Selecting Your Next Oscilloscope

Understanding Key Oscilloscope Specifications and Features

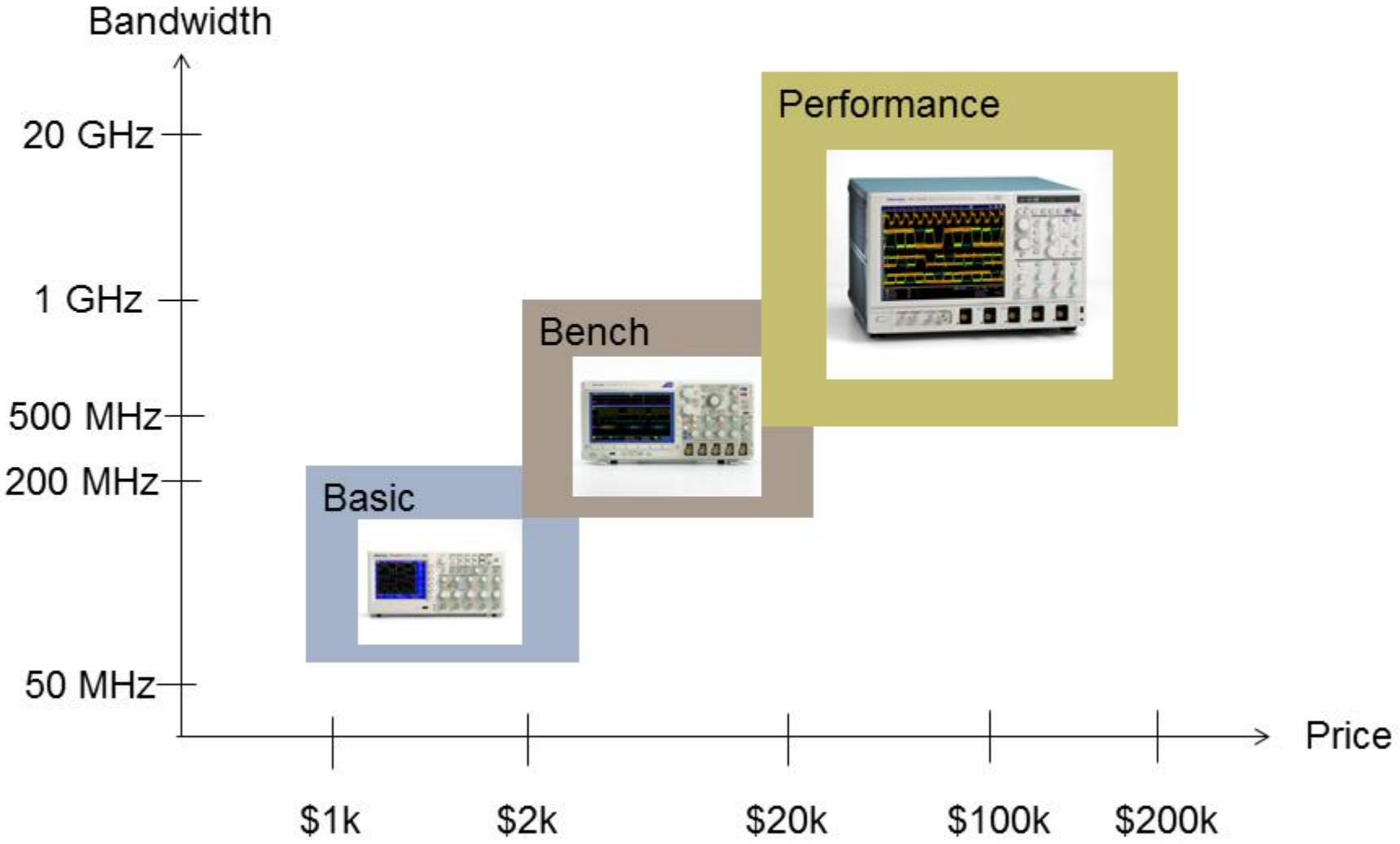
Tektronix®

What to Look for in an Oscilloscope

- Accurately captures your signals
- Provides features that expand your capabilities and save you time
- Works how and where you work

Tektronix®

Oscilloscope Categories



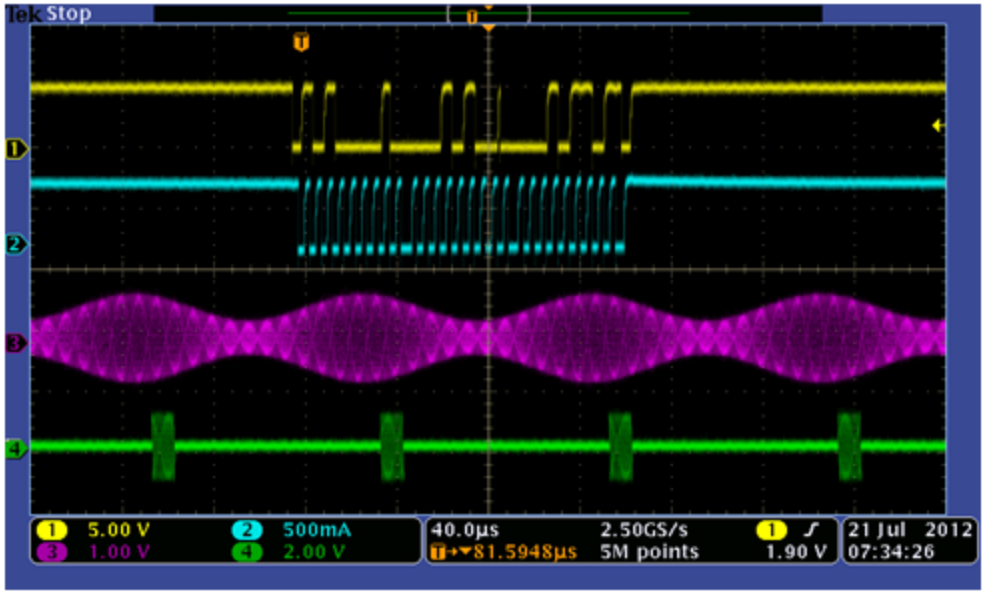
Tektronix

Your next oscilloscope should

ACCURATELY CAPTURE YOUR SIGNALS

Tektronix®

Consider Your Signals

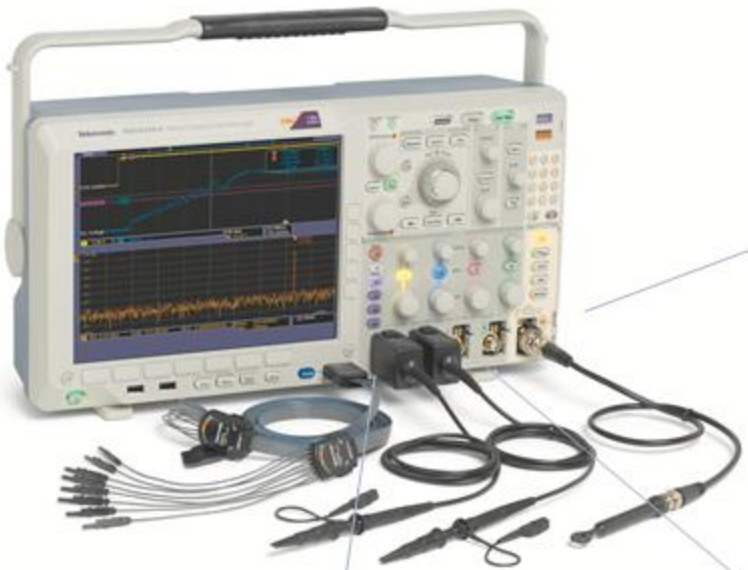


- Frequency range?
- Rise times?
- What parameters?
- Key standards or technologies?
- Quick troubleshooting? Or precision measurements? Or both?

Tektronix®

Number and Types of Input Channels

- Provides a time-correlated view among the various inputs
- 2 or 4 analog channels
- 8 or 16 Digital Channels (Mixed Signal Oscilloscope)
- RF Channel (Mixed Domain Oscilloscope)



RF Input Channel

4 Analog Input Channels

16 Digital Input Channels

Tektronix®

Number and Types of Input Channels

- Provides a time-correlated view
- 2 or 4 analog channels
- 8 or 16 Digital Channels (Mixed Signal Oscilloscope)
- RF Channel (Mixed Domain Oscilloscope)

4 Analog Input Channels

Tektronix®

Number and Types of Input Channels

- Provides a time-correlated view
- 2 or 4 analog channels
- 8 or 16 Digital Channels (Mixed Signal Oscilloscope)
- RF Channel (Mixed Domain Oscilloscope)

16 Digital Input Channels

Tektronix®

Number and Types of Input Channels

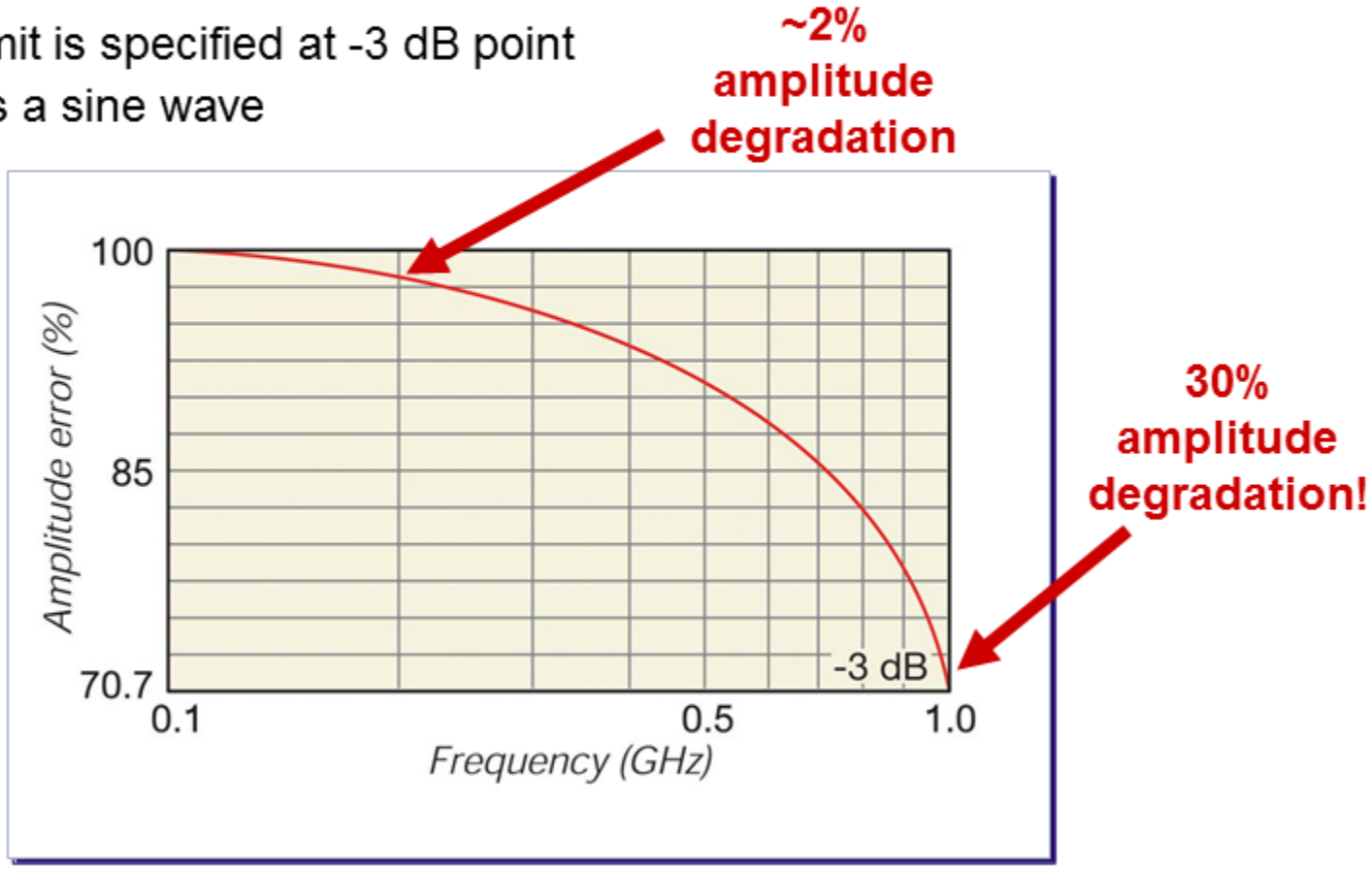
- Provides a time-correlated view
- 2 or 4 analog channels
- 8 or 16 Digital Channels (Mixed Signal Oscilloscope)
- RF Channel (Mixed Domain Oscilloscope)

RF Input Channel

Tektronix

Bandwidth

- Indicates the frequency range over which an oscilloscope can measure
  - Upper limit is specified at -3 dB point
  - Assumes a sine wave

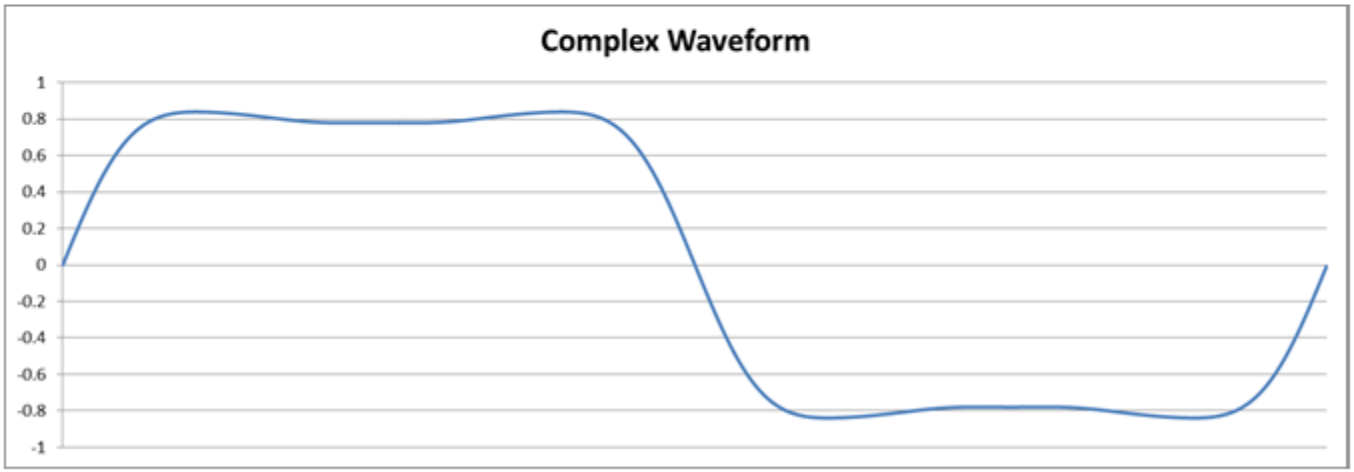


Typical frequency response curve for a basic oscilloscope

Tektronix

Working with Complex Signals

- Complex signals contain many spectral components that add to form the signal
- This means frequencies much higher than the fundamental frequency are present in these signals
- Consider the **highest frequency of interest**
  - If you work with complex waveforms like square waves, this will be some multiple of the fundamental frequency
  - You will have to have a sense of the spectrum of your signals
  - Or, for square waves, you can think in terms of rise time



Tektronix

Avoiding Bandwidth Measurement Errors

- Follow the “5 Times” Rule for Choosing Bandwidth
  - For less than +/- 2% roll-off error

$$Scope\ Bandwidth \geq 5\ x\ Highest\ Frequency\ of\ Interest$$

Tektronix®

Avoiding Bandwidth Measurement Errors

For example:

Say you work with 20 MHz sinusoidal waveforms.

A 100 MHz oscilloscope will allow you to see your signal with less than 2% attenuation due to the roll-off of the instrument.

Characteristics

Vertical System Analog Channels

Characteristic	MSO3012 DPO3012	MSO3014 DPO3014	MSO3032 DPO3032	MSO3034 DPO3034	DPO3052	MSO3054 DPO3054
Input Channels	2	4	2	4	2	4
Analog Bandwidth (–3 dB)	100 MHz	100 MHz	300 MHz	300 MHz	500 MHz	500 MHz
Calculated Rise Time 5 mV/div (typical)	3.5 ns	3.5 ns	1.17 ns	1.17 ns	700 ps	700 ps

Tektronix®

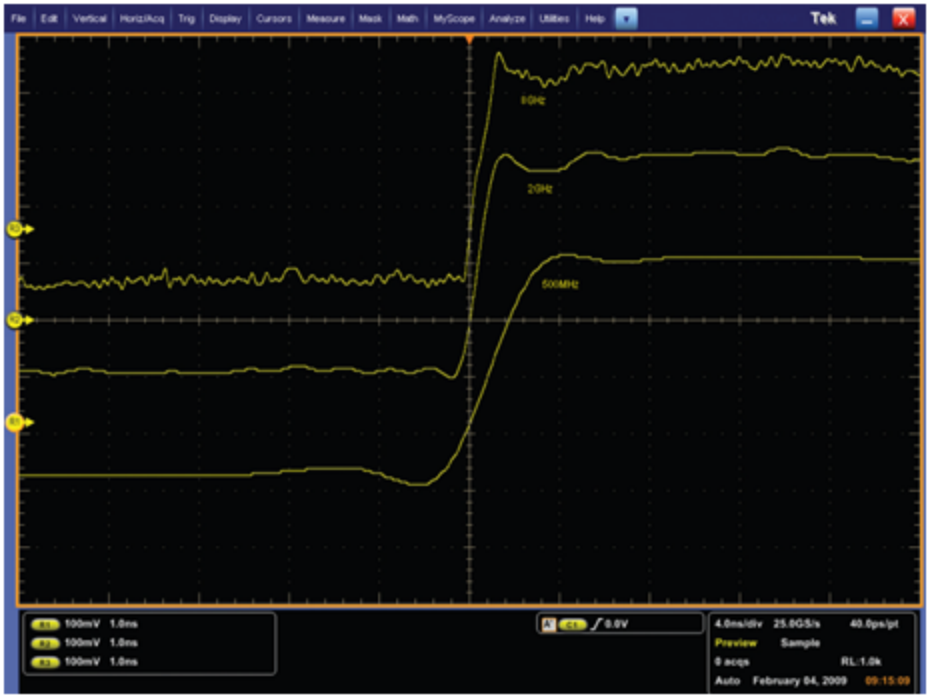
Rise Time

- Bandwidth and rise time are directly related
  - Higher bandwidth => faster rise time
- Oscilloscope rise time will affect your measurements

$$Measured\ RT = \sqrt{Oscilloscope\ RT^2 + Signal\ RT^2}$$

A signal with 1 ns rise time captured with

- 8 GHz bandwidth
- 2 GHz bandwidth
- 500 MHz bandwidth



Tektronix

“5 Times Rule” for Rise Time

$$Rise\ Time \leq \frac{Signal\ Rise\ Time}{5}$$

For example:

4 ns rise time implies a scope with faster than 800 ps rise time

Characteristics

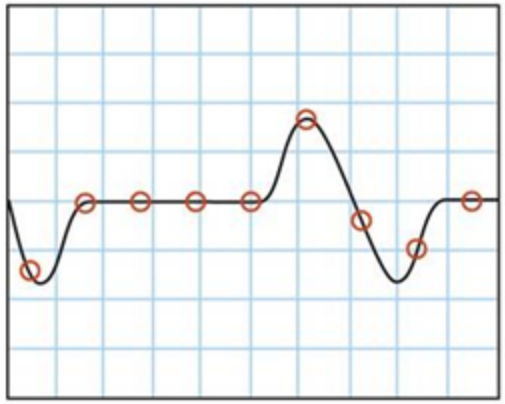
Vertical System Analog Channels

Characteristic	MSO3012 DPO3012	MSO3014 DPO3014	MSO3032 DPO3032	MSO3034 DPO3034	DPO3052	MSO3054 DPO3054
Input Channels	2	4	2	4	2	4
Analog Bandwidth (–3 dB)	100 MHz	100 MHz	300 MHz	300 MHz	500 MHz	500 MHz
Calculated Rise Time 5 mV/div (typical)	3.5 ns	3.5 ns	1.17 ns	1.17 ns	700 ps	700 ps

Tektronix®

Sample Rate

- Determines how frequently an oscilloscope converts the analog signal into digital samples
  - Faster sample rate, greater resolution and waveform detail
  - Resolution depends on both record length and sample rate
- Sample rate varies with horizontal scale
  - The sample rate shown in the banner specs is usually the maximum
  - Most instruments maintain some number of samples per division
  - Some instruments change sample rate as you turn on more channels. Check the footnotes
- Under-sampling can cause “aliasing”
  - Makes frequencies look much lower than expected



Tektronix®

“5 Times Rule” for Sample Rate

Minimum to avoid aliasing (Nyquist limit)

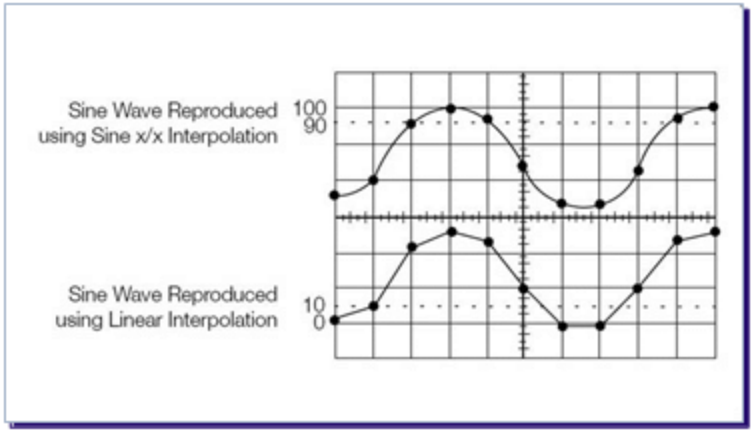
$$Sample\ Rate > 2\ x\ Highest\ Sine\ Frequency$$

For sin(x)/x interpolation

$$Sample\ Rate > 2.5\ x\ Highest\ Sine\ Frequency$$

For linear interpolation

$$Sample\ Rate > 10\ x\ Highest\ Sine\ Frequency$$



- Tektronix basic and bench oscilloscopes use sin(x)/x interpolation
- Sampling rate of 5 times the bandwidth is recommended to capture signal details

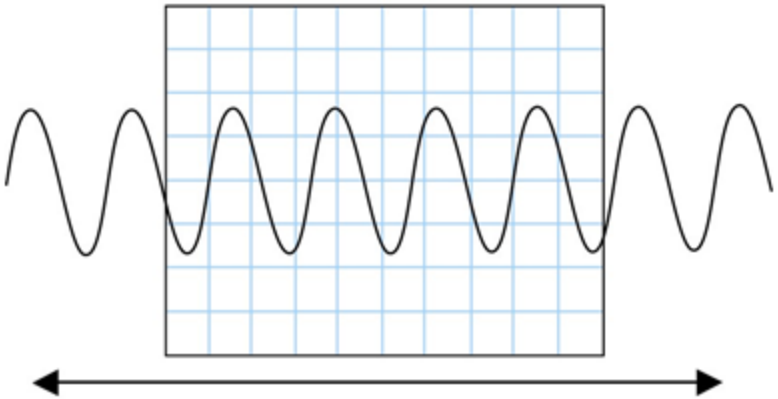
Horizontal System Analog Channels

Characteristic	All MSO3000 Models All DPO3000 Models
Maximum Sample Rate (all channels)	2.5 GS/s
Maximum Record Length (all channels)	5 Mpoints

Tektronix

Record Length

- Determines how much time and detail can be captured in a single acquisition
  - Longer record length => longer time window with high resolution



$$\text{Capture Time} = \frac{\text{Record Length}}{\text{Sample Rate}}$$

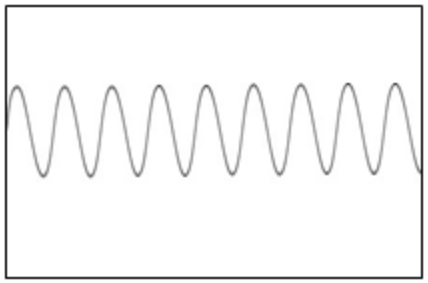
Horizontal System Analog Channels

Characteristic	All MSO3000 Models All DPO3000 Models
Maximum Sample Rate (all channels)	2.5 GS/s
Maximum Record Length (all channels)	5 Mpoints
Maximum Duration of Time Captured at Highest Sample Rate (all channels)	2 ms

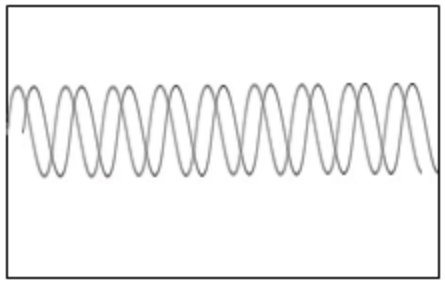
Tektronix®

Triggering (for a stable display)

- Triggering allow you to achieve a stable display
- Basic triggers include
  - Edge
  - Pulse width
  - Video
- All signals are referenced to a single trigger, to maintain time-correlation



Triggered Display



Untriggered Display

Tektronix®

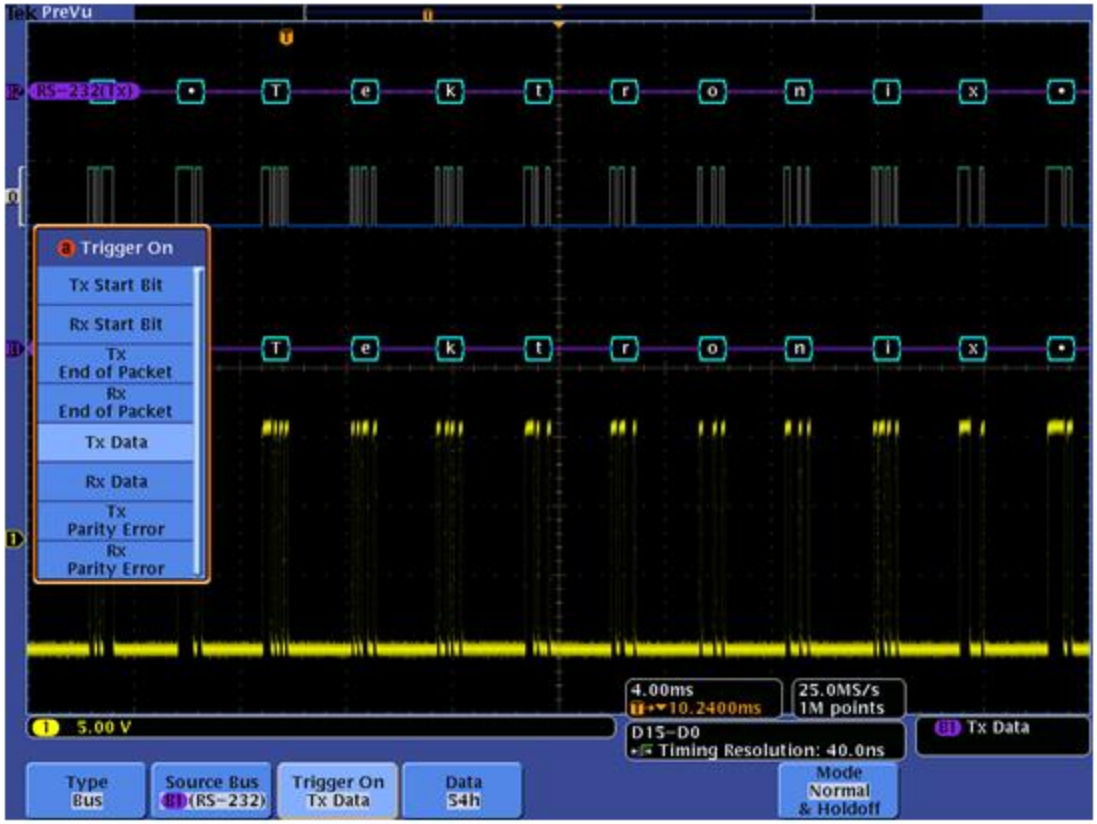
Your next oscilloscope should

EXPAND YOUR CAPABILITIES AND SAVE YOU TIME

Tektronix®

Advanced Triggering

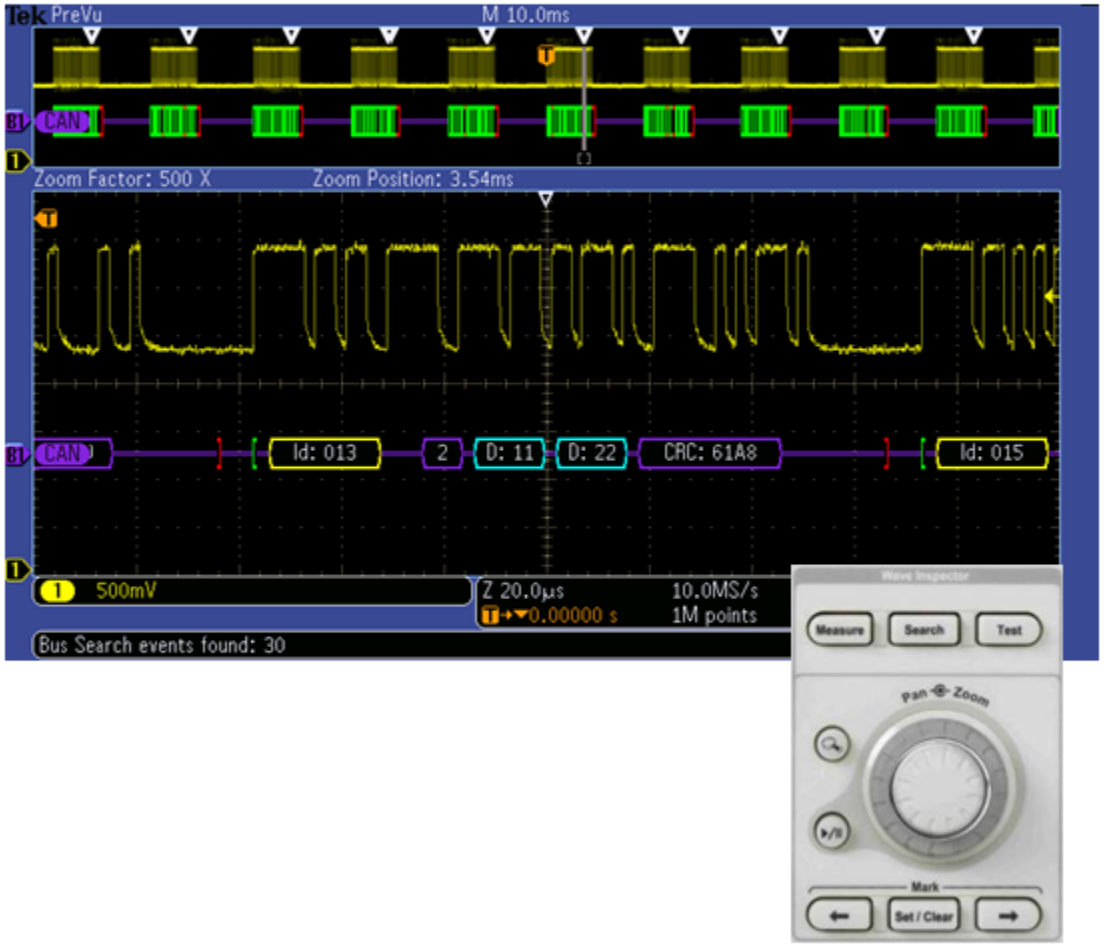
- Use advanced triggers to
  - Acquire anomalies
  - Make best use of record length
- Examples of advanced triggers:
  - Runt
  - Sequence
  - Rise/fall time
  - Logic
  - Glitch (pulse width)
  - Setup/hold
  - Serial packet
  - Parallel data



Tektronix

Advanced Searching

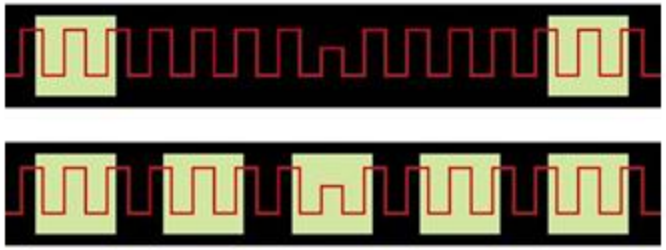
- Search for:
  - Edges
  - Runts
  - Rise/fall times
  - Logic Conditions
  - Glitches (pulse width)
  - Setup/hold violations
  - Serial packets
  - Parallel data
- Search and Triggers may use similar criteria



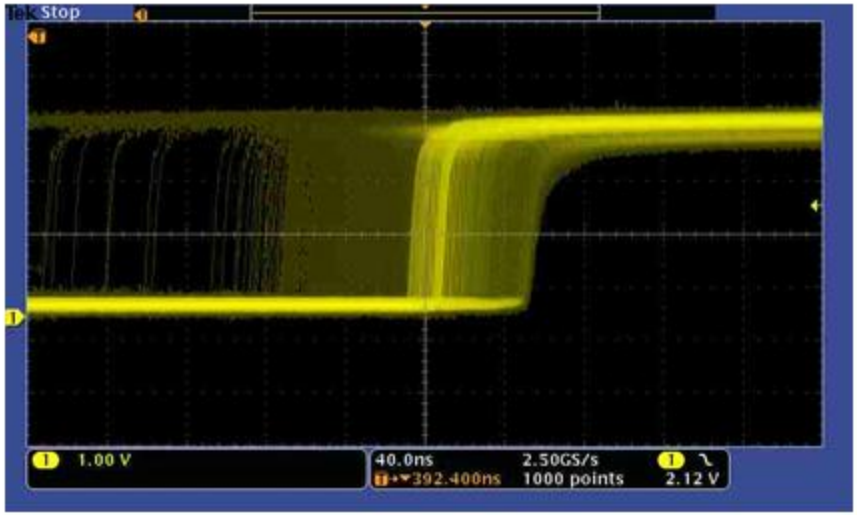
Tektronix

Waveform Capture Rate and Digital Phosphor

- Waveform capture rate
  - How fast a scope can acquire and display data
  - Faster capture rate means you'll find elusive glitches and other transient events faster



- Digital phosphor display with intensity-grading
  - Shows frequency of occurrence for better characterizing failures



Tektronix

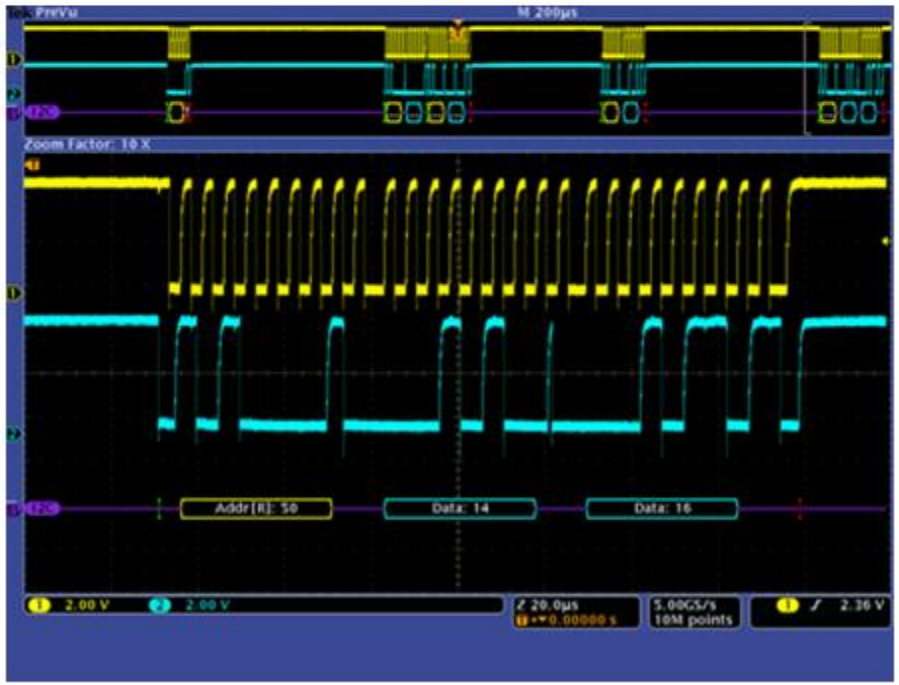
Bus Decode

- Serial bus information can be
  - Decoded and displayed
  - Used to trigger and search
- Analog and Bus information are time-correlated
- Available buses include I^2C, SPI, CAN, LIN, USB, Ethernet,RS-232…

Analog CH1

Analog CH2

Bus



Tektronix

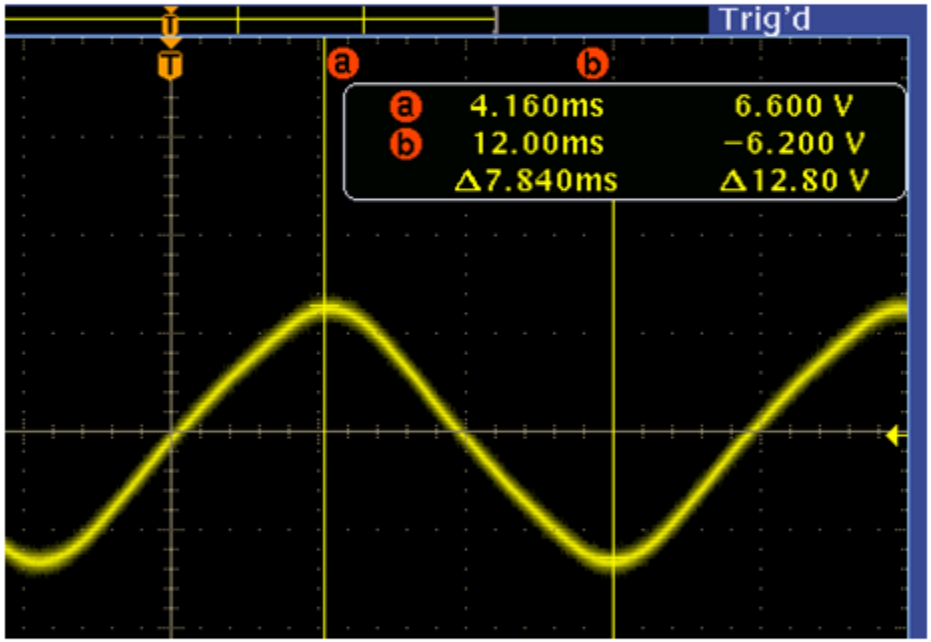
Serial Bus Decode and Support

- Refer to the scope's datasheet for details on serial bus triggering, decoding, and search capability.

Technology		Trigger	Bus Decode	Event Table	Search	Order Product
Embedded	I²C	X	X	X	X	DPO3EMBD
	SPI	X	X	X	X	DPO3EMBD
Computer	RS-232/422/485, UART	X	X	X	X	DPO3COMP
Automotive	CAN	X	X	X	X	DPO3AUTO
	LIN	X	X	X	X	DPO3AUTO
	FlexRay	X	X	X	X	DPO3FLEX
Military and Aerospace	MIL-STD-1553	X	X	X	X	DPO3AERO
Audio	I²S	X	X	X	X	DPO3AUDIO
	LJ, RJ	X	X	X	X	DPO3AUDIO
	TDM	X	X	X	X	DPO3AUDIO

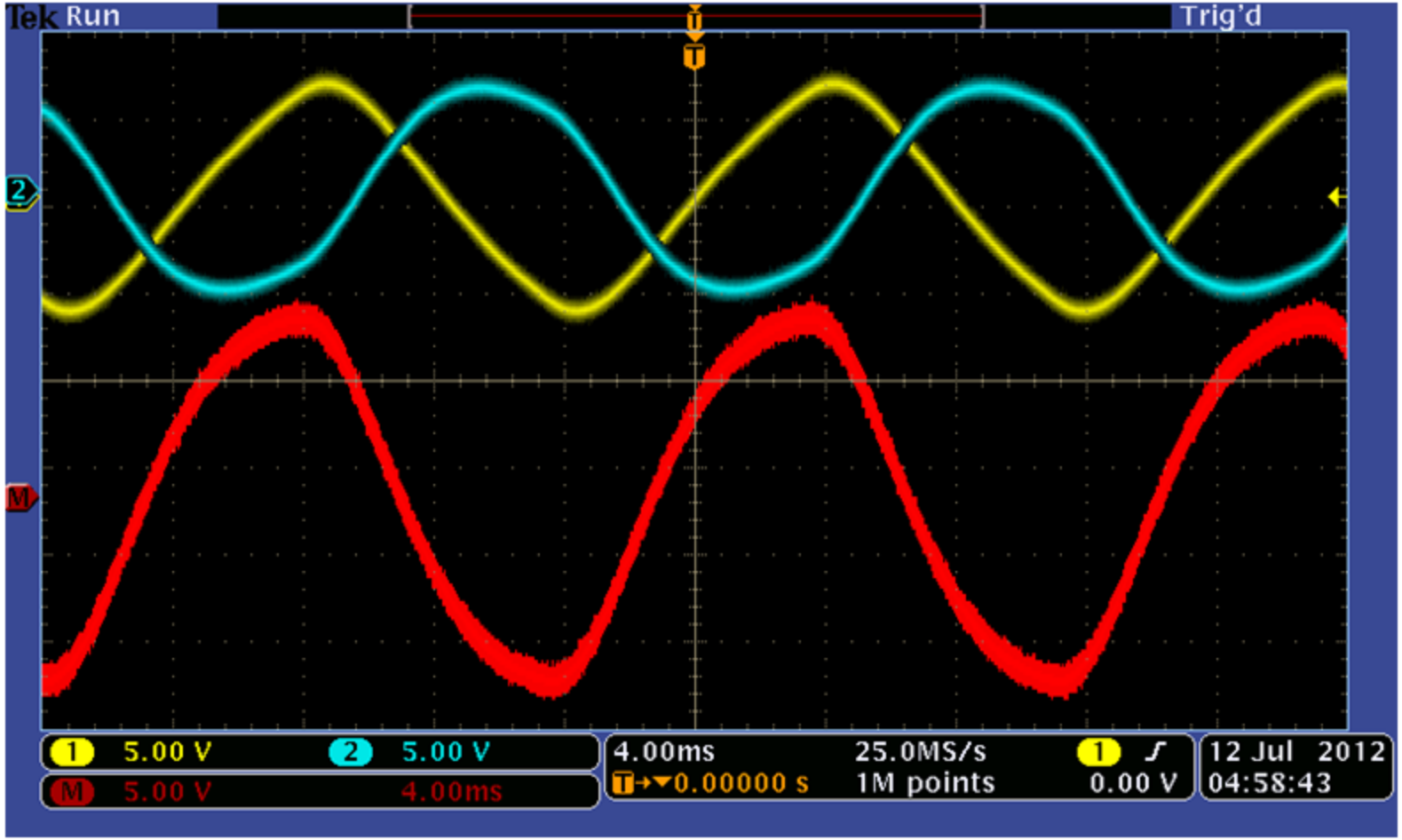
Tektronix®

Measurements and Analysis -- Cursors



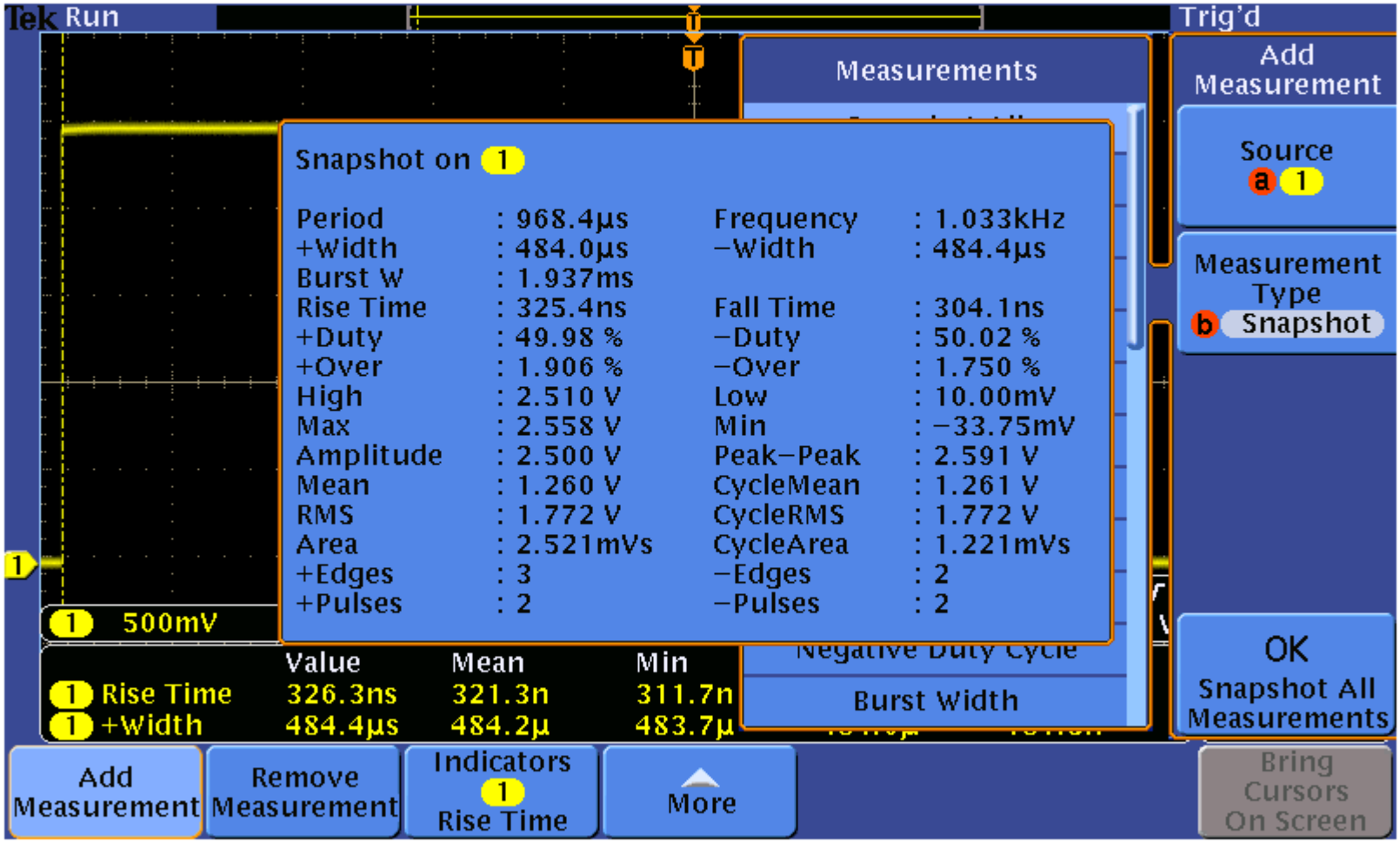
Tektronix®

Measurements and Analysis – Waveform Math



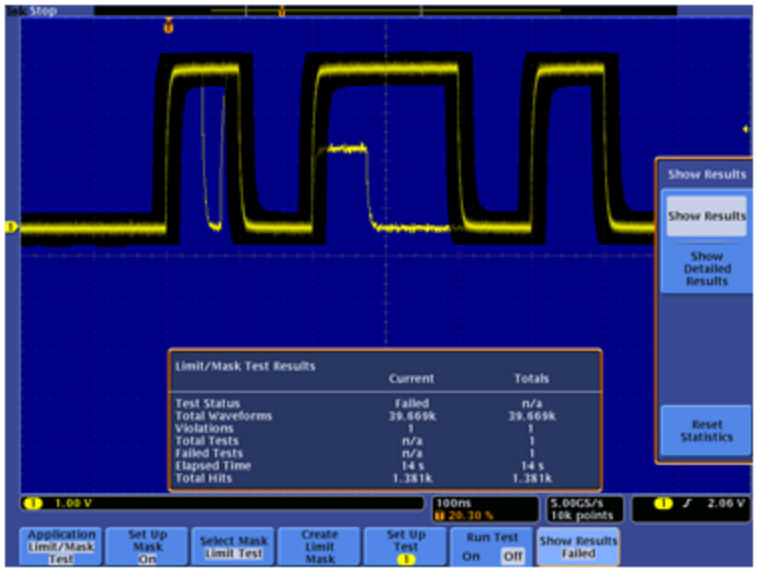
Tektronix

Measurements and Analysis – Automatic Measurements

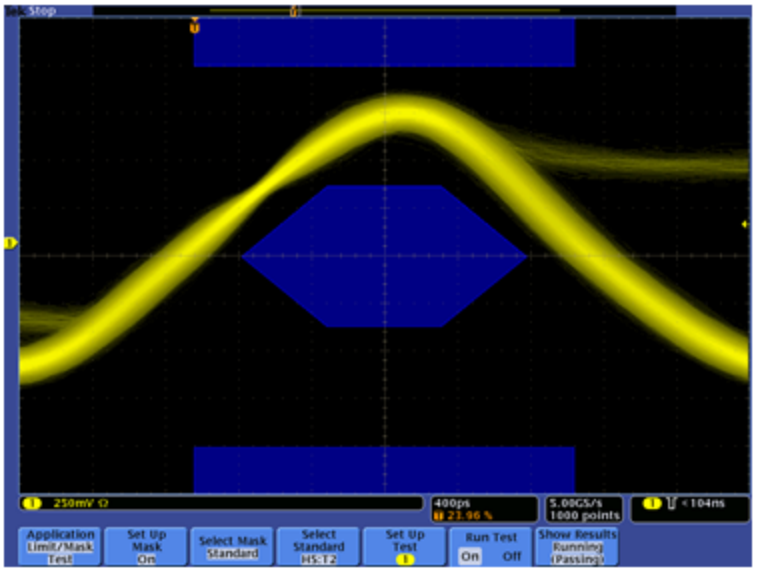


Tektronix

Measurements and Analysis – Limit and Mask Testing



Limit Testing



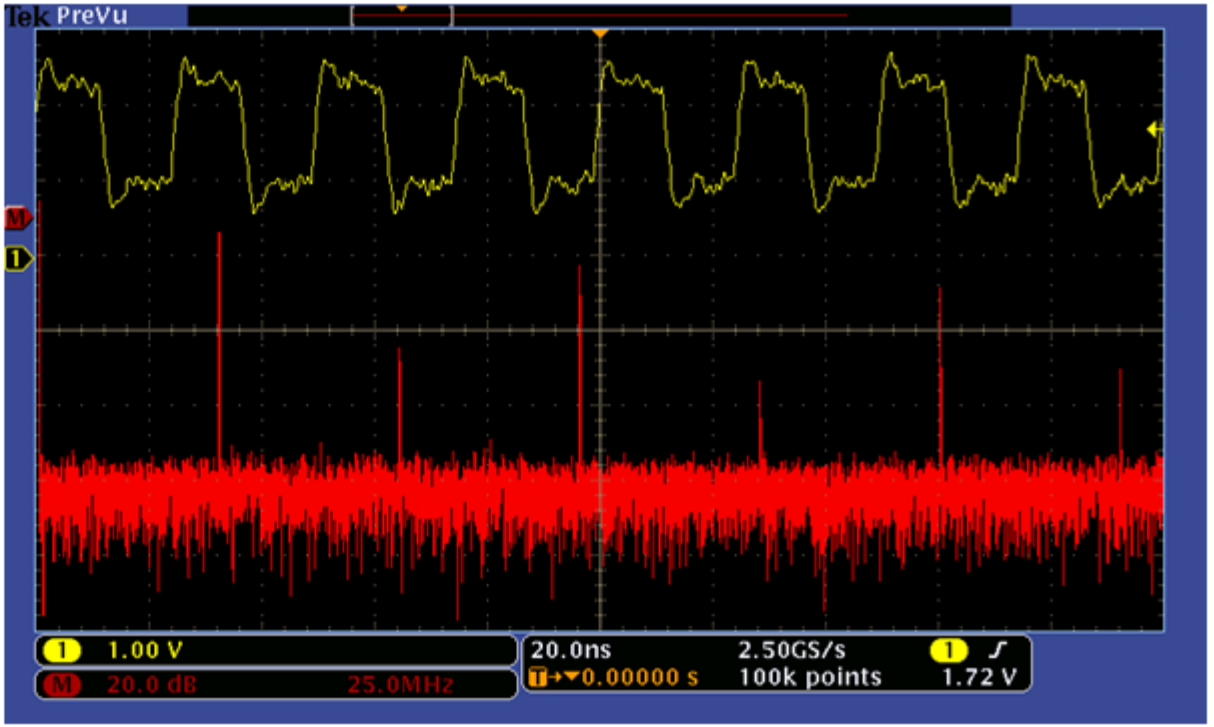
Mask Testing

Tektronix®

Fast Fourier Transform (Frequency vs. Time)

Amplitude versus Time

Amplitude Versus Frequency



- Amplitude versus Frequency

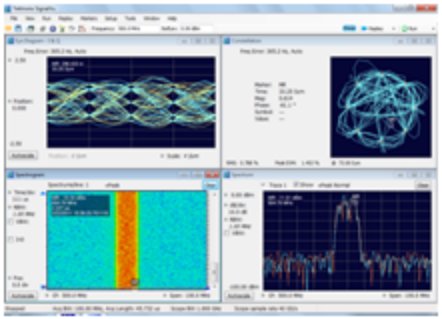
Tektronix

Tektronix Mixed Domain Oscilloscopes

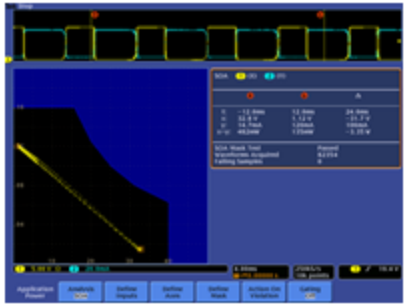
See time-correlated analog, digital, and RF in a single instrument

Application Specific Measurements and Analysis

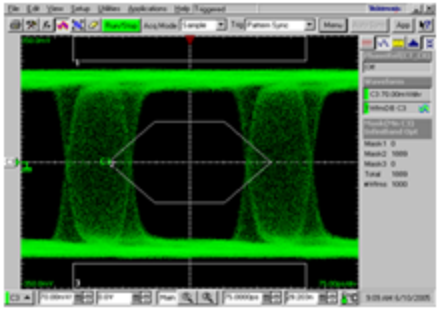
- RF Applications
  - View a frequency domain representation of the signal and perform in-depth analysis, including spectrograms and spurious searches.
- Power
  - Automated measurements for common power parameters like power quality, switching loss, harmonics, safe operating area, modulation, ripple, slew rate and more.
- Jitter
  - Automation of complex measurements and analysis tasks for clock, serial and parallel data signals, including jitter and timing measurements with pass/fail parameter testing and eye diagrams for mask testing of common industry standards.
- Compliance Testing
  - Specialized tests for testing compliance to strict industry standards like Ethernet and USB



RF



Power



Jitter

Tektronix®

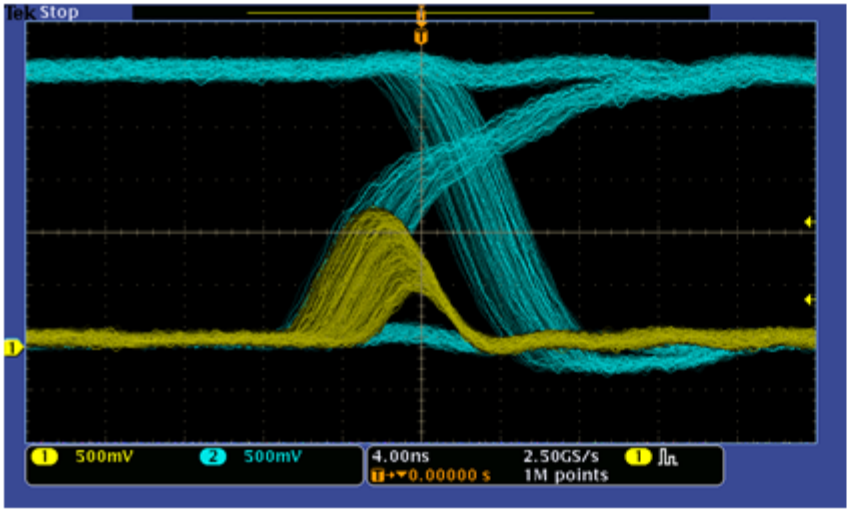
Your next oscilloscope should

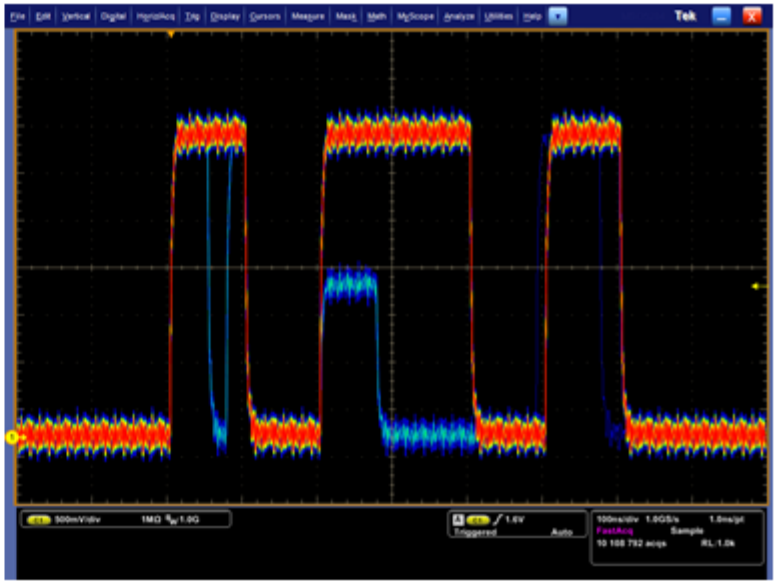
FIT THE WAY YOU WORK AND YOUR ENVIRONMENT

Tektronix®

The “Polarizing Question”

- Scope operating system (Windows or proprietary)
- Windows offers familiar operation
  - Supports mouse, keyboard, even touchscreen
- Built-in PC gives the ability to run other applications
  - Lets you perform analysis or prepare reports
  - Requires Windows “Care and Feeding”





Tektronix®

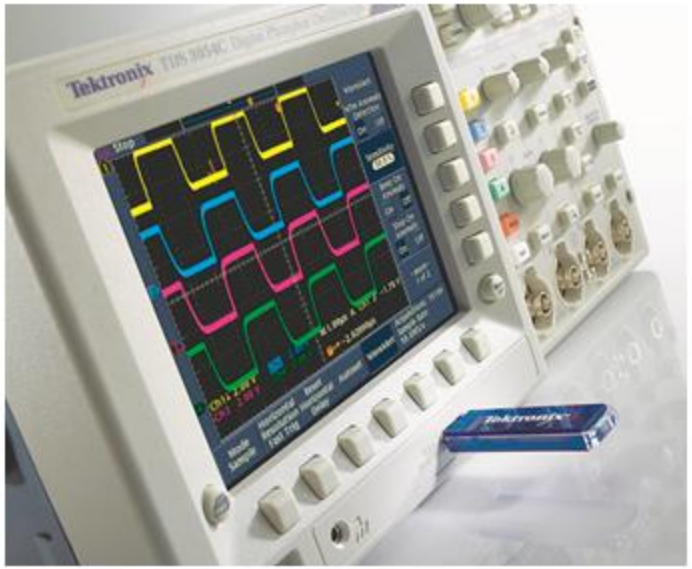
Interfaces, Remote Control, Data Export, Software

- Computer interfaces
  - USB
  - LAN (and LXI)
  - GPIB
  - RS-232
- Software and Drivers
  - Screen, settings, data capture
  - NI LabView
  - IVI drivers

Tektronix

Storing, Printing and Video Output

- Mass Storage
  - USB
  - Hard Drive
- Printer interfaces
  - PictBridge®
- Video Interfaces
  - VGA output



Tektronix®

Probes and Accessories

Passive Probes		• DC to 1 GHz • Most common, general purpose probe type. • Designed for cost efficiency and to be mechanically robust • Offer a wide dynamic range and large input resistance.
Active Probes		• Bandwidth up to 4 GHz • Reduced probe loading – capacitance as low as 0.5 pF • Single-ended, ground referenced signals • Best for small geometry applications
Differential Probes		• Bandwidths up to 20 GHz • View complementary (differential) signal pair using a single channel. • Capacitance as low as 0.3 pF • High common mode rejection
Current Probes		• Bandwidths from DC to 2 GHz • Ranges from 1 mA to 20,000 A.
High Voltage Probes		• Ranges up to 40 kV peak (100 ms pulse) • Single-ended or differential

- Check to see what probes are available to use with your next oscilloscope
- Check for carrying cases, shipping cases, and rackmounts if needed

Tektronix®

Battery Power, Portability

- Handheld or bench form factors
- Same basic specs as bench instruments
- Great for isolated and floating measurements

Selecting Your Next Oscilloscope

QUESTIONS?

Tektronix®