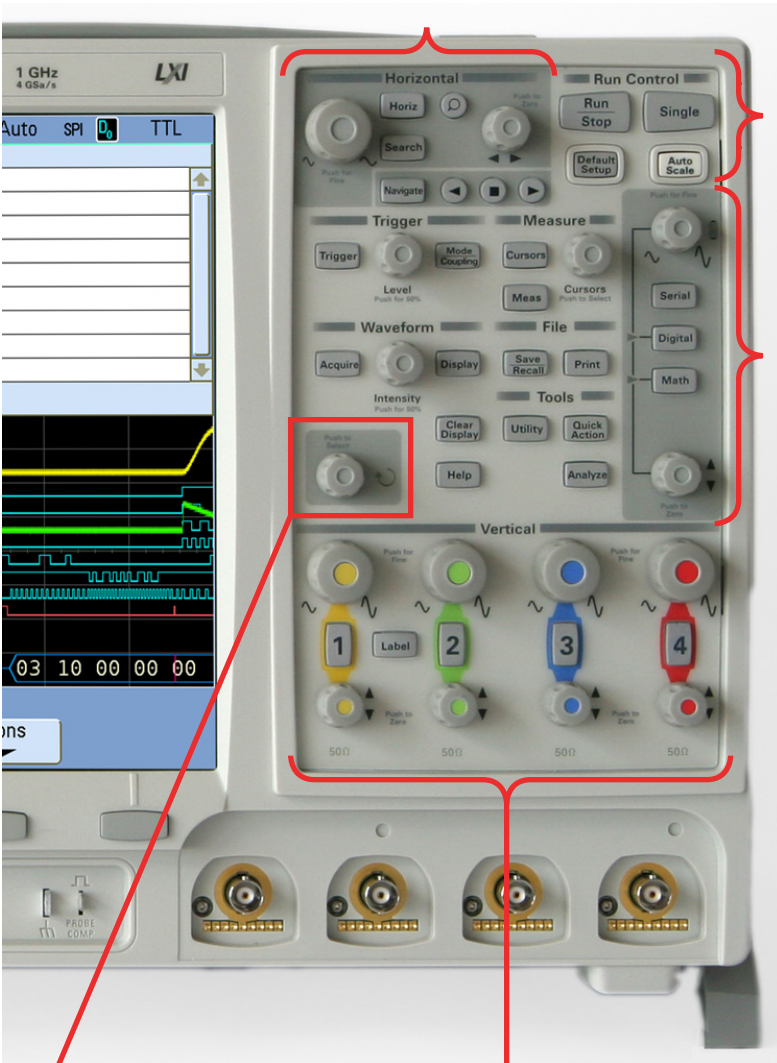
Serial Lister table shows a tabular view of captured serial data

Menu line for softkey control of menus selected on the front panel



Instant Help is available by simply pressing and holding down any key for 2 seconds

Horizontal controls  
Search and Navigate  
data record keys



Run control,  
default  
setup, and  
autoscale

Serial, digital,  
and math  
menu keys

Selection knob, immediate action keys,  
and special menus  
Push the knob to make a selection

Vertical color-coded  
controls for each  
oscilloscope channel

## Front Panel Overview

- 1 Run Control - When the oscilloscope is turned on, or if **[AutoScale]** is pressed, the acquisition will be set to **[Run]**. At any time you may **[Stop]** the acquisition process to examine a signal in detail or to save it.

- a The **[Default Setup]** key on the front panel sets the oscilloscope to the factory default configuration.



Because the oscilloscope may have been used in a variety of applications by a variety of people, it is a good measurement procedure to put the oscilloscope in a known starting mode (Default Setup). This will make it easy to duplicate measurements because no special conditions will be set.

- b The **[Autoscale]** key on the front panel automatically configures the oscilloscope by analyzing all active channels, turning them on and setting the time base, V/div, and trigger conditions for an initial display.
  - c Press the **[Single]** key to make a single acquisition and stop the acquisition process
- 2 Waveform:

- a The Waveform Intensity knob lets you set the desired signal brightness.
- b The **[Acquire]** key on the front panel lets you set the oscilloscope data acquisition modes.




### 3 Horizontal Control:

- a Turn the large knob in the Horizontal control section clockwise and counter-clockwise to control the time/div setting of the horizontal axis.



Observe the changes in the displayed signal. The current time base setting is displayed at the top of the display on the status line.

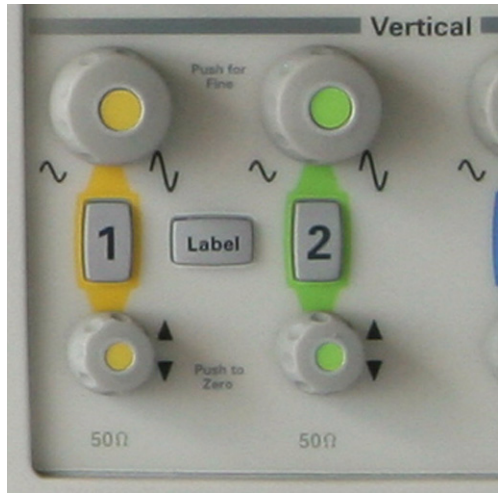
- b Turn the small knob in the horizontal control section to move the waveform horizontally from the trigger point.
- c Press the [**Horiz**] key to display the Horizontal menu. Note the various modes of Normal, Roll, XY and the zoom mode softkey.
- d Press the  zoom key to quickly turn on the zoom mode. This split-screen mode shows the big picture on top and an expanded view on the bottom. Turn the large time base knob counter clockwise to make the window on top larger.

For instant help on any topic, press and hold any key or softkey.



### 4 Vertical Controls:

- a Turn the **large yellow knob** in the Vertical section to control the V/div setting. The V/div setting is displayed in the upper left hand corner of the status line at the top of the display. Knobs are color coded to match the waveform color.
- b Press the [1] key to display the channel 1 menu. Press again to turn the channel on and off.
- c Turn the **small yellow knob** to control the offset position of the waveform, moving it up or down.



### 5 Trigger Controls:

- a Rotate the **Trigger Level knob** to move the trigger level up and down. The trigger level is displayed while it is adjusted. If the trigger level is above or below the signal, the oscilloscope will force a trigger and display a waveform when in Auto mode. Auto is a useful trigger mode to use, when unsure of the exact waveform, because activity will be displayed making it easy to better configure the oscilloscope's settings and trigger level.
- b Press the **[Mode/Coupling]** key in the Trigger controls section to view the coupling menu selections and to set trigger holdoff.
- c **Press and hold the Mode softkey** to read more about the Auto and Normal trigger mode using the built-in help system.





### 6 Tools:

- a Press the [**Clear Display**] key to clear the display.
- b Press the [**Help**] key to access the help menu.
- c Press the [**Utility**] key to access the file explorer, I/O ports, printer interface, language selection, and to set up the “Quick Action” mode.
- d Press the [**Quick Action**] key to perform a quick print of the screen or capture a screen image.
- e Press the [**Analyze**] key to access precision measurement mode or the mask testing application.





# 1 Capturing and Viewing Complex Signals with MegaZoom Technology

Viewing deep memory acquisitions on oscilloscopes often result in slow waveform update rates. Agilent's MegaZoom technology automatically turns on deep memory when needed to maximize resolution, while also maintaining responsive waveform update rates. In addition, Agilent's MegaZoom technology provides the highest waveform display resolution in the industry with up to 256 levels of intensity to show subtle waveform details. In this lab, we will capture a complex video waveform. We will then use various techniques to zoom-in and analyze the deep memory acquisition results.

## Setup

- 1 Connect the demo kit's 40-pin ribbon cable from the back of the Agilent InfiniiVision Series oscilloscope to the 40-pin connector on the demo board.
- 2 Connect channel 1 probe to the CH1 test point and ground (GND).
- 3 Connect channel 2 probe to the CH2 test point and ground (GND).
- 4 Set the rotary switch on the demo board for the Video signal (Mode #0).
- 5 Press **[Default Setup]**.

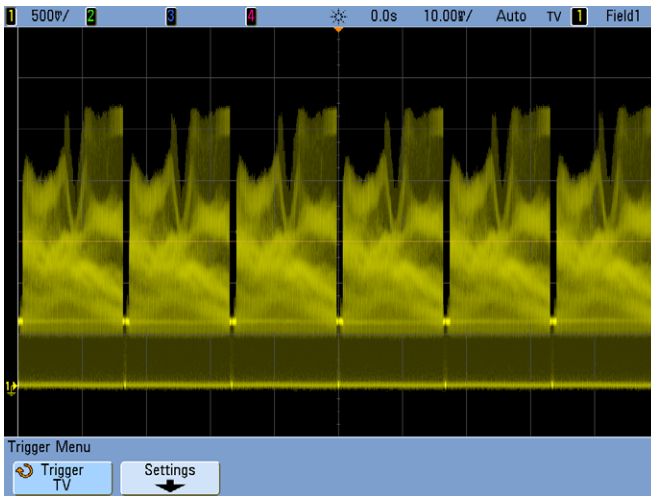
The oscilloscope is now set in the factory default configuration – just as it left the factory. Because the oscilloscope may have been used in a variety of applications by a variety of people, it is a good practice to put the oscilloscope in a known beginning setup state (Default Setup). This will make it easier to duplicate measurements for our labs because no special conditions will be set.



- 6 Set the channel 1 vertical scale to 500 mV/div using the large yellow knob.



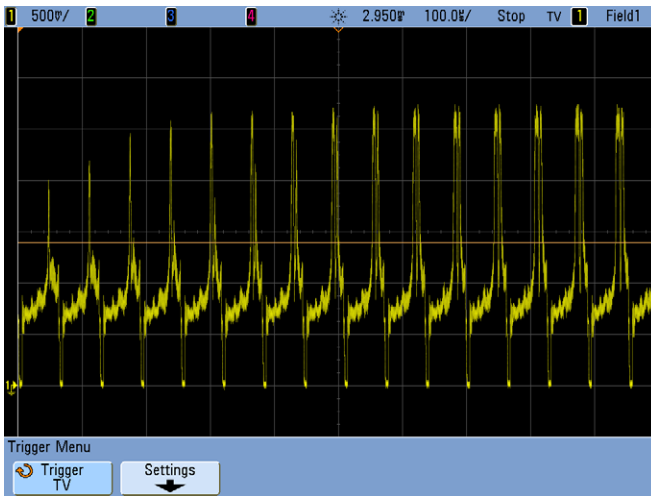
- 7 Set the channel 1 vertical offset to 1.5 V using the small yellow knob.
- 8 Set the timebase to 10.0 ms/div.
- 9 Press **[Trigger]**; then, select the **TV** triggering mode.
- 10 Push the Waveform Intensity knob to set the waveform intensity at 50%.





The oscilloscope is now capturing a complex video waveform utilizing Agilent’s MegaZoom technology. MegaZoom provides responsive deep memory acquisitions for fast waveform update rates. In addition, this technology provides up to 256 levels of waveform intensity to show complex details of your signals. Wave your hand in front of the video camera’s lens to see the responsiveness of the display while the oscilloscope’s is repetitively capturing deep memory. Let’s now zoom-in on this waveform and analyze it with higher visual resolution.

- 11 Press **[Single]** to perform a deep memory, single-shot acquisition (8,000,000 points).
- 12 Set the timebase to 100.0  $\mu$ s/div.
- 13 Press the **[▶]** forward key (near the **[Navigate]** key) to automatically scroll forward through the captured waveform.
- 14 Press the **[◀]** back key to stop scrolling; then, press it again to scroll back through the waveform.
- 15 Press the **[▶]** forward or the **[◀]** back keys multiple times to adjust the speed of scrolling/panning.

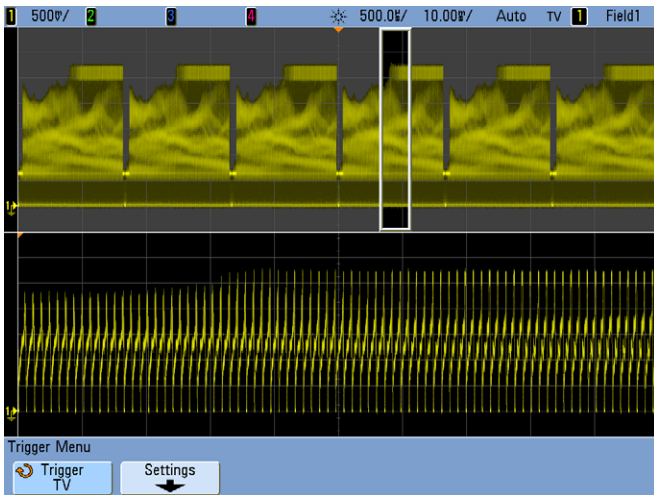
## 1 Capturing and Viewing Complex Signals with MegaZoom Technology



Note that, in addition to using the oscilloscope's automatic navigation capability to scroll through a deep memory acquisition, you can also manually use the horizontal controls (time/div, delay, and "zoom mode") to zoom-in on and scroll to particular parts of the captured waveform. Let's now use the "Zoom" function to view the waveform while using two different timebase settings.

- 16 Press the  stop key.
- 17 Push the horizontal delay/position knob to set the delay back to 0.0 sec.
- 18 Set the timebase back to 10.0 ms/div.
- 19 Press **[Run/Stop]** to begin repetitive acquisitions again.
- 20 Press the  zoom key to view our waveform using two different timebase settings.
- 21 Set the "zoom" timebase to 1.0 ms/div using the large timebase control knob.

- 22 Adjust the horizontal position/delay knob to view different parts of our waveform with higher resolution.





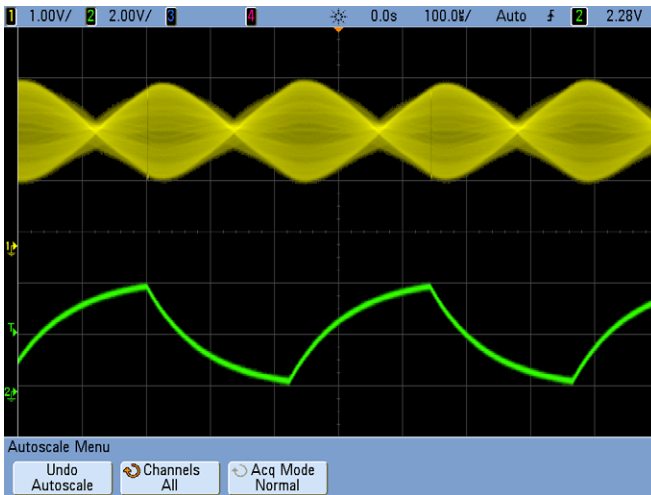
## 2 Using Auto Scale, Cursors, Measurements, and Waveform Math

In this lab, we use some of the automatic set up and measurement capabilities of the Agilent InfiniiVision Series oscilloscope including Auto Scale, cursor measurements, automatic parametric measurements, and waveform math functions.

### Setup

- 1 Connect the demo kit's 40-pin ribbon cable from the back of the Agilent InfiniiVision Series oscilloscope to the 40-pin connector on the demo board.
- 2 Connect channel 1 probe to the CH1 test point and ground (GND).
- 3 Connect channel 2 probe to the CH2 test point and ground (GND).
- 4 Set the rotary switch on the demo board for the AM signal (Mode #1).
- 5 Press **[Default Setup]**.
- 6 Press **[Auto Scale]**.
- 7 Push the Waveform Intensity knob to set the waveform intensity at 50%.





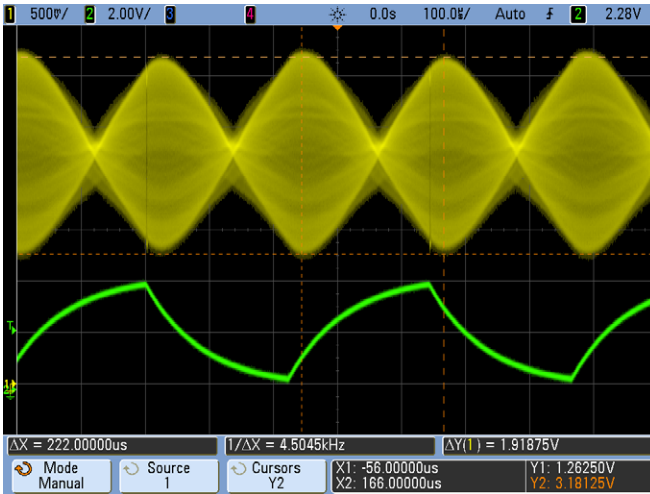
When [Auto Scale] is pressed, the oscilloscope automatically turns on and optimally scales (V/div) for all channels that have signal activity... including digital channels. Triggering is set to the standard “edge” mode on the highest analog channel number, which is channel 2 in this demo example. The timebase is set to display at least two cycles of the trigger source channel, which is based on channel 2 in this demo example. Let’s now manually rescale the channel 1 waveform, and then perform manual cursor measurements.

- 8 Set the channel 1 vertical scale to 500 mV/div and the vertical offset to 1.5 V (yellow knobs).
- 9 Push the Cursors knob; then, turn it to select the X1 cursor from the popup menu.
- 10 When the popup menu closes, turn the Cursors knob to set the X1 timing cursor near one of the peaks of the channel 1 modulated waveform.
- 11 Push the Cursors knob; then, turn it to select the X2 cursor from the popup menu.
- 12 When the popup menu closes, turn the Cursors knob to set the X2 timing cursor near the next peak of the channel 1 modulated waveform. The difference in X cursors shows the time between peaks of the envelope ( $\Delta X = 220.0 \mu\text{s}$ ).
- 13 Push the Cursors knob; then, turn it to select the Y1 cursor from the popup menu.



## 2 Using Auto Scale, Cursors, Measurements, and Waveform Math

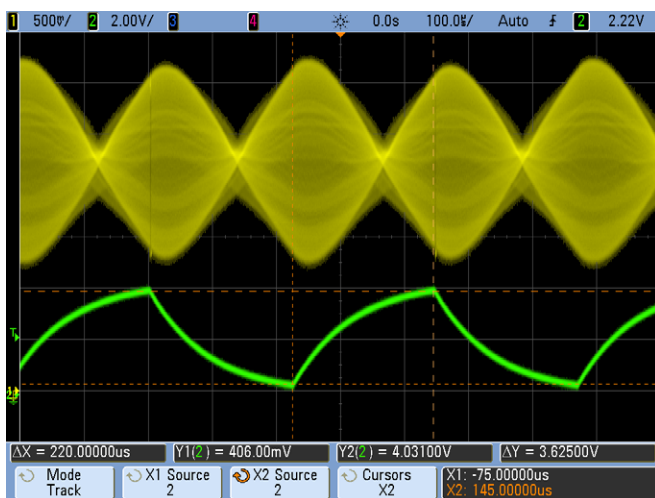
- 14 When the popup menu closes, turn the Cursors knob to set the Y1 voltage cursor at the bottom of the channel 1 waveform.
- 15 Push the Cursors knob; then, turn it to select the Y2 cursor from the popup menu.
- 16 When the popup menu closes, turn the Cursors knob to set the Y2 voltage cursor at the top of the channel 1 waveform. The difference in Y cursors shows the peak-to-peak amplitude of the envelope ( $\Delta Y = 2.0\text{ V}$ ).



Now that we've determined timing and voltage characteristics of the channel 1 modulated waveform using "manual" cursors, let's now perform "tracking" cursor measurements on the channel 2 waveform.

- 17 Press **Mode – Manual**; then, select **Track Waveform**.
- 18 Press **X1 Source** two times to assign the X1 tracking cursor to channel 2.
- 19 Press **X2 Source** two times to assign the X2 tracking cursor to channel 2.
- 20 Push the Cursors knob; then, turn it to select the X1 cursor from the popup menu.
- 21 When the popup menu closes, turn the Cursors knob to set the X1 cursor at the bottom of the channel 2 waveform using the Cursors knob.
- 22 Push the Cursors knob; then, turn it to select the X2 cursor from the popup menu.
- 23 When the popup menu closes, turn the Cursors knob to set the X2 cursor at the top of the channel 2 waveform using the Cursors knob.



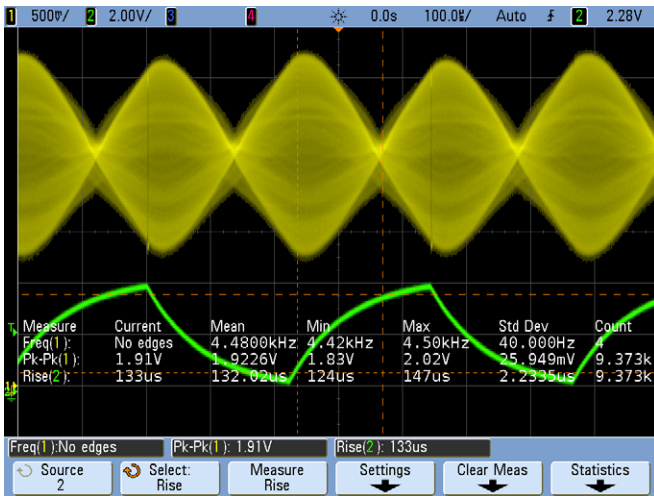


With “tracking” cursors, the voltage cursors “track” the selected waveform based on the position of the timing cursor (X1 and X2). Let’s now perform some automatic parametric measurements on these waveforms.

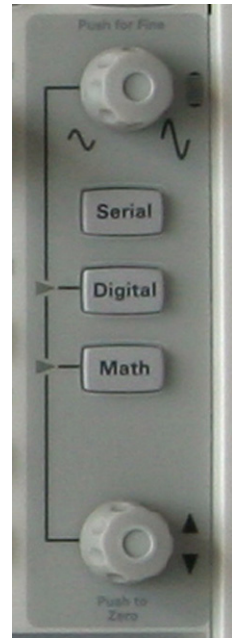
- 24 Press **[Meas]**.
- 25 Press **Source**; then, select **2**.
- 26 Press **Select**; then, select **Rise Time**.
- 27 To begin executing the “Rise Time” measurement on channel 2, either push the selection knob or press **Measure Rise**.

Up to four automatic parametric measurements can be selected and displayed with a complete set of measurement statistics. Default threshold levels for the rise and fall time measurements are set at 10% and 90%. All other timing measurements utilize the 50% threshold levels. If desired, threshold levels can be manually set to other relative (%) or absolute values (V). Let’s now perform a waveform math function (FFT) on the channel 1 waveform to determine the carrier frequency of this amplitude-modulated signal.

## 2 Using Auto Scale, Cursors, Measurements, and Waveform Math



- 28 Press **[Math]**.
- 29 Press **Operator**; then, select **FFT**.
- 30 Press **[Analyze]** (in the Tools section); then, select **Precision**.
- 31 Press **Feature – Precision** two times to engage higher precision waveform math.
- 32 Press **[Run/Stop]** to stop acquisitions.
- 33 Press **[Cursors]**.
- 34 Press **X1 Source**; then, select **Math: f(t)**.
- 35 Press **X2 Source**; then, select **Math: f(t)**.
- 36 Push the Cursors knob; then, turn it to select the X1 cursor from the popup menu.
- 37 When the popup menu closes, turn the Cursors knob to set the “X1” cursor on the highest peak of the FFT waveform.





The value of the “X1” cursor should now be measuring the carrier frequency of this signal, which is 2.0 MHz. Without “Precision” turned on, all automatic parametric measurements and waveform math provide approximately 0.1% measurement resolution based on the oscilloscope’s full-screen timebase setting. When “Precision” is turned on, at the cost of waveform update rate, measurement resolution increases to approximately 0.001%. The FFT measurement, which we used in this demonstration, is the slowest math function.



### 3 Discovering an Infrequent Glitch with Fast Waveform Update Rates

Capturing infrequent anomalies such as random glitches requires oscilloscopes with extremely fast update rates. Fast update rates improve the probability of capturing random events. This lab demonstrates capturing a glitch that occurs approximately one time every 30,000 cycles of a digital data stream. With up to 100,000 waveforms/sec update rate, we will be able to view this glitch multiple times a second. Oscilloscopes with longer dead times will have difficulty capturing and displaying this glitch.

## Setup

- 1 Connect the demo kit's 40-pin ribbon cable from the back of the Agilent InfiniiVision Series oscilloscope to the 40-pin connector on the demo board.
- 2 Connect channel 1 probe to the CH1 test point and ground (GND).
- 3 Connect channel 2 probe to the CH2 test point and ground (GND).
- 4 Set the rotary switch on the demo board for the Data w/ Glitch signal (Mode #2).

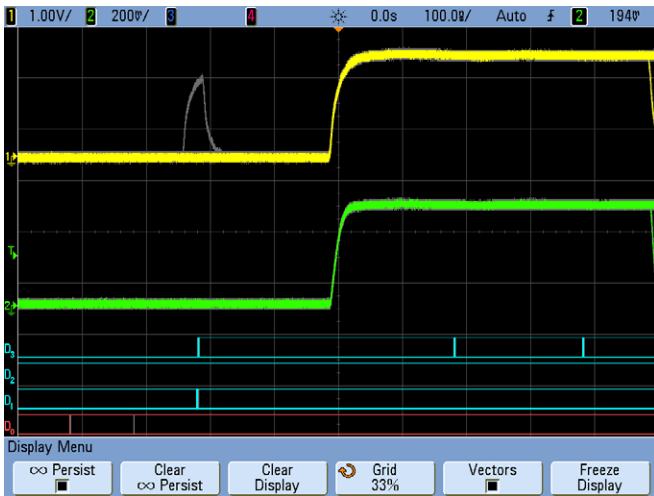
- 5 Press [**Default Setup**].
- 6 Press [**Auto Scale**].
- 7 Change the timebase to 100 ns/div.
- 8 Adjust the Waveform Intensity knob to 100% to more clearly see the infrequent glitch on channel 1 (yellow trace).



Note that the glitch is captured multiple times per second, thanks to Agilent's MegaZoom technology which minimizes dead time between acquisitions. Fast waveform update rates can even be achieved when digital channels are turned as demonstrated in this example.

- 9 To permanently capture the infrequent glitch, press [**Display**]; then, press  $\infty$  **Persist**.



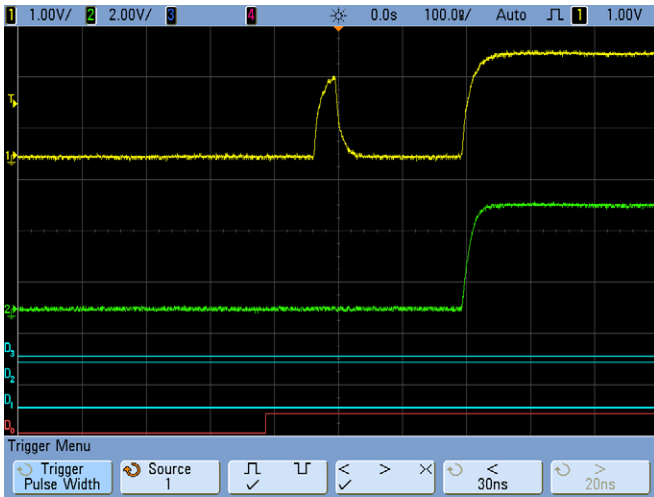


With the infinite persistence mode, all repetitive and “historical” acquisitions are accumulated and displayed on screen. This can be very useful when setting up an overnight measurement to capture an elusive event. Let’s now set up a glitch trigger condition that will trigger exclusively on the anomaly.

- 10 Press **[Display]**; then, press  $\infty$  **Persist** to turn off the infinite persistence display mode.
- 11 Press **Clear Display** to clear previous acquisitions.
- 12 Press **[Trigger]**; then, select the **Pulse Width** trigger mode.

### 3 Discovering an Infrequent Glitch with Fast Waveform Update Rates

13 Next, press **Source**; then, select channel 1 as the input trigger source.





## 4 Using Pass/Fail Mask Testing to Discover a Signal Violation

With mask testing you can set up a pass/fail test criteria for automatically testing waveforms to see if they conform to specific wave shapes. In this lab we will test a digital signal that includes an infrequent glitch. With InfiniiVision's hardware-based mask testing capability, we will be able to test up to 100,000 waveforms per second and gain insight into the statistical occurrences of this particular glitch. To enable Mask Testing, your oscilloscope must have the mask test option (Option LMT) installed. You can verify the installed options on your oscilloscope at **[Utility] > Service > About Oscilloscope**.

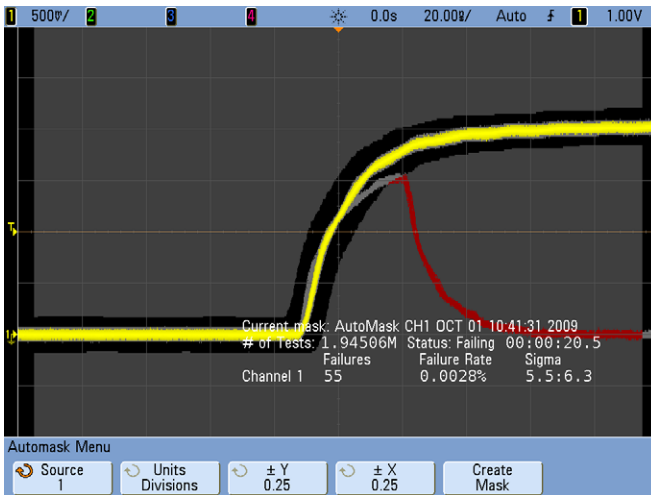
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- 1 Connect the demo kit's 40-pin ribbon cable from the back of the Agilent InfiniiVision Series oscilloscope to the 40-pin connector on the demo board.
- 2 Connect channel 1 probe to the CH1 test point and ground (GND).
- 3 Connect channel 2 probe to the CH2 test point and ground (GND).
- 4 Set the rotary switch on the demo board for the Data w/ Glitch signal (Mode #2).
- 5 Press **[Default Setup]**.
- 6 Set the channel 1 vertical scale to 500 mV/div and the vertical offset to 1.0 V.
- 7 Push the Trigger Level knob to set the trigger level at 50%.
- 8 Set the timebase to 20 ns/div.
- 9 Set the waveform intensity to 100% using the Waveform Intensity knob (full clockwise).
- 10 Press **[Analyze]**.
- 11 Press **Features Mask** two times to turn on mask testing.
- 12 Press **Automask**.



## 4 Using Pass/Fail Mask Testing to Discover a Signal Violation

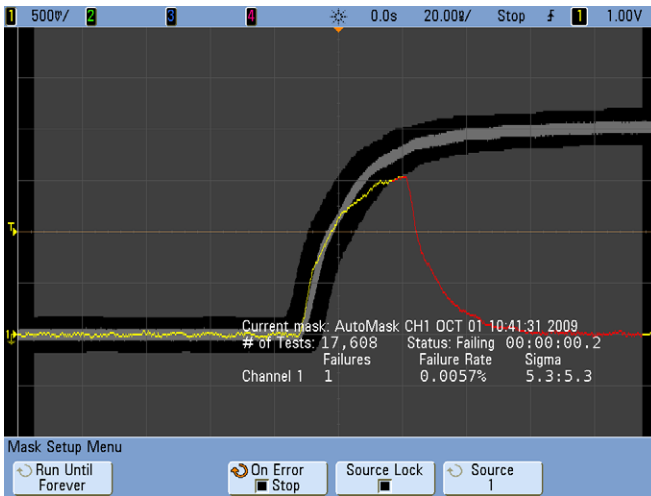
- 13 Press **Create Mask** to automatically create a pass/fail mask around this waveform.



Because the InfiniiVision oscilloscope's mask testing capability is hardware-based, it can test up to 100,000 waveforms/sec and provide detailed pass/fail statistics including failure rate in terms of both percent and a Sigma quality factor. A Sigma quality factor of  $6\sigma$  relates to approximately three or fewer defects per million tested. Let's now set up the oscilloscope to stop on the first failure.

- 14 Press **[Run/Stop]** to stop acquisitions.
- 15 Press the **Back** back/up key.
- 16 Press **Statistics**.
- 17 Press **Reset Statistics** to clear the statistics from the previous test.
- 18 Press the **Back** back/up key.
- 19 Press **Setup**.
- 20 Press **On Error – Stop** two times.
- 21 Press **[Clear Display]**.
- 22 Press **[Run/Stop]** to begin a new "Stop-on-Error" test.





In addition to stopping acquisitions when an error is detected, you can also save a waveform, save an image, print, or perform a specific measure when an error is detected. Using the “Run Until” selection, you can also set up mask testing to run for a specific number of tests, minimum time, or minimum Sigma test criteria. Note that in addition to creating a pass/fail mask using the auto-mask creation feature as demonstrated in this lab, you can also import a mask based on industry specifications, such as an eye-diagram mask, from a USB memory device. These types of imported masks can be easily created within a standard text editor, such as NotePad, on your PC.



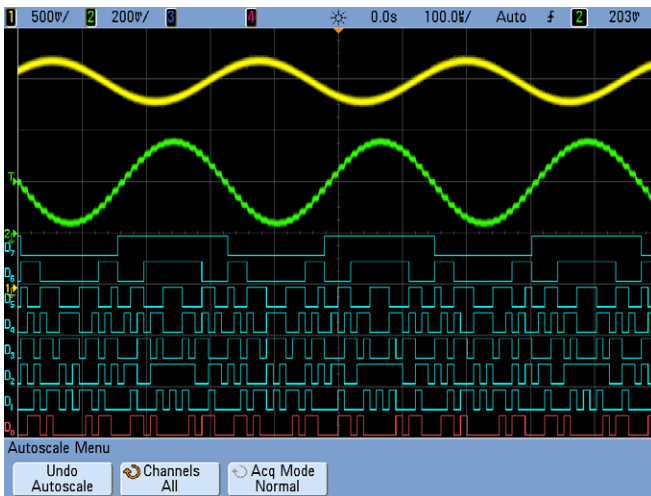
## 5 Viewing Multiple Signals in an MCU-based Design with an MSO

In mixed analog and digital designs, it is often important to view multiple analog and digital channels, which is significantly beyond the capability of a typical 2- or 4-channel oscilloscope. With 2 or 4 oscilloscope channels plus 16 logic timing channels, the unique Mixed Signal Oscilloscope (MSO) affords the opportunity to view more signals and to make time-correlated measurements across all channels.

### Setup

- 1 Connect the demo kit's 40-pin ribbon cable from the back of the Agilent InfiniiVision Series oscilloscope to the 40-pin connector on the demo board.
- 2 Connect channel 1 probe to the CH1 test point and ground (GND).
- 3 Connect channel 2 probe to the CH2 test point and ground (GND).
- 4 Set the rotary switch on the demo board for the DAC signal (Mode #4).
- 5 Press **[Default Setup]**.
- 6 Press **[Auto Scale]**.
- 7 Push the Waveform Intensity knob to automatically set the waveform intensity to 50%.

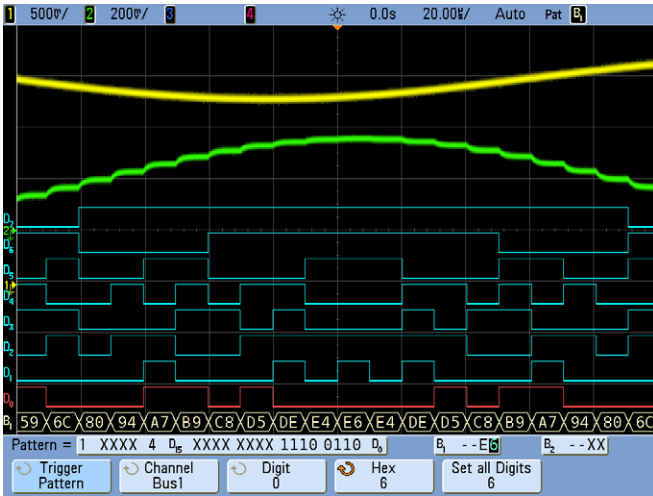




The channel 2 signal (green trace) shows the stair-step sine wave output of microcontroller-based Digital-to-Analog Converter (DAC). The channel 1 signal (yellow trace) is a low-pass filtered version of the DAC output. Channels D0 – D7 (blue, red) are the digital inputs to the DAC. Using Auto Scale, the oscilloscope triggers on channel 2, which in this example is a repetitive sine wave. However, what if we wanted to trigger on a specific DAC input value using pattern trigger?

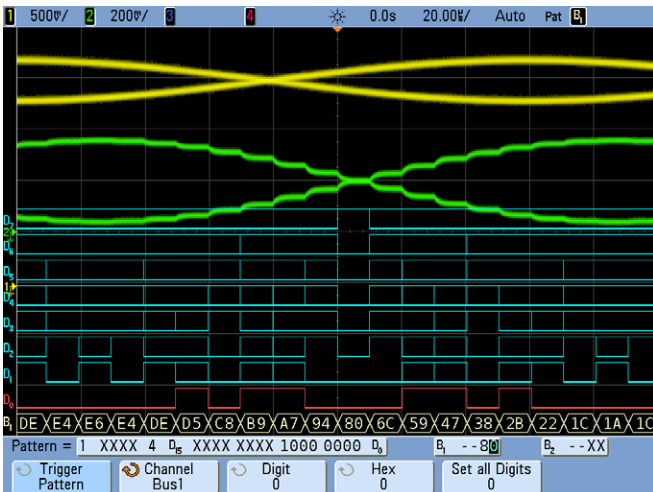
- 8 Press **[Digital]**.
- 9 Press **Bus**.
- 10 Press **Bus-Bus1** two times to turn on the bus display mode. This will display an overlay of digital channels D0 through D7.
- 11 Set the timebase to 20  $\mu$ s/div in order to read the state of this 8-bit bus.  
Note that when the DAC output, which is the channel 2 waveform (green trace), is at its highest level, Bus1 has a hex value of E6. Let's now set up the oscilloscope to trigger on this condition.
- 12 Press **[Trigger]**.
- 13 Change the trigger mode to **Pattern**.
- 14 Press **Channel**; then, select **Bus1**.
- 15 Press **Hex**; then, select "E".
- 16 Press **Digit**; then, select the "0" digit.
- 17 Press **Hex** ; then, select "6".

## 5 Viewing Multiple Signals in an MCU-based Design with an MSO



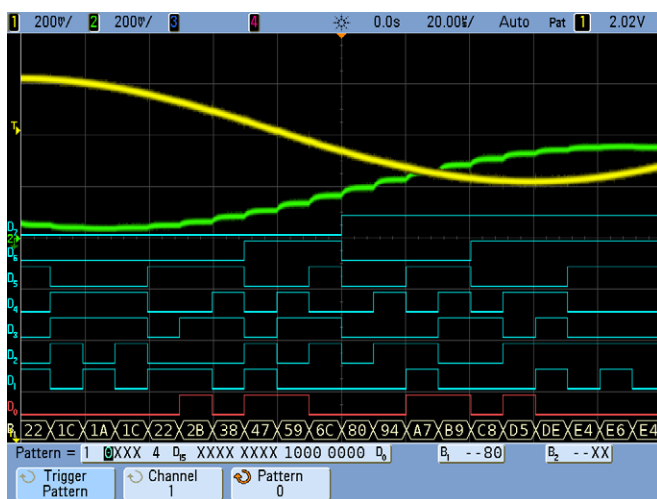
The oscilloscope should now be triggering (trigger point at center-screen) on pattern E6 on Bus1 (D7-D0 = 1110 0110), which is coincident with the highest output level of the DAC. Triggering at this point using simple edge triggering on channel 2 would be virtually impossible. Let's now set up the oscilloscope to trigger at the 50% output level of the DAC using pattern triggering.

- 18 Using the **Digit** and **Hex** softkeys along with the selection knob, change the B1 pattern to "80 hex" (1000 0000).



Although the oscilloscope should be triggering on a stable pattern of “80h” on Bus1, you should be seeing two phases of the sine wave. This is because this particular pattern occurs both when the output of the DAC is increasing in value and decreasing in value. Let’s further qualify the trigger condition using mixed-signal triggering (analog + digital triggering) in order to trigger only when the DAC is increasing in value.

- 19 First, set the channel 1 vertical scale to 200 mV/div and the vertical offset to 1.6 V.
- 20 Next, press **Channel B1**; then, select **1**.
- 21 Now, press **Pattern X**; then, select “**0**” as the pattern on channel 1.



The oscilloscope should now be triggering on pattern “80h” of B1 while channel 1 is low (or below its trigger level).



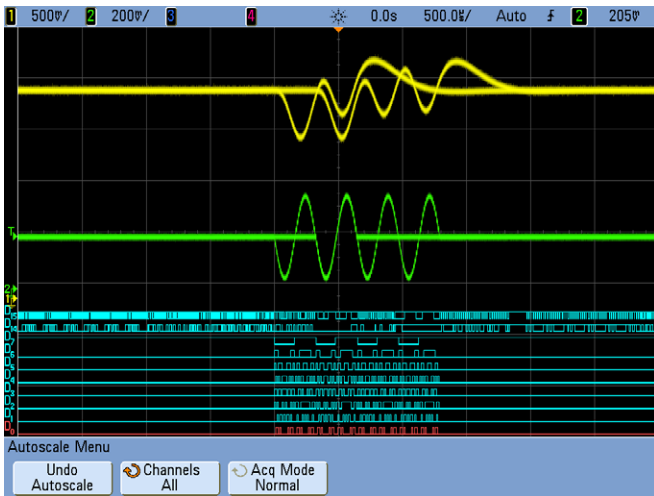
## 6 Verifying I<sup>2</sup>C Serial Bus Communication

Many of today's embedded designs include serial bus communications using protocols such as I<sup>2</sup>C (Inter-Integrated Circuit). The I<sup>2</sup>C bus is primarily used for chip-to-chip communications. In this lab you will see that the I<sup>2</sup>C bus generates a series of commands to instruct the microcontroller to generate three specific chirps (or bursts) with a varying numbers of pulses. Our goal is to synchronize the oscilloscope's display on specific chirps using the oscilloscope's I<sup>2</sup>C trigger capabilities and verify the serial data transmissions. To enable I<sup>2</sup>C decoding, your oscilloscope must have the low-speed serial bus decode option (Option LSS) installed. You can verify the installed options on your oscilloscope at **[Utility] > Service > About Oscilloscope**.

### Setup

- 1 Connect the demo kit's 40-pin ribbon cable from the back of the Agilent InfiniiVision Series oscilloscope to the 40-pin connector on the demo board.
- 2 Connect channel 1 probe to the CH1 test point and ground (GND).
- 3 Connect channel 2 probe to the CH2 test point and ground (GND).
- 4 Set the rotary switch on the demo board for the I<sup>2</sup>C signal (Mode #5).
- 5 Press **[Default Setup]**.
- 6 Press **[Auto Scale]**.
- 7 Set the timebase to 500  $\mu$ s/div.

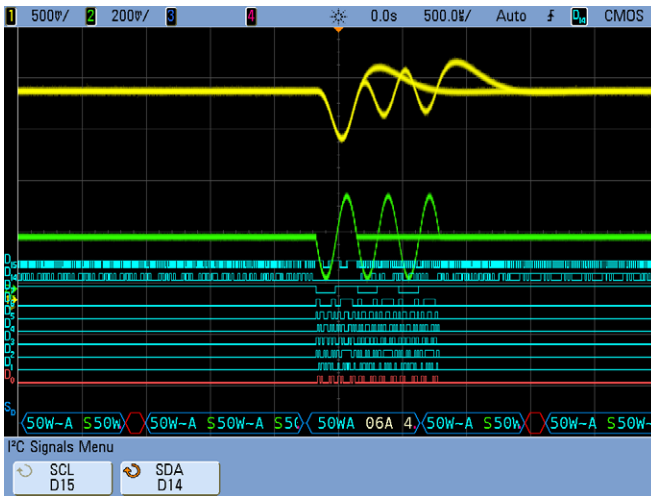




Notice that the oscilloscope may trigger on multiple chirps of different lengths (1, 2, or 3 cycles) using standard edge triggering (default trigger mode after Auto Scale). To trigger on the first chirp that consists of three sine wave cycles, we can set up the I<sup>2</sup>C triggering of the oscilloscope to trigger on a Write cycle based on a specific address and serial data content. Digital signals D7-D0 are the digital inputs to the DAC generated by the MCU. D15 is the I<sup>2</sup>C clock signal (SCL) and D14 is the I<sup>2</sup>C data signal (SDA). Before we set up the trigger condition, we will first turn on I<sup>2</sup>C serial decoding. Note that although the I<sup>2</sup>C clock and data signals are being captured by the digital channels of the oscilloscope, I<sup>2</sup>C triggering and decoding on the oscilloscope can also utilize the analog channels as input sources for the clock and data signals.

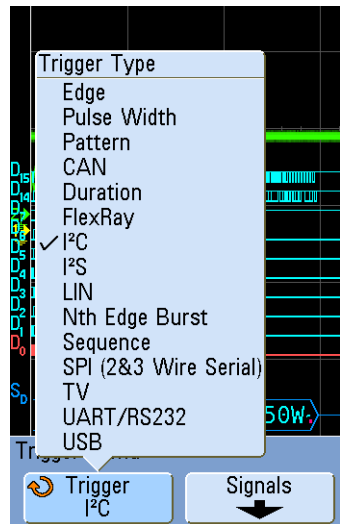
- 8 Press **[Serial]**; then, select the I<sup>2</sup>C decode mode (default serial decode mode).
- 9 Press **Settings**; then, select **D15** as the clock input source (SCL).
- 10 Next, press **SDA**; then, select **D14** as the data input source (SDA).

## 6 Verifying I<sup>2</sup>C Serial Bus Communication

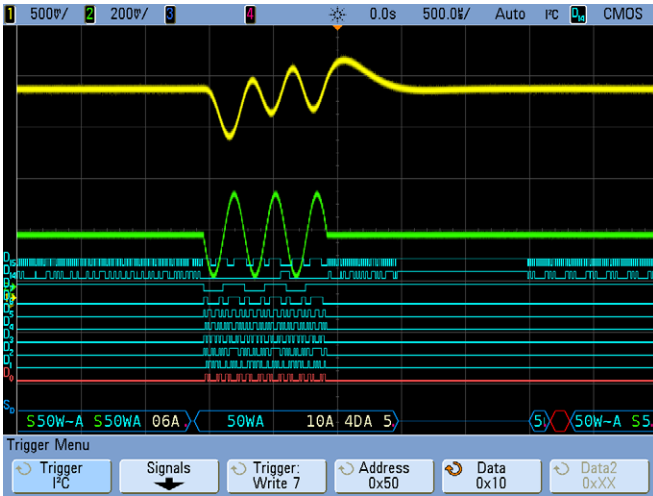


You should now be able to view the time-aligned serial decode trace at the bottom of the display showing I<sup>2</sup>C decoding of D14 (SDA). But the oscilloscope is not yet triggering on I<sup>2</sup>C. It is still triggering on an edge crossing of channel 2. Let's now set up the oscilloscope to trigger on a Write operation to address 0x50hex with an Acknowledge, followed by a data value of 0x10hex.

- 11 Press **[Trigger]**; then, select the **I<sup>2</sup>C** trigger mode.
- 12 Now press **Trigger:Start**; then, select **o Frame(Start:Addr7:Write:Ack:Data)** as the trigger condition
- 13 Press **Address 0xXX**; then, select **0x50**.
- 14 Press **Data 0xXX**; then, select **0x10**.



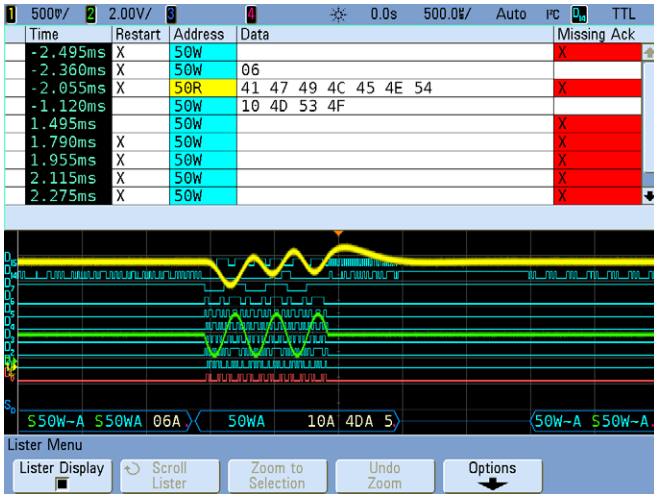




The oscilloscope should now be triggering on a Write operation to Address 50 hex with an Acknowledge (50WA), followed by a data byte value of 10 hex with an acknowledge (10A). This particular trigger condition is coincident with a transmission of a 3-cycle analog chirp shown on channel 1 (yellow waveform) and channel 2 (green waveform). Let's now view the I<sup>2</sup>C decoded data in the "lister" format.

- 15 Press **[Serial]**.
- 16 Press **Lister**.
- 17 Next, press **Lister Display** to turn on the Lister display mode.

## 6 Verifying I<sup>2</sup>C Serial Bus Communication



**18** To scroll through a stored list of I<sup>2</sup>C packets, first press **[Run/Stop]** to stop acquisitions.

**19** Rotate the selection knob to scroll through the list with direct time-correlation to the captured waveforms.

For additional information on how to automatically search and navigate within the Lister display, refer to ["Using Serial Search and Navigation"](#) on page 67.



## 7 Verifying SPI Serial Bus Communication

Another common serial bus protocol used in many embedded designs is the Serial Peripheral Interface (SPI) bus. Although this bus requires more signals than the I<sup>2</sup>C bus, it is a very flexible serial bus protocol that the designer can define, such as customizing the number of bits in each serial transmission. While the I<sup>2</sup>C bus is primarily used for chip-to-chip communication within a single PC board, the SPI bus can be used for chip-to-chip communication or for serial communication to nearby peripherals. To enable SPI decoding, your oscilloscope must have the low speed serial bus decode option (Option LSS) installed. You can verify the installed options on your oscilloscope at [**Utility**] > **Service** > **About Oscilloscope**.

### Setup

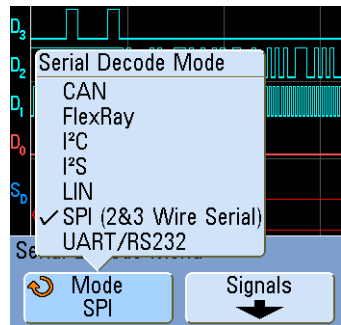
- 1 Connect the demo kit's 40-pin ribbon cable from the back of the Agilent InfiniiVision Series oscilloscope to the 40-pin connector on the demo board.
- 2 Connect channel 1 probe to the CH1 test point and ground (GND).
- 3 Connect channel 2 probe to the CH2 test point and ground (GND).
- 4 Set the rotary switch on the demo board for the SPI signal (Mode #6).
- 5 Press [**Default Setup**].
- 6 Press [**Auto Scale**].



## 7 Verifying SPI Serial Bus Communication

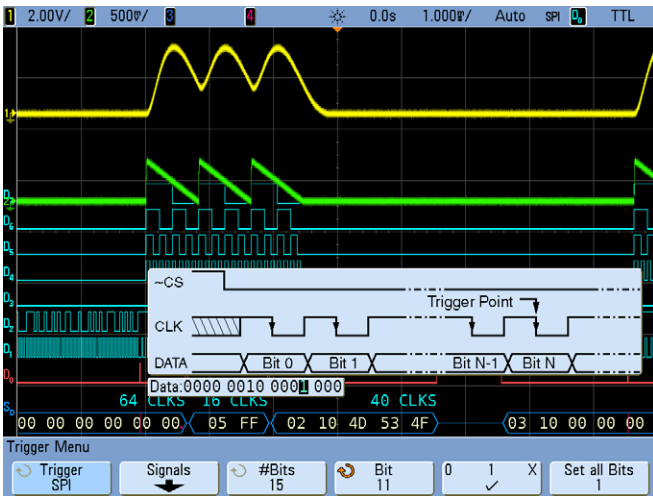
- 7 Press [**Serial**]; then, select the **SPI** decode mode.
- 8 Press **Signals**; then, select the **D1** as the Clock source.
- 9 Press **Data**; then, select **D3** as the serial data signal source.
- 10 Press **~CS**; then, select **D0** as the Chip Select (not) source.

You should now be able to view the SPI serial decode trace at the bottom of the display.



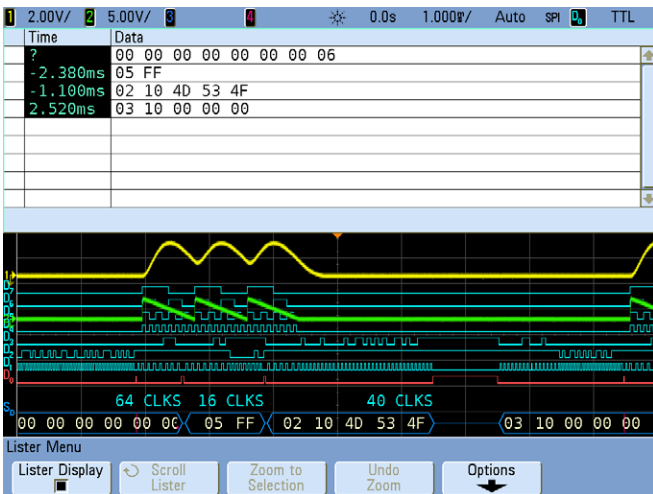
Let's now set up the oscilloscope to trigger on a specific SPI transmission of data (02 10) in order to synchronize acquisitions coincident with a specific burst of the analog signals.

- 11 Press [**Trigger**]; then, select the **SPI** trigger mode.
- 12 Press **#Bits**; then, select **16** as the number of bits to trigger on.
- 13 Press **0 1 X** to select "0"; then, press **Set all Bits 0** to preset all 16 bits to "0".
- 14 Using the **Bit** softkey, the selection knob, and the **0 1 X** softkey, enter "000 0010 0001 0000" as the specific serial bit pattern to trigger on.



The oscilloscope should now be triggering on a stable serial pattern showing a 3-cycle “chirp” on the oscilloscope’s display. Let’s now set up the oscilloscope to display the decoded SPI data in a “lister” format.

- 15 Press **[Serial]**.
- 16 Press **Lister**.
- 17 Press **Lister Display** to turn on the Lister display mode.



- 18 To scroll through a stored list of SPI packets, first press **[Run/Stop]** to stop acquisitions.

## 7 Verifying SPI Serial Bus Communication

**19** Rotate the selection knob to scroll through the list with direct time-correlation to the captured waveforms.

For additional information on how to automatically search and navigate within the lister display, refer to ["Using Serial Search and Navigation"](#) on page 67.



## 8 Verifying RS-232/UART Serial Bus Communication

The RS-232 and UART serial buses are typically used to communicate between a CPU/MCU and peripheral devices such as printers, storage devices, and/or EEPROM programmers. The bus consists of separate transmit and receive signals and the clock is embedded in these signals. The RS-232/UART bus is very flexible in terms of user-definable baud rates, number of bits, bit polarity, bit order, and parity. Each of the parameters can be defined on the Agilent InfiniiVision Series oscilloscope for triggering and decoding this bus. You can also use the RS-232/UART trigger and decode option on many RS-485 applications because the RS-485 specification is an electrical specification only; not a protocol specification. To enable RS-232/UART decode and triggering, your oscilloscope must have the RS-232/UART serial bus decode option (Option 232) installed. You can verify the installed options on your oscilloscope at [**Utility**] > **Service** > **About Oscilloscope**.

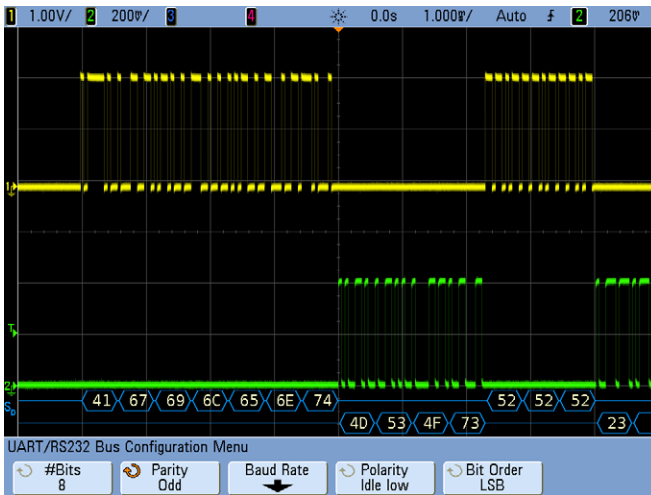
### Setup

- 1 Connect the demo kit's 40-pin ribbon cable from the back of the Agilent InfiniiVision Series oscilloscope to the 40-pin connector on the demo board.
- 2 Connect channel 1 probe to the CH1 test point and ground (GND).
- 3 Connect channel 2 probe to the CH2 test point and ground (GND).
- 4 Set the rotary switch on the demo board for the RS-232 signal (Mode #7).
- 5 Press [**Default Setup**].
- 6 Press [**Auto Scale**].
- 7 Set the timebase to 1.0 ms/div.
- 8 To turn on UART/RS-232 decode, first press [**Serial**]; then, select the **UART/RS232** serial decode mode.



## 8 Verifying RS-232/UART Serial Bus Communication

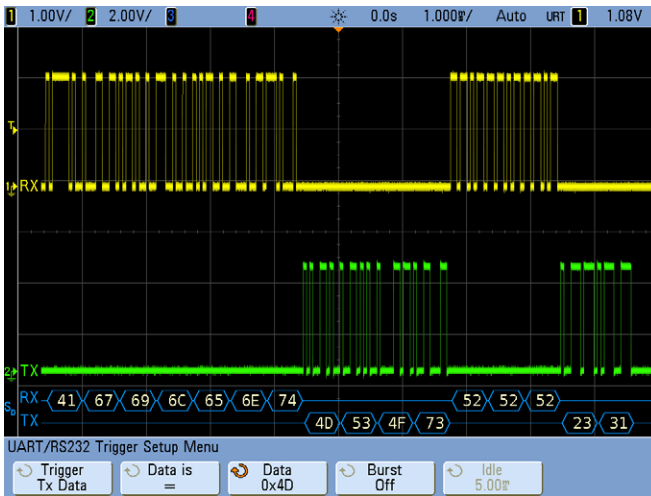
- 9 To configure the bus for odd parity, press **Bus Config**; then, press **Parity** three times to select **Odd** parity.



The oscilloscope should now be decoding both the transmit and receive RS-232 signals in hex format. Let's now turn on default RS232 waveform labels so that we can see which analog channel is capturing the transmit data stream and which analog channel is capturing the receive data stream. Let's also set up the oscilloscope to trigger on a specific transmit byte (0x4D). The oscilloscope should currently be triggering on an edge crossing of channel 2 (Auto Scale default triggering).

- 10 Press **[Label]** (between the channel 1 and channel 2 keys) to turn on default labels.
- 11 Press **[Trigger]**; then, select the **UART/RS232** triggering mode.
- 12 Press **Trigger Setup**; then, select **Tx Data**.
- 13 Next, press **Data 0x00**; then, select **0x4D**.





With default labels turned on, we can now clearly see which input signals are the transmit (TX) and receive (RX) signals, and which serial decode trace is the transmit decode (TX) and the receive decode (RX). In addition, we should see that the oscilloscope is triggering on 4D hex of the transmit signal at exactly center-screen. Note that in addition to decoding and triggering on hex formatted data, the InfiniiVision Series oscilloscopes are also able to decode and trigger on binary and ASCII formatted data. Let's change the decode base from the default hex setting to ASCII and see if we can uncover a secret encoded message generated by the demo board's signals.

- 14 Press **[Serial]**; then, press **Settings**.
- 15 Press **Base**; then, select **ASCII**.

## 8 Verifying RS-232/UART Serial Bus Communication

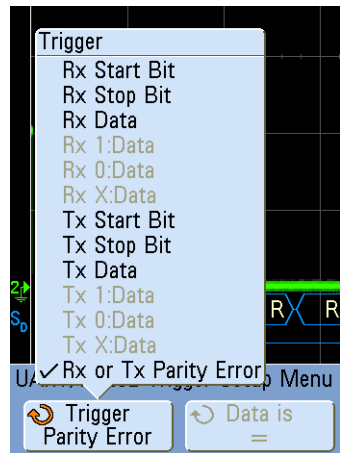


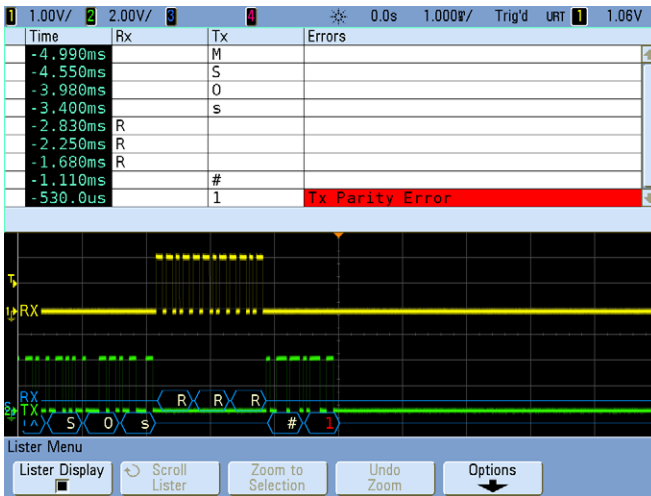
You should now see the encoded message: “Agilent MSOs RRR #1”. In addition, you may notice that the last decoded byte (1) is occasionally flashing in red. This is an indication of an infrequent parity error. Let’s now set up the oscilloscope to trigger specifically on a parity error condition. But because this error condition is infrequent, we will first need to change the trigger mode to NORMAL to prevent the oscilloscope from auto triggering.

- 16 Press **[Mode/Coupling]** and then press **Mode** twice to select the **Normal** trigger mode.
- 17 Press **[Trigger]**; then, press **Trigger Setup**.
- 18 Next, press **Trigger Tx Data**; then, select **Rx or Tx Parity Error** as the trigger condition.

You should now see that the oscilloscope is triggering on the parity error (red “1”) at center-screen and the “1” ASCII character is constantly red (no longer flashing). Let’s now analyze transmitted and received data both before and after this particular error byte using the oscilloscope’s “lister” display mode.

- 19 Press **[Serial]**; then, press **Lister**.
- 20 Next, press **Lister Display** to turn it on.





- 21 To scroll through a stored list of RS232/UART packets, first press [Run/Stop] to stop acquisitions.
- 22 Rotate the selection knob to scroll through the list with direct time-correlation to the captured waveforms.

For additional information on how to automatically search and navigate within the lister display, refer to ["Using Serial Search and Navigation"](#) on page 67.



## 9 Verifying CAN Serial Bus Communication

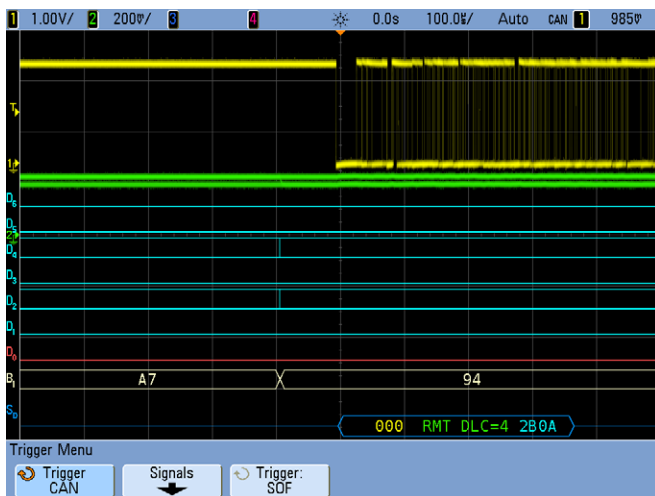
The Controller Area Network (CAN) bus is used in a variety of today's automotive and industrial applications. Because this bus is typically differential, it is a very robust bus with lots of noise immunity and can be used to communicate over relatively long distances between devices. Because the CAN bus is usually a differential bus, a differential active probe is typically required. However, the CAN signal on our demo board is a single-ended signal (CAN\_L). So for this lab, we will be using a standard high impedance passive probe. With a CAN bus signal, there is not an explicit clock signal as there is with I<sup>2</sup>C and SPI. Clocking is embedded within the CAN signal, and CAN receivers must recover the clock based on a known baud rate. To enable CAN decoding, your oscilloscope must have the CAN/LIN serial bus decode option (Option AMS) installed. You can verify the installed options on your oscilloscope at **[Utility] > Service > About Oscilloscope**.

### Setup

- 1 Connect the demo kit's 40-pin ribbon cable from the back of the Agilent InfiniiVision Series oscilloscope to the 40-pin connector on the demo board.
- 2 Connect channel 1 probe to the CH1 test point and ground (GND).
- 3 Connect channel 2 probe to the CH2 test point and ground (GND).
- 4 Set the rotary switch on the demo board for the CAN signal (Mode #8).
- 5 Press **[Default Setup]**.
- 6 Set the channel 1 vertical scale to 1.0 V/div and the vertical offset to -1.0 V.
- 7 Push the Trigger Level knob to set triggering on channel 1 at the 50% level.
- 8 Turn on channel 2.



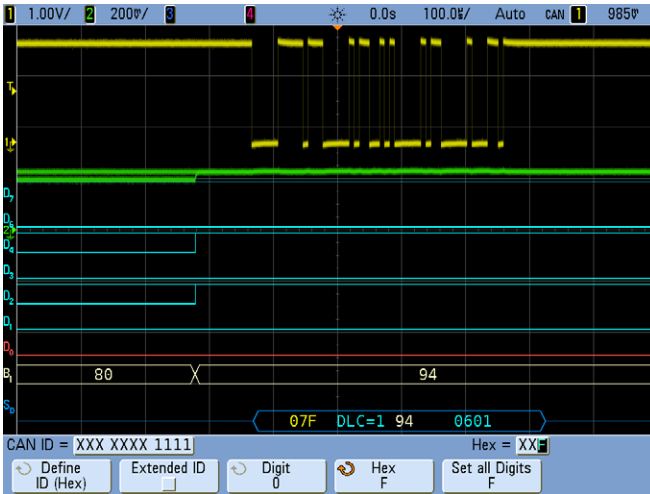
- 9 Press [**Digital**] to turn on digital channels; then, press **Turn off D15-D8** to turn off these unused channels.
- 10 Next, press **Bus**; then, press **Bus1** two times.  
Note that Bus1 is an overlaid display of D7-D0. We will use this mode later to make a time-correlated measurement. Let's now set up the oscilloscope to decode and trigger on CAN frames.
- 11 To turn on CAN decode, first press [**Serial**]; then, select the **CAN** serial decode mode.
- 12 To set decoding for the appropriate baud rate, press **Settings**.
- 13 Press **Baud.**; then, select **125 kb/s**.
- 14 To trigger on the channel 1 CAN signal, first press [**Trigger**]; then, select the **CAN** triggering mode.




The oscilloscope should now be triggering on Start-of-frame (SOF) of any CAN frame. Let's now set up the oscilloscope to trigger on a specific data frame ID (07F hex).

- 15 Press **Trigger: SOF**; then, select **Data Frame ID (~RTR)** as the CAN triggering mode.
- 16 Press **Bits**.
- 17 Next, press **Hex**; then, select "F".

## 9 Verifying CAN Serial Bus Communication



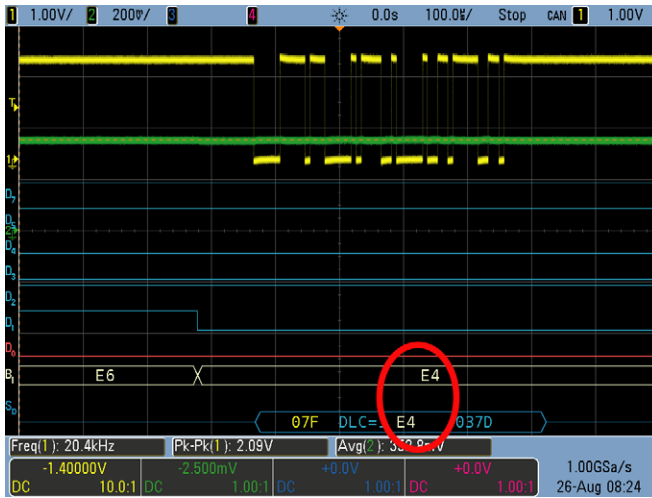
The oscilloscope should now be triggering on frame 07F. Because “F” is unique in the lower nibble of the ID for our demo board signal, specifying the upper two nibbles (07) is not necessary in order to trigger on 07F hex. Let’s now make some time-correlated measurements across analog, digital, and serial bus signals.

- 18 To measure the average voltage of the channel 2 waveform (1 Hz signal), first press [**Meas**], and then change the Source to “2”.
- 19 Next, press **Select**; then, select **Average**.
- 20 To begin executing the selected measurement, either push the selection knob or press **Measure Avg**.
- 21 In order to view both the measurements and the value of the parallel digital bus (B1), press the  back/up key (above the power switch).

The channel 2 signal (green waveform) might represent the output of an analog sensor in an automobile or an industrial system. Perhaps it is an electrical representation of temperature. This analog signal is then converted to an 8-bit digital byte using an ADC. The digital output of the 8-bit ADC is represented by the eight digital waveforms (D0-D7) and Bus1, which is an overlay display of all eight bits. This 8-bit digital output of the ADC is then converted to a serial string of data embedded within CAN frame ID: 07F. This serial data byte is displayed as the 2-digit hex white characters within the CAN serial decode trace shown at the bottom of the display. We can now see all three (analog waveform with measurement, digital bus, and serial data) all time-correlated. However, the update rate of the input signals and the oscilloscope are too fast to

verify that these signals have correlated values. So let's stop acquisitions and "freeze" the display in order to verify a time-correlated measurement on just one acquisition.

## 22 Press [Run/Stop].



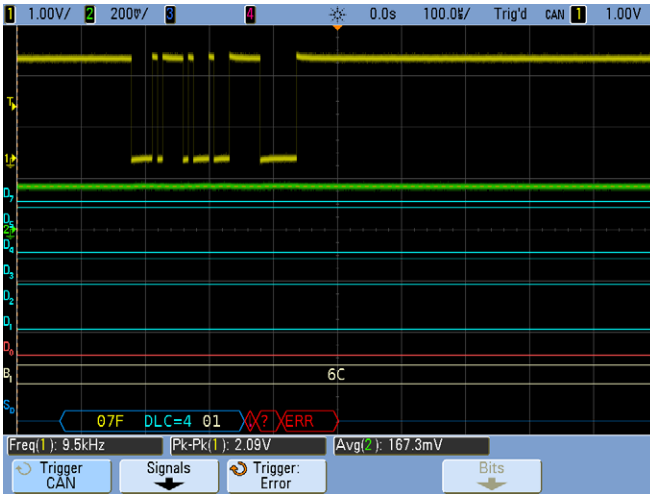
You should now see that the hex value of the parallel bus (Bus1) is exactly the same as the hex value of the data byte within the CAN decode trace. And, both of these directly relate to the average voltage of the channel 2 input signal (Avg(2)). Let's now see if our CAN signal includes any error frames.

## 23 Press [Run/Stop] to begin repetitive acquisitions again.

Notice within the serial decode trace at the bottom of the display a red flashing "ERR" message near the end of the frame/packet. This is an indication that the oscilloscope is detecting error frames. With hardware-based decoding, Agilent InfiniiVision Series oscilloscopes are able to capture infrequent errors and display them on-screen very quickly. All other oscilloscopes on the market today utilize software-based decoding which tends to be slow, especially when using deep memory. This means that critical information can be missed, such as these infrequent error frames. Now that we know our system has errors, let's set up the oscilloscope to trigger on just error frames, instead of triggering on frame ID:07F. However, because the error frames on our CAN demo signal occur relatively infrequently, we will need to select the Normal trigger mode to prevent the oscilloscope from auto triggering due to a low repetition rate trigger event.

## 9 Verifying CAN Serial Bus Communication

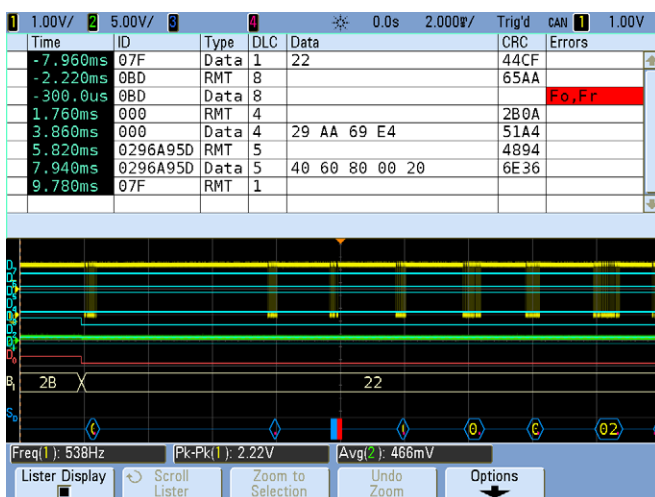
- 24 Press [**Mode/Coupling**]; then, press **Mode** two times to select the **Normal** trigger mode.
- 25 To trigger on just CAN error frames, first press [**Trigger**].
- 26 Next, select to trigger on **Error Frame**.



The oscilloscope should now be triggering exclusively on error frames. To analyze transmitted data both before and after these error frames, let's re-scale the oscilloscope's timebase in order to capture more frames, and then let's turn on the "Lister" display mode.

- 27 Set the timebase to 2.0 ms/div.
- 28 Press [**Serial**]; then, press **Lister**.
- 29 Next, press **Lister Display** to turn on the Lister display mode.





- 30 To scroll through a stored list of CAN packets, first press **[Run/Stop]** to stop acquisitions.
- 31 Rotate the selection knob to scroll through the list with direct time-correlation to the captured waveforms.

For additional information on how to automatically search and navigate within the Lister display, refer to ["Using Serial Search and Navigation"](#) on page 67.



# 10 Verifying LIN Serial Bus Communication

The LIN serial bus is another protocol that is used in many automotive applications. The LIN protocol is more often used in less safety-critical applications as compared to CAN automotive applications. LIN is a single-ended bus (signal to ground) with voltage levels usually based on the car's battery voltage. Similar to CAN, the clock is embedded within the LIN data signal. This bus is typically slower and lower cost than CAN technology. Typical non-safety critical applications include seat and mirror controls. To enable LIN decode and triggering, your oscilloscope must have the CAN/LIN serial bus decode option (Option AMS) installed. You can verify the installed options on your oscilloscope at **[Utility] > Service > About Oscilloscope**.

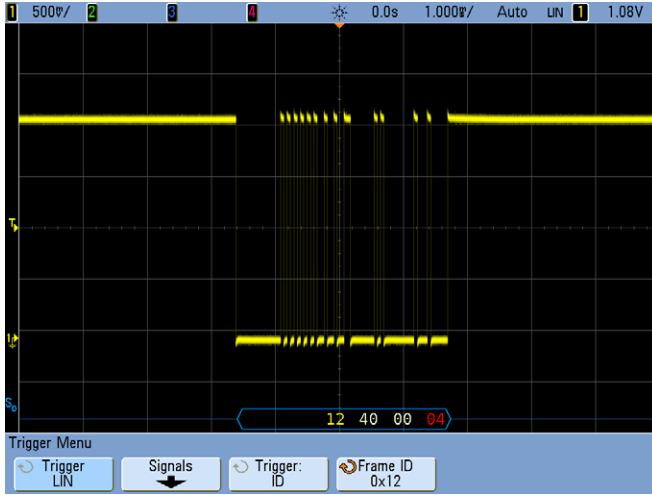
## Setup

- 1 Connect the demo kit's 40-pin ribbon cable from the back of the Agilent InfiniiVision Series oscilloscope to the 40-pin connector on the demo board.
- 2 Connect channel 1 probe to the CH1 test point and ground (GND).
- 3 Connect channel 2 probe to the CH2 test point and ground (GND).
- 4 Set the rotary switch on the demo board for the LIN signal (Mode #9).
- 5 Press **[Default Setup]**.
- 6 Set the channel 1 vertical scale to 500 mV/div and the vertical offset to +1.0 V.
- 7 Push the Trigger Level knob to set the channel 1 trigger level to 50%.
- 8 Set the timebase to 1.0 ms/div.
- 9 To turn on LIN decode, first press **[Serial]**; then, select the **LIN** serial decode mode.
- 10 To set decoding for the appropriate baud rate of our demo signal, press **Settings**.
- 11 Press **Baud Rate**; then, select **19.2 kb/s**.



The oscilloscope should now be decoding the LIN data, but not yet triggering on this LIN signal. Let's now set up the oscilloscope to trigger specifically on LIN frame ID 12 hex.

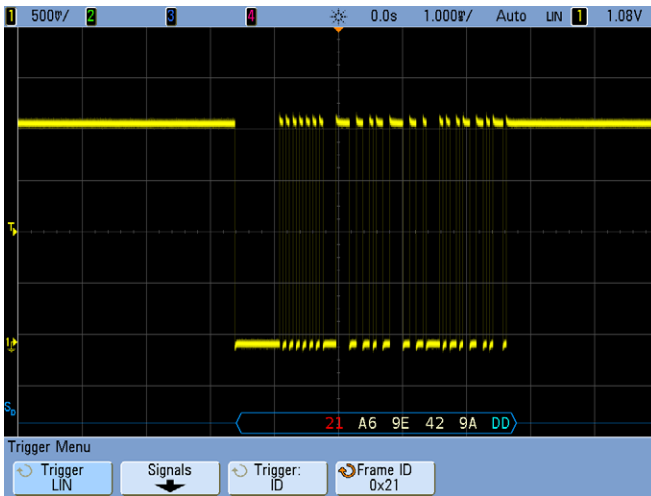
- 12 Press **[Trigger]**; then, select the **LIN** triggering mode.
- 13 Press **Trigger: Sync**; then, select the **ID-Frame ID** trigger mode.
- 14 Press **Frame ID 0xXX**; then, select **0x12**.



The oscilloscope should now be triggering on frame: 12 hex. Notice the last byte in the serial decode string. This is the checksum byte. This byte is sometimes displayed in red. This is an indication of checksum errors. Let now trigger on frame ID: 21 hex so that we can see another type of error condition.

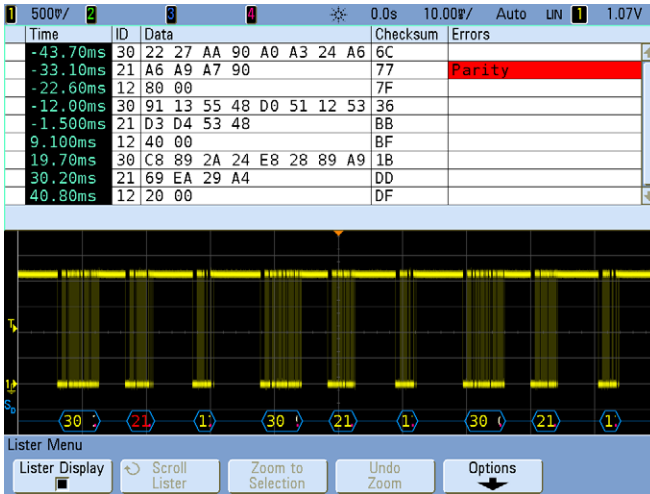
- 15 Press **Frame ID 0x12**; then, select **0x21**.

## 10 Verifying LIN Serial Bus Communication



Notice the first byte in the serial decode string is sometimes shown in red. This is the frame ID field. When this field is displayed in red, it is an indication of a parity error in the header field of this frame. To analyze transmitted data both before and after this particular frame (21 hex), let's turn on the "Lister" display mode. But first, let's re-scale the timebase to 10.0 ms/div in order to capture several LIN frames on-screen.

- 16 Set the timebase to 10.0 ms/div.
- 17 Press **[Serial]**; then, press **Lister**.
- 18 Next, press **Lister Display** to turn on the Lister display mode.



- 19 To scroll through a stored list of LIN packets, first press **[Run/Stop]** to stop acquisitions.
- 20 Rotate the selection knob to scroll through the list with direct time-correlation to the captured waveforms.

For additional information on how to automatically search and navigate within the lister display, refer to ["Using Serial Search and Navigation"](#) on page 67.



# 11

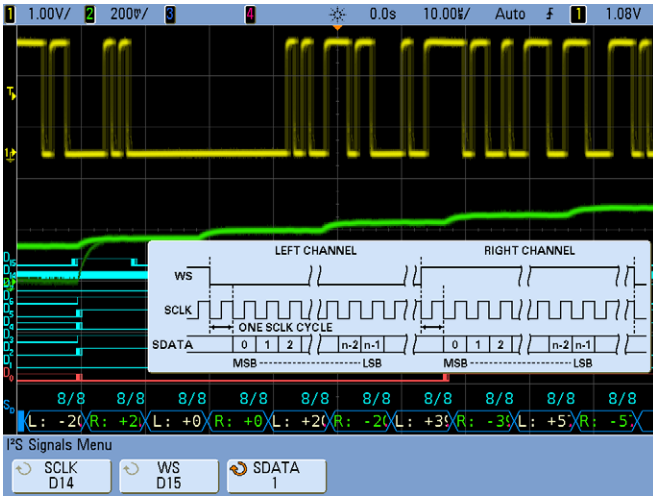
## Verifying I<sup>2</sup>S Serial Bus Communication

The Integrated Interchip sound (I<sup>2</sup>S) bus is a serial bus interface standard used for connecting digital audio devices together, such compact disc, digital audio tape, digital sound processors, and digital TV sound. The I<sup>2</sup>S serial bus is based on a 2's complement format. The serial data channel includes both left and right channel audio information (stereo). In addition to the serial data signal, the I<sup>2</sup>S protocol also includes an explicit clock signal (SCLK) and a word select (WS) signal. To enable I<sup>2</sup>S decoding, your oscilloscope must have the I<sup>2</sup>S serial bus decode option (Option I2S) installed. You can verify the installed options on your oscilloscope at [**Utility**] > **Service** > **About Oscilloscope**.

### Setup

- 1 Connect the demo kit's 40-pin ribbon cable from the back of the Agilent InfiniiVision Series oscilloscope to the 40-pin connector on the demo board.
- 2 Connect channel 1 probe to the CH1 test point and ground (GND).
- 3 Connect channel 2 probe to the CH2 test point and ground (GND).
- 4 Set the rotary switch on the demo board for the I<sup>2</sup>S signal (Mode #C).
- 5 Press [**Default Setup**].
- 6 Press [**Auto Scale**].
- 7 Set the timebase to 10.0  $\mu$ s/div.
- 8 To turn on I<sup>2</sup>S decode, first press [**Serial**]; then, select the I<sup>2</sup>S serial decode mode.
- 9 To define the I<sup>2</sup>S serial input signals, first press **Signals**; then, select the D14 input as the serial clock (**SCLK**) source.
- 10 Next, press **WS**; then, select the **D15** input as the Word Select source.
- 11 Now press **SDATA**; then, select the channel **1** input as the serial data source.





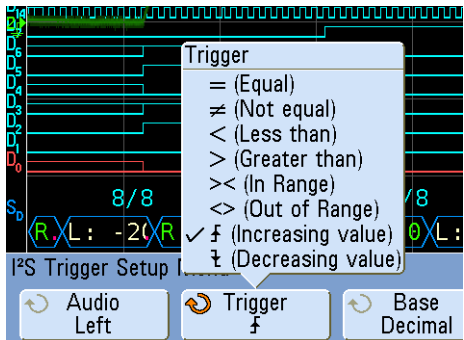
You should now see I<sup>2</sup>S decoding based on 8-bit words of “left” channel and “right” channel data. Note that this might represent stereo information in a digital audio/sound system. Let’s now set up the oscilloscope to trigger on a specific transmitted audio data.

- 12 Press **[Trigger]**; then, select the I<sup>2</sup>S trigger mode.
- 13 Press **Trigger Setup** to view the default I<sup>2</sup>S trigger condition.

Note that the default trigger condition is to trigger when the left-channel data equals “0” (signed decimal value), and we can see that this condition occurs when the analog waveform on channel 2 (green trace) crosses through the 50% level of a sine wave output in either the positive or negative direction. Let’s now set up the oscilloscope to trigger on a specific direction of the output analog signal (increasing or decreasing data value).

- 14 Press **Trigger =**; then, select **(Increasing Value)** as the trigger condition.

The oscilloscope should now be triggering on +20, which is the first left-channel data value captured after crossing through -10 and +10

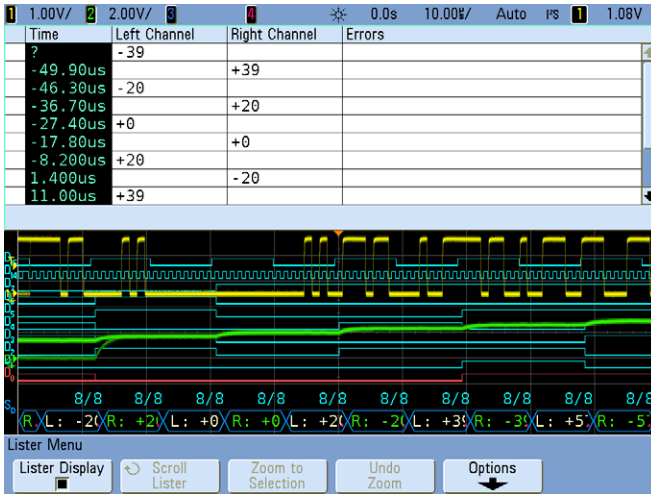


## 11 Verifying I<sup>2</sup>S Serial Bus Communication

(default setting). To analyze left and right channel data both before and after this particular byte, let's turn on the "Lister" display mode.

15 Press **[Serial]**, and then press **Lister**.

16 Next, press **Lister Display** to turn it on.



17 To scroll through a stored list of I<sup>2</sup>S packets, first press **[Run/Stop]** to stop acquisitions.

18 Rotate the selection knob to scroll through the list with direct time-correlation to the captured waveforms.

For additional information on how to automatically search and navigate within the lister display, refer to ["Using Serial Search and Navigation"](#) on page 67.





## 12 Using Segmented Memory Acquisition to Capture More Data

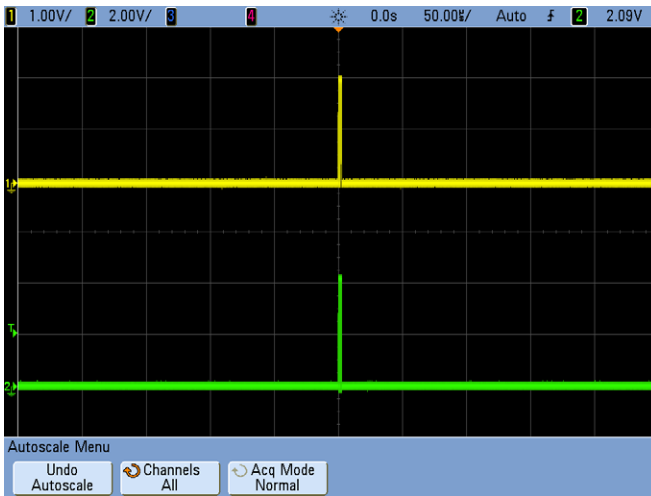
Segmented Memory acquisition is a special mode of acquisition that conserves and optimizes the oscilloscope's acquisition memory. It is ideal for capturing multiple low duty cycle signals where there may long dead-times between important events. Typical applications include burst radar, pulsed lasers, as well as many serial bus applications that utilize packetized data. During this lab, we will demonstrate an application using a "burst" signal, as well as a CAN bus application. To enable Segmented Memory acquisition as well CAN decode, your oscilloscope must have the Segmented Memory and CAN/LIN options (Option SGM and Option AMS) installed. You can verify the installed options on your oscilloscope at **[Utility] > Service > About Oscilloscope**.

### Part A: Using Segmented Memory on "Burst" Signals

- 1 Connect the demo kit's 40-pin ribbon cable from the back of the Agilent InfiniiVision Series oscilloscope to the 40-pin connector on the demo board.
- 2 Connect channel 1 probe to the CH1 test point and ground (GND).
- 3 Connect channel 2 probe to the CH2 test point and ground (GND).
- 4 Set the rotary switch on the demo board for the "Burst" signal (Mode #3).
- 5 Press **[Default Setup]**.
- 6 Press **[Auto Scale]**.



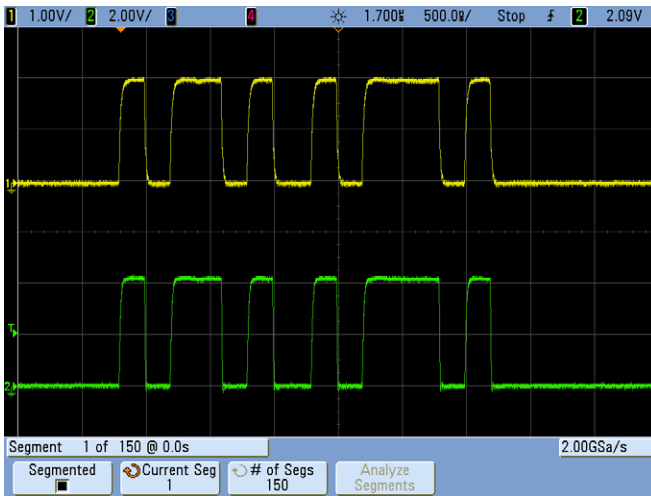
## 12 Using Segmented Memory Acquisition to Capture More Data



It may appear that the oscilloscope is capturing a repetitive low-cycle pulse. But it is actually capturing a burst of pulses. You can re-scale the timebase to 1.0  $\mu$ s to view the burst of pulses. To capture and compare multiple bursts of signal activity, you could re-scale the timebase to capture a longer time-span. However, with limited acquisition memory (8M on InfiniiVision Series oscilloscopes) the oscilloscope would automatically reduce its sample rate to capture the longer time-span. This would reduce measurement accuracy. Another alternative would be to use the oscilloscope's Segmented Memory acquisition mode. Let's now set up a Segmented Memory acquisition to capture 150 consecutive occurrences of this burst of signals.

- 7 Set the timebase to 500 ns/div and the horizontal delay to 1.700  $\mu$ s.
- 8 Press **[Acquire]**.
- 9 Press **Segmented**; then, select **150** (# of Segments).
- 10 Now press **Segmented** to begin a Segmented Memory acquisition.

## Using Segmented Memory Acquisition to Capture More Data 12



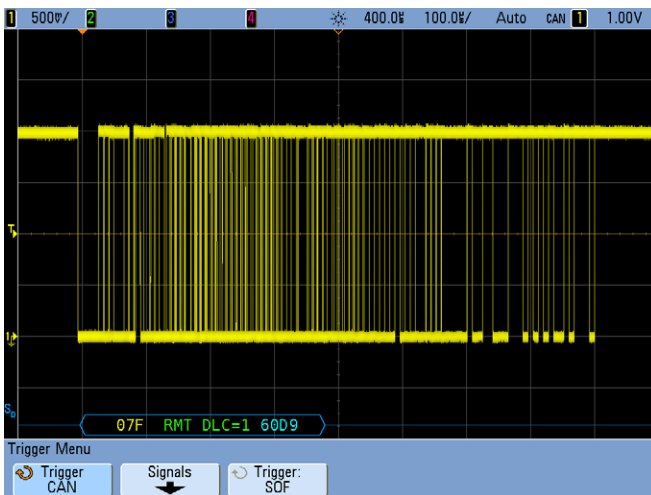
The oscilloscope should have just captured 150 consecutive waveform segments with Segment #1 shown on-screen. Let's now review all of the waveform segments and determine how long of a time-span the oscilloscope just captured.

- 11 Press **Current Seg**.
- 12 Review all 150 waveform segments by rotating the selection knob.
- 13 Rotate the selection knob until **Segment #150** is selected and shown on screen.

Notice that each segment/burst has been time-tagged with a time value relative to the first captured segment (Segment #1). Segment #150 should have a time-tag of approximately 149 ms. Capturing this much waveform information at a high sample rate using conventional acquisition memory would be impossible. Let's now see how Segmented Memory can be used on packetized serial bus signals.

### Part B: Using Segmented Memory on Packetized Serial Bus Signals

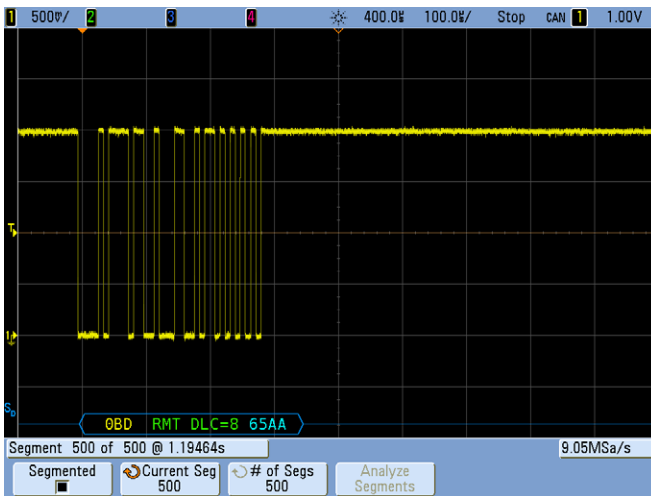
- 1 Connect the demo kit's 40-pin ribbon cable from the back of the Agilent InfiniiVision Series oscilloscope to the 40-pin connector on the demo board.
- 2 Connect channel 1 probe to the CH1 test point and ground (GND).
- 3 Connect channel 2 probe to the CH2 test point and ground (GND).
- 4 Set the rotary switch on the demo board for the "CAN" signal (Mode #8).
- 5 Press **[Default Setup]**.
- 6 Set the channel 1 vertical scale to 500 mV/div and the vertical offset to +1.0 V.
- 7 Push the Trigger Level knob to automatically set the trigger level to 50%.
- 8 Press **[Serial]**; then, select the **CAN** serial decode mode.
- 9 Press **Settings**.
- 10 Press **Baud** ; then, select **125 kb/s** as the baud rate
- 11 Press **[Trigger]**; then, select the **CAN** triggering mode.
- 12 Set the timebase to 100.0  $\mu$ s/div and the horizontal delay to +400.0  $\mu$ s.



## Using Segmented Memory Acquisition to Capture More Data 12

The oscilloscope should now be capturing random CAN frames (packets of data) while triggering on Start-of-frame (SOF). Again, to capture more frames, we could re-scale the timebase. However, the number of consecutive frames that the oscilloscope could capture using conventional acquisition memory at a high sample rate would be limited. Let's now set up a Segmented Memory acquisition to capture 500 consecutive CAN frames.

- 13 Press **[Acquire]**.
- 14 Press **Segmented**; then, select **500** (# of Segments).
- 15 Now, press **Segmented** to begin a segmented memory acquisition.



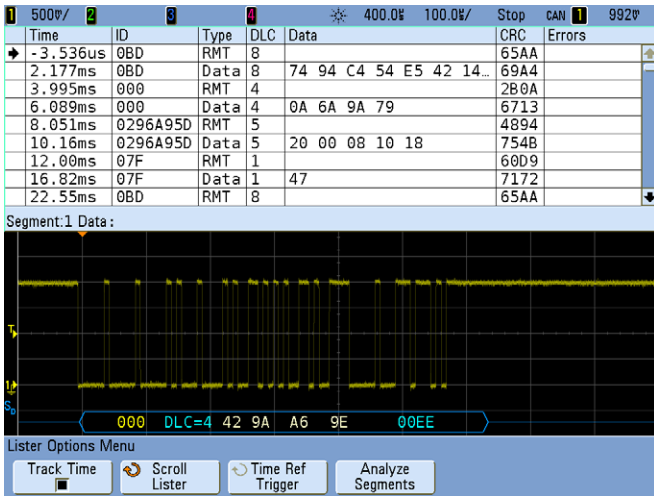
The oscilloscope should have just captured and decoded 500 consecutive CAN frames. Let's now review all of the CAN frames and determine how long of a time-span the oscilloscope just captured.

- 16 Press **Current Seg**.
- 17 Review all 500 packets of CAN data by rotating the selection knob.
- 18 Rotate the selection knob until **Current Segment 500** is selected on shown on screen.

Notice that each segment/burst has been time-tagged with a time value relative to the first captured segment (Segment #1). Segment #500 should have a time-tag of approximately 1 second. Capturing this much serial data using conventional acquisition memory would be impossible. Let's now see how we can examine this serial data in the oscilloscope's serial "lister" display mode.

## 12 Using Segmented Memory Acquisition to Capture More Data

- 19 Press [Serial].
- 20 Press **Lister**.
- 21 Press **Lister Display** to turn it on (Lister shows just one CAN frame).
- 22 Press **Options**.
- 23 Press **Analyze Segments**.



- 24 To review all 500 frames, rotate the selection knob to scroll through all segments/frames.

For additional information on how to automatically search and navigate within the lister display, refer to "Using Serial Search and Navigation" on page 67.



## 13

# Using Serial Search and Navigation

Searching through a deep memory acquisition of serially decoded data can sometimes be a tedious process. But with InfiniiVision's new Search and Navigate capability on the 7000B Series DSOs and MSOs, finding specific serial events is much easier now. In this lab we will first use a manual process for reviewing captured serial packets utilizing the serial decode "lister" display. We will then use the new automatic Search and Navigate capability that is available on this oscilloscope. Although the instructions for this lab are based on using the CAN serial bus demo signal, if your oscilloscope is not equipped with the CAN/LIN option, you can use one of the other serial bus signals and options that your oscilloscope may be equipped with. However, we suggest that you first become familiar with that particular serial bus by referencing one of the previous serial bus labs. You can verify the installed options on your oscilloscope at **[Utility] > Service > About Oscilloscope**.

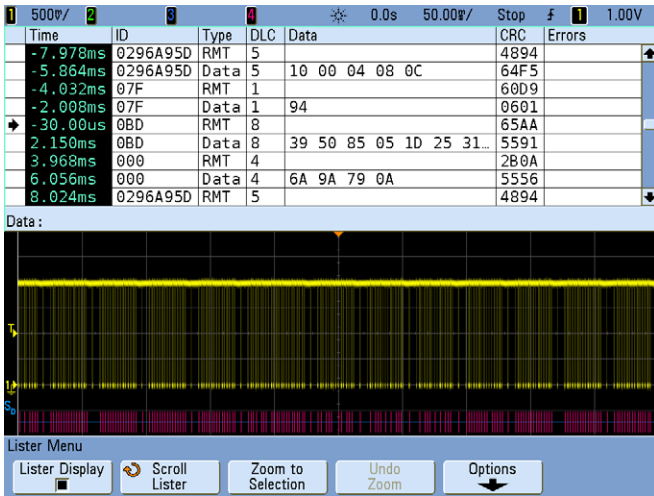
## Setup

- 1 Connect the demo kit's 40-pin ribbon cable from the back of the Agilent InfiniiVision Series oscilloscope to the 40-pin connector on the demo board.
- 2 Connect channel 1 probe to the CH1 test point and ground (GND).
- 3 Connect channel 2 probe to the CH2 test point and ground (GND).
- 4 Set the rotary switch on the demo board for the "CAN" signal (Mode #8).
- 5 Press **[Default Setup]**.
- 6 Set the channel 1 vertical scale to 500 mV/div and the vertical offset to 1.0 V.
- 7 Push the Trigger Level knob to set the trigger level at 50%.
- 8 Press **[Serial]**; then, select the **CAN** decode mode.
- 9 Press **Settings**.
- 10 Press **Baud**; then, select **125 kb/s**.



## 13 Using Serial Search and Navigation

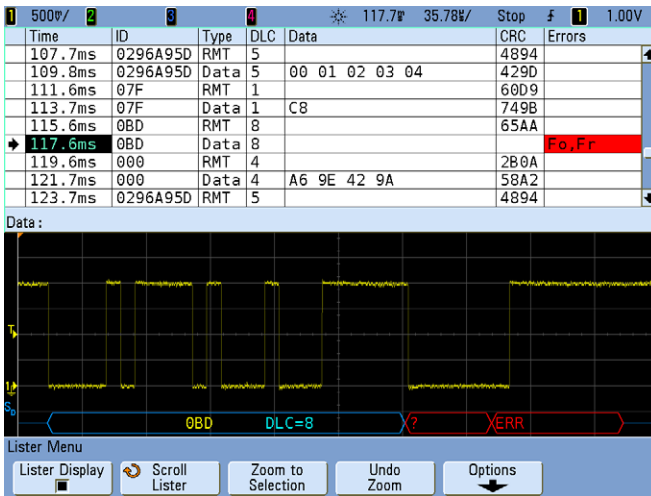
- 11 Set the timebase to 50 ms/div in order to capture multiple serial packets.
- 12 Press **[Serial]**.
- 13 Press **Lister**.
- 14 Press **Lister Display** to view the decoded list.
- 15 Press **[Run/Stop]** to stop acquisitions.



At this point, we have a few different options to use in order to search and navigate through this deep memory acquisition of CAN serial packets. We will begin by manually searching through our list and waveform. We will then use the oscilloscope's automatic search and navigate capabilities.

- 16 Rotate the selection knob to scroll through the decode list.
- 17 Point to a particular CAN frame-of-interest, such as a frame with an error (Fo, Fr).
- 18 Either push the selection knob or press **Zoom to Selection** to zoom-in on this packet.





Let's now set up the oscilloscope to automatically search and navigate based on specific serial search criteria. Let's now "mark" each CAN frame with the ID of 07F hex, and then view these frames time-correlated with the waveform.

19 Press **[Search]**.

20 Press **Search for;** then, select **Data Frame ID (~RTR)** to search on.

Note that all "Data Frames" based on ID = XXX (don't care) are now marked in orange in the left-most column. Let's now narrow our search to just "Data Frames" with ID = 07F hex.

21 Press **Bits**.

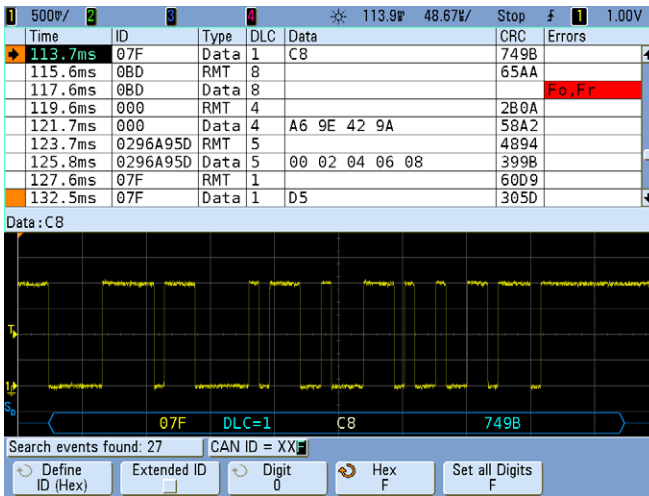
22 Press **Hex;** then, select **"F"**.

At this point we could manually scroll to these "marked" frames, or we could use the oscilloscope's navigation capability to automatically scroll to and display these particular "marked" frames. Let's use the automatic navigation capability.

23 Press the **▶** forward key (near the **[Navigate]** key) multiple times to find all of the occurrences of CAN frame 07F.

24 Press the **◀** back key to navigate back up the list.

## 13 Using Serial Search and Navigation



In addition to navigating to specific frames based on a particular search criteria, we can also “time” navigate by “playing” through waveform.

- 25 Press **[Navigate]**.
- 26 Select the **Time** navigation mode.
- 27 Press the **▶** forward key to navigate forward in time.
- 28 Press the **◀** back key to stop and then press it again to navigate back in time.
- 29 Press the **▶** forward or the **◀** back keys multiple times to speed up or slow down the time navigation.
- 30 Press the **■** stop key to stop navigation.

Note that “time” navigation is not limited to serial bus waveforms. It can be used to navigate through the acquisition memory on any set of captured waveforms.



## Appendix A

# Using Trigger Holdoff to Synchronize Acquisitions/Display on Complex Signals

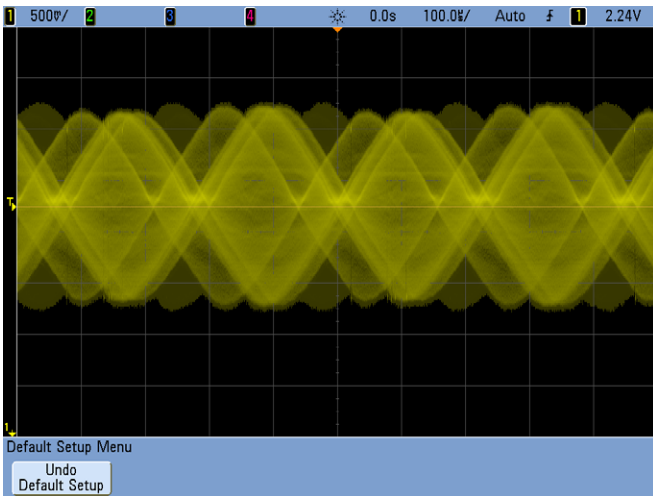
Triggering on simple repetitive signals is very easy using standard edge triggering. But if you need to synchronize your oscilloscope's acquisitions/display on more complex signals, such as an amplitude-modulated signal, you will need to use your oscilloscope's trigger holdoff capability, unless you have an external synchronization signal available. This lab will show you how to use trigger holdoff to achieve a stable trigger in the absence of a synchronization signal.

### Setup

- 1 Connect the demo kit's 40-pin ribbon cable from the back of the Agilent InfiniiVision Series oscilloscope to the 40-pin connector on the demo board.
- 2 Connect channel 1 probe to the CH1 test point and ground (GND).
- 3 Connect channel 2 probe to the CH2 test point and ground (GND).
- 4 Set the rotary switch on the demo board for the "AM" signal (Mode #1).
- 5 Press [**Default Setup**].
- 6 Set the channel 1 vertical scale to 500 mV/div and the vertical offset to 2.0 V.
- 7 Push the Trigger Level knob to set the trigger level at 50%.
- 8 Push the Waveform Intensity knob to set the waveform intensity at 50%.

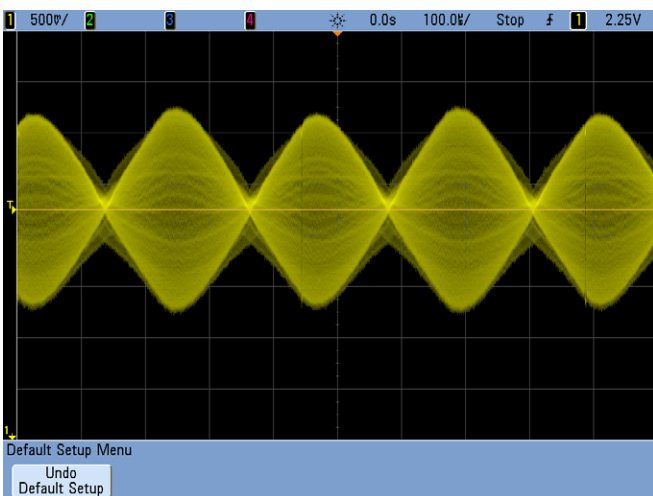


## A Using Trigger Holdoff to Synchronize Acquisitions/Display on Complex Signals



Notice that even though this signal crosses the trigger level setting at approximately the 50% level, the waveform appears to be not triggered. This is because the oscilloscope is randomly triggering on any edge crossing of the carrier signal. To properly trigger on this complex signal, we need to set up the oscilloscope to synchronize trigger arming and disarming based on the modulating frequency. We can do this with trigger “holdoff”.

- 9 Press the [Run/Stop] front panel to stop repetitive acquisitions.

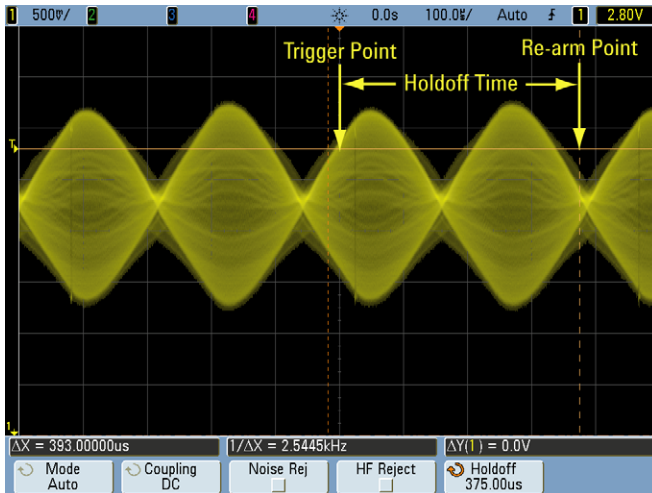


## Using Trigger Holdoff to Synchronize Acquisitions/Display on Complex Signals A

We can now visually determine how often this signal repeats. But first, notice that there appears to a narrow “gap” in every 2nd modulation. In addition, we can see that one modulation has a slightly higher peak-to-peak voltage than the next modulation. If you use the oscilloscope’s timing cursors to measure the time between every 2nd modulation, you will see that this signal repeats approximately every 420  $\mu$ s.

To establish distinct trigger arm, disarm, and then re-arm points on a complex signal such as this, there must be a large timing gap between trigger events. We can create this timing gap by changing the trigger level away from the 50% level. We can then set the trigger holdoff to a value less than the repeat time of the signal to establish a stable trigger point. Let’s try it.

- 10 Set the trigger level to the approximate 75% level by rotating the Trigger Level knob until the trigger level is approximately 2.8 V.
- 11 Press **[Mode/Coupling]**.
- 12 Press **Holdoff**; then, set the holdoff value to approximately 375  $\mu$ s.
- 13 Press **[Run/Stop]** to begin repetitive acquisitions again.



The oscilloscope should now trigger on edge crossings of the carrier signal at the 2.8 voltage level. Triggering will then be disarmed and then re-armed 375  $\mu$ s later, which should be during a large “gap” between every 2nd modulation. The oscilloscope then triggers again on the next edge crossing of the carrier signal at 2.8 V.





## Agilent InfiniiVision 7000B Series Oscilloscopes

Model	Bandwidth	Max. sample rate	Memory	# Ch	Other standard features
DS07012B	100 MHz	2 GSa/s		2	<ul style="list-style-type: none"> <li>• Dedicated controls for each channel</li> <li>• AutoScale</li> <li>• Automatic and cursor measurements</li> <li>• Front panel USB port</li> <li>• Built-in help</li> <li>• InfiniiMax AutoProbe interface</li> </ul>
MS07012B	100 MHz	2 GSa/s		2 + 16	
DS07014B	100 MHz	2 GSa/s		4	
MS07014B	100 MHz	2 GSa/s		4 + 16	
DS07032B	350 MHz	2 GSa/s		2	
MS07032B	350 MHz	2 GSa/s		2 + 16	
DS07034B	350 MHz	2 GSa/s	Mega-Zoom III memory 8 Mpts standard	4	
MS07034B	350 MHz	2 GSa/s		4 + 16	
DS07052B*	500 MHz	4 GSa/s		2	
MS07052B*	500 MHz	4 GSa/s		2 + 16	
DS07054B*	500 MHz	4 GSa/s		4	
MS07054B*	500 MHz	4 GSa/s		4 + 16	
DS07104B*	1 GHz	4 GSa/s		4	
MS07104B*	1 GHz	4 GSa/s		4 + 16	

\* Maximum sample rate and memory are interleaved

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