Mixed Domain Oscilloscopes

A new oscilloscope category....

....unique and powerful capabilities

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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

![Diagram of analog, digital, and RF signals combined]
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
**Architecture Overview**

<table>
<thead>
<tr>
<th>Span</th>
<th>RF Acquisition Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;2 GHz</td>
<td>2.5ms</td>
</tr>
<tr>
<td>&gt;1 GHz – 2 GHz</td>
<td>5ms</td>
</tr>
<tr>
<td>&gt;800 MHz – 1 GHz</td>
<td>10ms</td>
</tr>
<tr>
<td>&gt;800 MHz – 800 MHz</td>
<td>12.5ms</td>
</tr>
<tr>
<td>&gt;600 MHz – 800 MHz</td>
<td>20ms</td>
</tr>
<tr>
<td>&gt;500 MHz – 600 MHz</td>
<td>25ms</td>
</tr>
<tr>
<td>&gt;200 MHz – 250 MHz</td>
<td>40ms</td>
</tr>
<tr>
<td>&gt;160 MHz – 200 MHz</td>
<td>50ms</td>
</tr>
<tr>
<td>&gt;125 MHz – 160 MHz</td>
<td>62.5ms</td>
</tr>
<tr>
<td>&lt;125 MHz</td>
<td>79ms (max)</td>
</tr>
</tbody>
</table>
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

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

Notice the peak is at CF which corresponds to the time domain view.
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 turns on to charge tag
- Reader Interrogates tag
- Tag RN16 response
- Reader acknowledgement
- Tag sends data

**Diagram Details**
- Reader TX/Enable
- Reader Tag data_clock
What makes this product unique?:

- **Dynamic Range:** Better than any scope. \(65\text{dB}!!!\)
- **Capture Bandwidth:** Way more than any high performance VSA \(1\text{ to } 3\text{GHz}!!!\)
- **Great troubleshooting displays:**
  - Time correlated displays between Analog, Digital and RF Channel
  - VSA (vs time) displays: Amplitude, Frequency and Phase
  - Ability to "browse the spectrum" throughout the acquisition
  - Spectrogram
  - "Spectrum Time" placing using the wave inspector

**Key Differentiators**
MDO4000B - With SignalVu-PC

- 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

“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
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

The Ultimate 6-in-1 Integrated Oscilloscope

Completely customizable, providing what you need now – and later
MDO3000 Platform

- **New!** Automatic dimming of display
- **New!** 5.8 inches (147 mm) deep!

- **New!** Automatic dimming of display

**Push encoders on Vertical:**
- Position (center channel handle)
- Scale (Fine/Coarse)

**Push encoders on Horizontal:**
- Position (center when delay on, set to 10% when delay off)

9” WVGA

**New!**
- TekVPI inputs with low-C probing
- 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*
Oscilloscope – Capture
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*
Oscilloscope – Search

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

Ensure you capture and can find all events of interest quickly
Spectrum Analyzer

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

<table>
<thead>
<tr>
<th>Waveform</th>
<th>Maximum Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sine</td>
<td>50 MHz</td>
</tr>
<tr>
<td>Square, Pulse</td>
<td>25 MHz</td>
</tr>
<tr>
<td>Gaussian, Lorentz, Haversine, Exponential Rise/Decay</td>
<td>5 MHz</td>
</tr>
<tr>
<td>Sin(x)/x</td>
<td>2 MHz</td>
</tr>
<tr>
<td>Ramp (Triangle), Cardiac</td>
<td>500 kHz</td>
</tr>
</tbody>
</table>

*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

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

MSO Option/Upgrade
MDO3MSO: 16 digital channels

AFG Option/Upgrade
MDO3AFG: Arbitrary Function Generator

Analysis Upgrades
MDO3xxx: Serial bus trigger and analysis application modules
MDO3PWR: Power Measurements
MDO3LMT: Limit/Mask test

Digital Voltmeter
Free with product registration

Spectrum Analyzer Frequency Range Option/Upgrade
MDO3SA: Increase spectrum analyzer input range to 9kHz – 3GHz
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.)