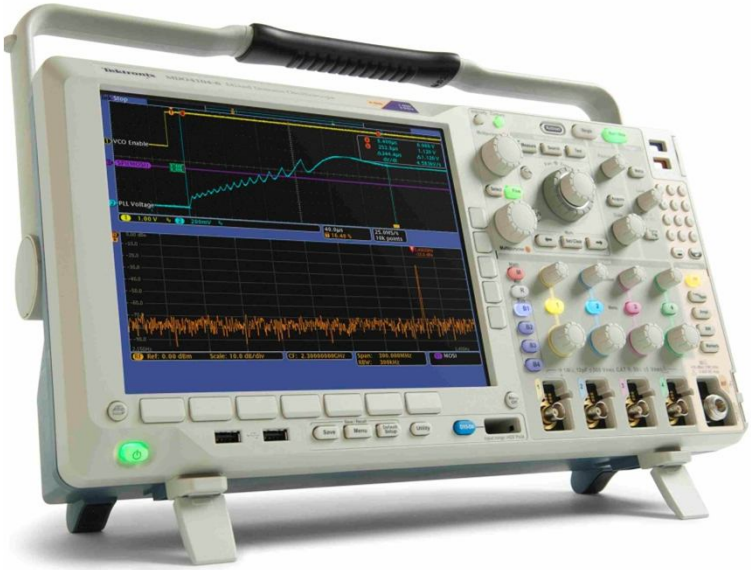
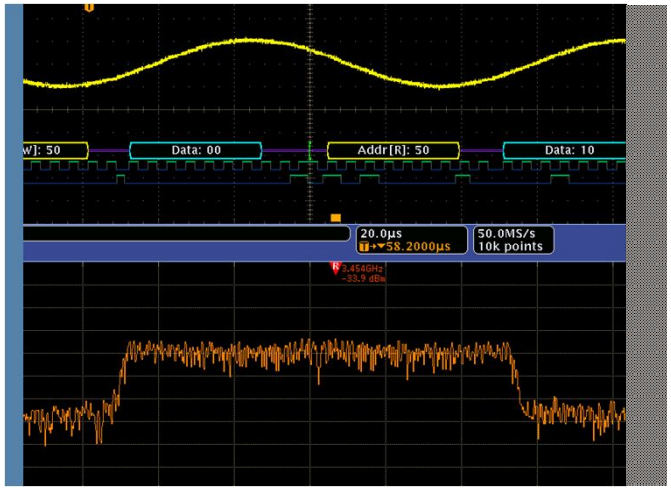
使用MDO多域示波器來量測
RF嵌入式系統中的 RF+時域+數位訊號

Richard Ding





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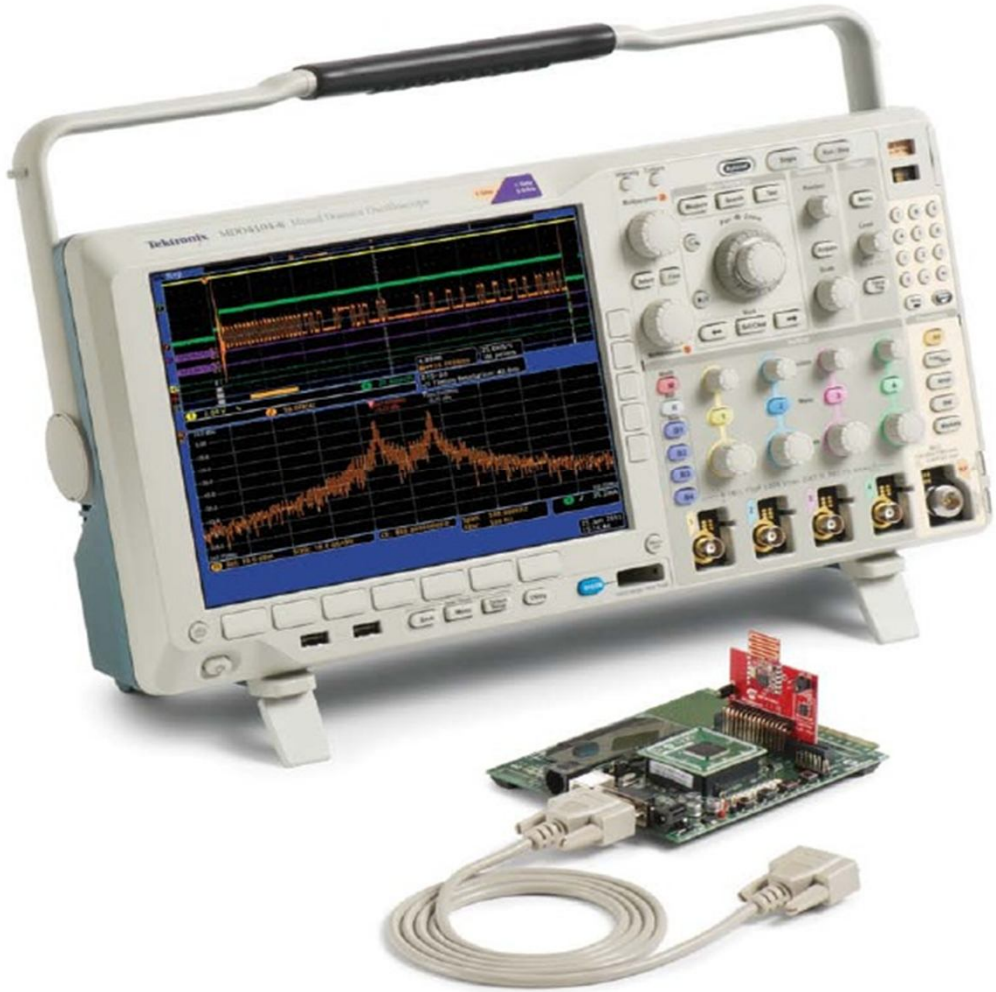
Agenda

- Introduce MDO4000 Series Mixed Domain Oscilloscope
- RF Embedded System Application Case Study
  - Design considerations: 900 MHz ISM band radio
  - Test setup and design challenges
  - RF Performance Verification
  - System Performance Verification (Europe and North America)
- MDO4000 Performance
- Conclusions / Questions

Tektronix MDO4000 Series Mixed Domain Oscilloscope and Microchip Radio Test Board Module



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Tektronix MDO4000 Series

Introducing the World's First Mixed Domain Oscilloscope

The only Oscilloscope

with a built-in Spectrum Analyzer

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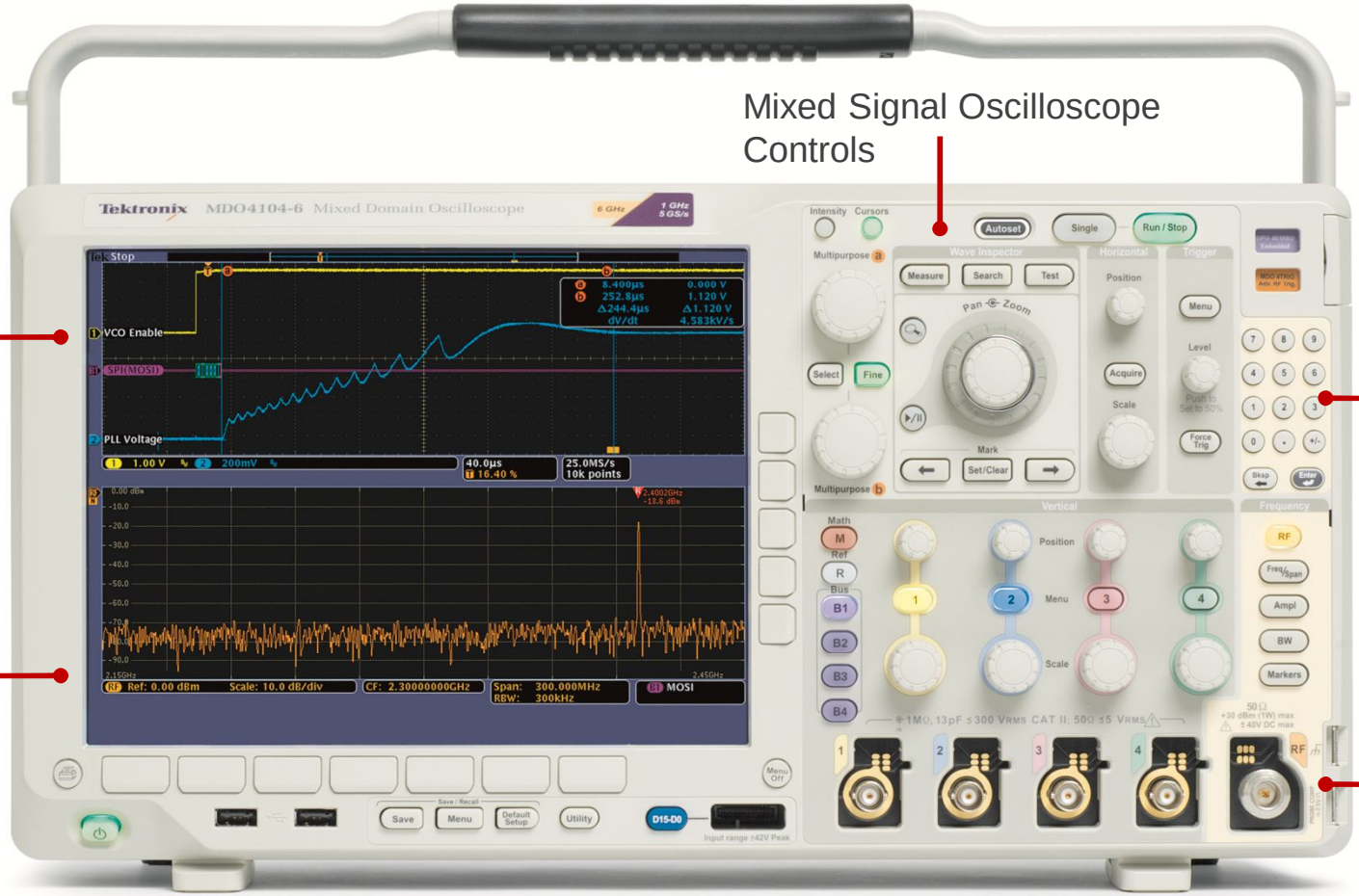
Complete System Visualization

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



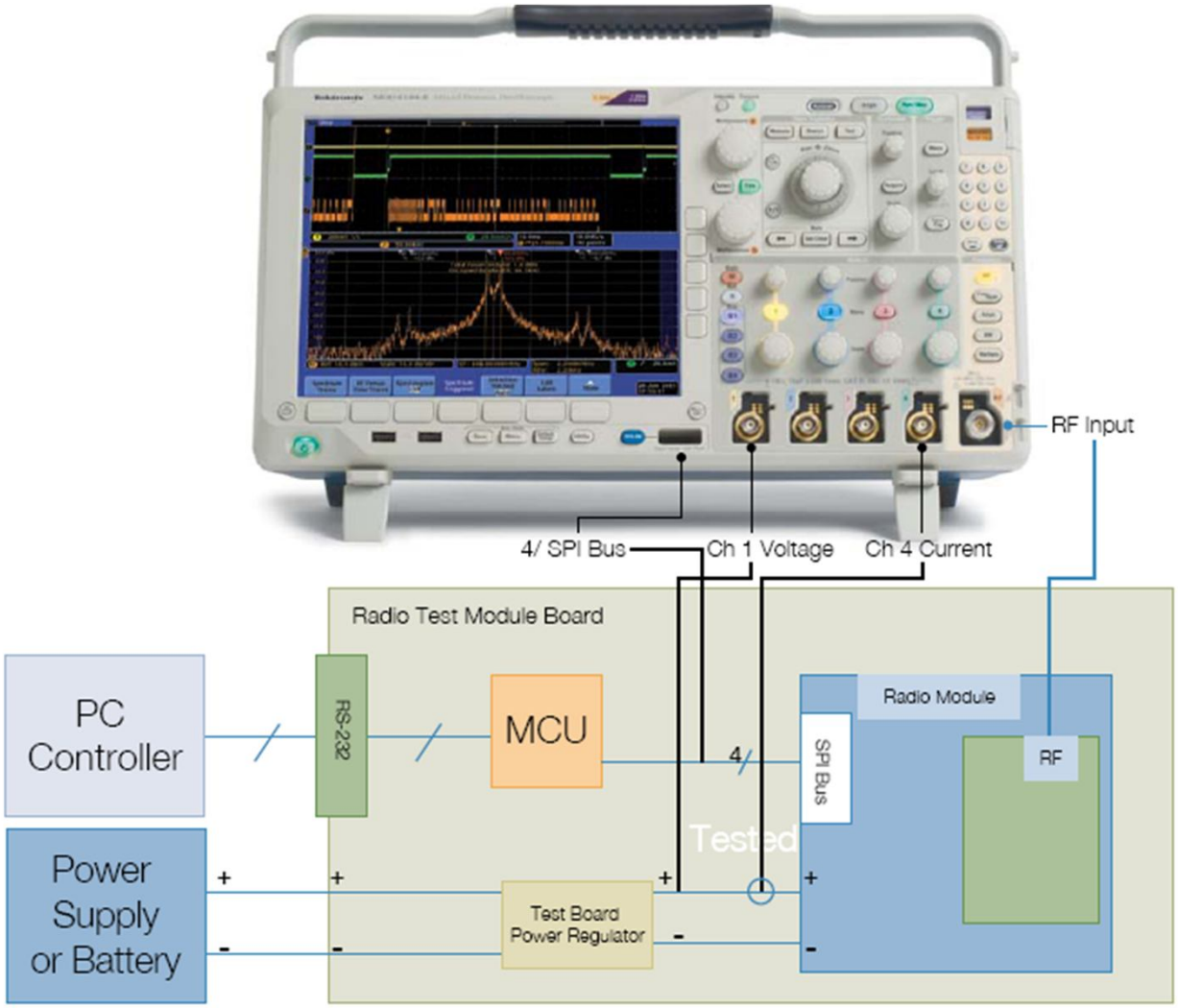
Selecting the Frequency, Power, and Operational Bandwidth for 900 MHz Band Radios

- For unlicensed radio communications, the 900 MHz range of frequencies offer advantages over 2.4 GHz radios
  - Longer range
  - Better building penetration
  - Potential power savings

- Flexible radio ICs can be used for a variety of applications
  - European 868 MHz narrow band medium range appliations
  - North American narrow band very short range applications
  - North American wideband “digital modulation” longer range systems

- Proper integration raises many issues
  - RF performance
  - Digital control
  - Power supply

Test Setup for Validating Radio Integration



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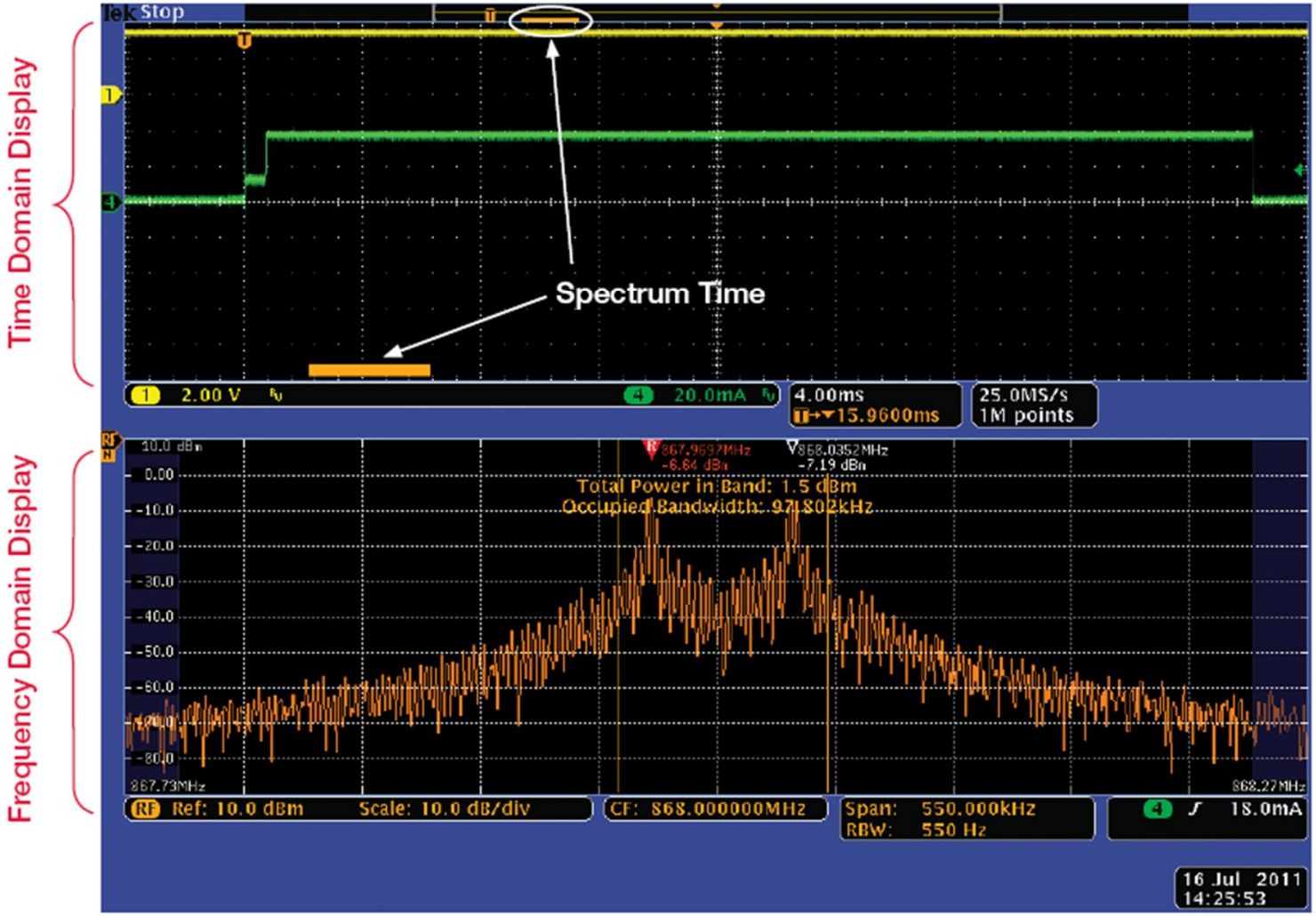
Performance Settings and Measurements

- European setup under ETSI EN300 220 rules
  - Generally limited to about 25 mW of transmitter power
  - Band is segmented into segments with different rules
  - Many segments allow up to 100 kHz occupied bandwidth

- For demonstration the radio IC is set to 5 kbits per second with 33 kHz deviation

Time Domain and Frequency Domain Views of Low Powered Radio



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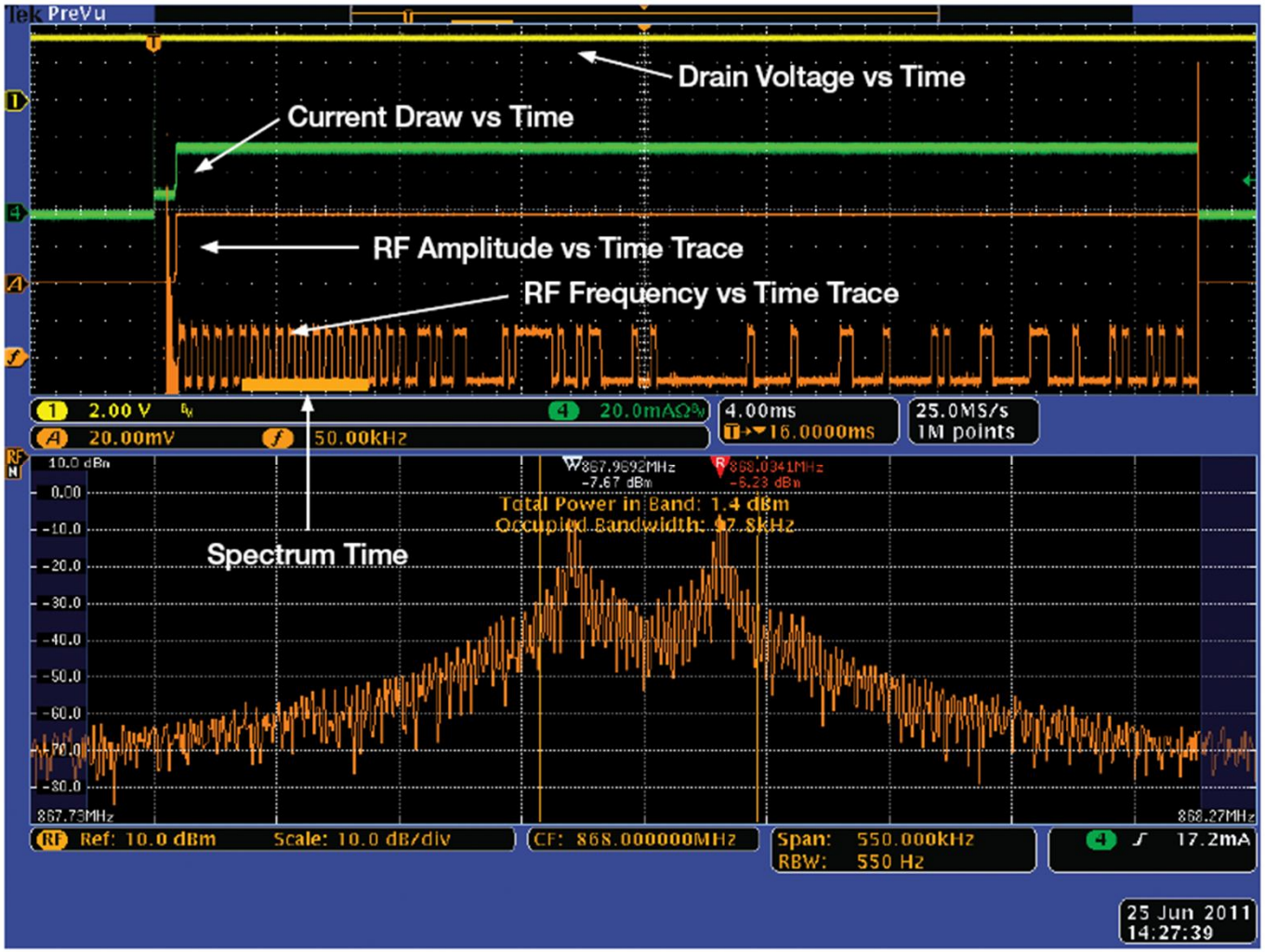
Correlated RF Amplitude and Frequency vs. Time Traces



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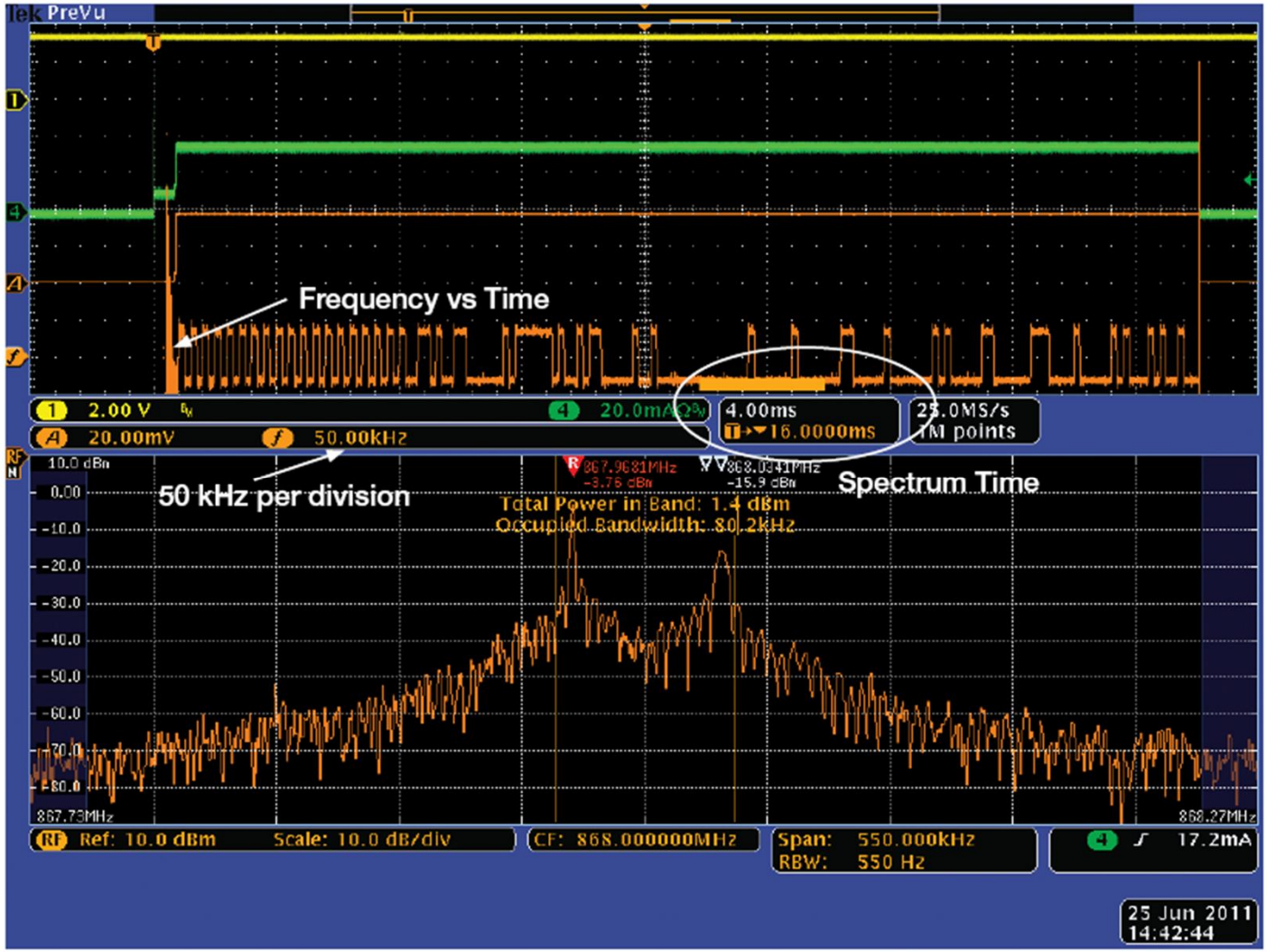
Spectrum Time Moved Later in the Packet Transmission



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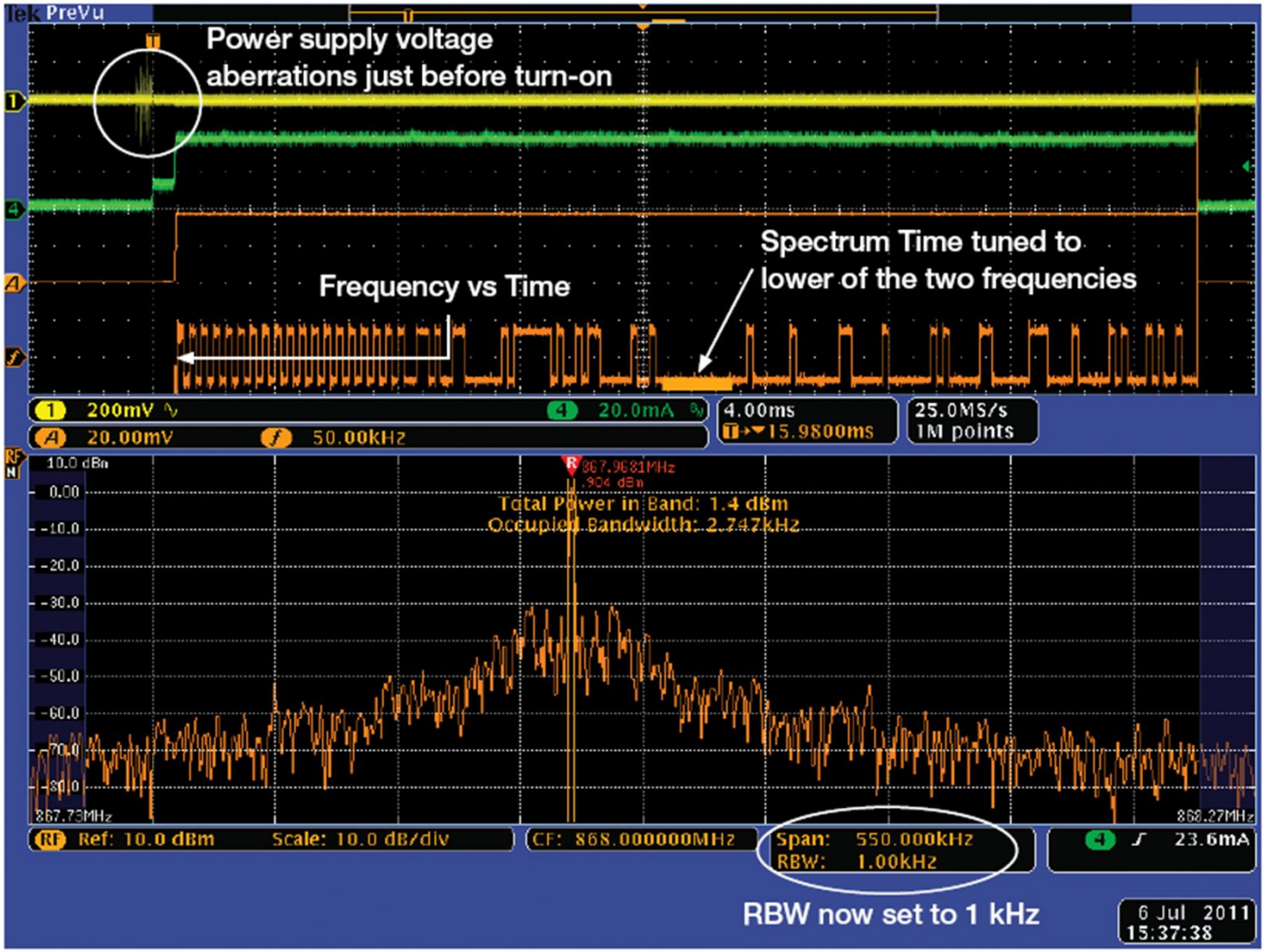
Spectrum During an Interval of only One Frequency in the FSK Signal



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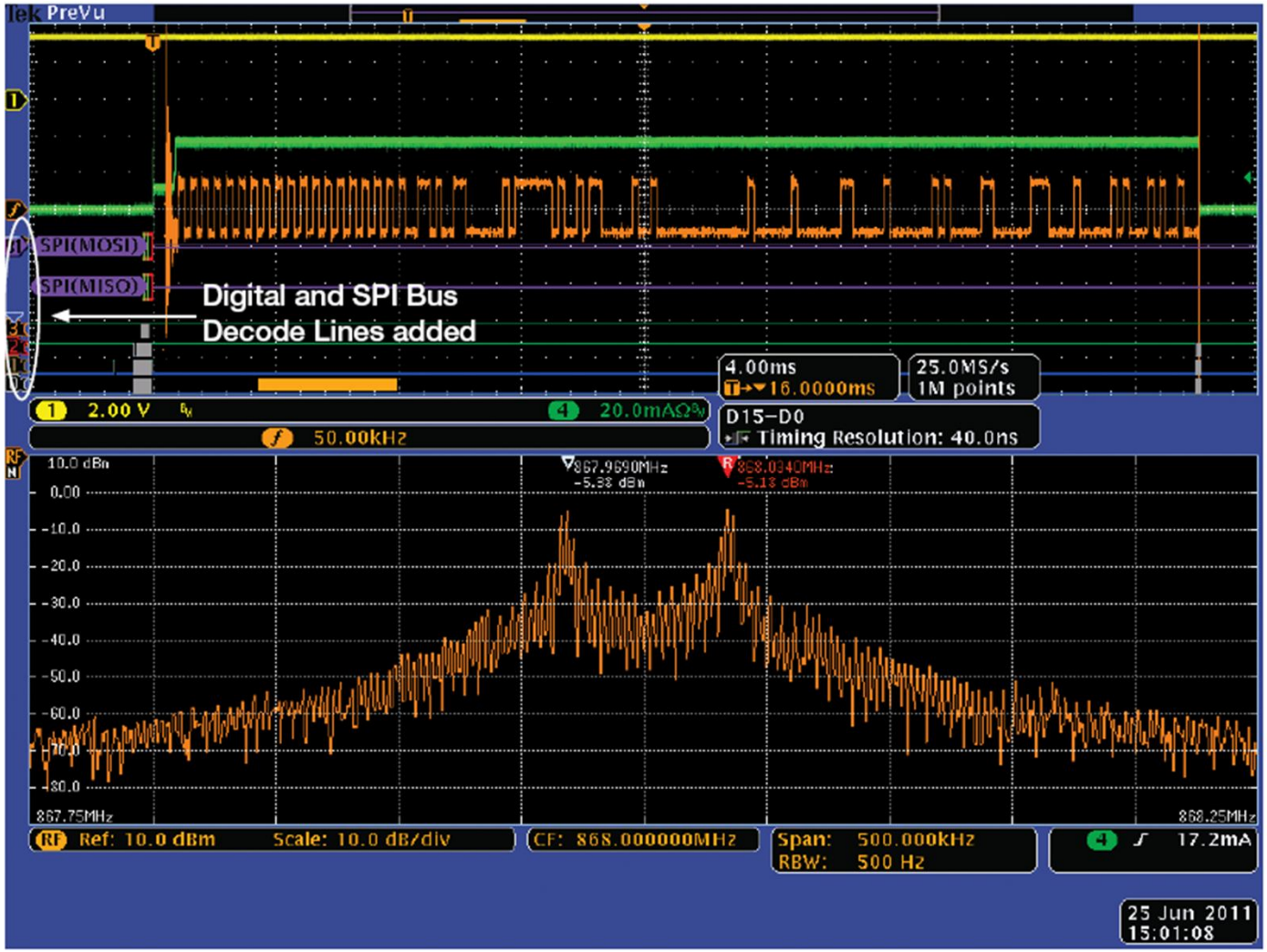
SPI Digital Decoded Data is Displayed



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Decoded SPI Data to the Radio Module

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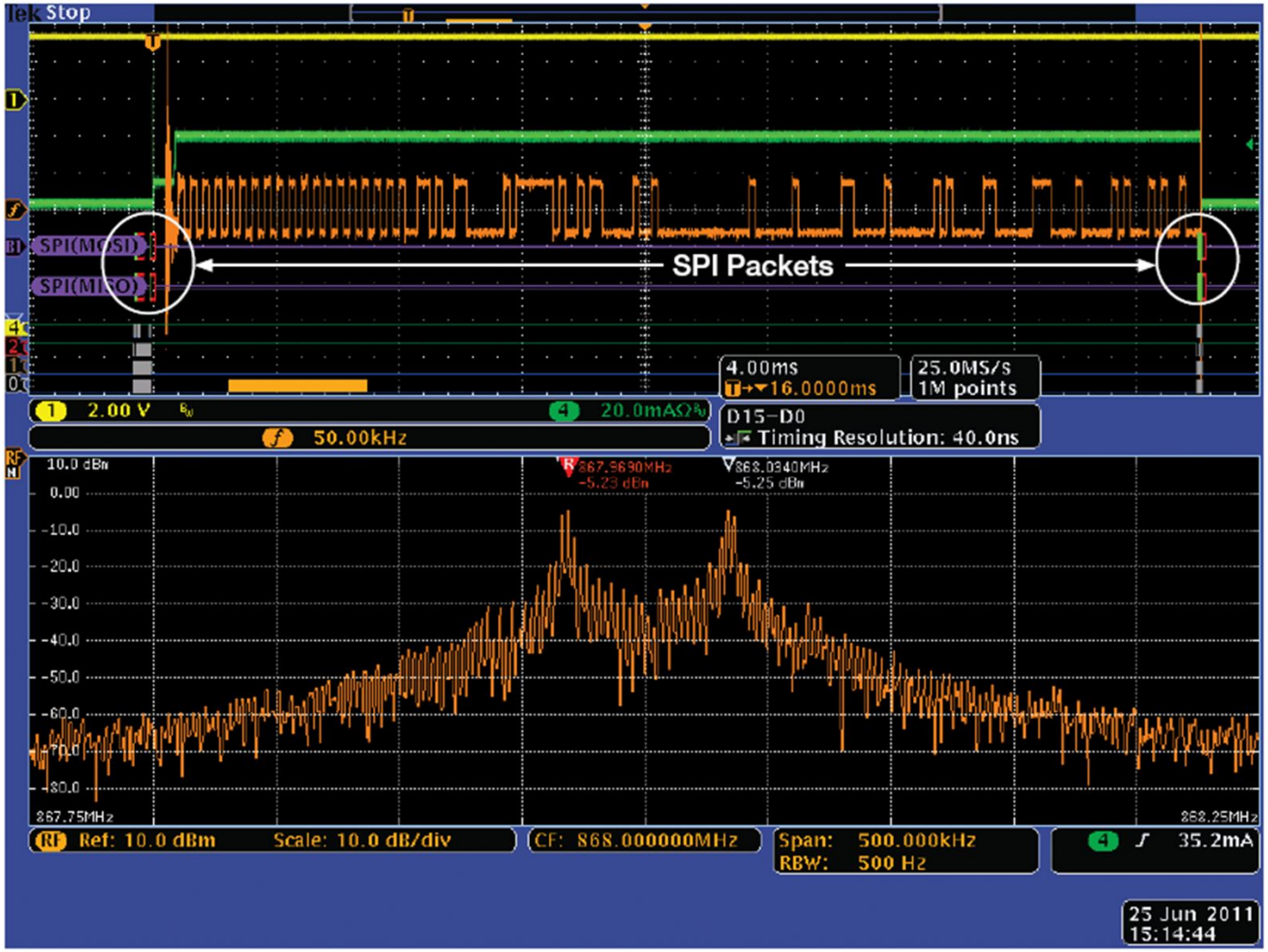
Spectrum with SPI Digital Commands



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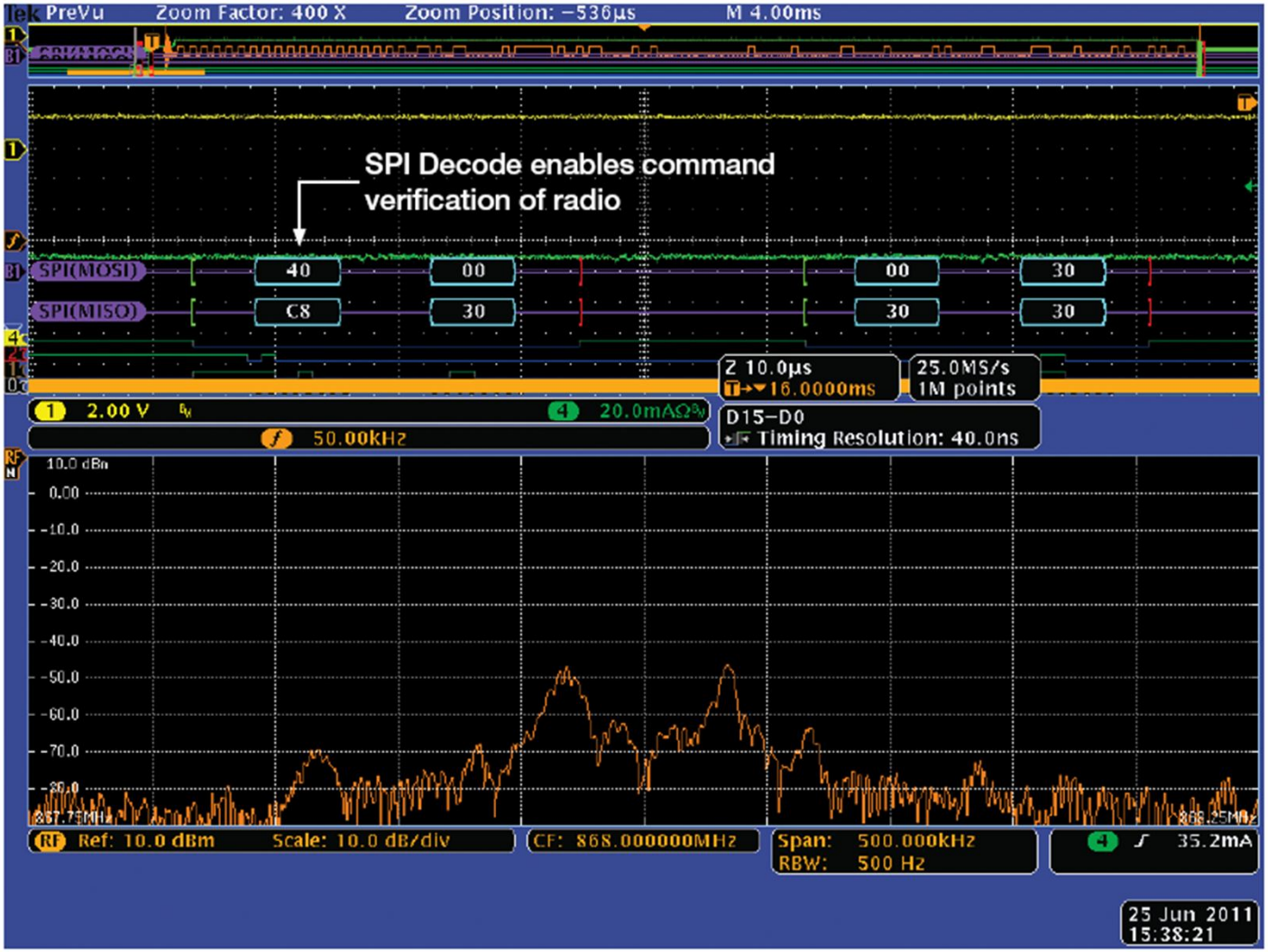
Decoded Commands and Digital Waveforms



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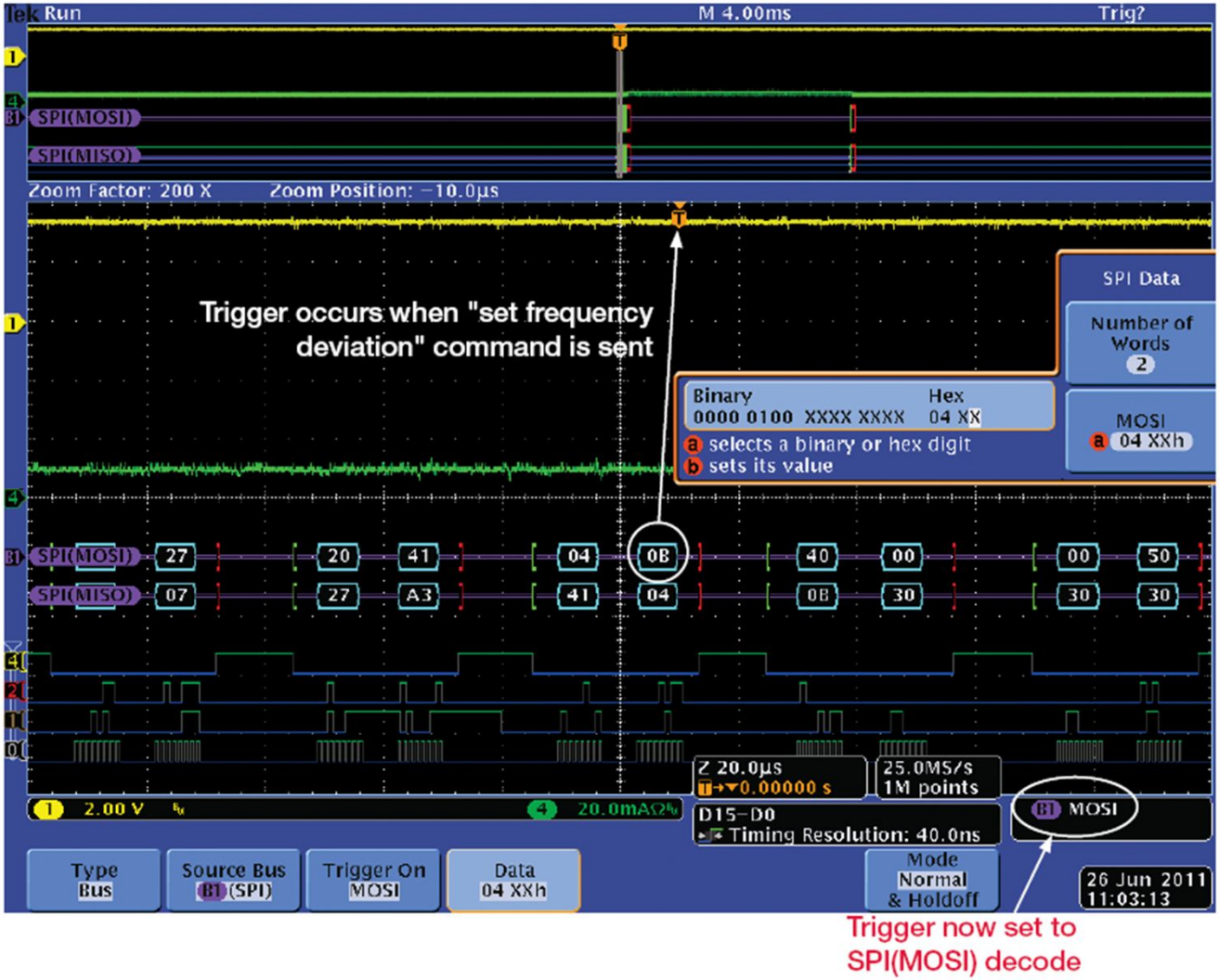
Triggering on a set Frequency Deviation Command



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Triggering on the MOSI Command and Viewing the Frequency vs Time Trace

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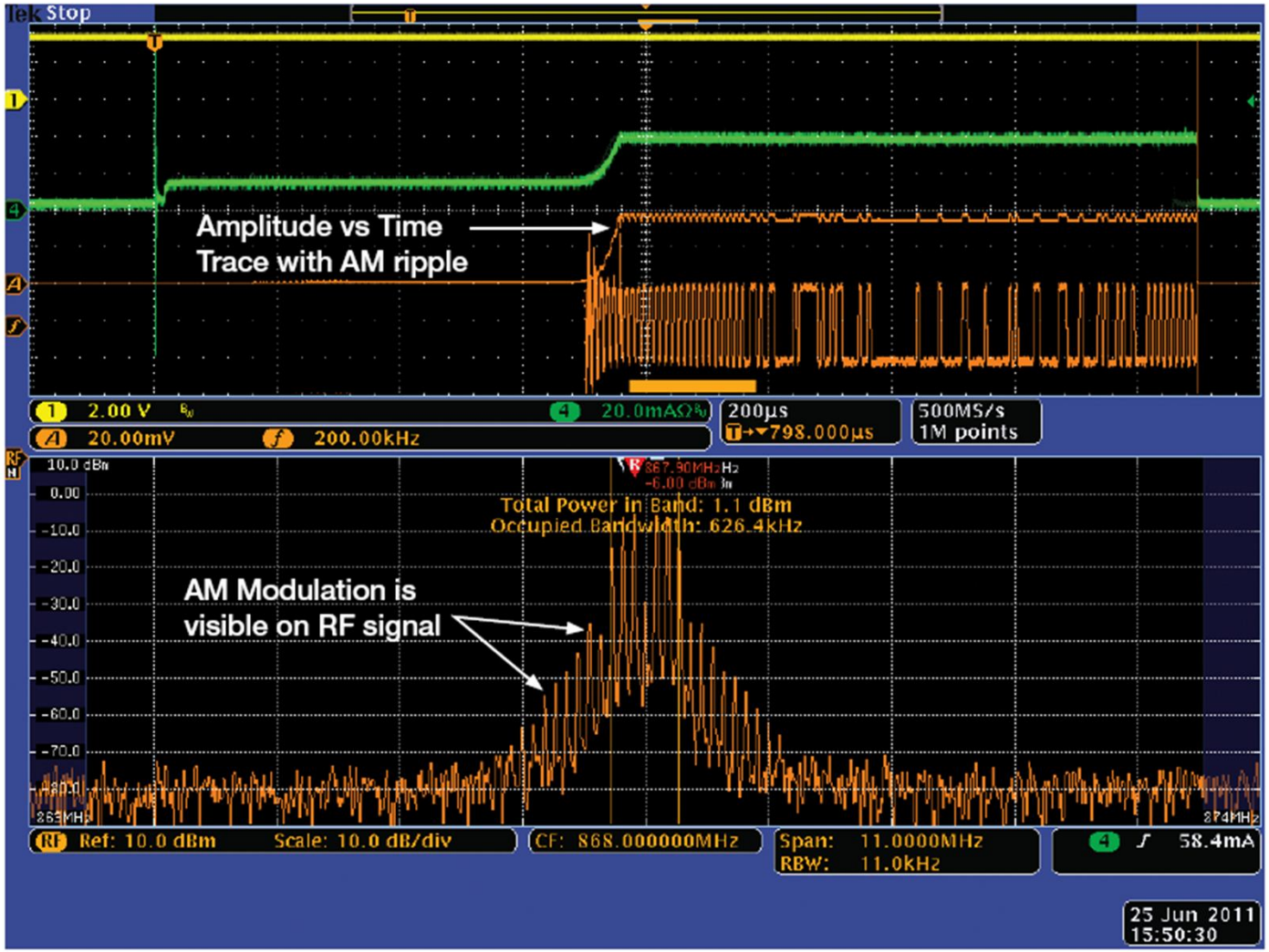
North American Setup

- North America generally follows FCC part 15.247
  - Operation permitted from 902 to 928 MHz (and other bands for other radio ICs)
  - Generally limited to 1 Watt of transmitter power
  - Digital modulation rules require occupied bandwidth of at least 500 kHz
  - Maximum power spectral density must be less than 8 dBm in any 3 kHz band within the total 6 dB bandwidth

- For demonstration the radio IC is set to 200 kbits per second with 200 kHz deviation

Wide Band Spectrum and Measurements for North American Unlicensed Band



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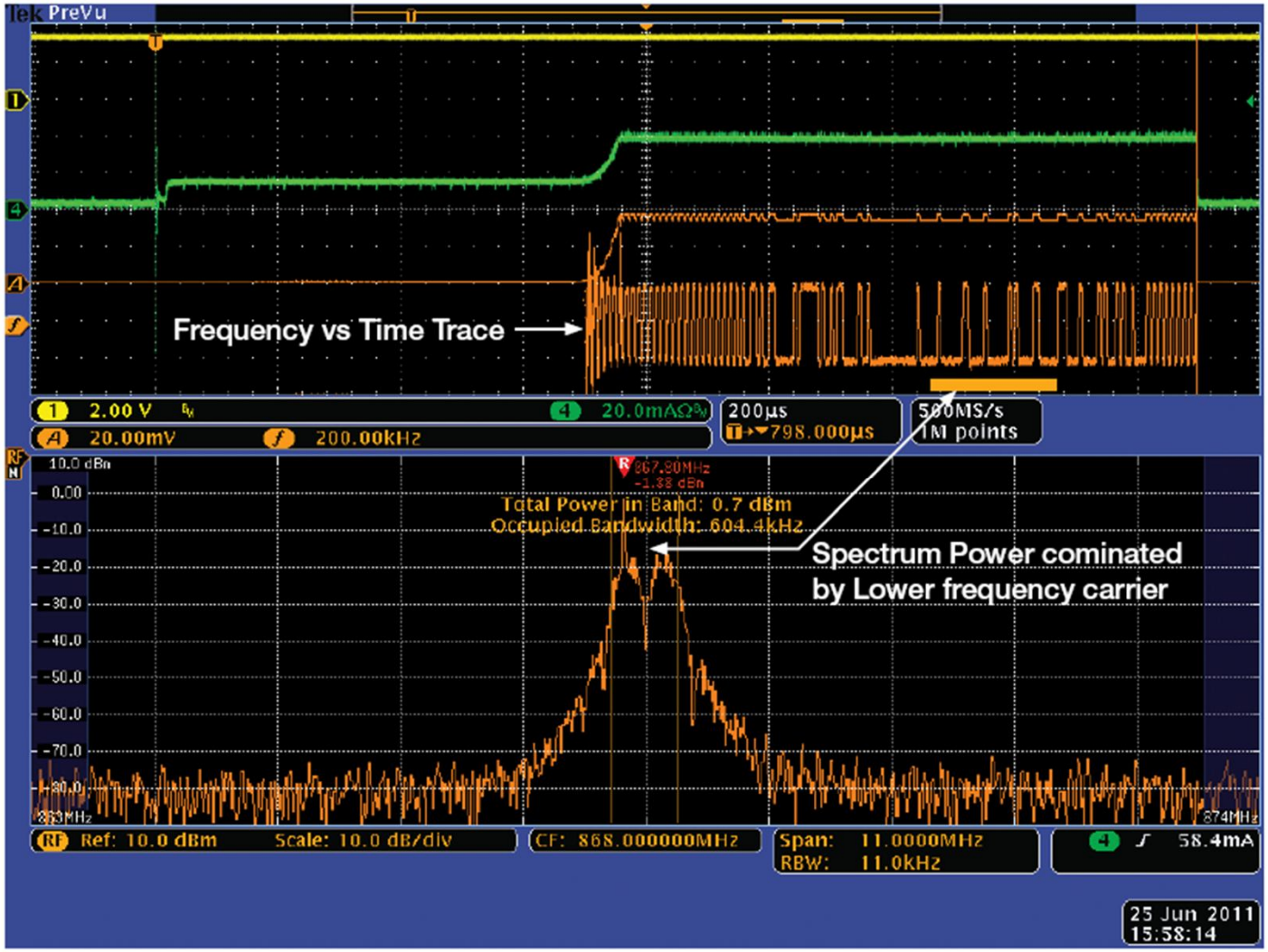
Wide Band Spectrum and Measurements during Data Transmission



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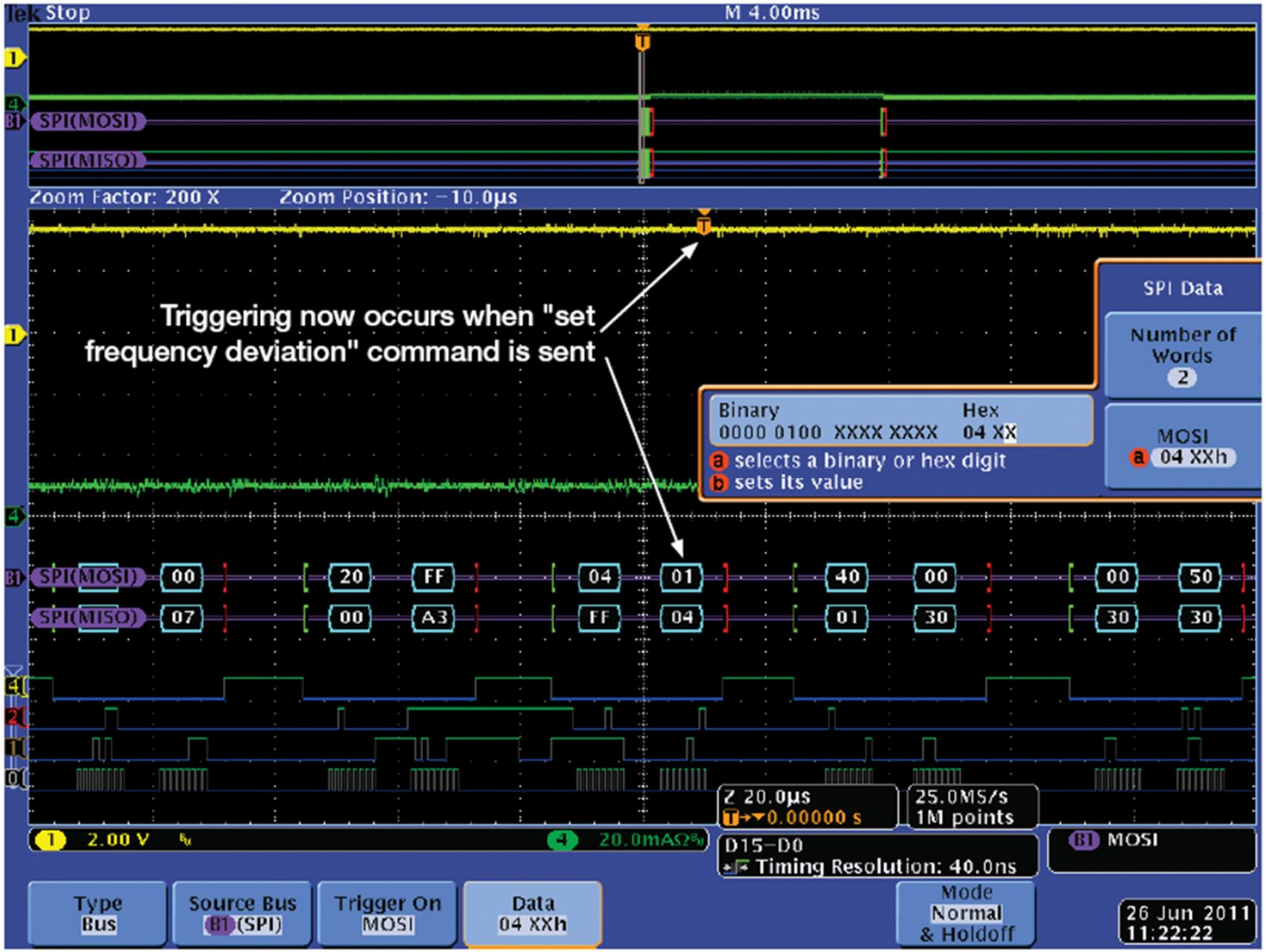
Triggering on a set Deviation Command



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Summary

- Embedded radio ICs and modules offer flexible operation
  - Can meet a variety of regional requirements
    - Frequency
    - Power level
    - Data rate
    - Occupied bandwidth
  - Typically internal registers are used to select these options

- The Tektronix MDO4000 Series Mixed Domain Oscilloscope is a uniquely powerful tool for make these measurements
  - 4 Analog channels to 1 GHz
  - 16 Digital channels
  - RF spectrum analysis to 6 GHz
  - Bus decode
  - Compact and portable

The MDO4000 Series from Tektronix

- Up to 21 channels provide complete system visibility
- Built-in spectral analysis
- Time-correlated analog, digital, and RF in a single instrument

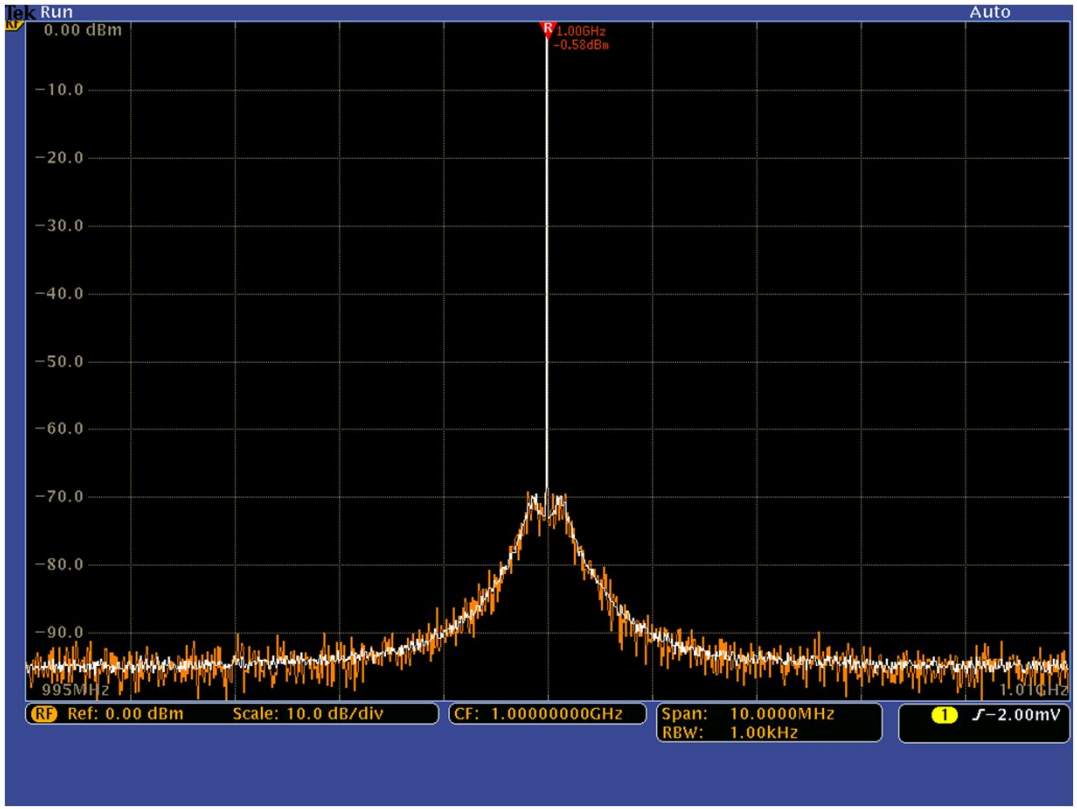
Model	Analog Channels	Analog Bandwidth	Digital Channels	RF Channels	RF Freq. Range
MDO4054-3	4	500 MHz	16	1	50 kHz – 3 GHz
MDO4054-6	4	500 MHz	16	1	50 kHz – 6 GHz
MDO4104-3	4	1 GHz	16	1	50 kHz – 3 GHz
MDO4104-6	4	1 GHz	16	1	50 kHz – 6 GHz

Example: Typical RF Performance Benchmarks

- Freq. Range :

  50KHz to 3GHz / 6GHz
- Real Time Capture BW ≥ 1 GHz
- RBW Range 20K to 10MHz
- DANL ≤ -152 dBm/Hz
- SFDR ≤ -60 dBc
- Φ noise ≤ -95 dBc/Hz

  (2GHz CW @100KHz)



For more information: http://www.tektronix.com/mdo4000

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Thank You for Joining Us