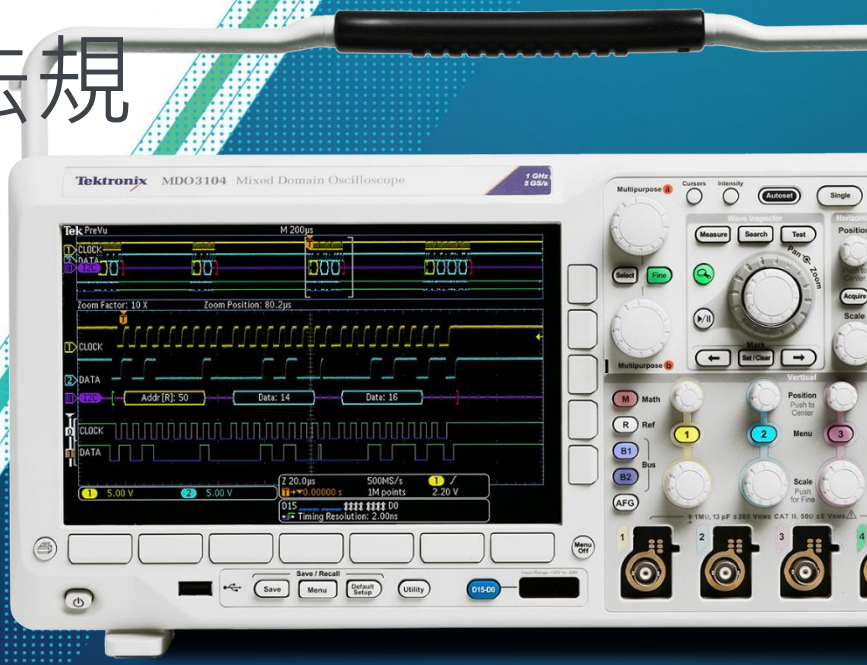

TEK Talks -
決勝行動高速介面量測新戰場
Tektronix

EMI 相容性測試
預相容性測試及量測法規

30 SEPTEMBER 2016



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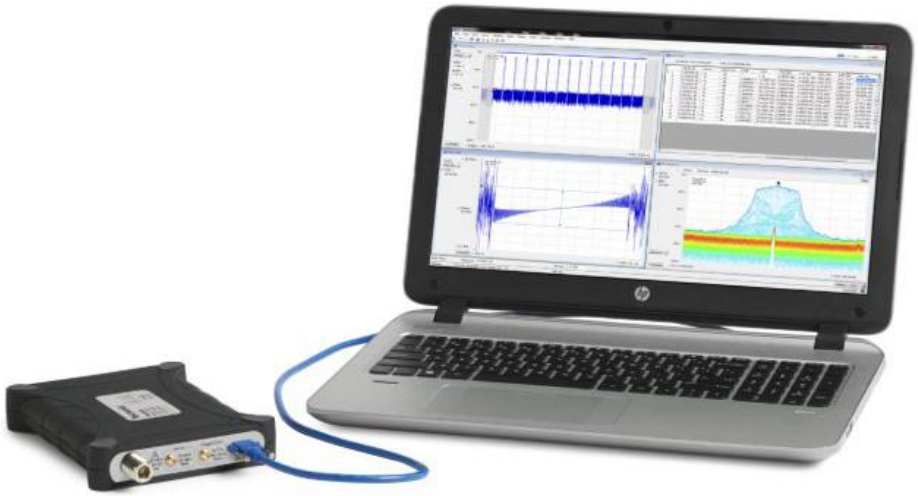
Agenda

- EMI introduction
- EMI pre-compliance and debugging tools
- RSA306B demo
- MDO4000C demo lab



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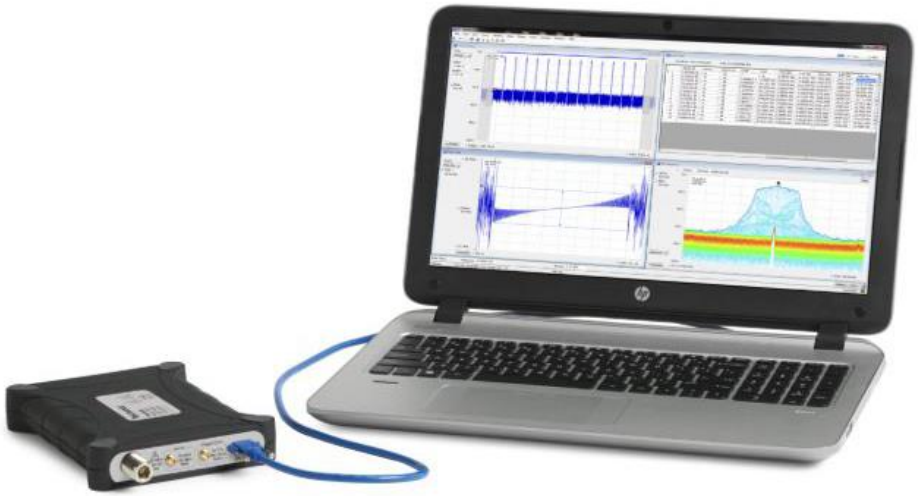


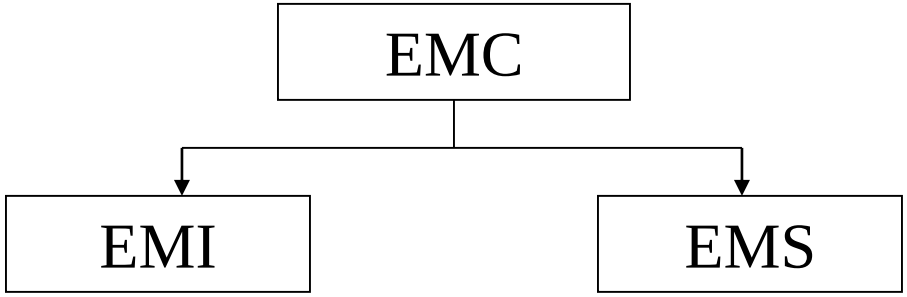
Definition

EMC : Electromagnetic Compatibility

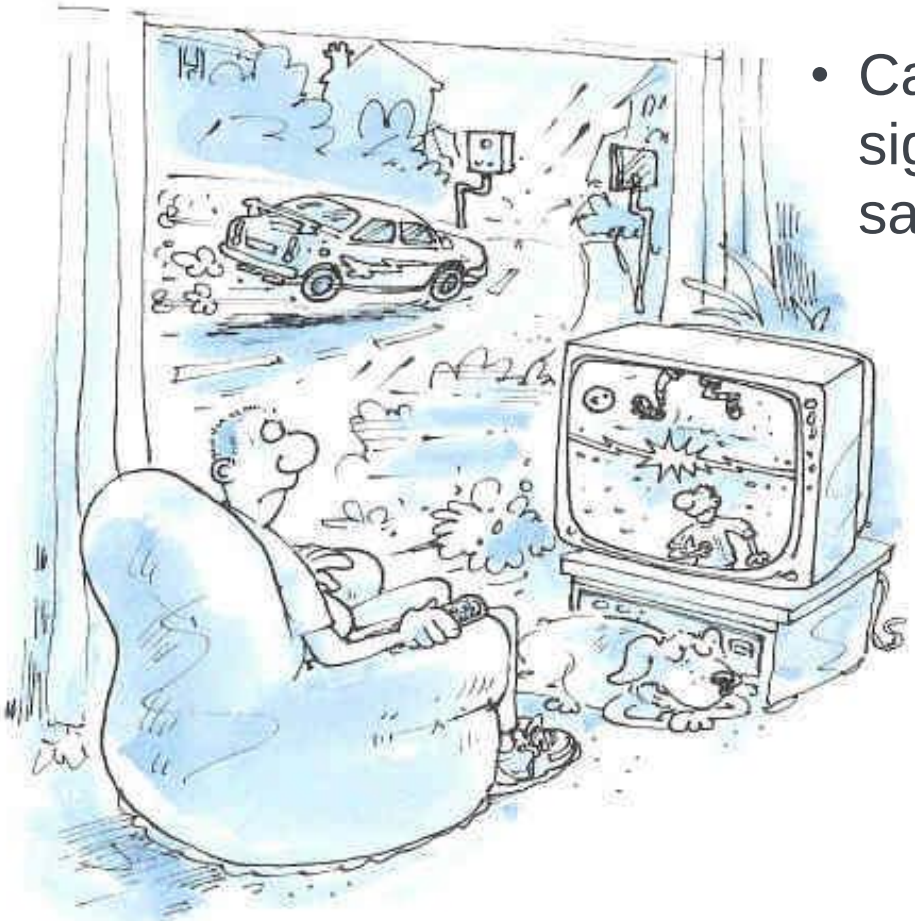
EMI : Electromagnetic Interference

EMS :Electromagnetic Susceptibility

EMC = EMI + EMS



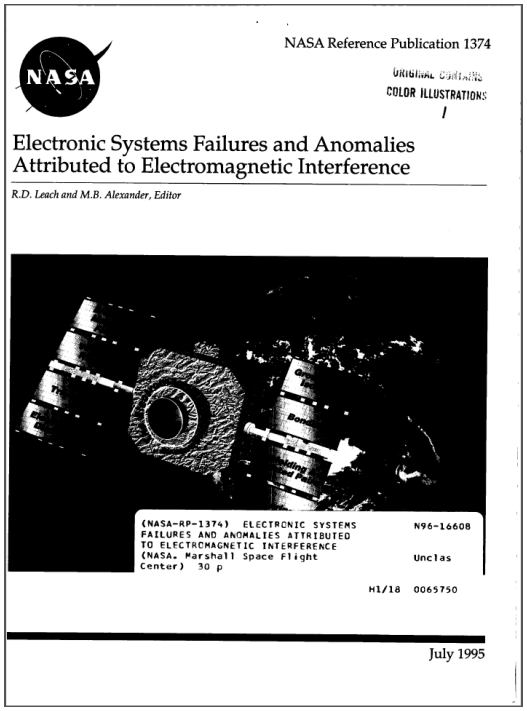
EMI Example: Car Radar Detectors



- Car radar detectors that emitted signals that caused interference to satellite digital television in the UK.

http://www.emcuk.co.uk/awareness/Pages/InterferenceExamples/Automotive.htm

EMI Example: DC-10 Autopilot Failure



NASA Reference Publication 1374

ORIGINAL CONTAINS COLOR ILLUSTRATIONS

Electronic Systems Failures and Anomalies Attributed to Electromagnetic Interference

R.D. Leach and M.B. Alexander, Editor

(NASA-RP-1374) ELECTRONIC SYSTEMS FAILURES AND ANOMALIES ATTRIBUTED TO ELECTROMAGNETIC INTERFERENCE (NASA. Marshall Space Flight Center) 30 p

N96-16608

Unclas

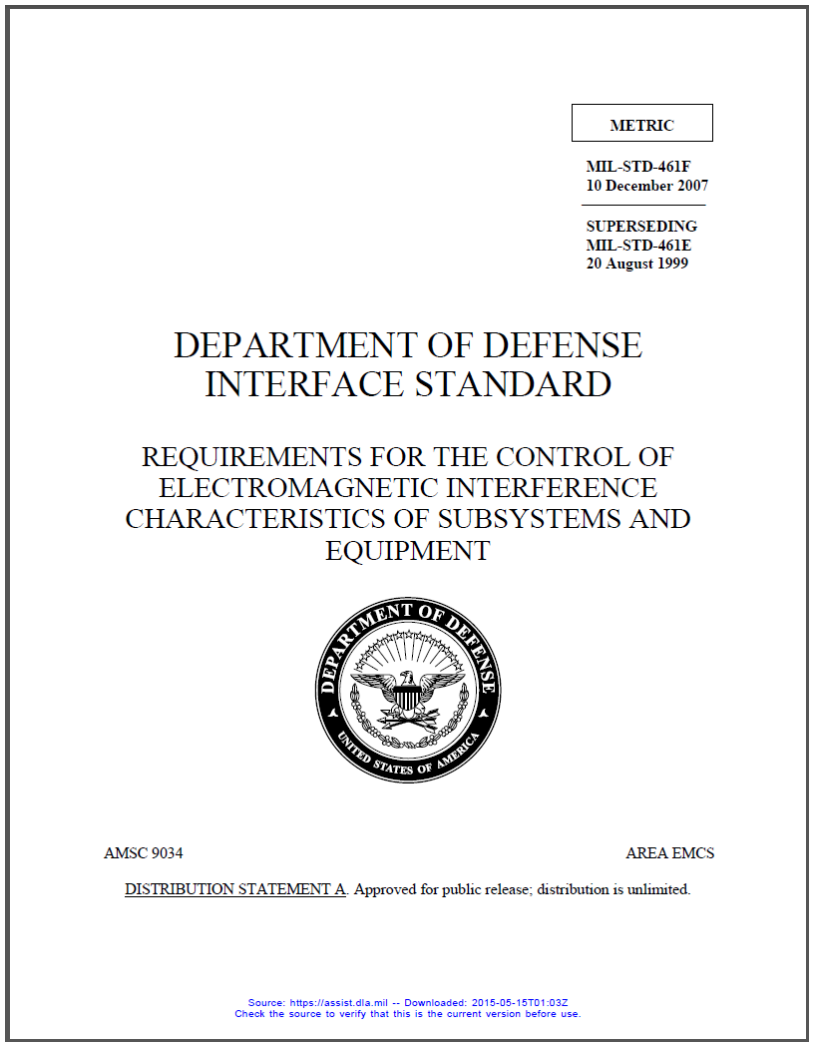
H1/18 0065750

July 1995

- 1993 DC-10 autopilot was disrupted during final landing approach by a battery–powered CD player operated by a passenger in first-class.
- To prevent the aircraft from crashing after suddenly veering off course, the pilot had to manually take control of the aircraft.

http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19960009442.pdf

EMI Standards



METRIC

MIL-STD-461F
10 December 2007

SUPERSEDING
MIL-STD-461E
20 August 1999

DEPARTMENT OF DEFENSE
INTERFACE STANDARD

REQUIREMENTS FOR THE CONTROL OF ELECTROMAGNETIC INTERFERENCE CHARACTERISTICS OF SUBSYSTEMS AND EQUIPMENT

AMSC 9034 AREA EMCS

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

Country	Standard
United States	FCC Part 15
United States Military	MIL-STD-461F
Canada	ICES 003
Australia	AS 3548
Japan	VCCI - V series
New Zealand	Ministry of Commerce - CISPR 22
Europe	EN 55022 IEC / CISPR 22 CISPR 11 CISPR 13 CISPR 20 EN 61000-6-3 EN 61000-6-4 EN 60601-1-2 EN 61000-3-2 EN 61000-3-3 EN 61326-1
Chinese Taipei - Taiwan	CNS 13438

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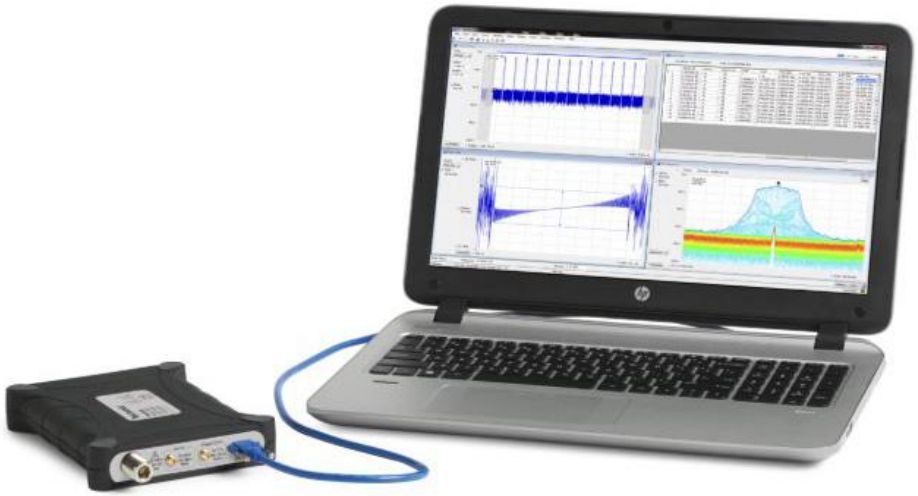


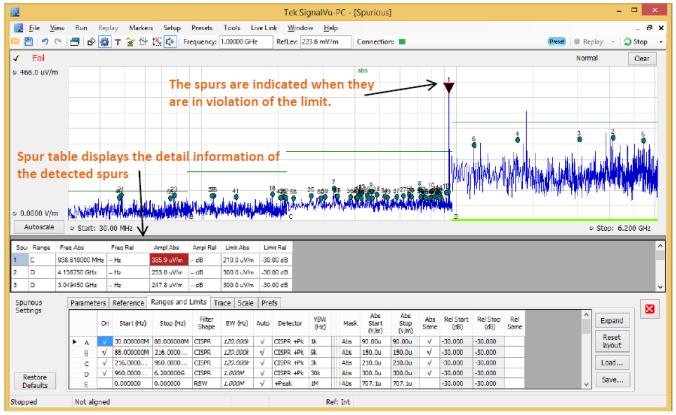
EMI Compliance Test

Anechoic Chamber

1k-3k/day

Open-Air Test Site (OATS)

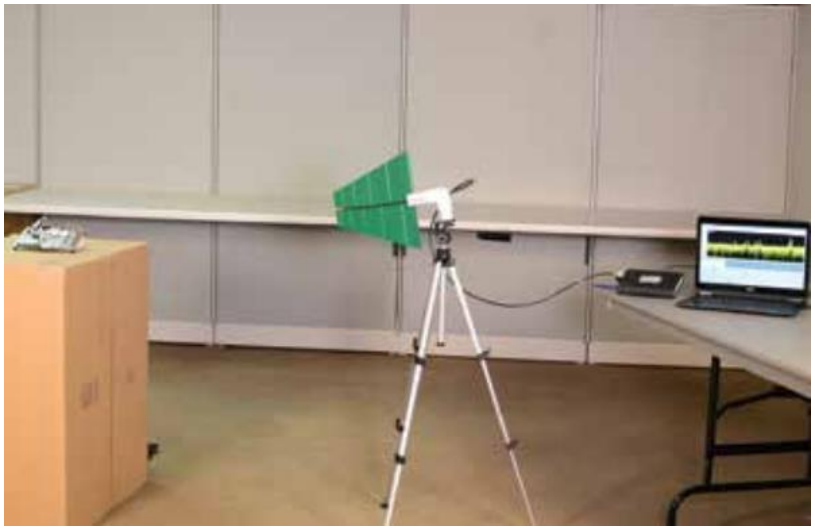
EMI receiver/ LISN/ Antenna/ …



Professional Software/ Report

EMI Pre-compliance Test

- Spectrum analyzer with peak detector (quasi-peak optional)
- Preamplifier (optional)
- Antenna with non-metallic stand for radiated emissions
- Line impedance stabilization network (LISN) for conducted
- Power limiter for conducted Near field probes for diagnostics (optional)



Selecting Spectrum Analyzer for EMI Test

- Frequency Range
- Resolution Bandwidth
- Detection Methods
- Video Filters

Frequency Range	Bandwidth (6 dB)	Reference BW
9 kHz to 150 kHz (Band A)	100 Hz to 300 Hz	200 Hz
0.15 MHz to 30 MHz (Band B)	8 kHz to 10 kHz	9 kHz
30 MHz to 1000 MHz (Bands C and D)	100 kHz to 500 kHz	120 kHz
1 GHz to 18 GHz (Band E)	300 kHz to 2 MHz	1 MHz

Table 2. Measurement Bandwidth versus Frequency specified by CISPR 16-1-1.

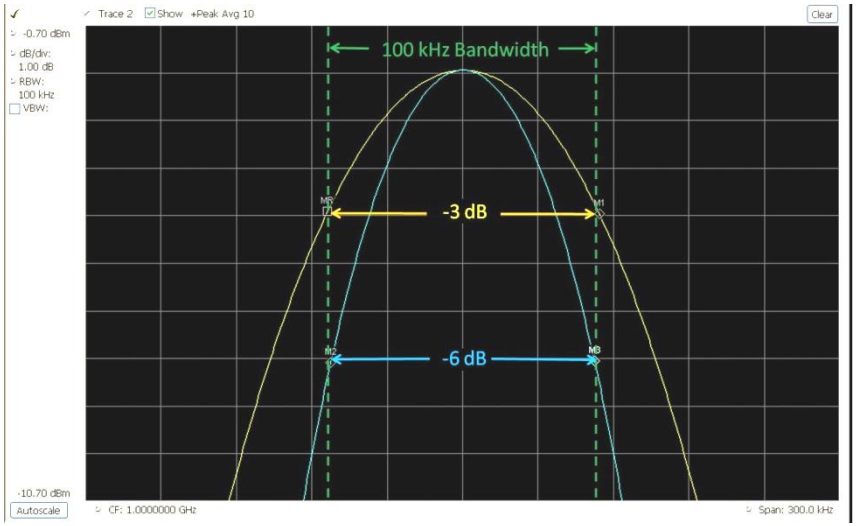
Frequency Range	Bandwidth (6 dB)
10 Hz-20 kHz	10, 100, and 1000 Hz
10-150 kHz	1 and 10 kHz
150 kHz-30 MHz	1 and 10 kHz
30 MHz-1 GHz	10 and 100 kHz
1-40 GHz	0.1, 1.0 and 10 MHz

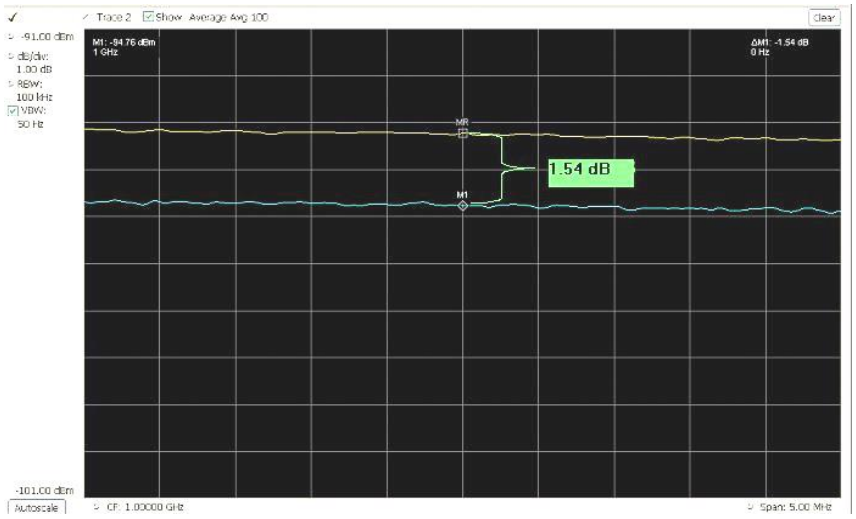
Table 3. Bandwidths versus frequency specified for peak, average and RMS detectors by ANSI C63.2.

Frequency Range	Bandwidth (6 dB)
30 Hz – 1 kHz	10 Hz
1 kHz-10 kHz	100 Hz
10 kHz-150 kHz	1 kHz
150 kHz-30 MHz	10 kHz
30 MH-1 GHz	100 kHz
Above 1 GHz	1 MHz

Table 4. Bandwidths versus Frequency specified by Mil-STD-461E.

Measurement settings: bandwidth effects





Analyzer with selectable -3 dB (RBW) and -6 dB filter definitions, 1 dB/division

Random noise measured with 100 kHz filters.
-3dB, 100 kHz response in yellow,
-6dB, 100 kHz response in blue.

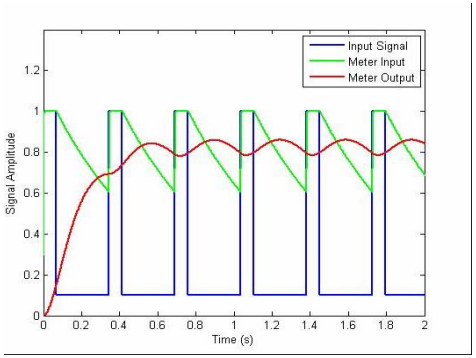
The power difference is 1.5 dB, in close agreement with the theoretical value.

$10*Log_{10}(BW1/BW2)$, or 10*Log(71/100)=-1.5dB difference from using wrong BW
EMI filters (CISPR, MIL) are specified at the -6 dB bandwidth

Measurement settings: Peak, QP and Average Detectors

- Detectors were designed to place emphasis on frequently occurring signals that would annoy a listener or viewer of broadcast communications

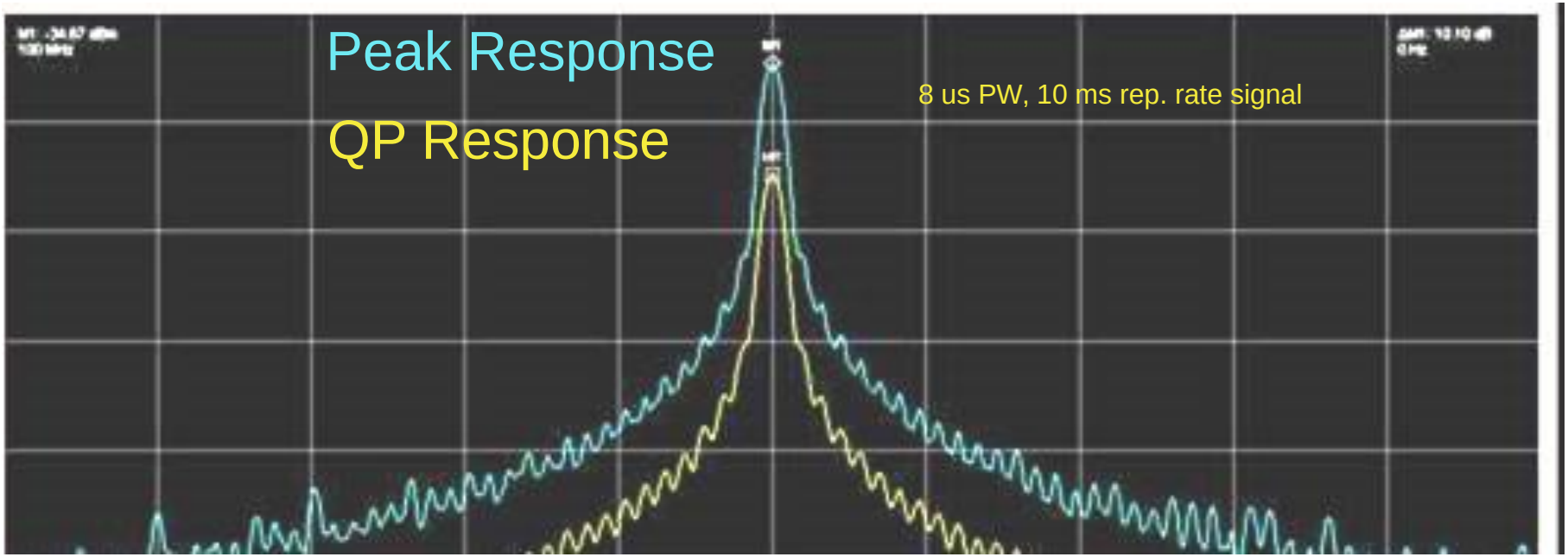
- Originally, the QP detector really was a RC circuit and a voltmeter- now it's implemented digitally



Characteristics	9 kHz-150 kHz (Band A)	0.15 MHz to 30 MHz (Band B)	30 MHz to 1000 MHz (Bands C and D)
Bandwidth (6dB)	0.2 kHz	9 kHz	120 kHz
Detector charge time	45 ms	1 ms	1 ms
Detector discharge time	500 ms	160 ms	550 ms
Time constant of critically damped meter	160 ms	160 ms	100 ms

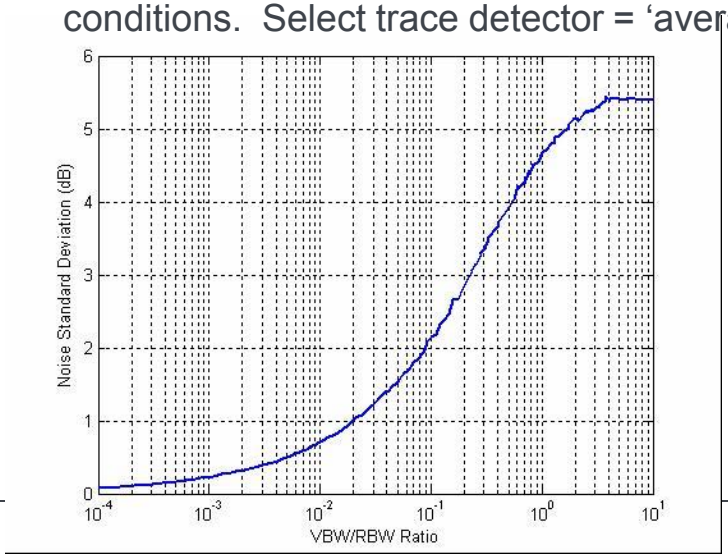
Measurement settings: Detector and meter response

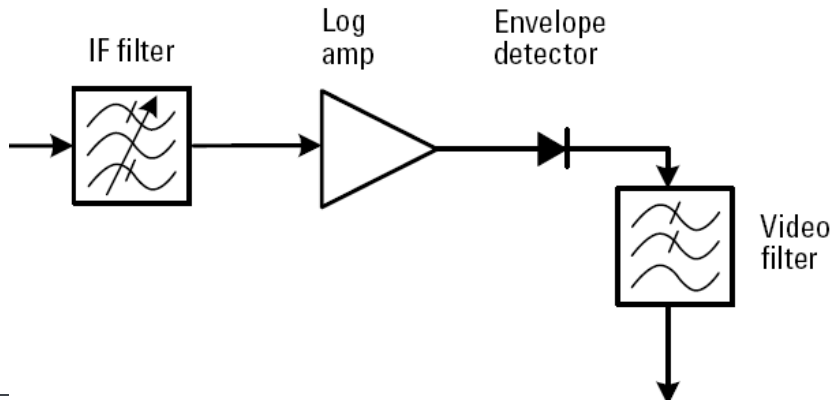
- Average or QP+ Meter is always ≤ Peak measurement
- Measured CW power are equal for Average, QP and Peak detectors



Measurement settings: video filter

- Used to reduce the effect of noise on the displayed signal amplitude
- A low-pass filter comes after the log envelope detector on traditional swept analyzers
- Reconfigurable to perform averaging on either a log, voltage or power scale on modern spectrum analyzers
  - Video filtering of the Log of detected video was the original method, because the log amplifier was ahead of the video filter, and these used to be real hardware- now they are both digital, and can be applied in different orders
  - Log-Video filters result in errors on digitally modulated carriers and noise (about -2.5 dB for Gaussian distributions)
  - We use rms voltage detectors for accurate results under any signal condition under default conditions. Select trace detector = 'average of logs' to get the legacy (wrong) answer





Reduce Time to Market

By quickly debugging EMI & passing EMI compliance testing the first time.

Faster EMI Pre-compliance without having to wait for access to a lab	Find elusive EMI signals faster	Faster EMI Debugging and Troubleshooting	Avoid EMI caused by intentional RF transmitters
▪ Pre-compliance testing is done with your RSA306 ▪ Low cost & PC-based real time spectrum analyzer ▪ Small form factor for portability	▪ Faster detection of short duration EMI signals with RSA306 DPX real-time technology ▪ Long recording time to capture infrequent EMI bursts	▪ MDO4000B's frequency & time correlation quickly identifies the noise source. ▪ Understand the root cause analog and/or digital signals that are causing the EMI noise.	▪ Understand change in EMI signature due to intentional RF transmission ▪ Correlate EMI events with RF transmission with using RSA306 on Spectrum Emission Mask and DPX

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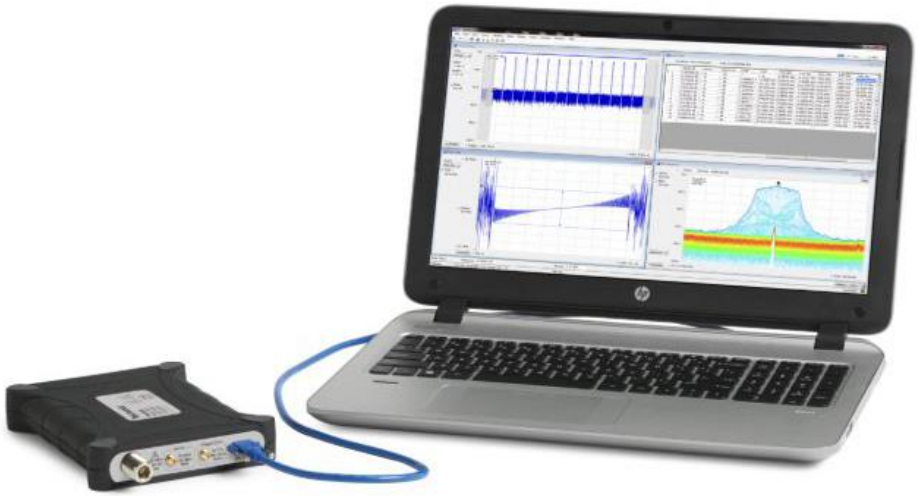
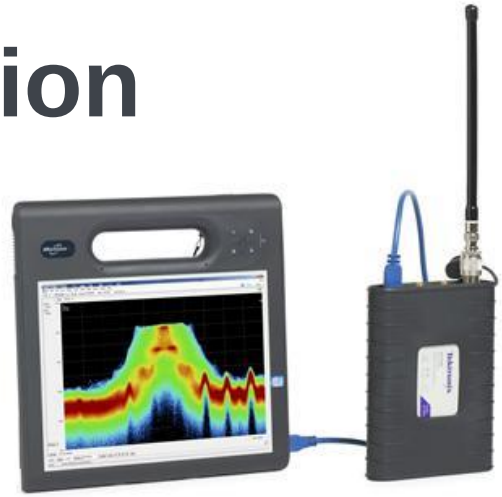


RSA306B Banner Specification



- Unmatched price/performance
  - $4,500 (U.S. MSRP)
- Frequency range: 9 kHz – 6.2 GHz
- Dynamic Range
  - Measurement Range from -160 dBm to +20 dBm
- Accuracy
  - 1 ppm Frequency Accuracy
- Form Factor
  - Weight: 0.59 kg
  - Ruggedized: meets Mil-Std 28800 Class 2 requirements for harsh conditions
- Class leading real-time spectrum analysis comes standard
  - Acquisition bandwidth: 40 MHz
  - Minimum signal duration: 100 µsec

PC Requirements
- USB 3.0
- Minimum 8 GB RAM
- 4th Generation Intel i7 for full real time specification
- Windows 7 or 8 64-bit
- Reduced processor results in degraded min. signal duration for 100% POI

New USB RSAs

HIGHER PERFORMANCE EMI PRE COMPLIANCE & DIAG. FEWER SPURS, BETTER EMI CHECKS

- 4-Models
  - RSA603A/607A, AC operated, laboratory form factor
  - RSA503A/507A, battery operated, field ruggedized
- 2 frequency ranges
  - 5/603A: 9 kHz to 3.0 GHz
  - 5/607A: 9 kHz to 7.5 GHz
- Tracking generator options
  - 10 MHz to maximum frequency range of unit
- Acquisition bandwidth: 40 MHz
- Min. Sig. Duration, 100% POI: 100 us
- **Spurious-free dynamic range: 70 dB**

RSA603A, RSA607A

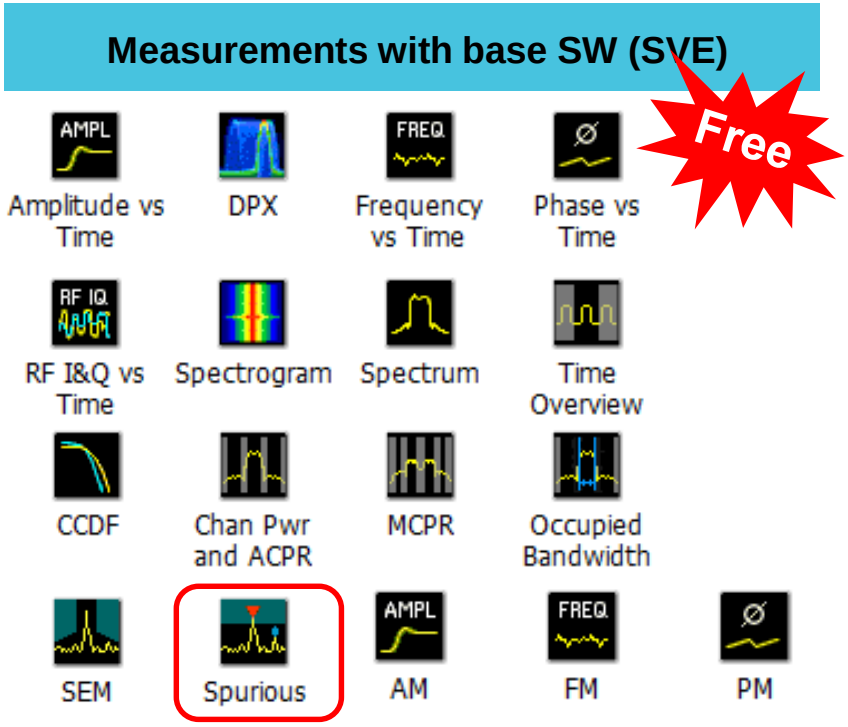
Lab performance for design of IoT at around half the cost of competitive instruments

RSA503A, RSA507A

Solves your toughest interference problems and Puts a 1 kg PC in your hands instead of a 3 kg spectrum analyzer

SignalVu-PC Software

- SignalVu-PC Essentials contains 17 different measurements:
  - Essentials now free of charge!
- Shared UI with other RSA's, Scopes with SignalVu, MDO4000C with SignalVu-PC
- Analysis options **dramatically reduced** in price
  - VSA
  - Audio Analysis
  - Settling time
  - Pulse Measurements
  - Wi-Fi measurements through 802.11ac
  - P25
  - Flexible OFDM
  - Mapping
  - Bluetooth
  - Record/Playback
  - LTE

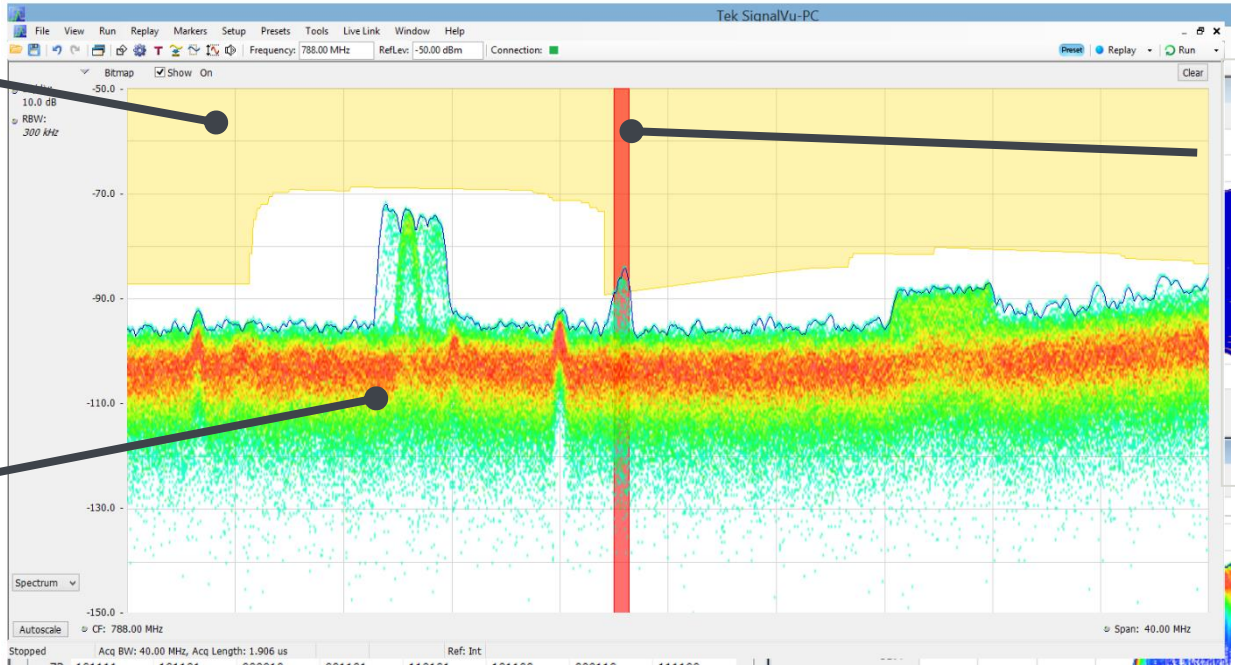


Benchtop Performance Analysis

DPX – Discover EMI Burst Signals

User Defined Mask helps when “staring” within a Bandwidth to identify an interfering signal

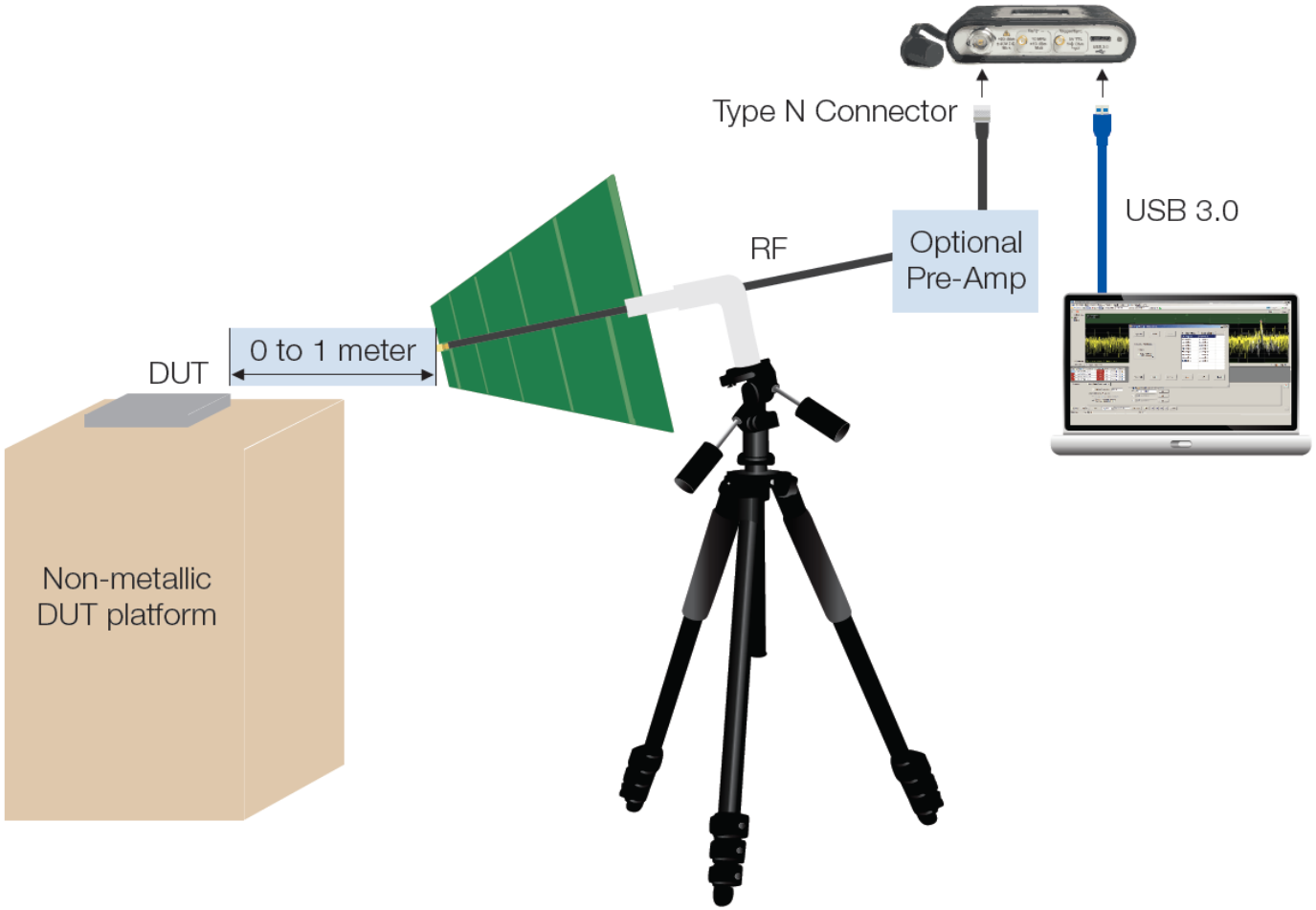
DPX bitmapped trace helps quickly discover signals of interest



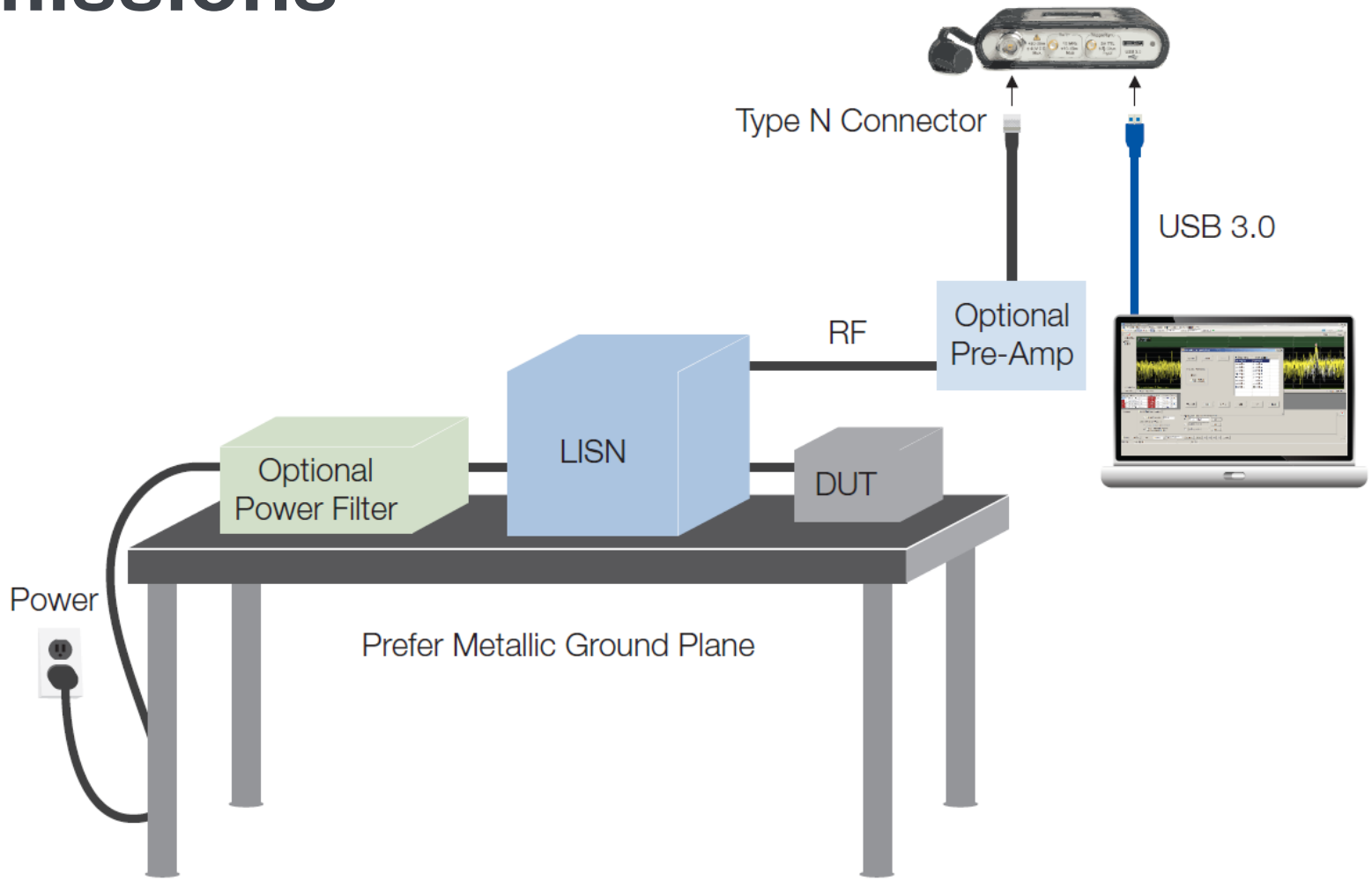
Mask Violation shown when signal breaks into mask area. Further actions like save IQ data or screen shot are available

- Discover interfering signals with DPX and Mask Search, then perform actions like Save IQ data on Trigger or Take a Screen Shot
- High performance PC generating 10,000 spectrums/second

Pre-compliance Testing: Radiated Emissions



Pre-compliance Testing: Conductive Emissions

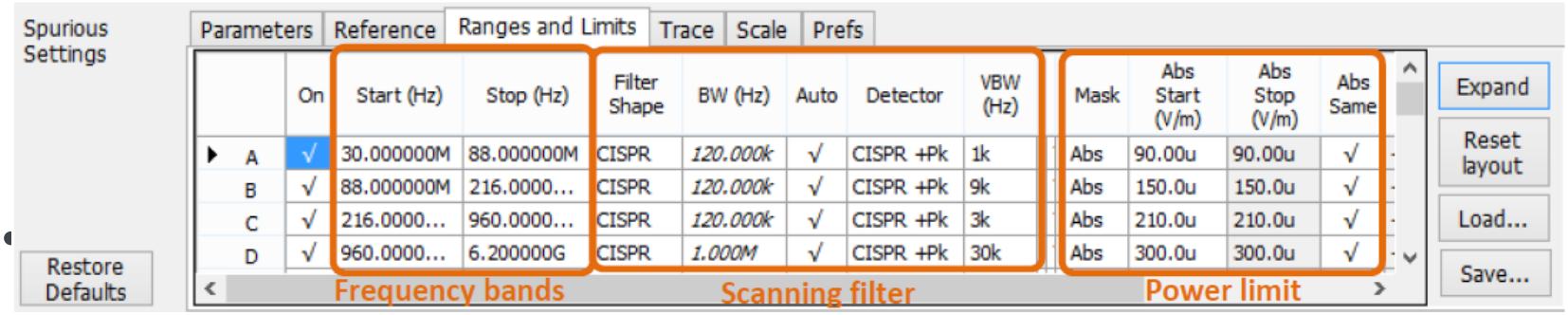


Example: Unintentional Radiator

Standard Example: FCC § 15.109 (b)

The field strength of radiated emissions from a Class A digital device, as determined at a distance of 10 meters, shall not exceed the following:

Frequency of emission (MHz)	Field strength (microvolts/meter)
30–88	90
88–216	150
216–960	210
Above 960	300



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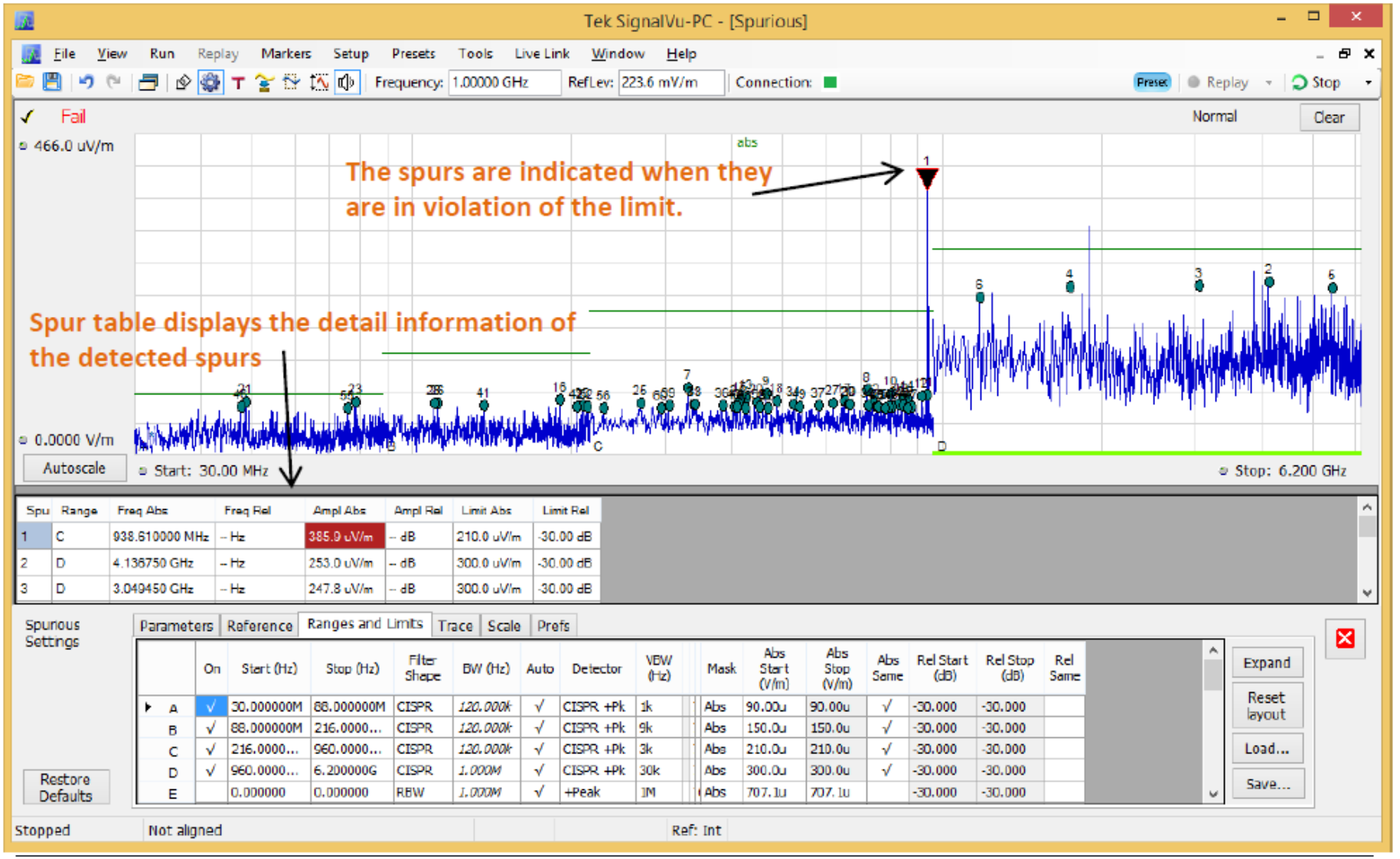

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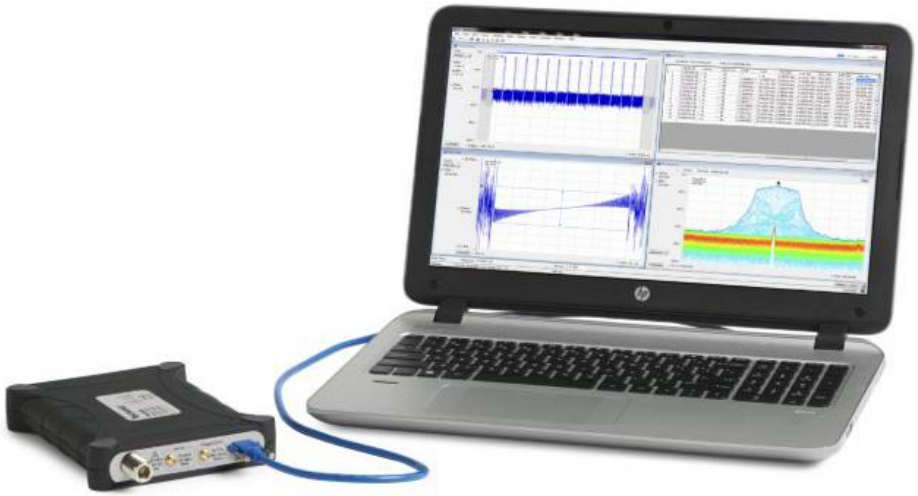
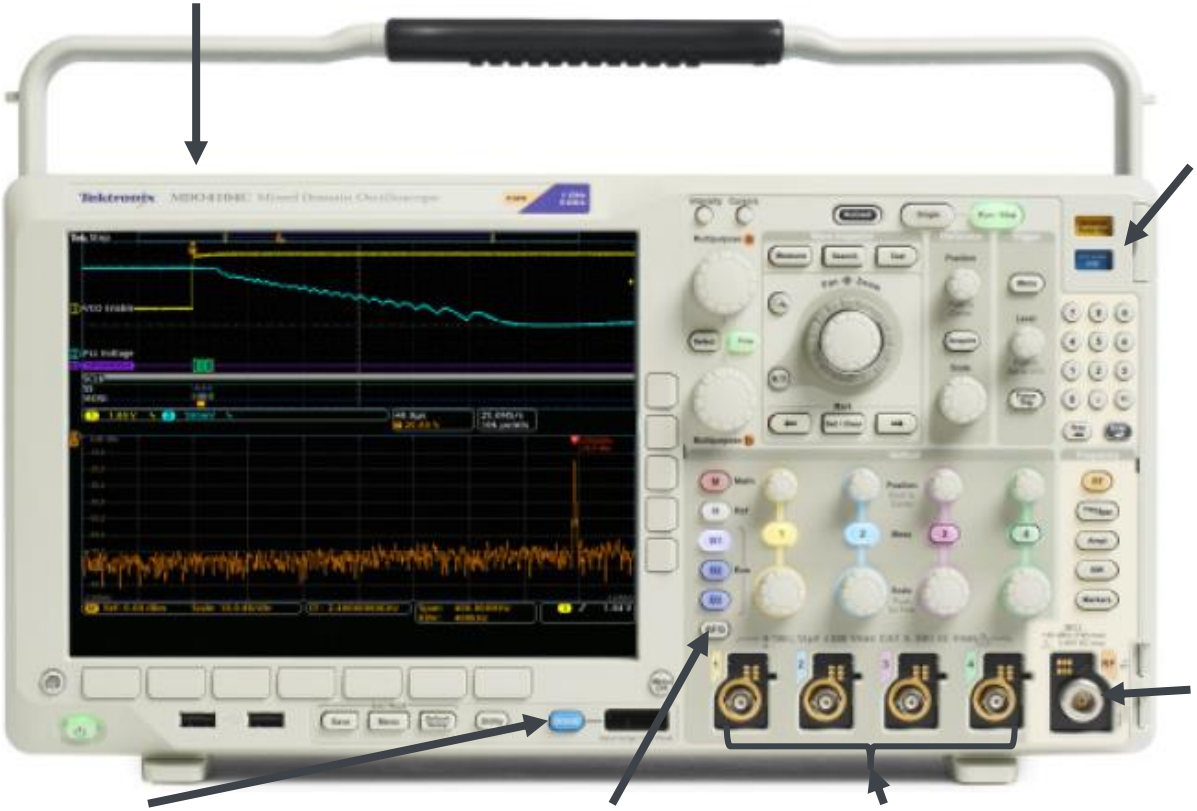


Fully Upgradeable Platform – MDO4000C

Bandwidth Upgrades
200MHz, 350MHz, 500MHz, 1GHz



Analysis Upgrades

MDO4xxx: Serial bus trigger and analysis application modules

MDO4PWR: Power Measurements

MDO4LMT: Limit/Mask test

Spectrum Analyzer Frequency Range Option/Upgrade
MDO4SA3/6: Increase spectrum analyzer input range to 9kHz – 3/6GHz

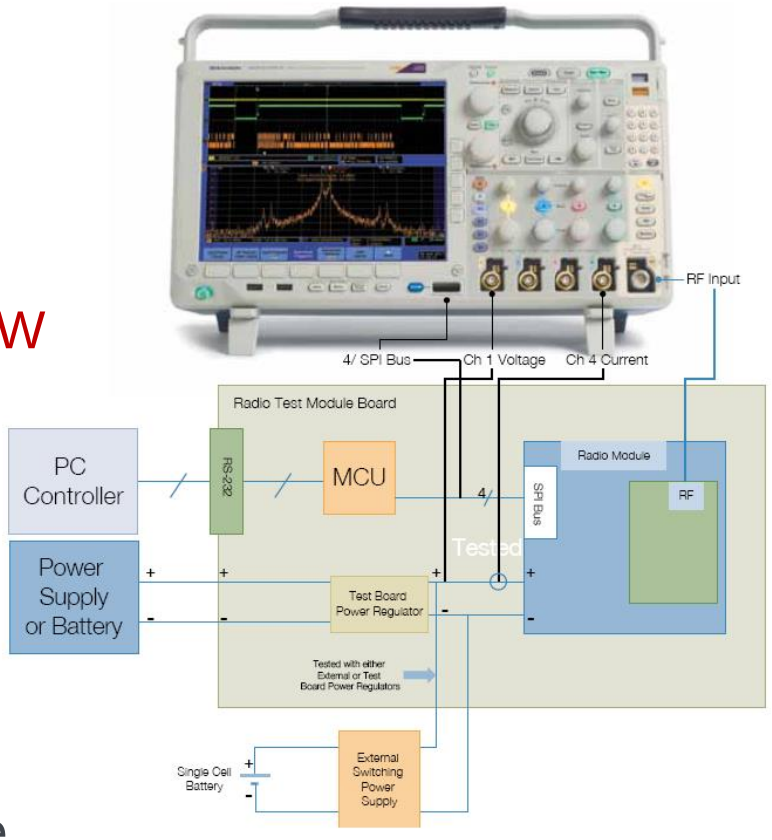
MSO Option/Upgrade
MDO4MSO:
16 digital channels

AFG Option/Upgrade
MDO4AFG: Arbitrary Function Generator

Digital Voltmeter
Free with product registration

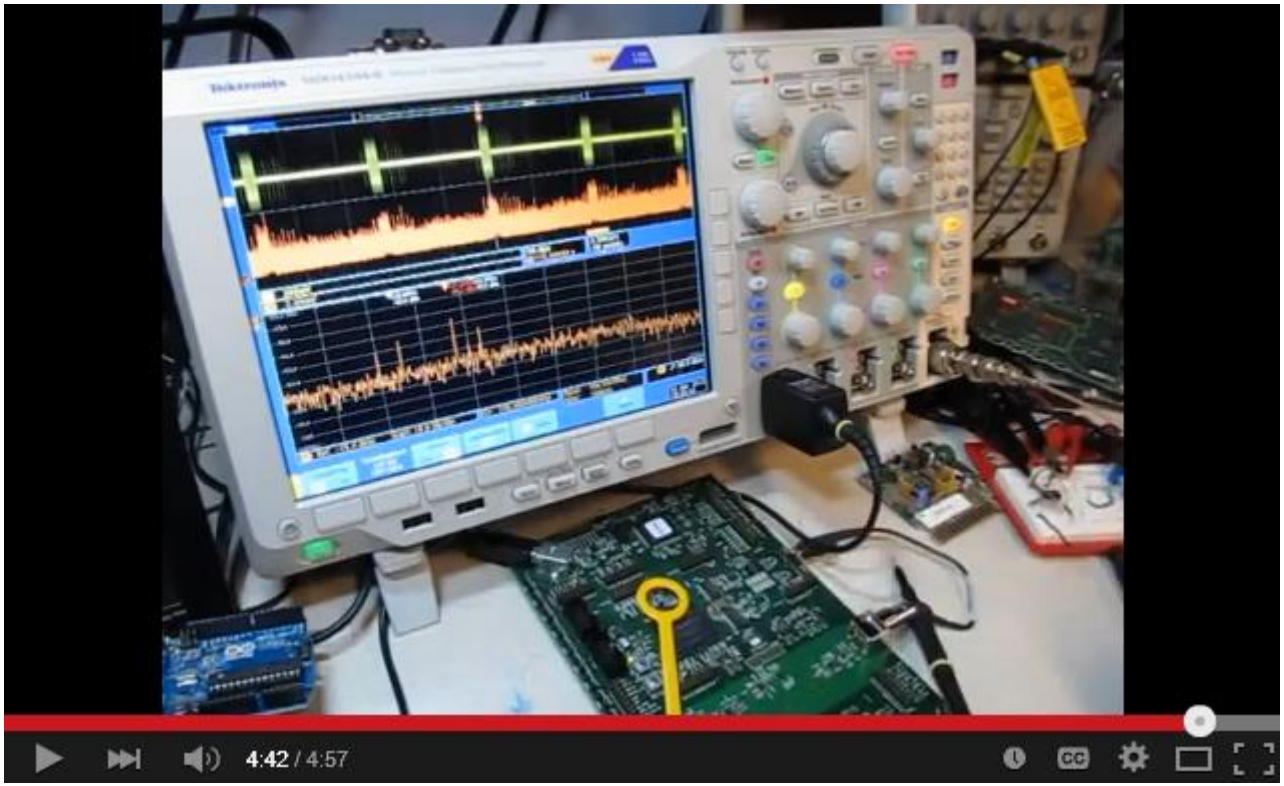
Tools for Modern EMI Problems

- **MDO4000C Mixed Domain Oscilloscope**
  - Combines Spectrum Analyzer with Mixed Signal Oscilloscope
  - 6 Instruments in one
  - *ALL TIME CORRELATED*
- Discrete Fourier Transform analysis
  - Dedicated SA channel: 9kHz-3/6GHz
  - FFT on scope channels: DC-Scope BW
- Spectral Analysis vs. Time
  - Spectrum vs. time
  - Spectrograms
  - Correlate to analog and digital signals and events
  - Amplitude, Frequency, Phase vs. time



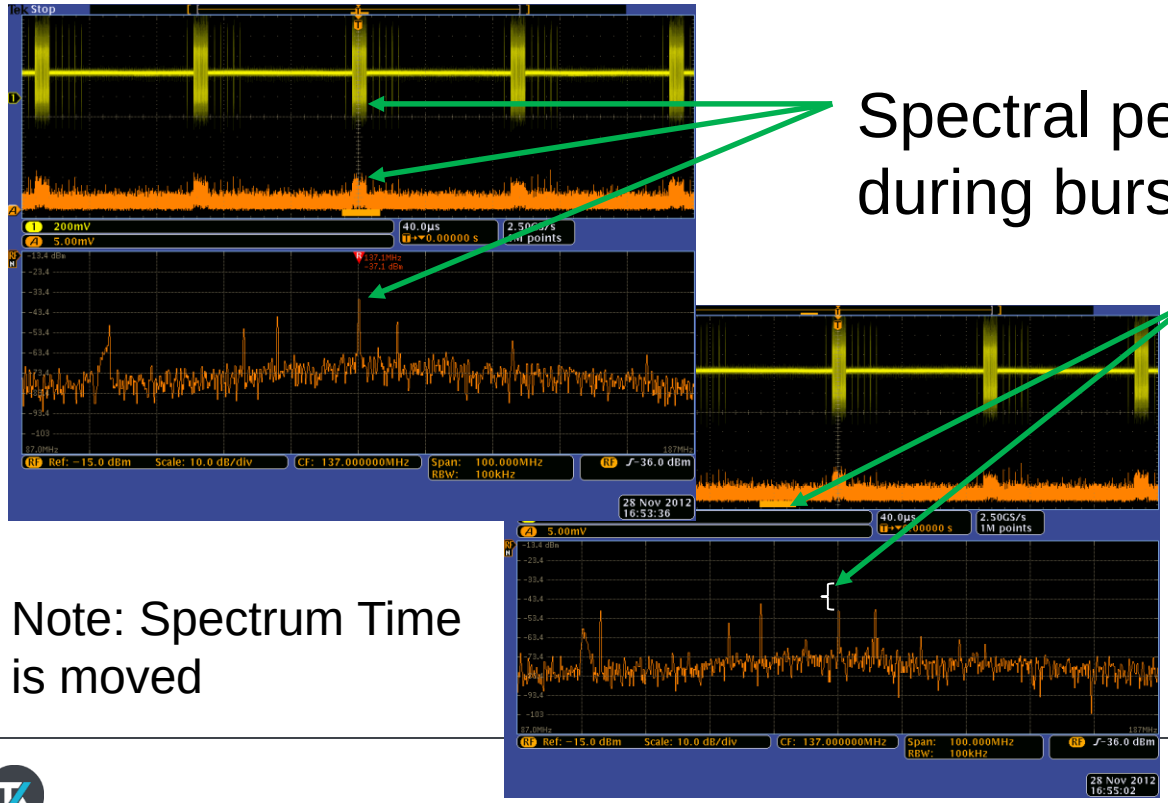
Alan Wolke's, Tektronix AE YouTube EMI Video

- #76: Debug Transient EMI signal with a Mixed Domain Oscilloscope MDO4000 Tektronix
  - https://youtu.be/AhXEI3ihEFI



Identifying Coincident Signals & Events

- Coincidence is KEY to fixing transient EMI issues
- Locate source/cause of the emission
- Simultaneous capture on ALL inputs
- Common trigger across all channels



Spectral peak occurs during burst

Spectral peak lower off of burst

Note: Spectrum Time is moved

THANK YOU