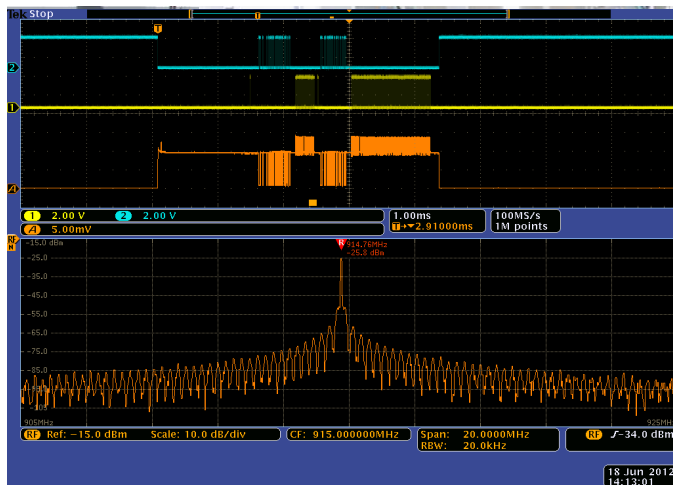


Mixed Domain Oscilloscopes

A new oscilloscope category....

....unique and powerful capabilities

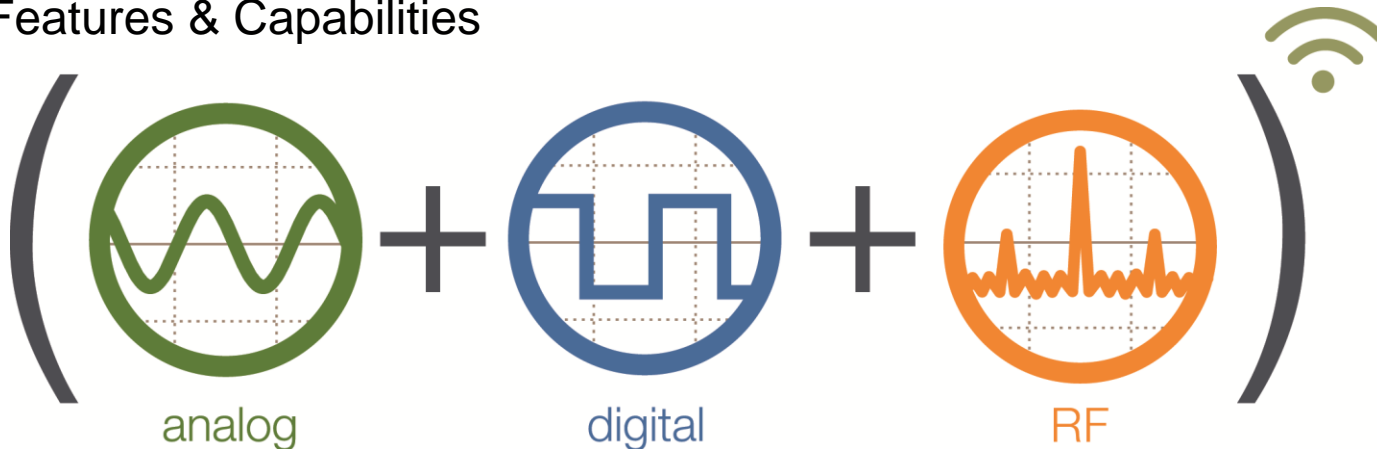


Alan Wolke – W2AEW
RF Applications Engineer

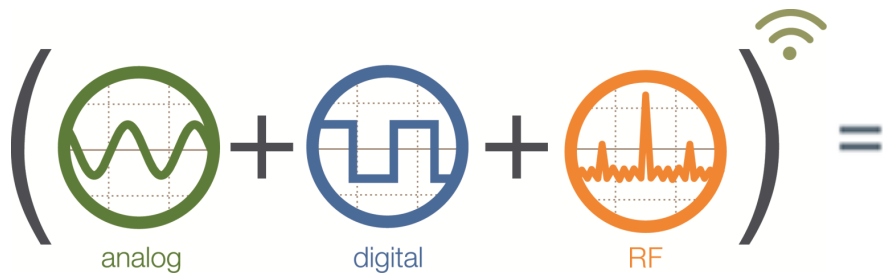
Tektronix[®]

Agenda

- What is a Mixed Domain Oscilloscope (MDO)?
- Overview of the family
- MDO4000B series – *the first born*
 - Architecture
 - Features & Capabilities
 - Advanced Measurements
- MDO3000 series – *the newest family member*
 - Similarities and Differences
 - Features & Capabilities



What is a Mixed Domain Oscilloscope?



- An oscilloscope that incorporates both time domain and frequency domain measurement hardware
 - Analog oscilloscope inputs = traditional scope measurements
 - Digital inputs = basic logic analyzer
 - Spectrum Analyzer = basic RF measurements

The MDO Family



MDO4000B

- All domains **time correlated**
 - RF capture vs. time
 - Examine “*choreography*” of analog, digital and RF signals
- Wideband RF signal analysis
 - RF vs. Time traces (AM/FM/PM)
 - **1GHz Vector Signal Analysis** with PC-based software

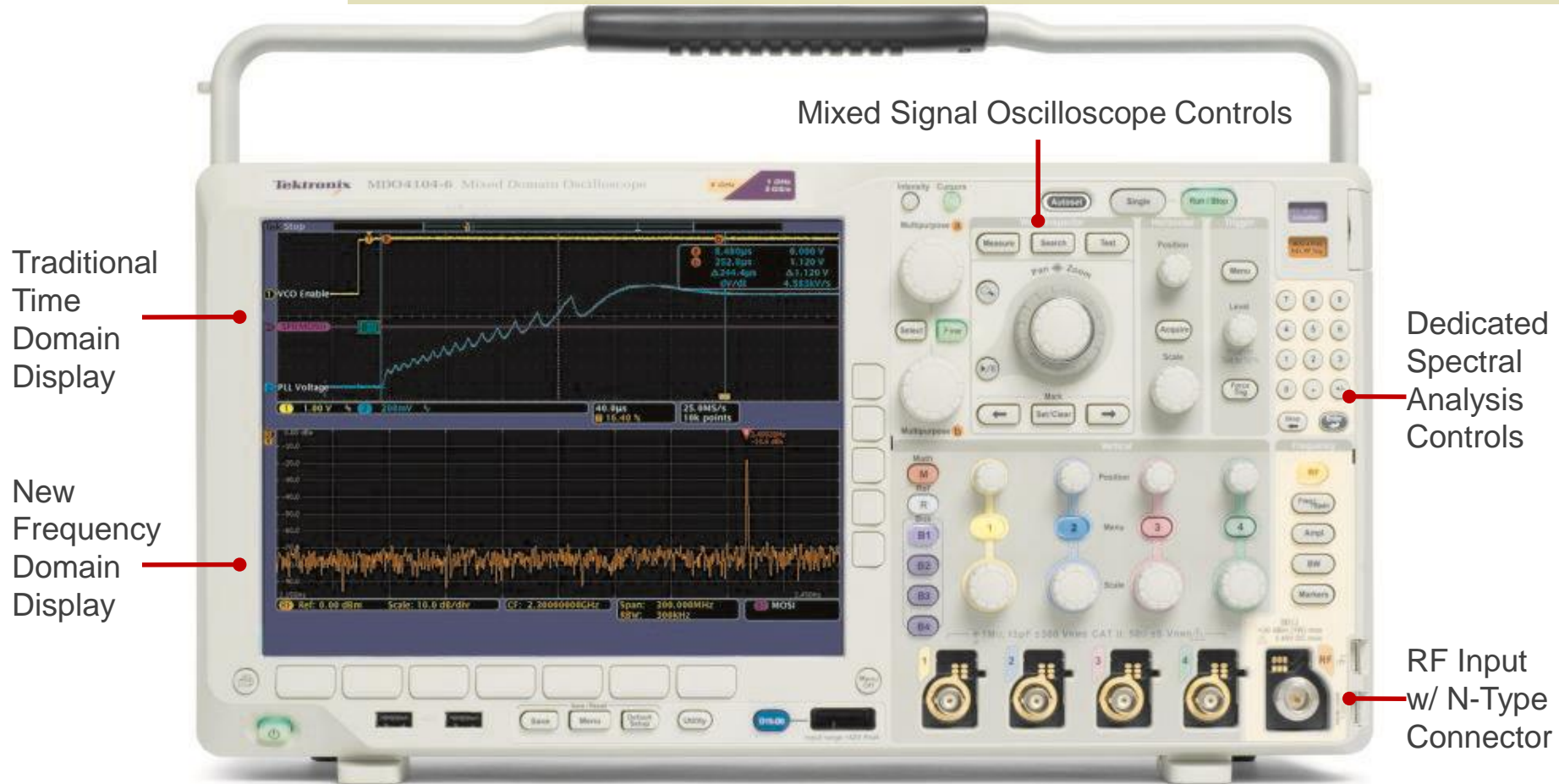


MDO3000

- 6 in 1 Instrument
 - Analog Oscilloscope
 - Logic Analyzer
 - Spectrum Analyzer
 - Protocol Analyzer
 - **DVM + Frequency Counter**
 - **Arbitrary Function Generator**
- *No RF signal capture vs. time*

Tektronix MDO4000B Series of Mixed Domain Oscilloscopes

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



Dedicated Hardware Optimized for Analog & RF

Span	RF Acquisition Time
>2 GHz	2.5ms
>1 GHz – 2 GHz	5ms
>800 MHz – 1 GHz	10ms
>500 MHz – 800 MHz	12.5ms
>300 MHz – 500 MHz	20ms
>150 MHz – 300 MHz	25ms
>200 MHz – 250 MHz	40ms
>160 MHz – 200 MHz	50ms
>125 MHz – 160 MHz	62.5ms
<125 MHz	79ms (max)

Architecture

Overview

Computation & Display

DDC

Memory

A/D
10GSs

Block Down converter

Independent
50dBm and RL
RF

MDO Dynamic Range and Capture BW vs. alternatives

A Unique

Combination

of BW and DR



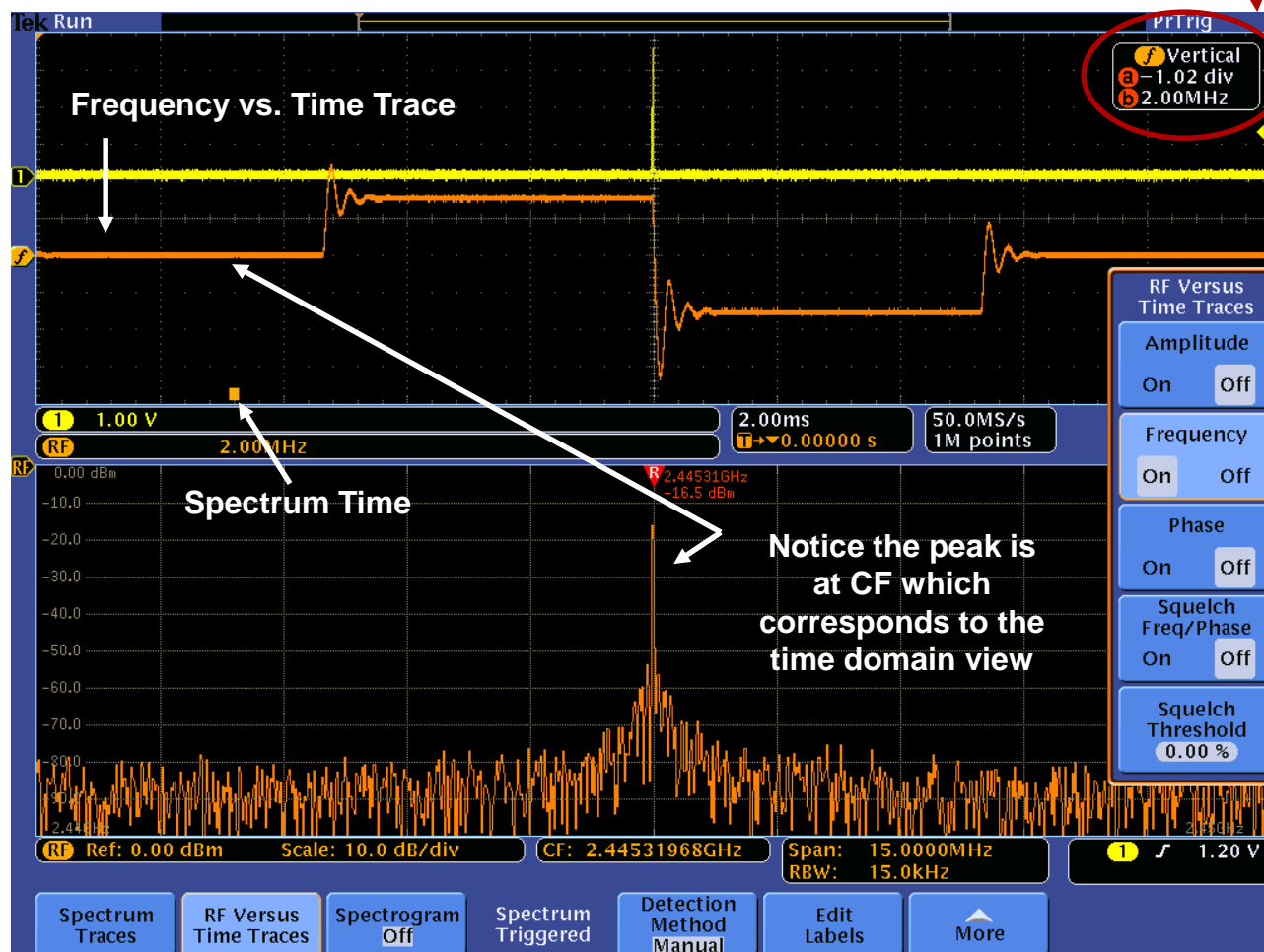
Time Correlated Multi-Domain Display

An example of RF Time Domain Traces

Scale and Position for Frequency vs. Time Trace

The RF input is connected to a frequency hopping signal and a Frequency vs. Time trace is active.

- Frequency vs. Time trace handle represents Center Frequency
- When the trace is above this level, it's > than the Center Frequency
- When the trace is below this level, it's < than the Center Frequency



Demonstration of MDO4000B Capabilities

- Quick Overview
- Integrated Spectrum Analyzer features
- Mixed Domain characterization examples
 - Transient tuning behavior of a PLL
 - Tracking down source of bursty EMI issue
 - More?

Applications

RADAR System test

- RF Characteristics
- RF vs. Time
- Discrete Signals
- ...all time correlated



Spectrum display can be turned off for more detailed view of time domain signals, if desired

Applications

RFID System Characterization

- RFID Reader & Tag Transaction

- Reader Interrogation
- Tag Response
- System Signals

RF Amplitude vs. Time

Reader TX /Enable

Reader Tag data_clock

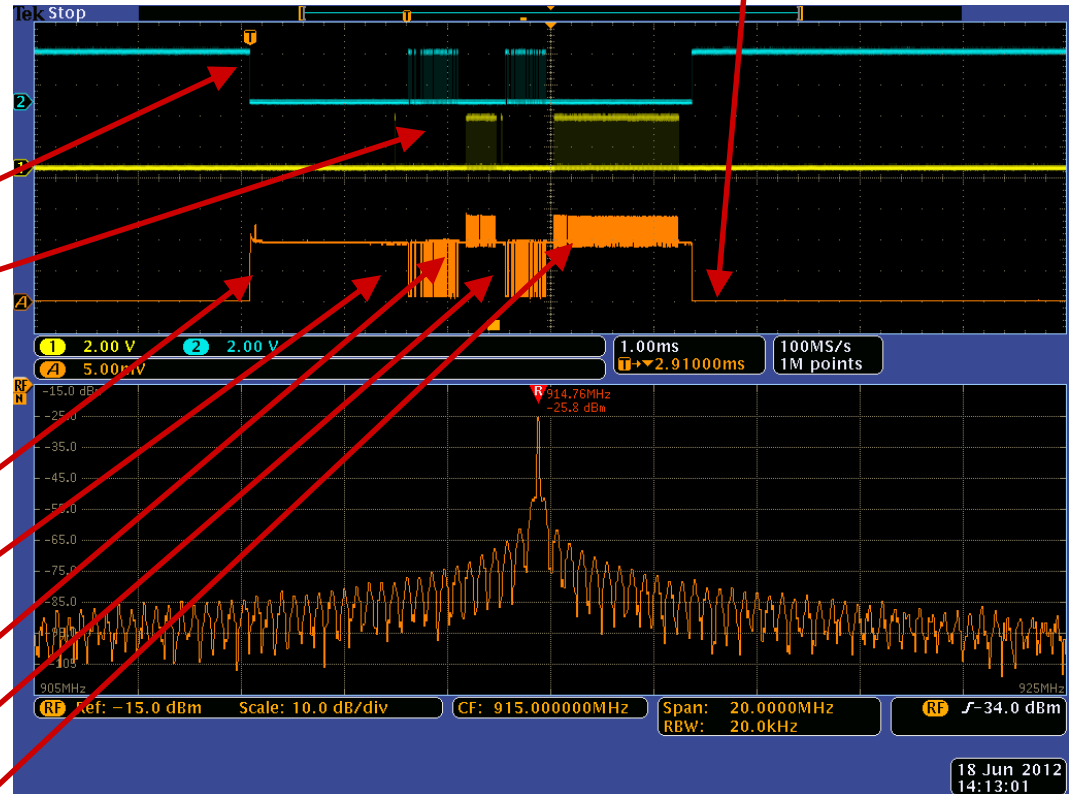
Reader turns on to charge tag

Reader Interrogates tag

Tag RN16 response

Reader acknowledgement

Tag sends data



What makes this product unique?:

- **Dynamic Range:** Better than any scope. **65dB !!!**
- **Capture Bandwidth:** Way more than **1 to 3GHz !!!**
any high performance VSA
- **Great troubleshooting displays:**

Key

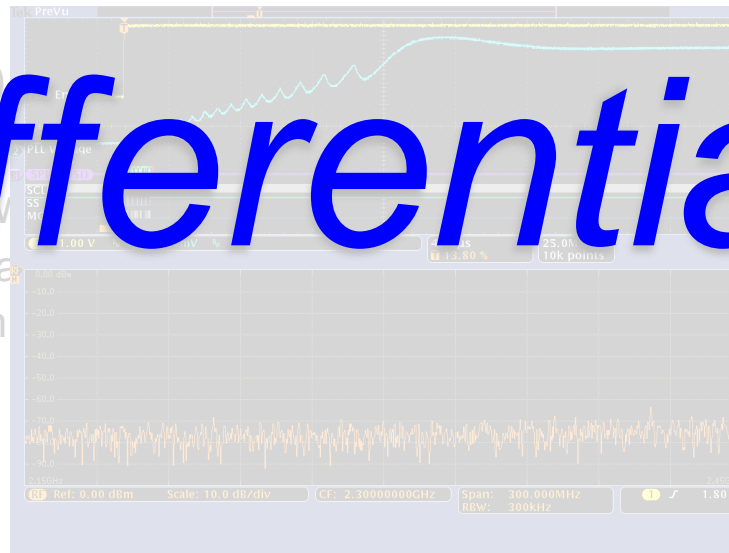
– Time correlated displays between Analog, Digital and RF Channel

– VSA (vs time) and Phase

– Ability to “grow” resolution

- Spectrogram
- “Spectrum”

Differentiators



MDO4000B - With SignalVu-PC



“The MDO4000B with SignalVu-PC delivers the right capabilities at the right price point to enable embedded and wireless LAN module designers to rapidly debug systems without a steep learning curve”

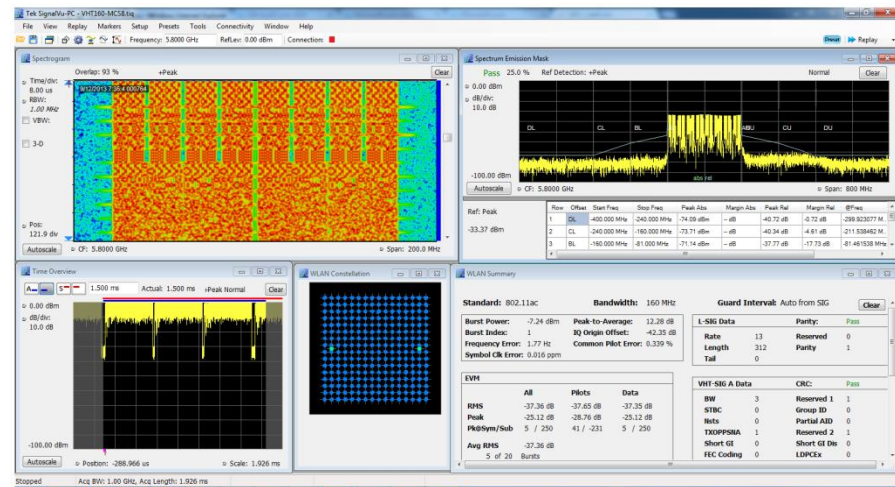
– Fanny Mlinarsky, President/CTO, octoScope

- SignalVu-PC extends the MDO4000B Spectrum Analyzer
 - Live link to SignalVu-PC for Advanced Spectrum, Time and Vector measurements
- SignalVu-PC turns the MDO4000B into the industry’s only 1 GHz acquisition bandwidth Vector Signal Analyzer
 - No need to sweep to measure Spectral Emission Mask (SEM)
 - Spectrum and modulation measurements at the same time
 - Error Vector Magnitude (EVM) (802.11ac 256QAM 5/6FEC 160MHz) -37.3dB
- MDO4000B for >160MHz BW signal analysis is approximately half the cost of other mid-range solutions

SignalVu-PC

In-depth, Offline Analysis Software for Complex RF Signals

- Runs on Windows Tablet or PC
- Live link updates SignalVu-PC displays continuously when connected to MDO4000B
- **NEW!** Options for Wi-Fi support standard 802.11a/b/g/j/n/p/ac tests
- Same User Interface for RTSAs, Windows Oscilloscopes, and MDO
- Multi-domain Vector Signal Analysis
 - **Time-correlated**, multi-domain displays (frequency, phase, amplitude, modulation)

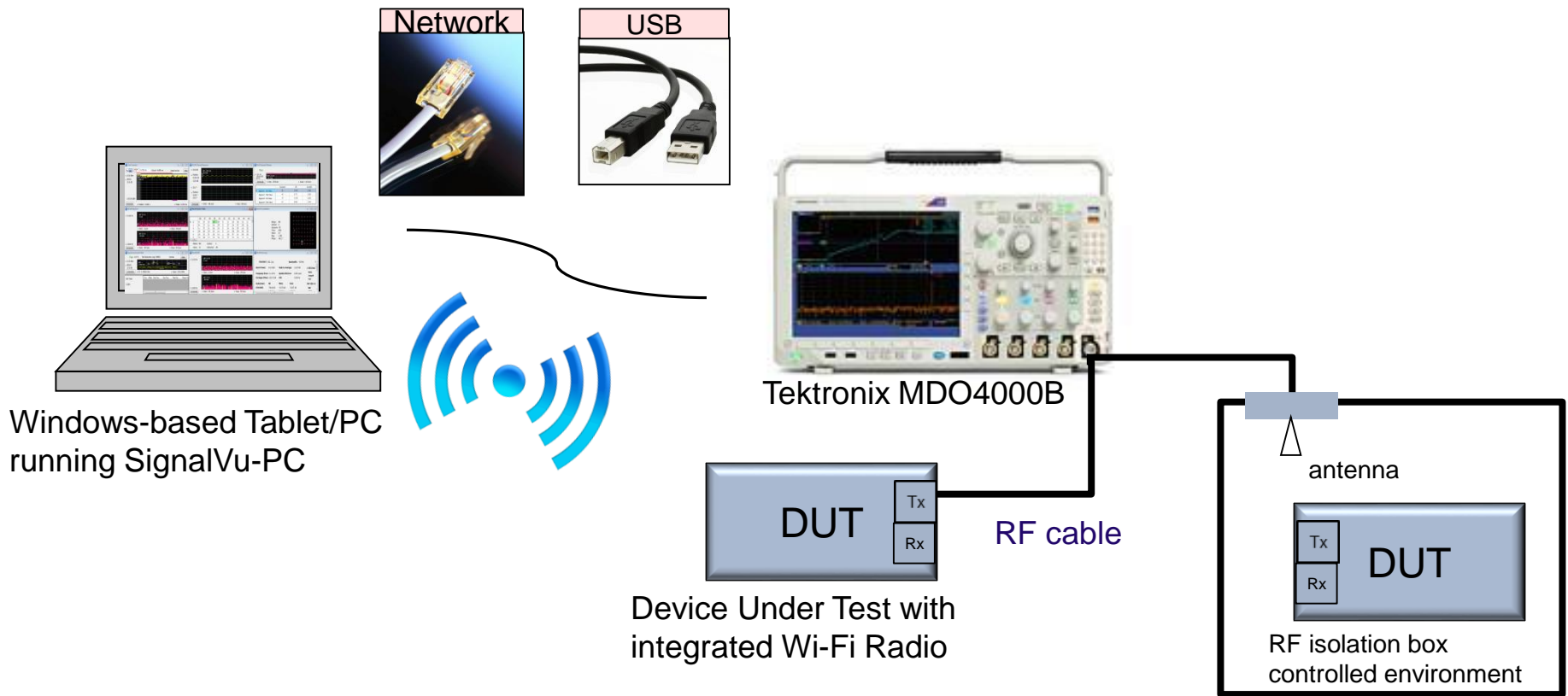


Key Measurements for SignalVu-PC

- Wi-Fi Signal Analysis
- Vector Signal Analysis
- Pulsed Signal Analysis
- Audio Analysis Measurements
- AM/FM/PM Measurements
- Spurious Measurements
- Spectrogram
- Settling Time Analysis
- Modulation Measurements

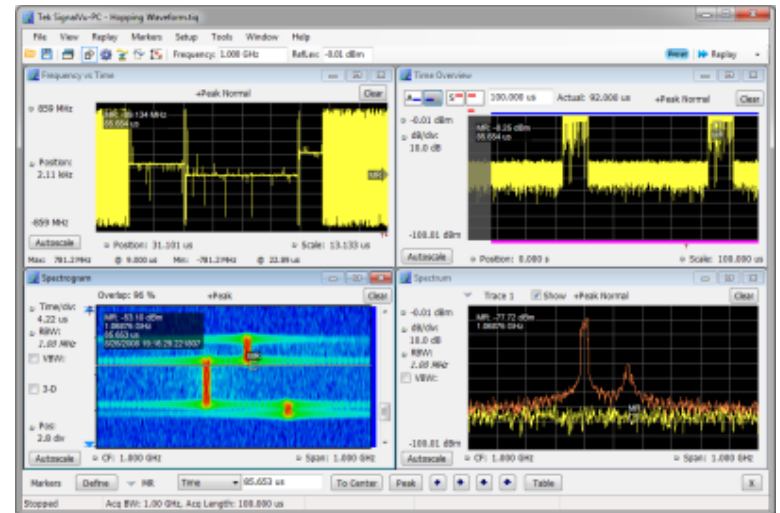
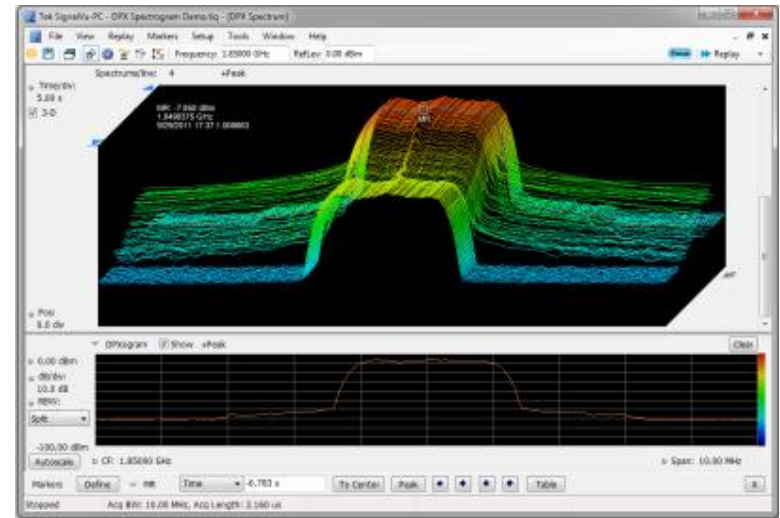
Live Link Offers Three Ways to Connect

- MDO4000B and PC/tablet connected via Company Network (LAN or WLAN)
- Ad hoc wireless connection between MDO4000B and Tablet/PC via Access Point
- Direct USB/LAN cable connection between MDO4000B and PC/Tablet



SignalVu-PC Software Features


- In-depth analysis of complex signals
 - Time-correlated, multiple displays (frequency, phase, amplitude, modulation)
 - Time overview shows total RF power within the acquisition bandwidth
 - Correlated markers across all measurements
- Perform offline analysis on a Windows Tablet or PC
 - Gather information in the field or lab for later analysis
 - Works with raw data (IQ) - enables users to change settings and re-analyze
 - E.g. resolution bandwidth, modulation type, change measurements
 - Great for documentation and troubleshooting across teams



Demonstration of Wideband Vector Signal Analysis

- Connect SignalVu-PC to the MDO
- Analyze wideband RF signal
 - 802.11ac 160MHz channel

MDO3000 Series Mixed Domain Oscilloscopes

- 
1. Oscilloscope
 2. Spectrum Analyzer
 3. Arbitrary Function Generator
 4. Logic Analyzer
 5. Protocol Analyzer
 6. DVM/Counter

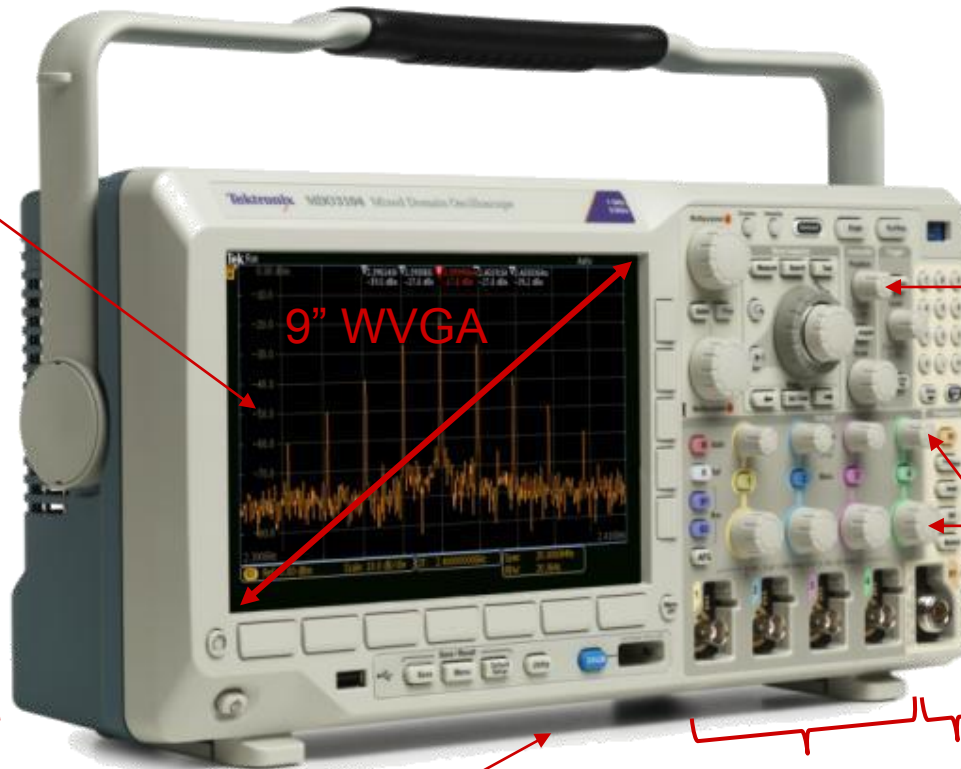


The Ultimate 6-in-1 Integrated Oscilloscope

Completely customizable, providing what you need now – and later

MDO3000 Platform

New! Automatic dimming of display



New! Push encoders on Horizontal:

- Position (center when delay on, set to 10% when delay off)

New! Push encoders on Vertical:

- Position (center channel handle)
- Scale (Fine/Coarse)

5.8 inches
(147 mm)
deep!

New! 50MHz Arbitrary Function Generator (rear panel)

TekVPI inputs with low-C probing

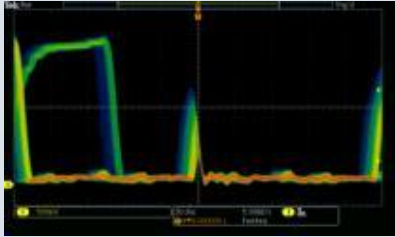
New! Dedicated RF input

Differences compared to MDO4000B

- Integrated Arbitrary Function Generator
- Integrated Digital Voltmeter and Frequency Counter
- New FastAcq mode, measurement and front panel convenience features
- No RF capture vs. time

Comprehensive Tools Speed Every Stage of Debug

Discover



- **New!** FastAcq high speed waveform acquisition
 - >280,000 wfm/s
- **New!** Color-graded, Inverted waveform palette digital phosphor display

Capture



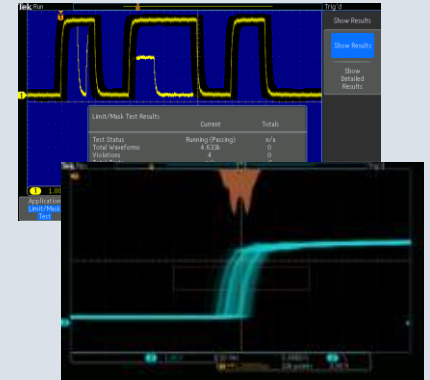
- **New!** Industry best standard voltage probes
- 10 Mpoints record
- Complete set of triggers
- **New!** Act-on-event

Search



- Wave Inspector® Navigation and Search
 - **New!** Search Mark table shows a listing of each search event

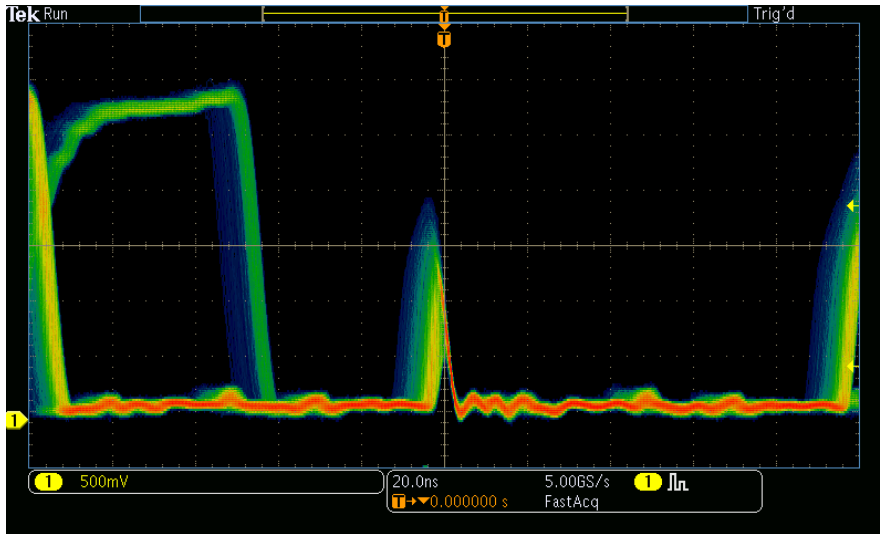
Analyze



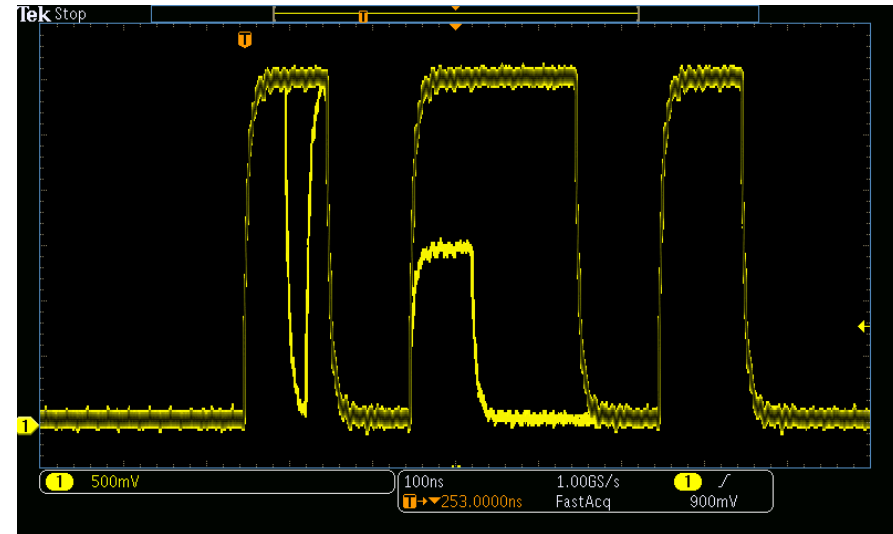
- 30 automated measurements
- Advanced waveform math and all video test tools **standard**
- **New!** Limit/Mask Testing
- Power analysis
- **New!** Waveform Histograms

Oscilloscope – Discover FastAcq

- **New!** FastAcq high speed waveform acquisition
 - > 235,000 wfms/s on 100 – 500 MHz models
 - > 280,000 wfms/s on 1 GHz models
 - Inverted waveform palette makes infrequent events instantly visible



Temperature color grading



Inverted palette instantly shows anomalies

Find elusive glitches and transients in seconds

Low Capacitance Passive Probes

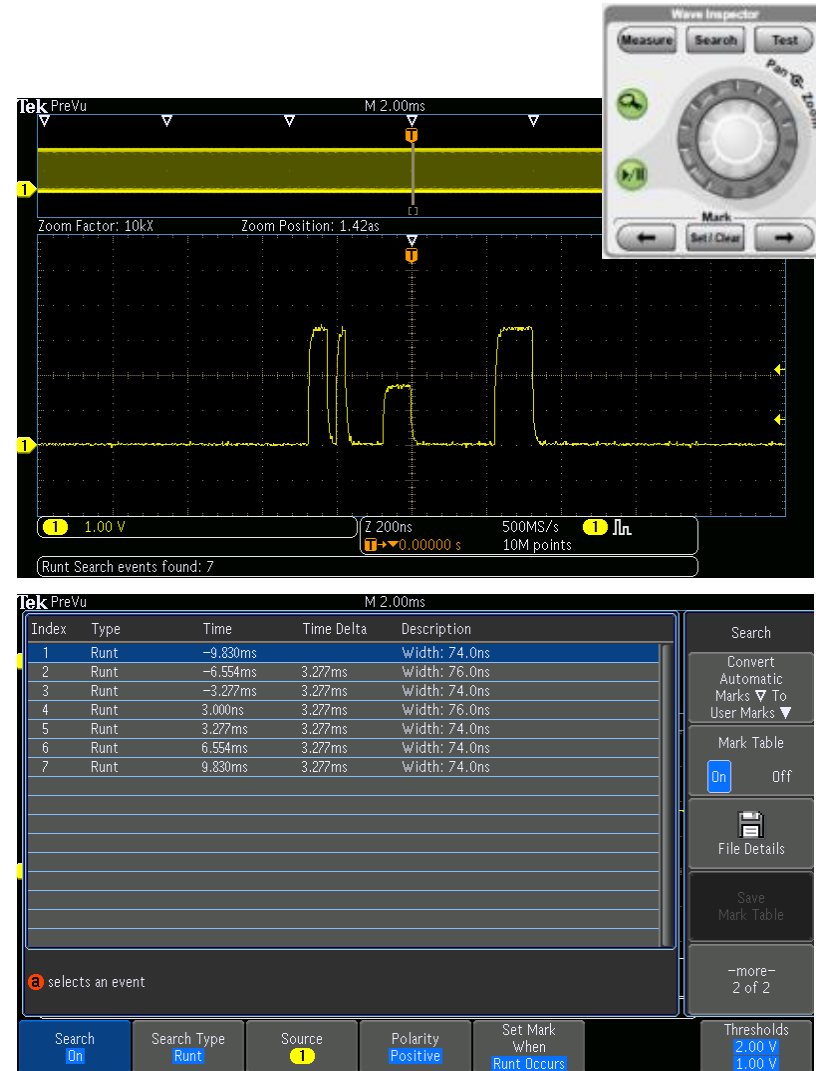
- **New!** Industry best standard voltage probes included with every scope
 - 3.9 pF input capacitance reduces the impact to signals being measured
 - TPP0250: 250 MHz passive voltage probe
 - Standard on 100MHz, 200MHz models
 - TPP0500B: 500MHz passive voltage probe
 - Standard on 350MHz, 500MHz models
 - TPP1000: 1GHz passive voltage probe
 - Standard on 1GHz models



Active probe performance with passive probe ease-of-use

Wave Inspector Navigation & Search

- Dedicated set of front panel controls quickly finds events of interest in long records
- Quickly find events using automated search
 1. Define your search criteria
 - Common trigger combinations
 - Parallel data
 - Serial bus content
 2. Wave Inspector marks every instance
 3. Use the arrow buttons to jump from event to event
- **New!** Search Mark table shows a listing of each event, time stamped for easy timing measurements
 - Export .csv for reporting

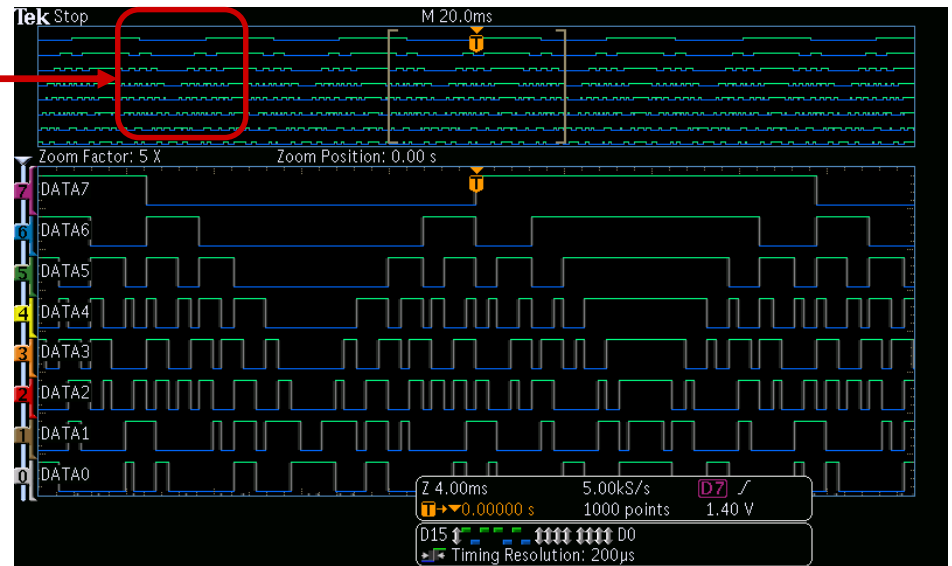


Find events of interest in long records in seconds

Logic Analyzer

Intuitive Digital Display

- Logical highs are identified in **Green** and lows in **Blue**
- Optional 16 digital channels
 - 500 MS/s with 10 M points record length
 - 8.25 GS/s (121.2 ps resolution) MagniVu high speed sampling



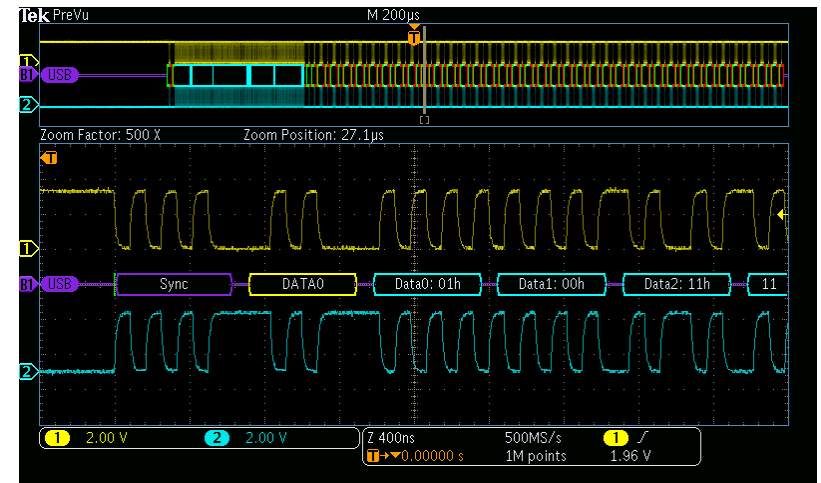
New! Monitor shows activity on digital channels at a glance

Color coding makes setup and operation a snap

Protocol Analyzer

Serial Trigger, Decode & Search

- Trigger on packet content
- Automatically decode packet content
- Automated search on specific packet content to locate events of interest in seconds
 - Same criteria as trigger
 - **New** search mark table
- Serial analysis standards available
 - I²C, SPI
 - RS-232/422/485/UART
 - CAN, LIN
 - FlexRay
 - **New!** USB 2.0
 - MIL-STD-1553
 - I²S, LJ, RJ, TDM



Time	Identifier	DLC	Data	CRC	Missing Ack
-488.3µs	101	2	0103	5620	
-354.0µs	10000001	5	1122 3344 55	6465	
-130.0µs	12345678	8	1122 3344 5566 7788	4C2	
138.2µs	1597EEB2	8	FFFF 0000 EEEE 1111	216E	
414.4µs	519	4	4269 606C	7744	
572.6µs	1597EEB2	8	AE4F FFF1 0272 DF6B	2180	
848.8µs	5270E32	1	11	7F30	
1.005ms	140014	3	1122 33	5E0C	
1.195ms	160016	5	1122 3344 55	3311	
1.417ms	18181818	7	F1F2 F3F4 F5F6 F7	5F9B	
1.682ms	0	8	0000 0000 0000 0000	304F	
1.982ms	757	0	Remote Frame	208B	
2.080ms	1A55A455	0	Remote Frame	3536	
2.216ms	57	6	4588 6065 7273	7035	
2.410ms	1597EEA3	8	DE55 CBFA 5D45 A08C	10B0	
2.677ms	13	2	1122	61A8	

a selects an event

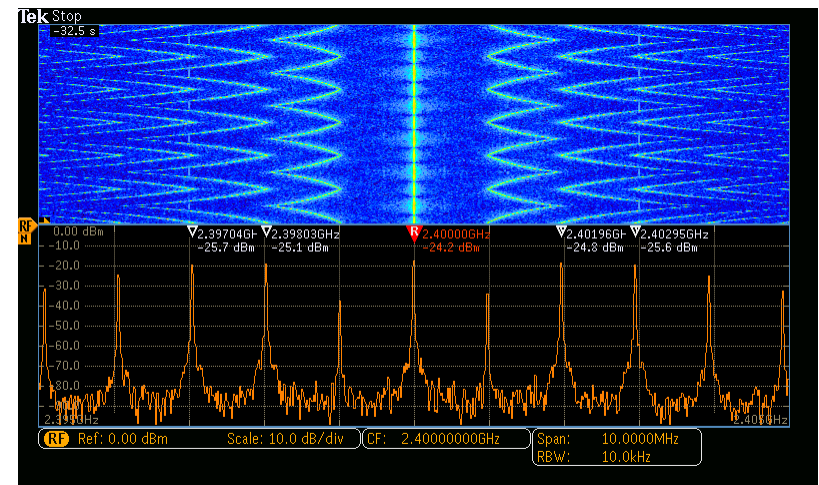
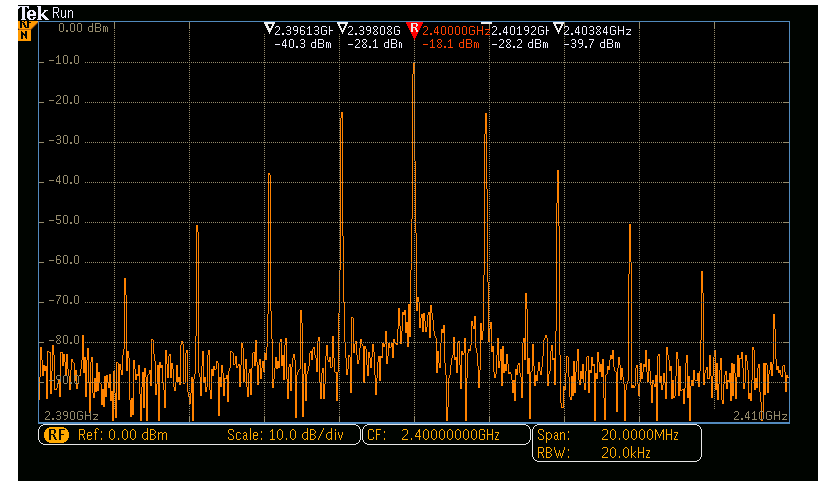
Event Table
Event Table
On Off
File Details
Save Event Table

Bus B1 CAN
Define Inputs
Thresholds
Bit Rate 500000
B1 Label CAN
Bus Display
Event Table

Ensure you capture and can find all events of interest quickly

Performance Superior to Scope FFT

- Wide capture bandwidth
 - Up to 3 GHz capture bandwidth allows you to see your entire signal at once
- Automated markers
 - Up to 11 markers automatically mark each user defined peak greatly simplifying the common task of peak identification
- Spectrogram display
 - Graphically see slowly changing RF phenomena at a glance
- Automated measurements
 - Make quick work of common RF measurements



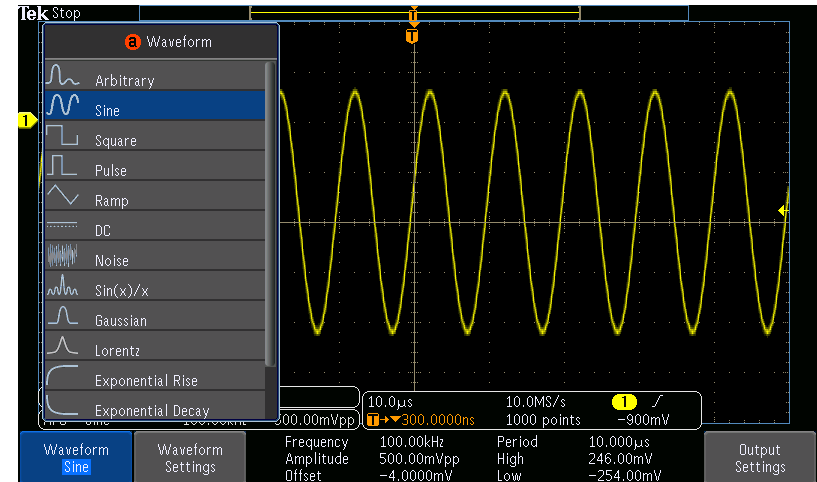
Performance you can't find in any other scope or spectrum analyzer

Arbitrary Function Generator

Fastest Integrated AFG

- Optional, integrated arbitrary function generator offering signal generation up to 50 MHz
 - **Industry's fastest integrated AFG**
 - Simulate sensor signals or other signals to represent missing blocks of a design
- AFG is available all the time – when the scope is in time domain or frequency domain
- Add noise to any signal type to simulate the presence of noise in a circuit
 - Noise amount adjustable from 0% to 100% of signal amplitude

Waveform	Maximum Frequency
Sine	50 MHz
Square, Pulse	25 MHz
Gaussian, Lorentz, Haversine, Exponential Rise/Decay	5 MHz
Sin(x)/x	2 MHz
Ramp (Triangle), Cardiac	500 kHz



Simulate missing signals to speed design

Arbitrary Function Generator

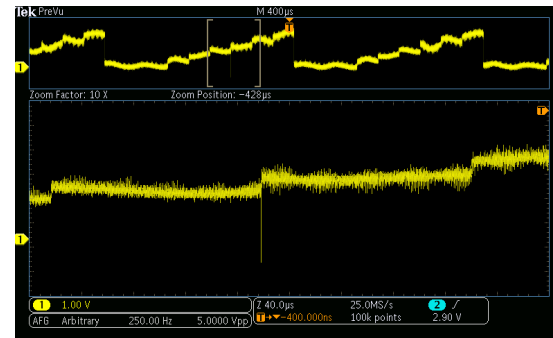
Fastest and Deepest Arbitrary Generation

- No longer need multiple instruments



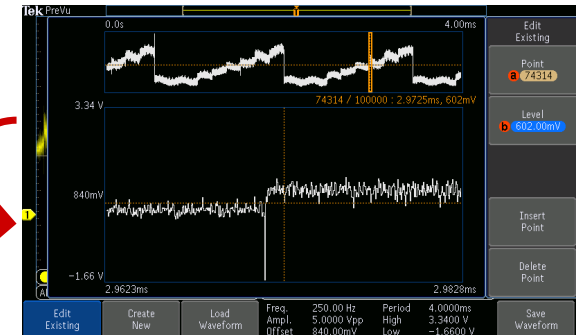
- Simplify replication of signals by using a single instrument
- High performance AFG enables simplicity
 - 128 kpoints edit memory – **8X longer than competitive products**
 - 250 MS/s output rate – **2X faster than competitive products**

- Use the built-in waveform editor or Tektronix ArbExpress® PC-based waveform creation & editing software to make waveform creation a snap

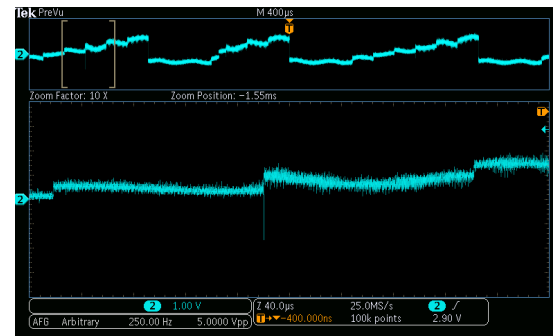


1 Load acquired waveform into arbitrary edit memory

2 Edit waveform shape in scope



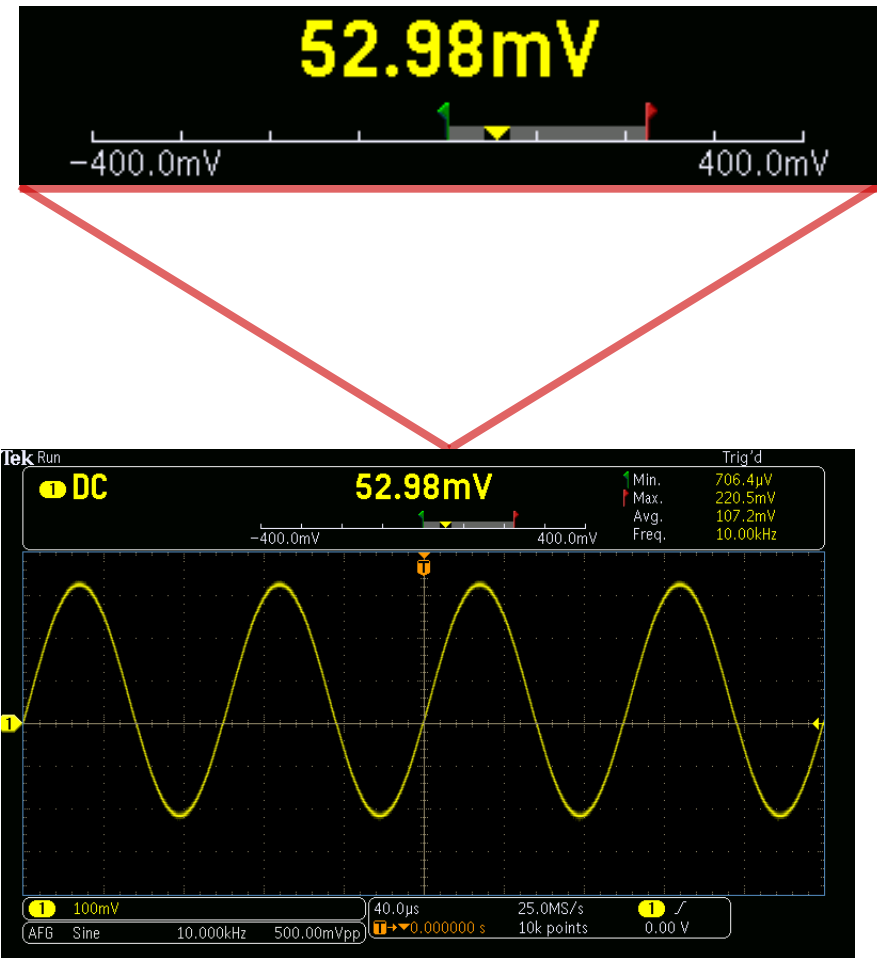
3 Replicate waveform out of AFG



Generate or Replicate complex waveforms easily

Digital Voltmeter (DVM) and Counter Measurement Types

- Monitor signals while the scope is running or stopped
 - Uses any of the analog scope inputs
 - Free-running & not tied to scope acquisition state
- 4-digit AC RMS, DC, AC+DC RMS voltage measurements
- 5-digit Frequency measurements
- Autoranging of vertical amplification
- Graphical representation of measurement results
 - Minimum
 - Maximum
 - Current Value
 - Five second rolling range of values

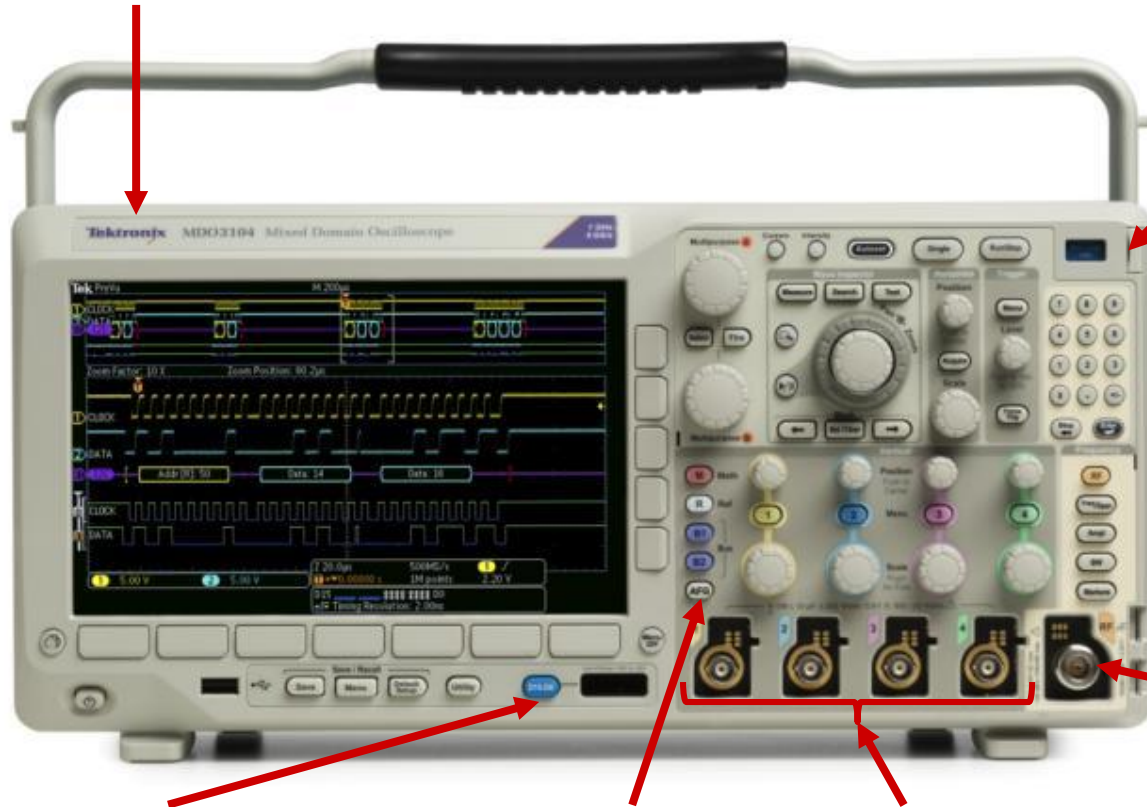


Monitor critical signals at a glance

A Fully Upgradeable Platform that Grows with You as Your Measurement Needs Change

Bandwidth Upgrades

100MHz, 200MHz, 350MHz, 500MHz, 1GHz



Analysis Upgrades

MDO3xxx: Serial bus trigger and analysis application modules

MDO3PWR: Power Measurements

MDO3LMT: Limit/Mask test

Spectrum Analyzer Frequency Range Option/Upgrade

MDO3SA: Increase spectrum analyzer input range to 9kHz – 3GHz

MSO Option/Upgrade
MDO3MSO:
16 digital channels

AFG Option/Upgrade
MDO3AFG: Arbitrary
Function Generator

Digital Voltmeter
Free with product
registration

Summary

- Mixed Domain Oscilloscopes offer time domain and frequency domain measurements in the same instrument
- **MDO4000B** offers
 - up to 6GHz spectrum analysis
 - Time correlation between analog, digital and RF signals
 - Wideband vector signal and modulation analysis
- **MDO3000** offers
 - 6 instruments in 1
 - Up to 3GHz spectrum analysis
 - Bench space & cost saving platform
 - Fully upgradeable at any time (features, bandwidth, etc.)



Tektronix®

