

# Tektronix MDO3000 Series Oscilloscope

Demonstration Guide



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## Tektronix MDO3000 Series Oscilloscope

Tektronix MDO3000 Mixed Domain Oscilloscope is the ultimate integrated 6-in-1 oscilloscope that offers a spectrum analyzer, arbitrary function generator (AFG), logic analyzer, protocol analyzer, and digital voltmeter (DVM), enabling you to quickly and cost effectively debug your designs.

**Oscilloscope** – At the core of the MDO3000 is the most popular oscilloscope in this class.

- 100, 200, 350, 500 MHz and 1 GHz bandwidth models
- Up to 5 GS/s sampling rate
- 10 Mpoint record length on every channel with Wave Inspector® navigation and search controls
- Up to a maximum waveform capture rate of >280,000 waveforms per second
- More than 125 trigger combinations

**Spectrum Analyzer** – Every MDO3000 ships standard with a dedicated spectrum analyzer input which provides better performance than a traditional oscilloscope FFT. The standard integrated spectrum analyzer input frequency is from 9 kHz to the bandwidth of the scope and is extendable to 3 GHz with the MDO3SA option.

**Arbitrary Function Generator (Optional)** – Choose from 13 predefined standard waveforms like sine, square or ramp, or replicate virtually any signal with the arbitrary waveform generation with 128k record length and 250MS/s sample rate. Even add noise to your waveform to perform margin testing on your circuits.

**Logic Analyzer (Optional)** – The MDO3000 provides a 16 digital channel logic analyzer with the MDO3MSO option, enabling you to look at multiple points in your design at once.

**Protocol Analyzer (Optional)** – The MDO3000 Series offers a robust set of tools for debugging serial buses with automatic trigger, decode, and search for I<sup>2</sup>C, SPI, CAN, LIN, FlexRay, USB 2.0, RS-232, RS-422, RS-485, UART, USB 2.0, Mil-Std 1553.

**Digital Voltmeter (DVM) (Optional)** – For fast voltage and frequency measurements, the optional digital voltmeter is easy-to-use. The DVM is free when you register your MDO3000 Series product.

**Upgradability** – The MDO3000 is completely upgradeable. Upgrade scope bandwidth and RF input frequency, add more functionality such as AFG, logic analyzer, and DVM, or add analysis capability such as serial bus triggering and decode, power measurement and limit/mask test, whenever you need it.

## About This Guide

This demonstration guide takes you through a series of step-by-step demonstrations on how the MDO3000 Series oscilloscope helps simplify the debug of mixed signal designs with its powerful functionality and integrated test instruments. This oscilloscope can help you discover new ways to quickly debug some of today's most challenging and common design problems.

**Note:** There are additional built-in product demos in MDO3000. To explore other product demos and features, press **Utility** front panel button, then press MDO3000 **Utility Page** lower-bezel button and use **Multipurpose a** to select **Demo**.

### To go through the exercises, you need:

- MDO demonstration board (includes a USB Y-cable used to power the demo board) with waveforms that represent a number of mixed-signal challenges facing today's designers. To find the desired signal on the demo board, refer to the "Locating Signals" section at the end of this demonstration guide.
- BNC cable to connect AFG output to analog channel and to connect to the spectrum analyzer input.
- N-BNC adapter to connect BNC cable to RF input channel (standard accessory)
- Serial bus triggering and analysis application modules
- DVM, AFG, Spectrum Analyzer options

**Note:** For demonstration purpose, all application modules and options are enabled in MDO3000 demo units. They are listed on the following page:

Category	Product	Description
<b>Serial Bus Analysis</b>	MDO3AERO	MIL-STD-1553 serial bus triggering and analysis module
	MDO3AUDIO	Audio serial triggering and analysis module (I <sup>2</sup> S, LJ, RJ, TDM)
	MDO3AUTO	Automotive serial triggering and analysis module (CAN, LIN)
	MDO3COMP	Computer serial triggering and analysis module (RS-232/422/485/UART)
	MDO3EMBD	Embedded serial triggering and analysis module (I <sup>2</sup> C, SPI)
	MDO3FLEX	FlexRay serial triggering and analysis module
	MDO3USB	USB2.0 (LS, FS) serial bus triggering and analysis and (HS – 1GHz models only) analysis module
<b>Analysis</b>	MDO3LMT	Limit/mask test
	MDO3PWR	Power measurement and analysis package
<b>Measurement</b>	N/A	Adds digital voltmeter to any MDO3000, free with product registration
<b>Instrument Options</b>	MDO3AFG	Adds arbitrary function generator to any MDO3000
	MDO3MSO	Adds 16 digital channels to a MDO3000; includes P6316 digital probe and accessories
	MDO3SA	Increases input range of spectrum analyzer to 9kHz - 3 GHz

## Powering on the Board

To connect and power on the demonstration board, follow these steps:

1. Plug the dual USB A connectors from one end of the “Y” USB cable, which comes with your board, into two USB ports of a PC or an oscilloscope. Do this before plugging the single USB B connector from the other end of the USB cable into the demonstration board. You need to attach both USB A connectors to provide adequate power to the demo board.
2. Plug the single B connector from the other end of the USB cable into the demo board. Two green and one red LEDs on the board turn on and remain steady when you apply adequate power to the board.

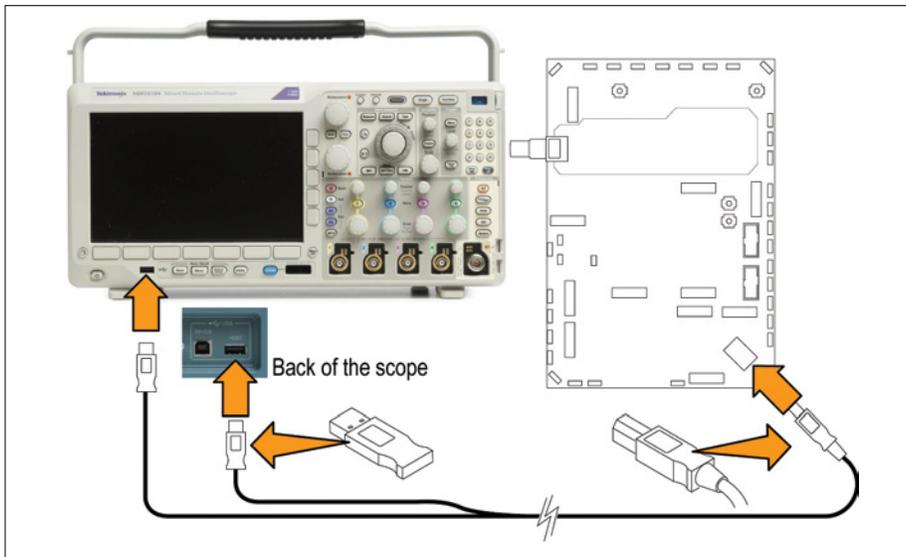
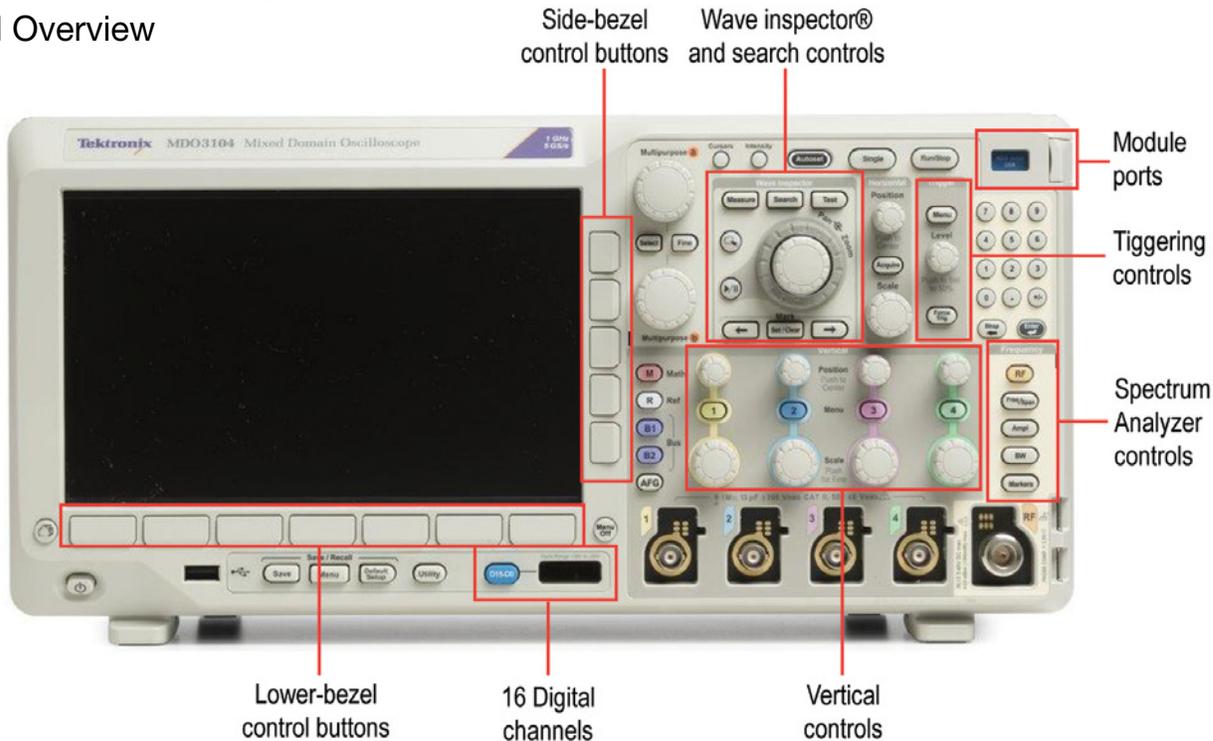


Figure 1.

## MDO3000 Series Front Panel Overview



## Exercise 1

### Capturing Elusive Events with FastAcq™ High Waveform Capture Rate

To debug a design problem, first you must know it exists.

The MDO3000 Series oscilloscope offers Tektronix proprietary FastAcq™ technology. It delivers a fast waveform capture – up to 280,000 waveforms per second – that enables you to see glitches and other infrequent transients within seconds, revealing the true nature of device faults.

To further enhance the visibility of rarely occurring events, intensity grading is used with multiple waveform palettes to choose from, indicating how often rare transients are occurring relative to normal signal characteristics. The FastAcq waveform palettes are Temperature (color-grading frequency of occurrence), Spectral (color-grading frequency of occurrence), Normal (gray-scale where frequently occurring events are bright) and Inverted (gray-scale where rare events are bright).

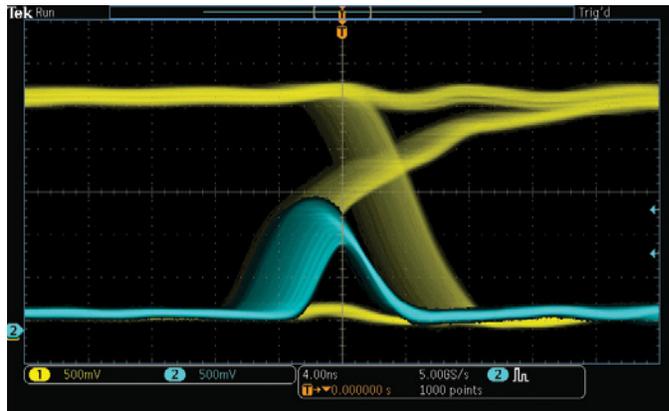


Figure 2.

This demo illustrates how FastAcq high waveform capture rate can find anomalies quickly and display them with color-grading. The demonstration looks for an erroneous runt signal that occurs approximately every 838.8ms.

1. Connect a passive probe to **channel 1** on the oscilloscope.
2. Connect the ground lead of the probe to the **GND** point and the probe tip to the **RARE\_ANOMALY** signal on the demonstration board.
3. Press **Default Setup** button to set the oscilloscope to the factory setup, and then press **Autoset**.

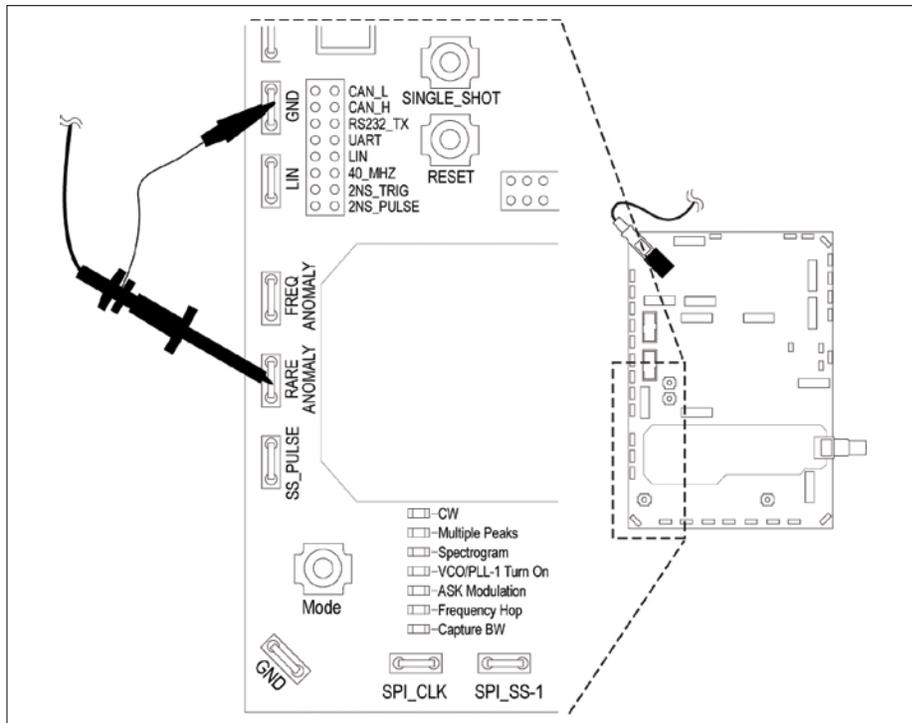


Figure 3.

- Press Trigger **Menu** front panel button.  
Press **Mode Auto & Holdoff** lower-bezel button.
- Turn **Multipurpose a** to increase holdoff time to **600.0000ns**.

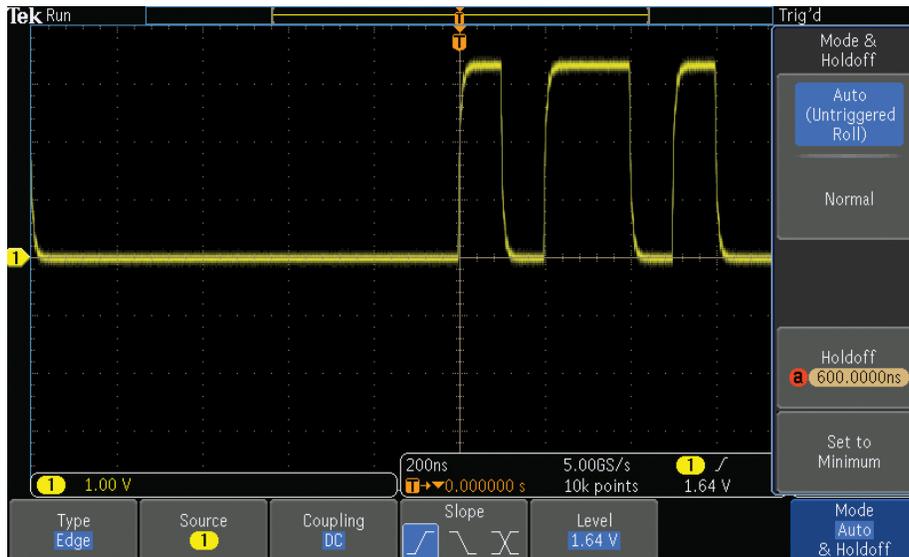


Figure 4.

6. Press the **Acquire** front-panel button.
7. Press **FastAcq** lower-bezel button. Turn on the FastAcq by pressing **FastAcq** side-bezel button and select **On**.
8. Press the lower-bezel **Waveform Display** button.
9. Turn **Multipurpose a** clockwise to adjust **persist time** to  $\infty$  s (infinite).

This step will ensure that all events captured will remain displayed on the oscilloscope. After several seconds you will notice that erroneous patterns in dark blue will begin filling the display. The digital phosphor display with color intensity grading shows the history of the signal's activity by using color to identify areas of the signal that occur more frequently, providing a visual display of just how often anomalies occur.

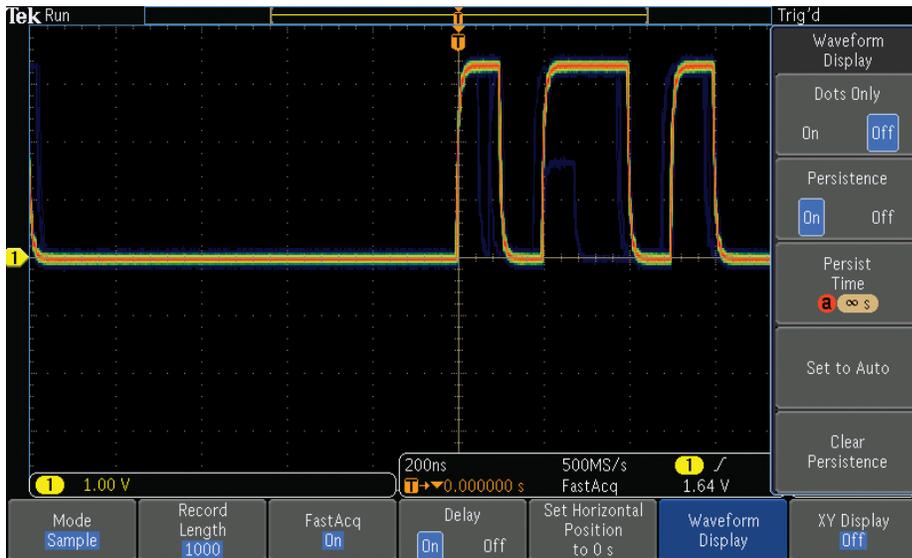


Figure 5.

Now we see an erroneous runt in the signal.  
To capture it, follow the steps below.

10. Press the side-bezel **Set to Auto** button to turn off infinite persistence.
11. Press **FastAcq** lower-bezel button and then press **FastAcq** side-bezel button to turn off FastAcq.
12. Press trigger **Menu**, select **Type Edge** bottom bezel button, use **Multipurpose a** to scroll down to **Runt**.
13. Press **Thresholds** lower-bezel button and adjust **High** to approximately **2.00 V** using **Multipurpose a**, adjust **Low** to about **1.00 V** using **Multipurpose b**.
14. Press **Mode** lower-bezel button. Press **Normal** side-bezel button.
15. Press the **Menu Off** button twice to remove the menus. You should be triggering on the runt signal.



Figure 6.

## Exercise 2

### Wave Inspector® Navigation and Automated Search

Trying to find one particular event, such as a spike on your signal or a runt pulse, in a long waveform record can be difficult. For example, a 10 M point record length on the MDO3000 is equal to over 10,000 oscilloscope screens worth of data! To make it easier to find what you are looking for, the MDO3000 Series has a special feature called Wave Inspector which provides tools for quickly moving through long records including an automated search function.

The following steps will explore the use of waveform navigation and search tools that greatly simplify finding events of interest.

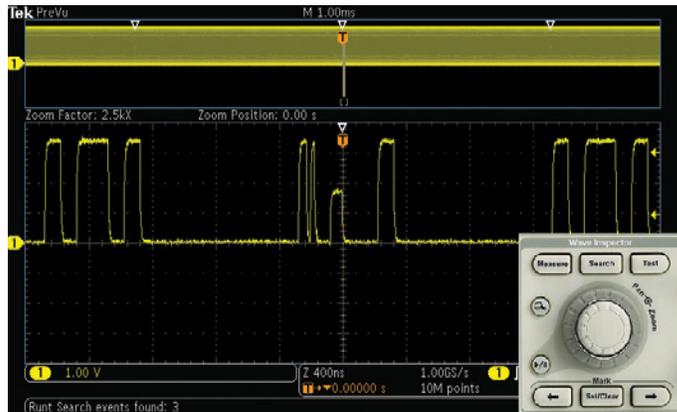


Figure 7.

1. Connect the channel 1 probe tip to the **FREQ\_ANOMALY** (Frequent Anomalies) signal on the demonstration board. Connect the ground lead of the probe to the **GND** point.
2. Press the front panel **Default Setup** button to set the oscilloscope to a known state. Press **Autoset**.
3. Press trigger **Menu**, select **Type Edge** lower-bezel button, use **Multipurpose a** to scroll down to **Runt**.
4. Press **Thresholds** lower-bezel button and adjust **High** to approximately **2.00 V** using **Multipurpose a**, adjust **Low** to about **1.00 V** using **Multipurpose b**.

Now you are triggering on a runt.

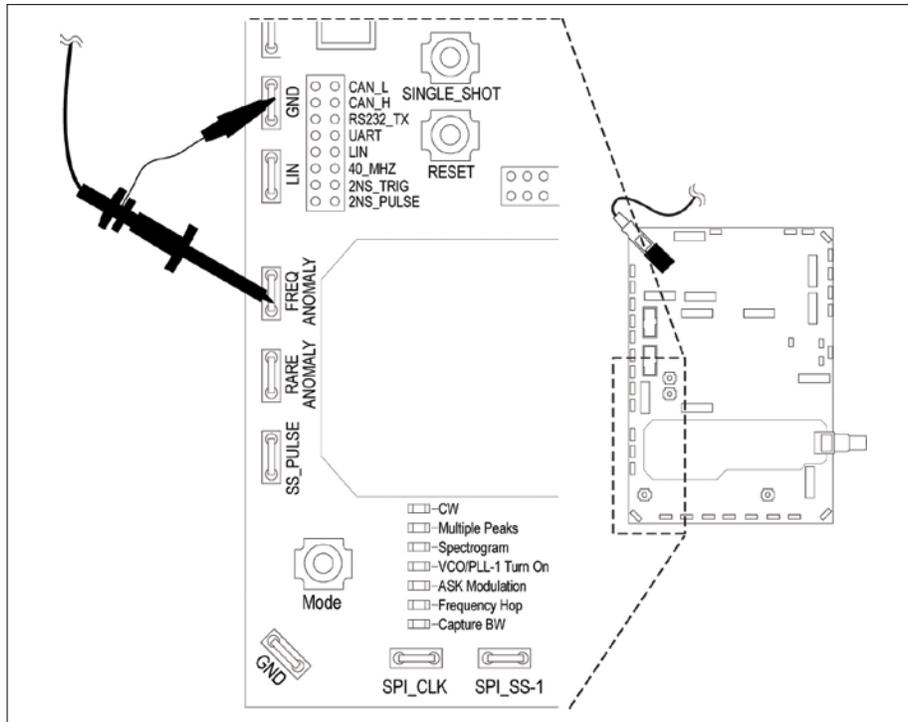


Figure 8.

Capturing the signal with sufficient detail is critical to successful debugging. For example, if you are interested in how frequent the runt signal occurs, you can acquire a long time window with a long record length and search for runt signals.

5. To increase the record length, press **Acquire**, select the **Record Length** lower-bezel button, then select the **10 M** points using **Multipurpose a**.
6. Press the **Menu Off** button to remove the menus.
7. Turn the Horizontal Scale knob to select **1.00 ms** per division.
8. Press the front panel **Single** button to make an acquisition.
9. Press the front panel **Search** button.
10. Press **Search** lower-bezel button.
11. Press **Copy Trigger Settings To Search** side-bezel button.

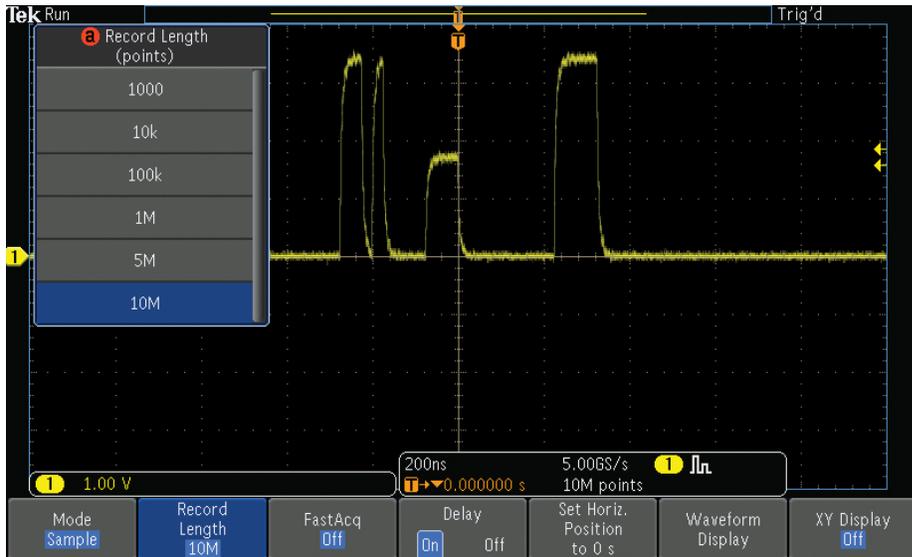


Figure 9.

Now all runts in the acquisition that meet this trigger specification are marked with a hollow white triangle at the top of the display. Notice the number of search events shown in the lower left corner is three.

13. Press the **Menu Off** button to remove the menus.



Figure 10.

It is very difficult to see much signal detail in this display. If we zoom in on the waveform, the details become visible.

14. Turn the inner **Wave Inspector** control and notice how the upper window of the display shows the context while the lower window shows the zoomed details.
15. Turn the outer, spring-loaded **Wave Inspector** control to pan right and left through the acquired waveform. The further you turn the control, the faster the panning.
16. You can also navigate to one of the marks using the ← and → arrow buttons.

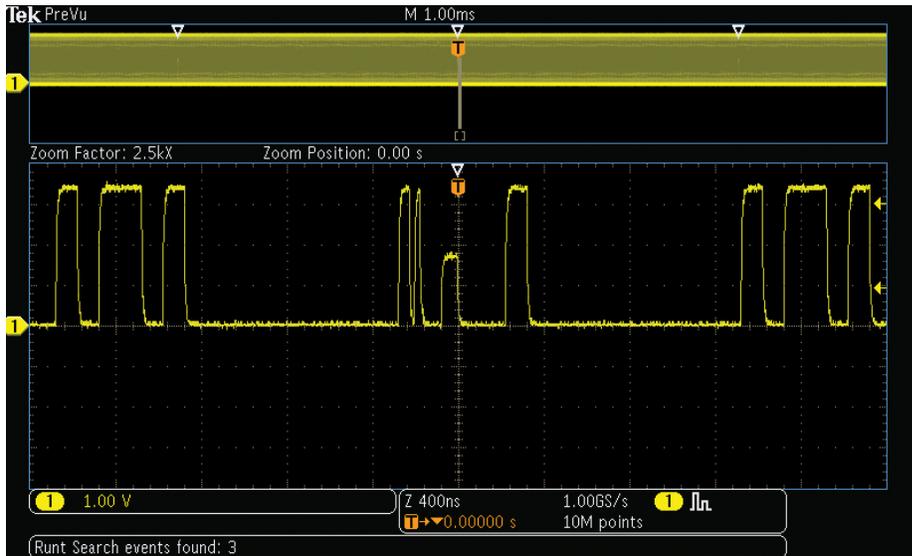


Figure 11.

## Exercise 3

### Decoding, Triggering and Searching Serial Buses

Tired of having to visually inspect serial data streams to determine if each bit is a 1 or a 0? Tired of having to start, stop, and then manually combine bits into bytes to determine hex values? The MDO3000 Series can automatically decode and trigger on packet-level content, such as the start of a packet, specific addresses, specific data content, and unique identifiers on popular serial interfaces, such as I<sup>2</sup>C, SPI, CAN, LIN, FlexRay USB2.0, RS-232, RS-422, RS-485, UART, Audio, MIL-STD-1553. The MDO3000 Series also provides a Bus Display view of the individual signals that make up the bus, such as clock, data, and chip enable. This Bus Display view makes it easy for you to identify where packets begin and end, and to identify sub-packet components, such as address, data, identifiers, CRC and so on.

This exercise demonstrates the ability of the MDO3000 Series to help you debug I<sup>2</sup>C circuits.

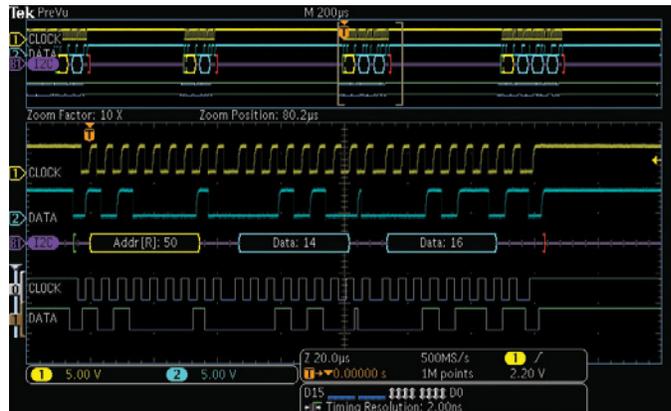


Figure 12.

**Note:** Serial Bus Analysis modules are available for purchase. For demonstration purposes all application modules and options are enabled in MDO3000 demo units.

**Note:** You can find more serial bus demonstrations in MDO3000 built-in demos. Press front panel **Utility** button. Press **Utility Page** lower-bezel button. Select **Demo** use **Multipurpose a**. More serial bus demos are under **Serial Bus** group.

1. Connect the ground lead of a probe to a point labeled **GND** on the demonstration board. Connect the probe from channel 1 on the oscilloscope to the **I2C\_CLK** test point on the demonstration board.
2. Connect the ground lead of a second probe to a point labeled **GND** on the demonstration board. Connect the second probe from channel 2 on the oscilloscope to the **I2C\_DATA** test point on the demonstration board.
3. Press the front-panel **Default Setup** button.
4. Press the front-panel channel **2** button to turn on channel 2. Press reset button on the demo board if there is no signal on the screen.

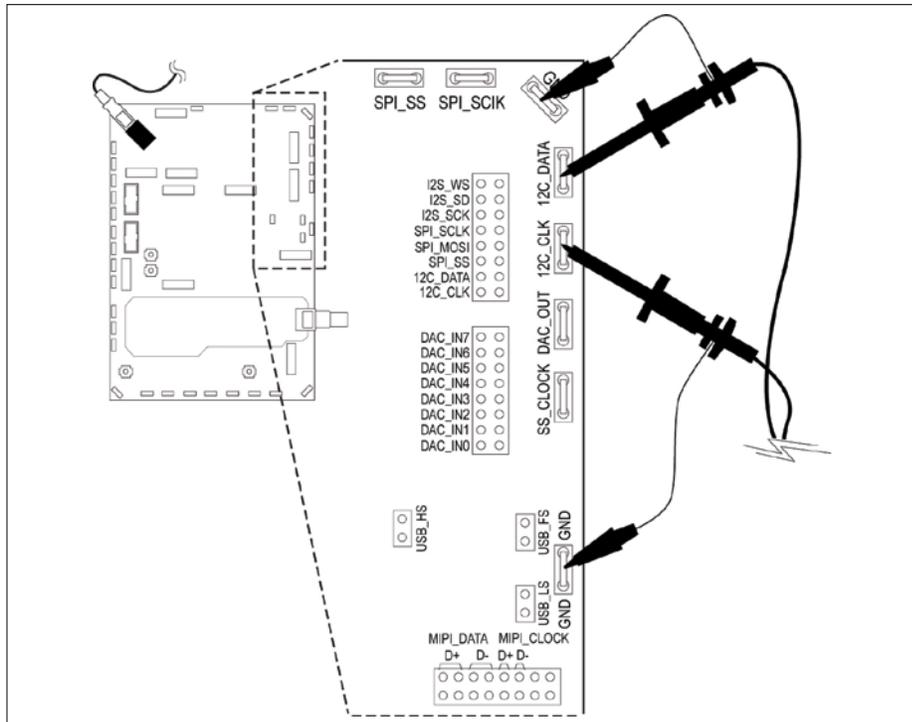


Figure 13.

- Turn the front-panel channel 1 and channel 2 **Vertical Scale** knobs so that both channel 1 and channel 2 are set to **2.0 V/div**.
- Turn the channel 1 and channel 2 **Vertical Position** knobs to position channel 1 near the top of the screen and channel 2 near the middle or bottom.
- Turn the front-panel **Horizontal Scale** knob to set the horizontal scale to **20.0 $\mu$ s/div**.
- Press the **B1** button.

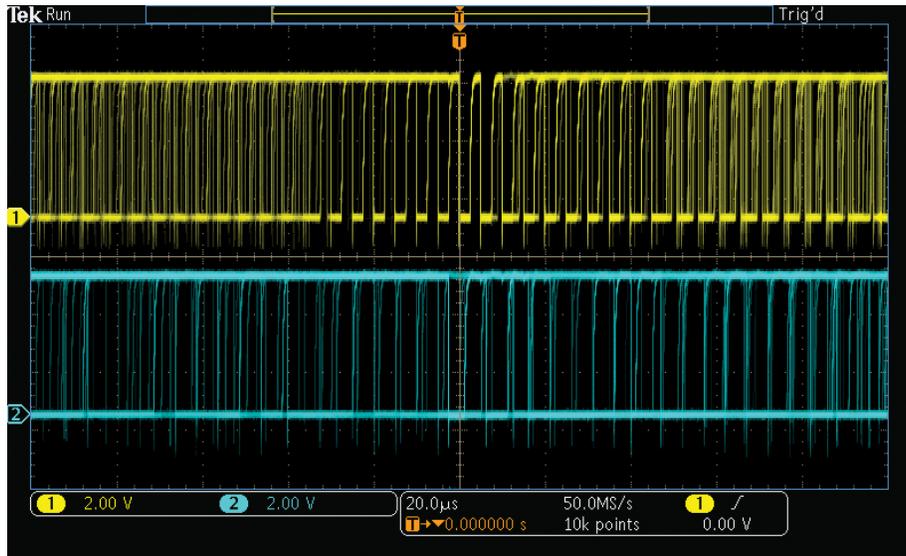


Figure 14.

9. Press the lower-bezel Bus **B1** button and turn **Multipurpose a**. Select **I2C**.
10. Press the lower-bezel **Define Inputs** button.
11. On the side-menu, confirm that the **SCLK Input** is set to channel 1 and that the **SDA Input** is set to channel 2.

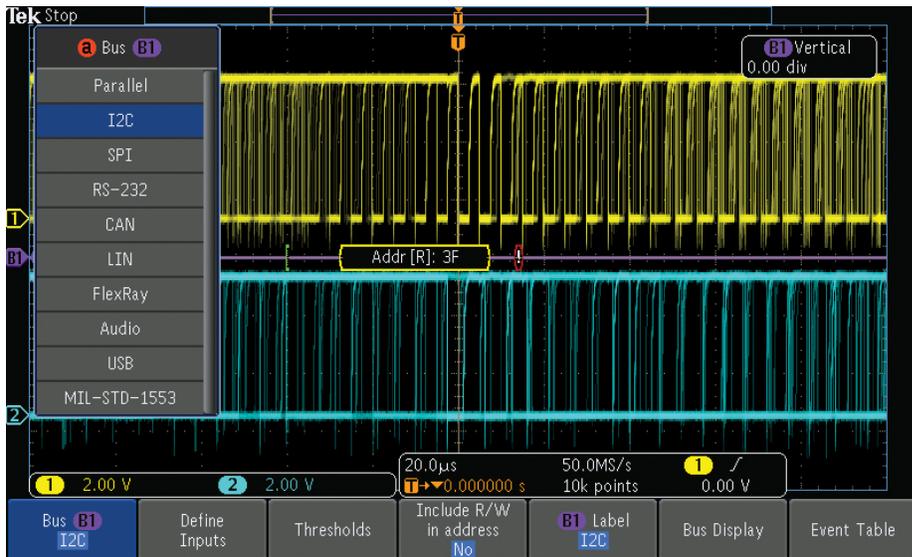


Figure 15.

12. Press the lower-bezel **Thresholds** button.
13. Turn multipurpose **a** and **b** to set the thresholds at about the midpoint of each waveform. You could also use the presets for common logic family voltages from the **Choose Preset** side menu.
14. Press the front-panel **Menu Off** button once to remove the side menu.
15. Press the front-panel **Single** button to acquire a single acquisition.

Now the scope automatically decodes I<sup>2</sup>C bus. The decode bus may be different from what you see here.

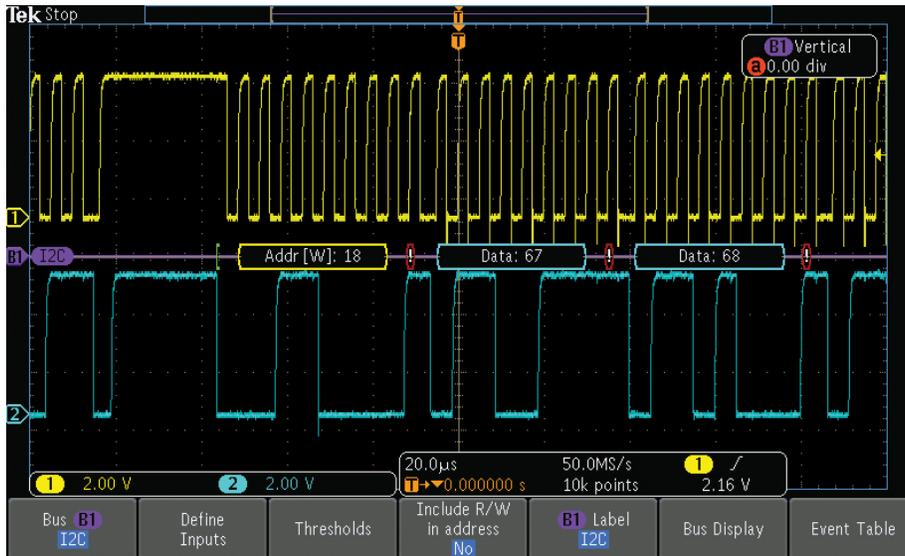


Figure 16.

When debugging a system, you often want to capture the state of some key signals when a certain event occurs. One key event may be the transmission of specific data over the I<sup>2</sup>C bus.

### The MDO3000 Series Oscilloscope triggers on:

- Start
- Repeat Start
- Stop
- Missing Acknowledgements
- Address
- Data
- Address & Data

To trigger on a specific address, follow these steps:

16. Press the front-panel **Trigger Menu** button.
17. Press the lower-bezel **Type** button and turn **Multipurpose a** to select Bus.
18. Press the lower-bezel **Trigger On** button.

Notice the list of trigger choices. The key is that you can trigger on all the important components of an I<sup>2</sup>C packet. Prior to this, you had to hope that the acquisition you were making contained the data of interest. Now you can guarantee it by specifying the trigger condition.

19. Turn **Multipurpose a** to select **Address**.
20. Press the lower-bezel **Address** button.
21. The side-bezel **Address** button should already be selected.
22. Turn **Multipurpose a** and **b** to enter a hex address of **50**.
  - Turn **Multipurpose a** clockwise to the first 'X' under Hex
  - Turn **Multipurpose b** clockwise to show the digit '5'.
  - Turn **Multipurpose a** clockwise to move the cursor to the next 'X'
  - Turn **Multipurpose b** clockwise to show the '0' digit

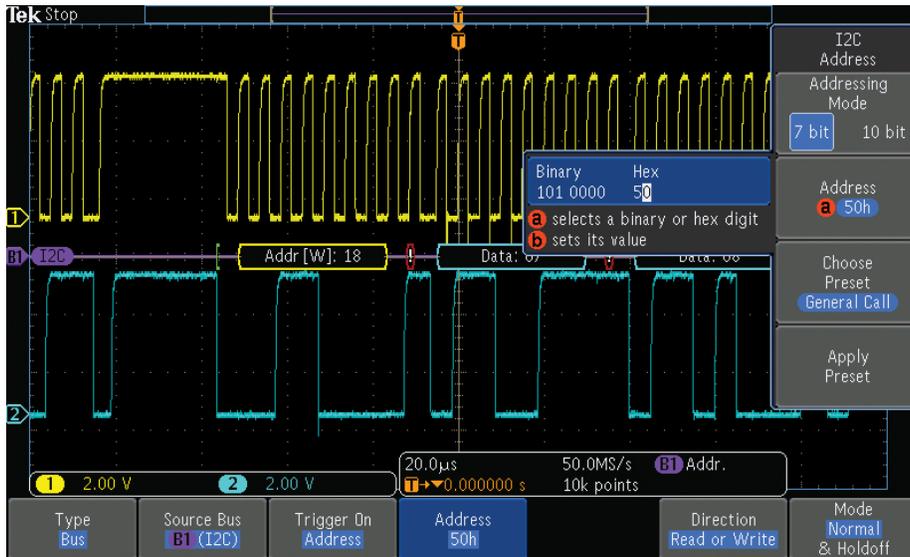


Figure 17.

23. Press the lower-bezel **Direction** button.
24. Select the side-bezel **Write** button.
25. Press **Single** to make an acquisition.
26. Press **Menu Off**.

Notice that the oscilloscope now triggers on address 50.

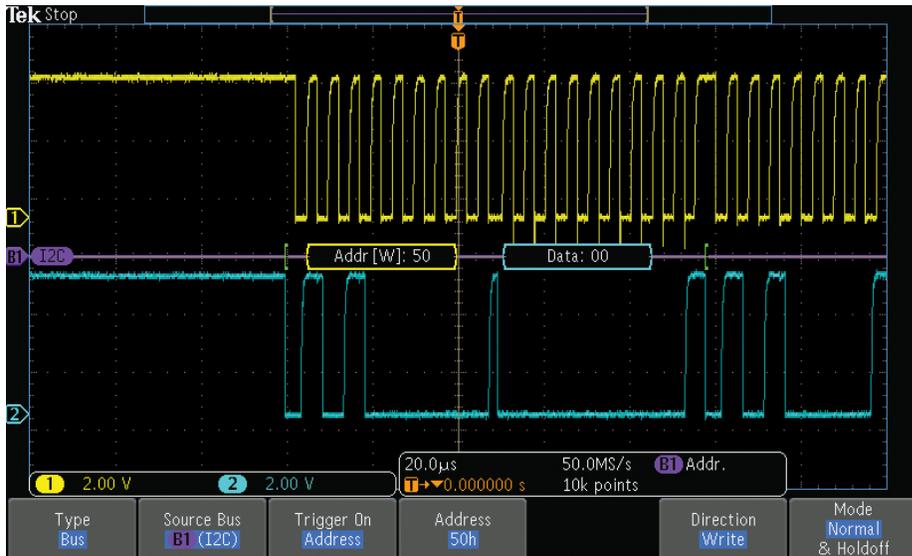


Figure 18.

In addition to seeing decoded packet data on the bus waveform itself, you can view all captured packets in a tabular view much like you would see in a software listing. Packets are time stamped and listed consecutively with columns for each component (Address, Data, etc.).

To view an event table:

27. Turn the front-panel **Horizontal Scale** knob to set the horizontal scale to **20.0 ms/div** to capture more data.
28. Set the record length to 1M points or higher to capture more details of the signal. To change the record length, press **Acquire**, select the **Record Length** lower-bezel button, then select the **1M** points.
29. Press **Single**.
30. Press **B1** bus
31. Press the lower-bezel **Event Table** button.
32. Press the side-bezel **Event Table On** button.
33. Scroll through table with **Multipurpose a**.

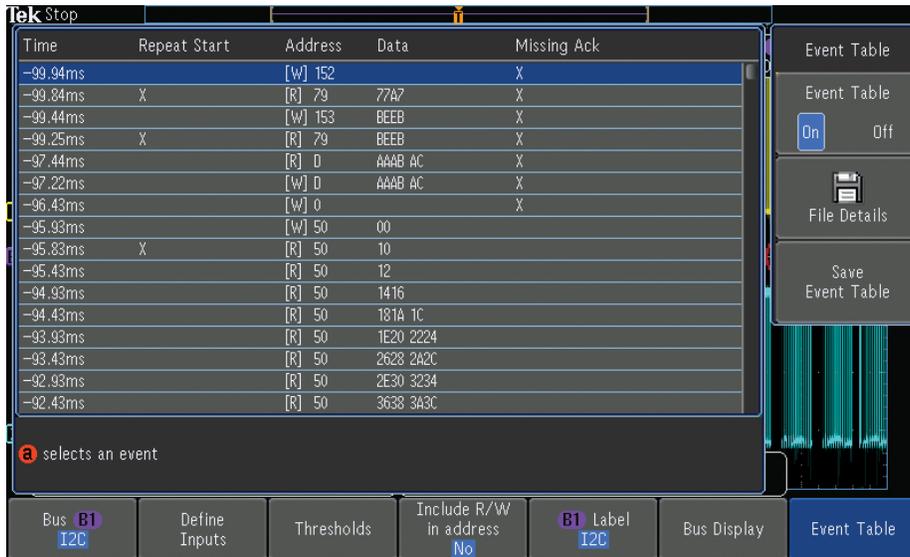


Figure 19.

You can also search for specific values or packets. To search for data value hex 17:

34. Press **Search** front panel button.
35. Press **Search** lower-bezel button and turn on search by pressing **Search On** side-bezel button.
36. Define search type. Press **Search Type** lower-bezel button. Select **Bus**.
37. Define search data. Press **Search For** lower-bezel button. Select **Data**. Press **Data** lower-bezel button. Press **Data** side-bezel button and set hex data to **17h**.

Now all data 17 in the acquisition that meet this search specification will be marked with a hollow white triangle at the top of the display. Notice the number of search events in the lower left corner.

You can use Wave Inspector to zoom in and navigate among marks.

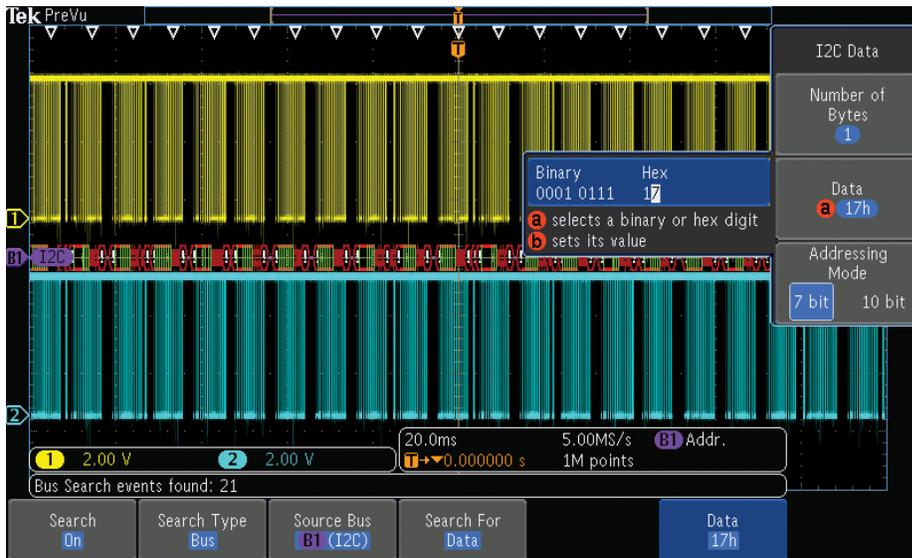


Figure 20.

## Exercise 4

### Acquiring Analog and Digital signals of a D/A Converter

Most embedded systems contain a mix of analog and digital circuitry. MDO3000 Series oscilloscope with its Mixed Signal Oscilloscope capability enables the acquisition of analog and digital signals and displays them time correlated on the display, providing insight into your complete system operation. Automated measurements work on both analog and digital channel data making it easy to learn even more about your signal behavior. And because everything is automatically time correlated, cursor measurements work across analog and digital channels. The digital channel monitor shows activity on digital channels at a glance without having to turn them on.

This exercise demonstrates how this oscilloscope can be used to simultaneously view analog and digital signals by probing both sides of a simple D/A converter.

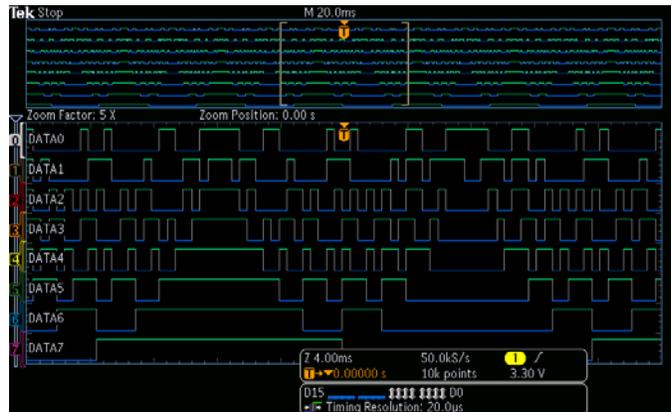


Figure 21.

**Note:** You could purchase the MDO3MSO instrument option to add 16 digital channels to your MDO3000, which includes the P6316 digital probe and accessories. For demonstration purposes, all application modules and options are enabled in MDO3000 demo units.

1. Connect Channel 1 to the **DAC\_OUT** signal on the demonstration board.  
 Connect the ground lead of a probe to a point labeled **GND** on the demonstration board.
2. Connect the P6316 Logic Probe to the front-panel Logic Probe connector below the oscilloscope display.

**Note:** Firmly insert the connector into the probe port on the front of the oscilloscope until you hear an audible 'click'. Test that you cannot remove the probe without pressing the buttons on the sides of the connector.

3. Connect **Group 1** of P6316 digital probe to J1002 header labeled **DAC\_IN\_0** through **DAC\_IN\_7** on the demonstration board.

**Note:** Make sure to connect the signal side of the probe header, with the color-coded channel labels, to the signal side of the connector and the ground side of the probe to the ground side of the connector.

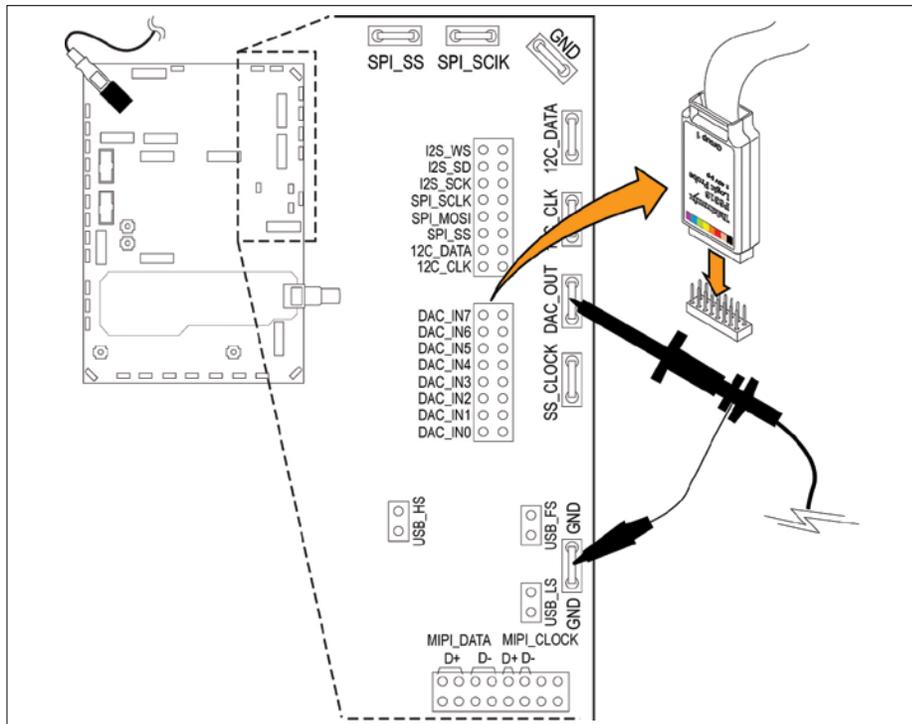


Figure 22.

4. Press the front-panel **Default Setup** button.
5. Change the horizontal scale to **4.00ms/div**
6. Change the vertical scale of Ch1 to **1.00 V/div**
7. Set the trigger level to **50%** of Ch1 by pressing the **trigger level control** knob.
8. Adjust the **Vertical Position** knob to place the signal on the upper half of the display.
9. Press the trigger **Menu** front panel button. Press the **Coupling DC** lower-bezel button. Select the **HF Reject** side-bezel button to reject high frequency components of the signal.

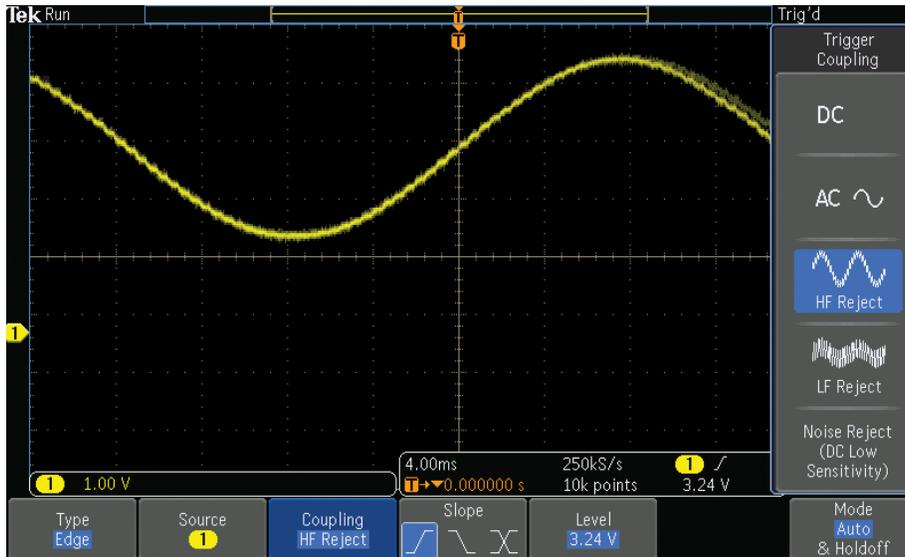


Figure 23.

10. Press the **blue D15-D0** front-panel button.
11. Press the lower-bezel **D15-D0 On/Off** button, not the blue D15-D0 front-panel button.
12. Press the side-bezel **Turn On D7-D0** button to display channels D0 through D7.
13. Position Ch1 above the digital channels in the upper portion of the display. Press the Monitor lower-bezel button to turn on the digital channel Monitor.
14. Press **Single** to make an acquisition.
15. Press **Menu Off**.

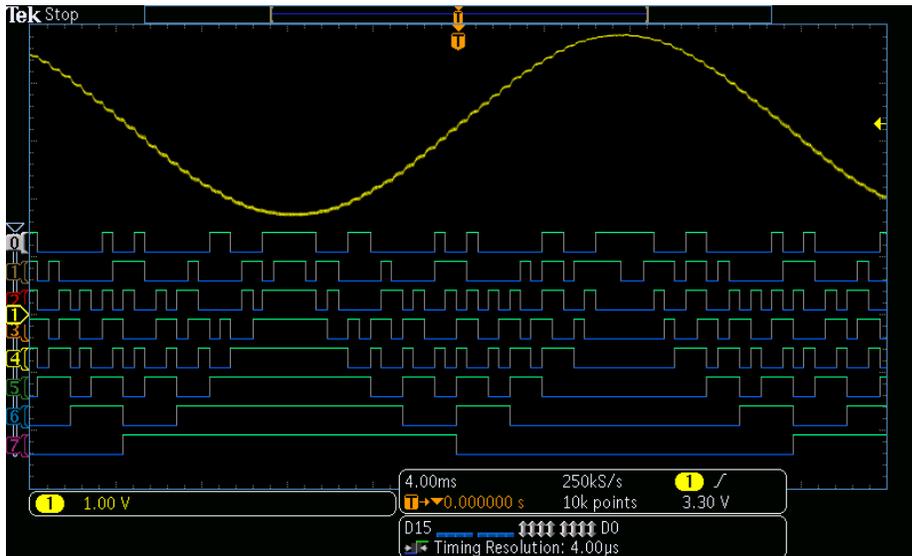


Figure 24.

## Exercise 5

### Using the Integrated Spectrum Analyzer

Designed with an independent RF acquisition system for the most accurate RF measurements, the MDO3000 offers better performance than FFT math operations found on traditional oscilloscopes.

The spectrum analyzer is integrated standard on MDO3000 with an input frequency of 9 kHz up to the analog bandwidth of the oscilloscope. The input frequency can be upgraded to 9 kHz - 3 GHz on any MDO3000 Series.

The following two exercises show you automated markers and spectrogram functionality on the MDO3000.

**Note:** You could purchase MDO3SA to increase the input range to 3GHz on your MDO3000. For demonstration purposes, MDO3SA option is enabled in MDO3000 demo units.

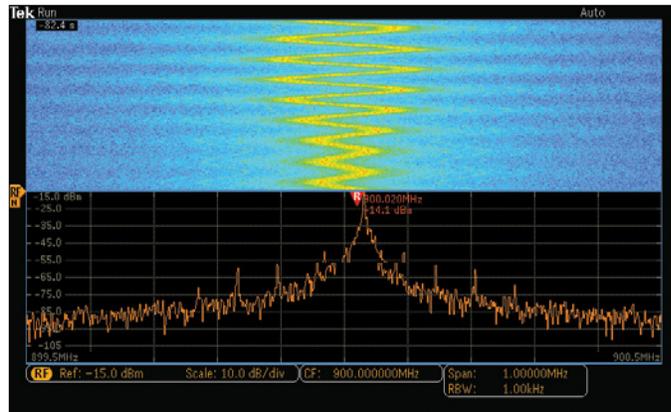


Figure 25.

## A. Multiple Peaks Demonstration

This exercise demonstrates how the frequency and amplitude of peaks in the spectrum are quickly identified with automatic peak markers.

1. Attach an **N-to-BNC** adapter to the **RF** input on the oscilloscope.
2. Connect a BNC cable to the adapter.
3. Connect the other end of the cable to the RF Out (BNC) connector on the demonstration board.
4. Press the **Mode** button on the MDO Demonstration board until the **Multiple Peaks** LED is lit.
5. Press **Default setup** front-panel button.

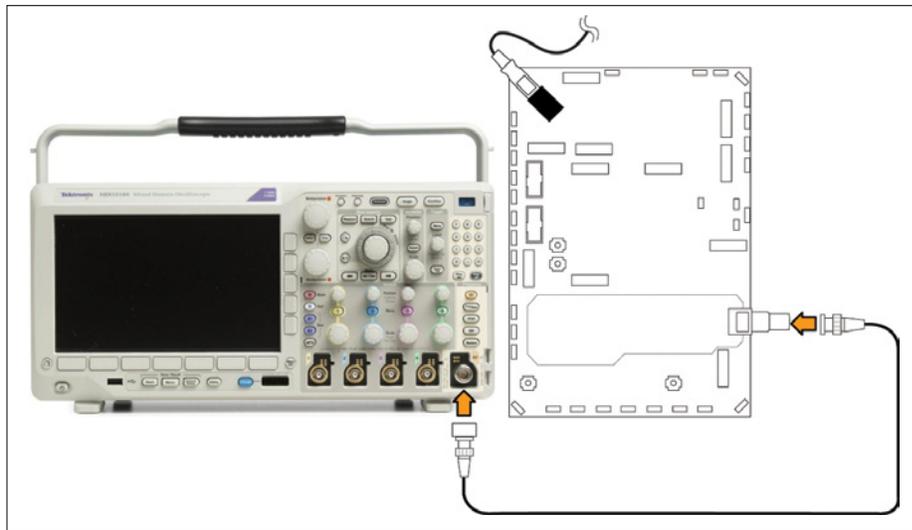


Figure 26.

6. Press **RF** front panel button to turn on the RF channel.
7. Press **Freq/Span** front-panel button under the spectrum analyzer controls.
8. Use **Multipurpose a** or the 10-digit keypad to set the center frequency to **2.4 GHz**.
9. Use **Multipurpose b** to set the span to **20 MHz**.
10. Press **menu off**.

Now you see multiple peaks with markers automatically marking the frequency and amplitude. The highest amplitude peak is the Reference Marker and is shown in red. **Reference Marker to Center** side-bezel button sets the Center Frequency to the frequency of the Reference Marker.

11. Press the **Markers** front panel button.  
You can set numbers of Peak Markers and Manual Marks using side-bezel buttons.

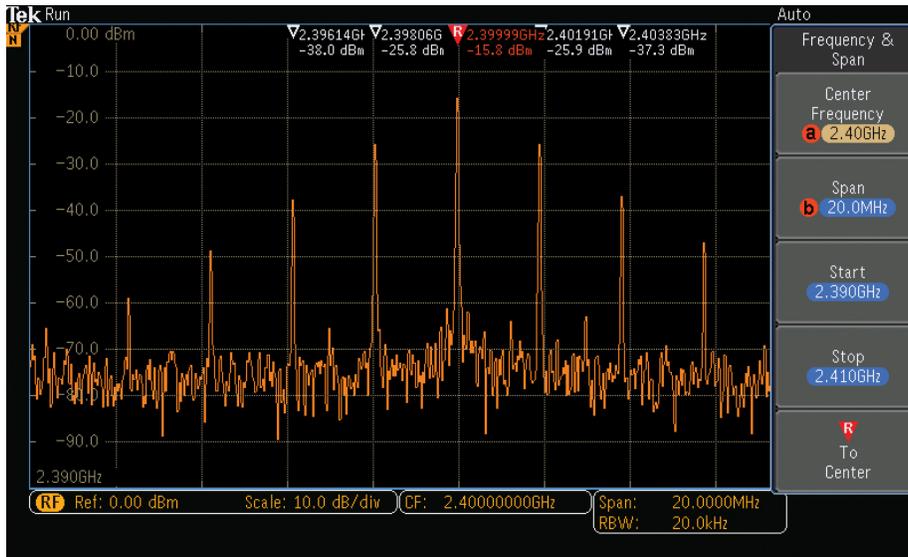


Figure 27.

## B. Spectrogram Demonstration

Spectrograms are useful for monitoring slowly changing RF events, and for identifying low amplitude signals that are too subtle for the eye to catch.

This exercise demonstrates how the oscilloscope spectrogram shows what is happening in the spectrum over time, and shows how to look at the Spectrum Slices using the **Multipurpose a** control.

1. Follow step 1 to 3 in the previous exercise to connect the RF channel to the demonstration board.
2. Press the **Mode** button on the Demonstration board until the **Spectrogram** LED is lit.
3. Press **Default setup** front-panel button.
4. Press the **RF** front panel button to turn on RF channel.
5. Press the **Freq/Span** front-panel button.
6. Press the **R to Center** side-bezel button to set the Center Frequency to the frequency of the reference marker.
7. Use **Multipurpose b** to set span to **10 MHz**.
8. Press the **RF** front panel button to turn on the RF menu.
9. Press the **Spectrogram** lower-bezel button.
10. Press the **Display On** side-bezel button to turn on the spectrogram.

11. Press the **Run/Stop** front panel button to stop acquiring.
12. Turn the **Multipurpose a** control to scroll through Spectrum Slices.

A Spectrogram shows how the spectrum changes over time. The x-axis is frequency, the y-axis is time. A Spectrogram is created by taking each spectrum and flipping it up on its edge so that it's one pixel row tall and then using color to indicate amplitude. Hotter colors (red, yellow) indicate higher amplitudes while colder colors (blue, green) indicate lower amplitudes.

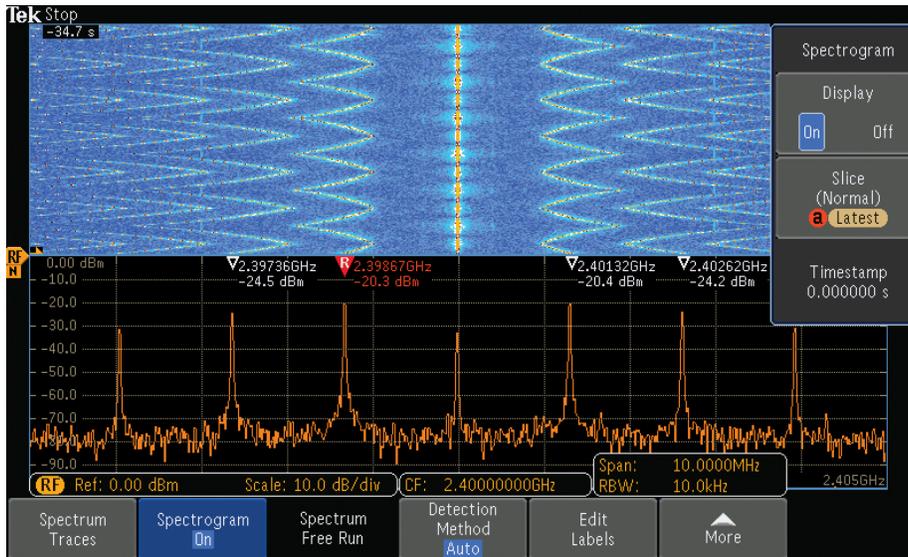


Figure 28.

## Exercise 6

### Generating Waveforms with the Integrated AFG

Arbitrary function generators (AFG) are useful in a number of applications, including adding noise to signals to test noise immunity in a system, emulating missing components in a design, and sweeping frequencies or modulating signals for characterization in time/frequency domains.

The MDO3000 Series oscilloscope with the 50 MHz integrated AFG can easily replicate signals acquired by the oscilloscope with added noise or other analog characteristics.

The MDO3000 also works in conjunction with ArbExpress PC-based arbitrary waveform editing software to create even more complex waveforms that can be generated by the AFG in the oscilloscope.

This exercise shows how you can capture a waveform on the oscilloscope, transfer it to the arbitrary function generator and replicate it.

**Note:** You could purchase the MDO3AFG option to enable the AFG functionality. For demonstration purposes MDO3AFG option is enabled in MDO3000 demo units.

1. Connect a BNC cable to **Channel 1** and to the **AFG output** on the rear of the oscilloscope.
2. Connect a passive probe to **Channel 2** on the oscilloscope.
3. Connect the ground lead of the probe to the **GND** point and the probe tip to the **RARE\_ANOMALY** signal on the demonstration board.
4. Press **Default Setup** front-panel button.
5. Press the **Channel 1** front-panel button twice to turn off channel 1 and press the **Channel 2** front-panel button to turn on channel 2.
6. Turn the Horizontal Scale knob to select **200 ns** per division.
7. Press trigger **Menu**, select **Type** lower-bezel button, use **Multipurpose a** to scroll down to **Run**.
8. Press **Source 1** lower-bezel button and change the source to **Channel 2**.



Figure 29.

9. Press the **Thresholds** lower-bezel button and adjust **High** to approximately **2.00 V** using **Multipurpose a**, adjust **Low** to about **1.00 V** using **Multipurpose b**.
10. Press the **Mode** lower-bezel button. Press the **Normal** side-bezel button.
11. Press **Single** to take one acquisition.
12. Press the **AFG** front panel button to open the AFG menu.
13. Under **Waveform Sine** lower-bezel button, use **Multipurpose a** to select **Arbitrary**.
14. Press the **Waveform Edit** lower-bezel button.
15. Press the **Load Waveform** lower-bezel button.
16. Press the **OK Load** button to copy the acquired waveform on Channel 2 into the arbitrary edit memory.

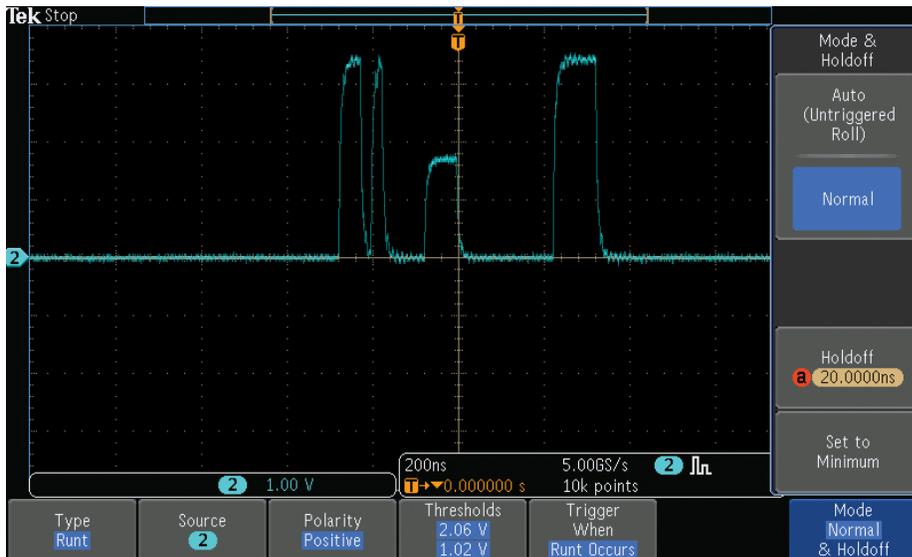


Figure 30.

17. Press the **Channel 2** front panel button twice to turn off channel 2 and press the **Channel 1** front panel button to turn on channel 1.
18. Press the **Run/Stop** front panel button to start acquiring the output of the AFG.
19. Turn the front-panel channel 1 **Vertical Scale** knob to set channel 1 to **1.00 V** per div.
20. Press the **Trigger Menu** front panel button.
21. Press the **Source** lower-bezel button and change the source to **Channel 1**.
22. Press the **Thresholds** lower-bezel button and adjust **High** to approximately **2.00 V** using **Multipurpose a**, adjust **Low** to about **1.00 V** using **Multipurpose b**.

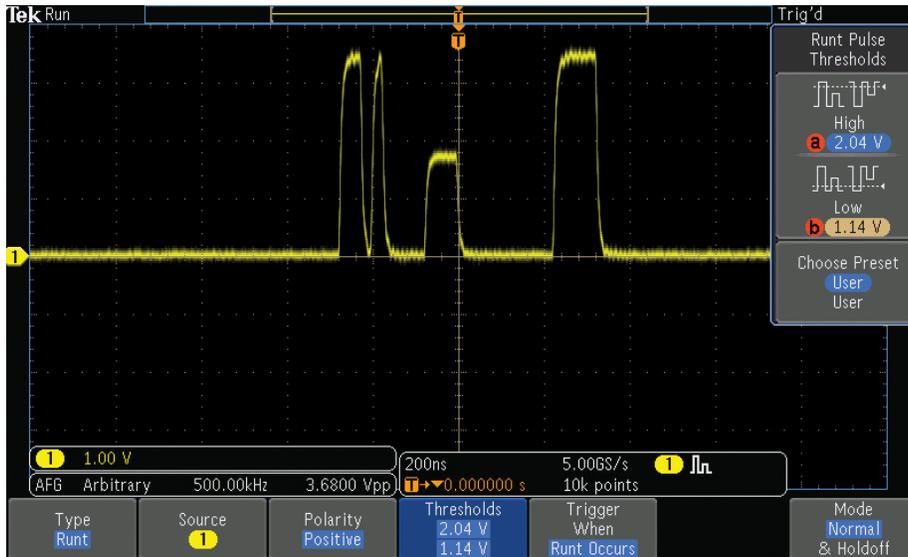


Figure 31.

Now you are triggered on the runt signal generated by MDO3000 integrated AFG.

## Exercise 7

### Measuring Signals with the Integrated DVM

The integrated digital voltmeter (DVM) is free when you register your MDO3000. It monitors voltage values of critical signals or power rails in your system at a glance without having to connect a separate meter. The oscilloscope offers **3.5-digit Voltage Measurements** for AC+DC RMS, AC RMS, and DC and **5.5-digit a Frequency Measurement** through the same probes as the oscilloscope channels. This functionality is decoupled from the scope trigger circuit allowing for uninterrupted measurements that are always available, even when the scope is not running.

**This exercise shows how you can measure DC voltage on a signal over time.**

1. Connect a BNC cable to **Channel 1** and to the **AFG output** on the rear of the oscilloscope.
2. Press **Default setup** front-panel button.
3. Press the **AFG** front panel button to bring up the AFG menu.
4. Select the **Waveform Settings** lower-bezel button to change the Amplitude and Offset of the sine waveform.
5. Use the **key pad** (or **Multipurpose a** and **b**) and side-bezel buttons to set the AFG with a Sine wave at **100 kHz** frequency, **1Vp-p** amplitude, and **500mV** offset.

- Set **horizontal scale** to **10 $\mu$ s/div**.
- Set Ch1 **vertical scale** to **200mV/div** and use vertical position to center the waveform.
- Press the Trigger **Level** control to set the trigger level to **50%** of Ch1.

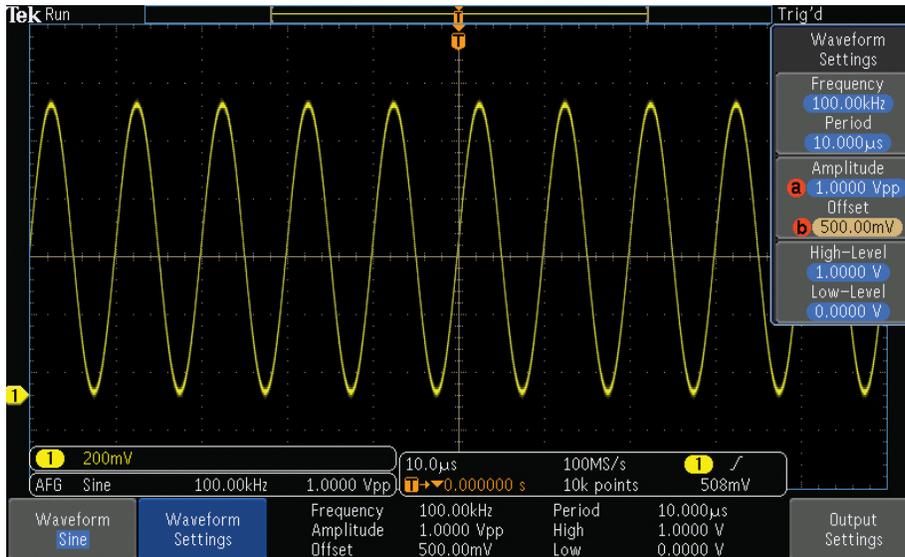


Figure 32.

9. Press the **Measure** front panel button.
10. Press the **DVM** lower-bezel button to turn on the DVM.
11. Use **Multipurpose a** to choose **DC** on Full display.
12. Press **Menu Off** to remove all menus.

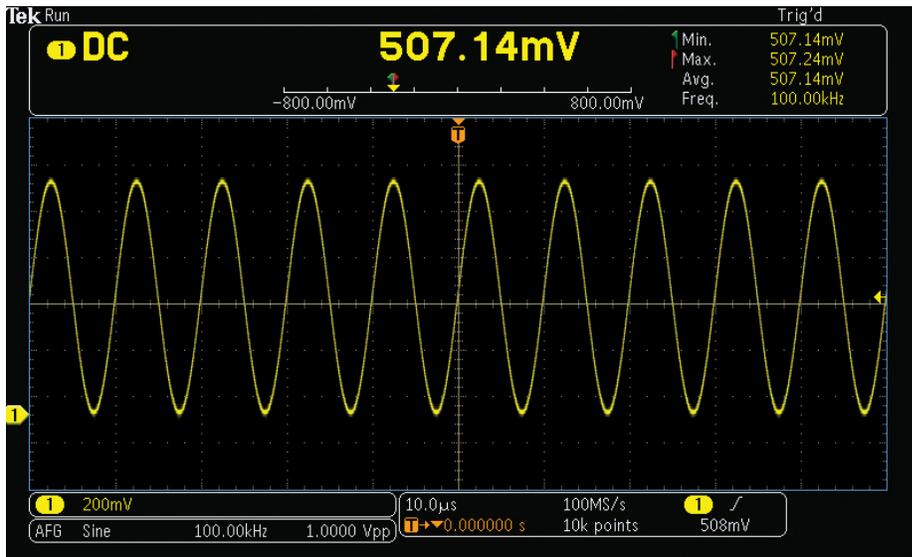


Figure 33.



## DAC Input, Parallel

**Board label:** DAC\_IN0, DAC\_IN1, DAC\_IN2, DAC\_IN3, DAC\_IN4, DAC\_IN5, DAC\_IN6, DAC\_IN7

**Grid location:** H3, H4

**Description:** These signals are the input to the DAC. These are also the 8-bit parallel output signals of the port expander in the middle of the mixed signal chain. The sine wave data from the SPI bus is converted to 8 parallel bits to drive the DAC. DAC\_IN0 is the LSB. (See Figure 35.)

## DAC Output

**Board label:** DAC\_OUT

**Grid location:** H3

**Description:** This is the output of the DAC at the end of the mixed signal chain. The DAC is driven from the port expander. The DAC output is a sine wave. Since the output is not filtered, the digitizing levels are present in the output waveform. (See Figure 35.)

The resulting DAC voltage is a sine wave with an amplitude of 0 to 3 volts, and a period of 31 ms.

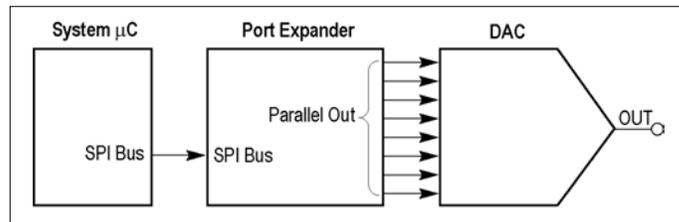


Figure 35. Mixed signal chain block diagram.

## Frequent Anomaly

**Board label:** FREQ\_ANOMALY

**Grid location:** A9

**Description:** There are two frequently occurring anomalies in this pulse train.

A half height runt signal occurs approximately every 104.8 ms. Use a Runt trigger to isolate the signal.

A 25 ns (narrow) pulse appears approximately every 104.8 ms. Use a Pulse Width trigger to isolate the signal.

The pulse train is a repeating group of three pulses. The three pulses are 100 ns, 200 ns, and 100 ns wide, with a 100 ns low between. The group repeats at a 1.6  $\mu$ s rate.

The anomaly is a group of four pulses. The four pulses are 100 ns, 50 ns (narrow), 100 ns (runt), and 100 ns wide, with a 100 ns low between, except for a 50 ns low before the runt.

## I<sup>2</sup>C Bus

**Board label:** I2C\_CLK, I2C\_DATA

**Grid location:** H2, H3

**Description:** These are the I2C (Inter-IC Communication) bus signals between the  $\mu$ C and a serial EEPROM.

There are several different types of data packets.

The clock rate is a 200 kHz, 0 to 5 volt signal.

## Mode Button

**Board label:** Mode

**Grid location:** A11

**Description:** Press this button to choose which of the seven alternative signals to send out of the RF output connector. Your current choice is identified by which of the seven related red LEDs is lighted.

## Multiple Peaks Demo

The RF output connector generates an array of frequencies, which are centered around 2.4 GHz, to show the ability of the MDO3000 Series oscilloscopes to dynamically mark each peak in the frequency domain with its exact frequency and amplitude.

The red LED labeled "Multiple Peaks" at grid location B11 turns on.

## Spectrogram Demo

The RF output connector generates an array of frequencies, which are centered around 2.4 GHz and are both amplitude and frequency modulated, to show the value of the Spectrogram function on slowly changing RF phenomena.

The red LED labeled "Spectrogram" at grid location B11 turns on.

## Rare Anomaly

**Board label:** RARE\_ANOM

**Grid location:** A10

**Description:** The two less-frequent anomalies in this pulse train can show up on high waveform capture rate oscilloscopes.

A half-height runt signal occurs approximately every 838.8 ms. Use a Runt trigger to isolate the signal.

A 25 ns (narrow) pulse appears in approximately 838.8 ms. Use a Pulse Width trigger to isolate the signal.

The pulse train is a repeating group of three pulses. The three pulses are 100 ns, 200 ns, and 100 ns wide, with a 100 ns low between each pulse. The group repeats at a 1.6  $\mu$ s rate.

The anomaly is a group of four pulses. The four pulses are 50 ns, 25 ns (narrow), 100 ns (runt), and 100 ns wide, with a 100 ns low between each pulse, except for a 25 ns low before the narrow pulse.

## Reset Button

**Board label:** RESET

**Grid location:** B7

**Description:** Press this button to start all generated signals from a common point.

## RF Output

**Board label:** None

**Grid location:** H9

**Description:** Use the RF output from this connector in the seven different RF demos controlled by the Mode button. Directly connect this output to the RF input of the MDO3000 Series oscilloscope.

**Contact Tektronix:**

**North America** 1 (800) 833-9200

**Worldwide** visit: [www.tektronix.com](http://www.tektronix.com) to find contacts in your area.

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