New way how to use an oscilloscope

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ROHDE&SCHWARZ

Agenda

- Rohde & Schwarz - Introduction
- Oscilloscope portfolio
- Products Description
- High definition option - 16bit resolution

- Live demonstration
  - FFT on the RTO/RTE

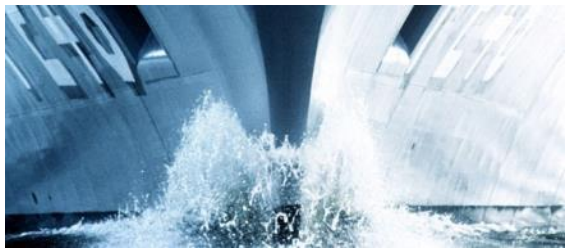
The company group at a glance

- **History**
  Established 1933 in Munich, Germany
- **Type of enterprise**
  Independent family-owned company
- **Global presence**
  In over 70 countries, approx. 60 subsidiaries
- **Net revenue**
  Approx. EUR 1.75 billion (FY 13/14, July through June)
- **Export share**
  More than 90 percent
- **Employees**
  9800 worldwide, with approx. **700 in the Czech republic - Vimperk**
- **Success**
  A leading international supplier in all of its fields of business

Our customers

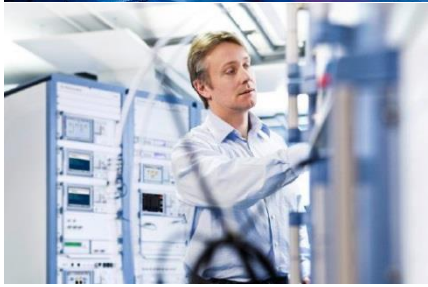
- Wireless communication industry for voice and data applications (suppliers of RF chip sets, modules, systems and mobile handsets)
- Wireless communication network element suppliers and operators
- Aerospace & defense wireless application suppliers
- Service centers
- Automotive industry
- Test houses
- Research (such as universities)





Our product groups

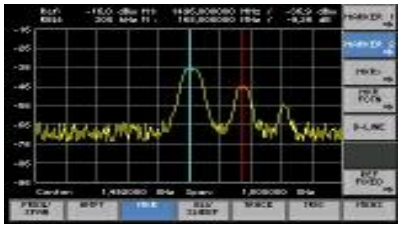
- Mobile radio measurements (voice and data)
- All-purpose RF and microwave measurements (for example signal generation & analysis)
- Oscilloscopes
- Audio measurements
- EMC measurements
- Automated test systems and turn-key solutions

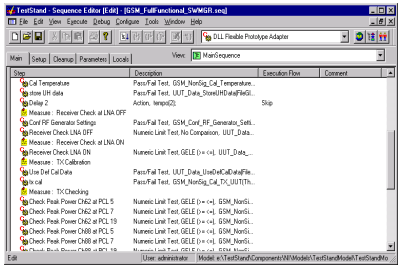


Typical product application fields

Research | Design | Industrialization | Manu-facturing | Service

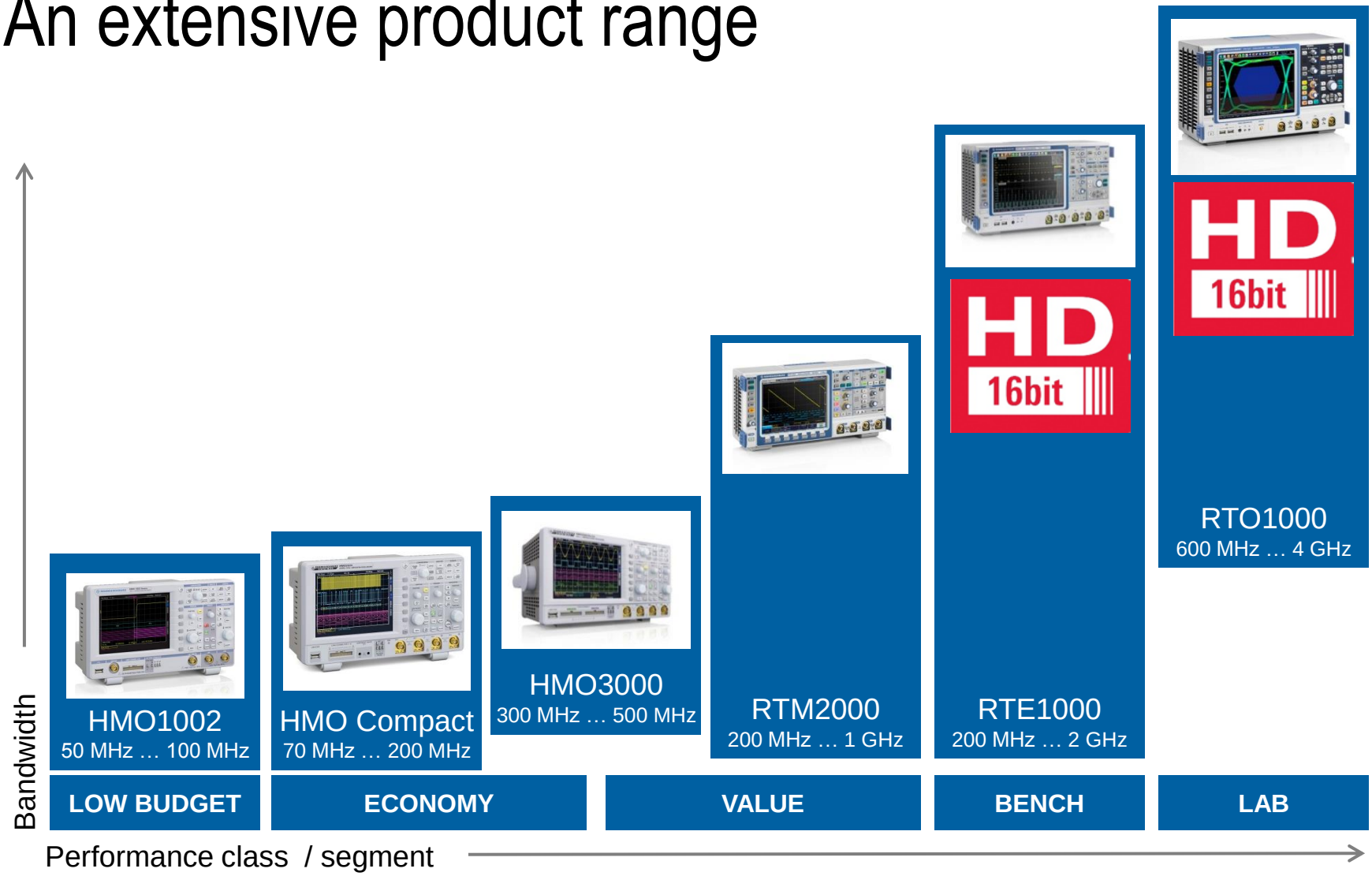
Mobile phone test
Base station test
Signal generation
Spectrum / signal analysis
Network analysis
Protocol analysis
Power measurement
Audio analysis
EMC solutions





The Rohde & Schwarz oscilloscope portfolio

An extensive product range



R&S®RTx at a glance

Model	R&S®RTM2000	R&S®RTE	R&S®RTO
Bandwidth	200 MHz 350 MHz 500 MHz 1 GHz	200 MHz 350 MHz 500 MHz 1 GHz 1,5 GHz 2 GHz	--- --- 600 MHz 1 GHz 2 GHz 4 GHz
Number of channels	2/ 4	2/ 4	2/ 4 / RTO1044: 4
Sampling rate	2.5 GSa/s 5 GSa/s interleaved	5 GSa/s	10 GSa/s RTO1044: 20 GSa/s interleaved
Memory depth Per ch / interleaved	10 MSa / 20 MSa	10 MSa / 40 MSa 50 MSa / 200 MSa max upgr.	20 MSa / 80 MSa 100 MSa / 400 MSa max upgr.
Acquisition rate	12.500 wfms/s	1.000.000 wfms/s	1.000.000 wfms/s
Max. vertical resolution	16 bit witt high resolution decimation mode	16 bit with High Definition option	16 bit with High Definition option
Min. input sensitivity @ 50 Ω coupling	1 mV/div at full bandwidth w/o magnification	**500 µV/div** at full bandwidth w/o magnification	1 mV/div at full bandwidth w/o magnification
Measurement/ trigger capabilities	Basic	Advanced Digital trigger system	Expert; max setup flexibility Digital trigger system
MSO	• Upgradable • 16 digital channels • 400 MHz, 2.5 GSa/s, 10 MSa	• Upgradable • 16 digital channels • 400 MHz, 5 GSa/s, 100 MSa, 200,000 wfms/s • Analog Bus Display	• Upgradable • 16 digital channels • 400 MHz, 5 GSa/s, 200 MSa, 200,000 wfms/s • Analog Bus Display

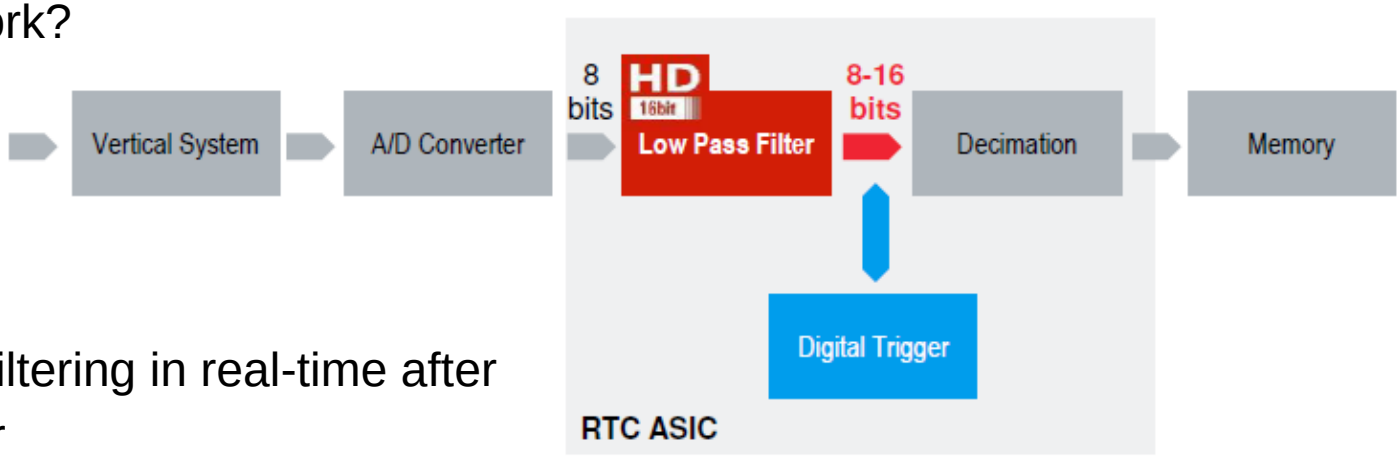
Software options

Designation	RTO	RTE	RTM
Software options - Serial triggering and decoding			
I²C/SPI serial triggering and decoding	YES	YES	YES
UART/RS-232/RS422/RS485 serial triggering and decoding	YES	YES	YES
CAN/LIN serial triggering and decoding, incl. CAN-dbc import	YES	YES	YES
FlexRay™ serial triggering and decoding	YES	YES	YES
I²S/LJ/RJ/TDM serial triggering and decoding	YES	YES	YES
MIL-1553 serial triggering and decoding	YES	YES	YES
ARINC 429 serial triggering and decoding	YES	YES	YES
Ethernet serial decoding	YES	YES	NO
CAN-FD serial triggering and decoding	YES	YES	NO
MIPI RFFE Triggering and Decoding	YES	NO	NO
Manchester and NRZ Serial Triggering and Decoding	YES	YES	NO
History and segmented memory	Standard	Standard	YES
Spectrum analysis and spectrogram	-	-	YES
8b10b Serial Decoding	YES	NO	NO
MDIO serial triggering and decoding	YES	YES	NO
USB 1.0/1.1/2.0/HSIC Triggering and Decoding	YES	YES	NO
Software Options - Compliance tests			
USB 2.0 Compliance Test Software	YES	NO	NO
Ethernet Compliance Test (10/100/1000BaseT)	YES	NO	NO
10G Ethernet Compliance Test	YES	NO	NO
BroadR-Reach Compliance	YES	NO	NO
MIPI D-PHY Compliance test	YES	NO	NO
Software Options - Analysis			
I/Q Software Interface	YES	NO	NO
Jitter Analysis	YES	NO	NO
Clock Data Recovery	YES	NO	NO
High Definition Mode, vertical resolution up to 16 bit	YES	YES	NO
Power Analysis	YES	YES	YES

R&S®RTO/RTE-K17 High Definition Option

- **16 bits** Vertical resolution
- **256x** Improvement over 8 bit resolution
- **0,04** Division trigger sensitivity
- **1ps** Trigger jitter w/o DSP correction

How does HD work?



Digital low pass filtering in real-time after the A/D converter

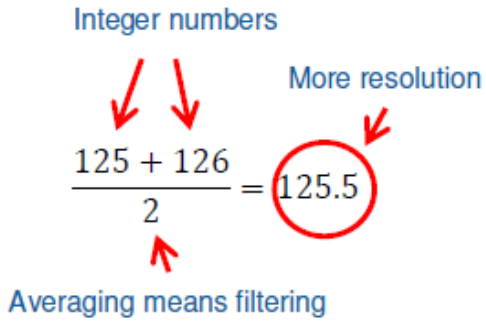
→ Noise is reduced

→ Signal-to-noise ratio (SNR) increases

→ Vertical resolution is enhanced

Theory

- Simple calculation on achieving higher resolution with moving average



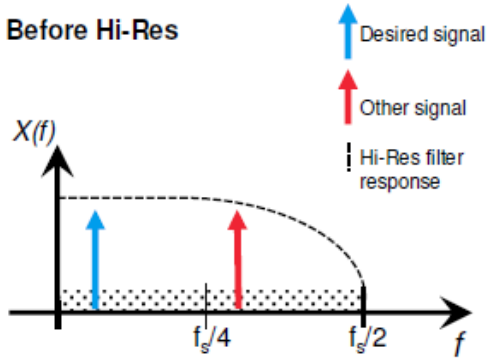
Summed values of 4

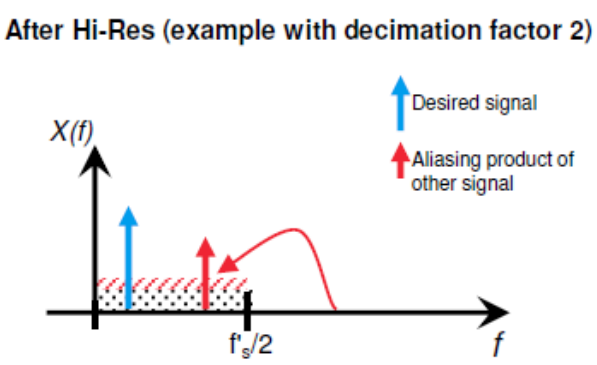
Increase 2 bits resolution

$$\frac{125 + 126 + 126 + 128}{4} = 126.25$$

For every increase of the number of summed values by the factor of 2, the resolution is doubled (increased of 1 bit resolution)

- Why not Hi-Res decimation?



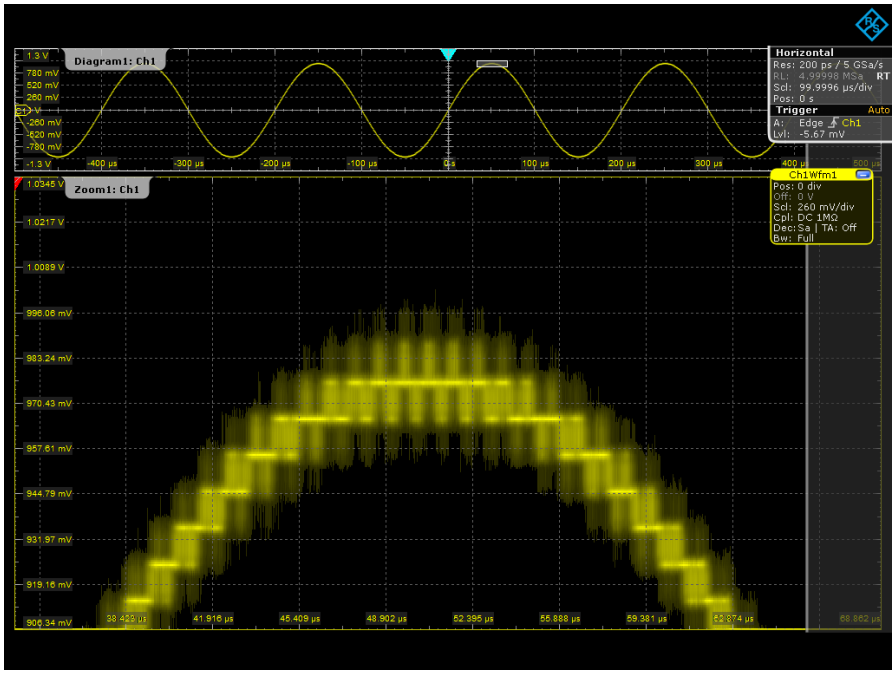


- Not alias-free
- Sample rate reduction

Example (I)

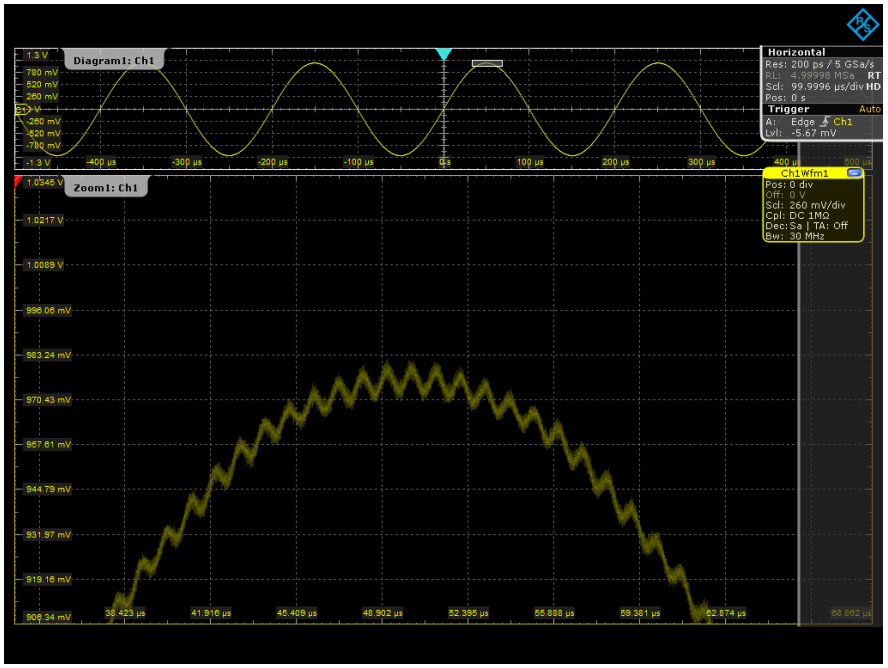
- **More signal details and more precise analysis results**

High Definition inactive



Quantization steps clearly visible.

High Definition active

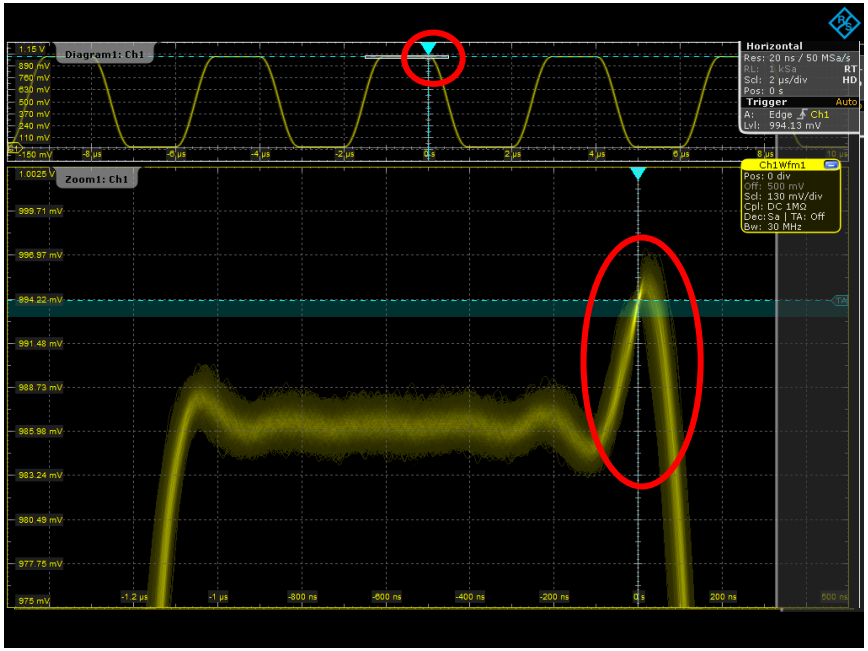


“Hidden” low level signal becomes visible.
Signal characteristics can be measured.

Example (II)

- **Real-time triggering on smallest signal details**

High Definition active



Overshoot of 9 mV an a 1 V signal

Vertical scaling is 140 mV/div

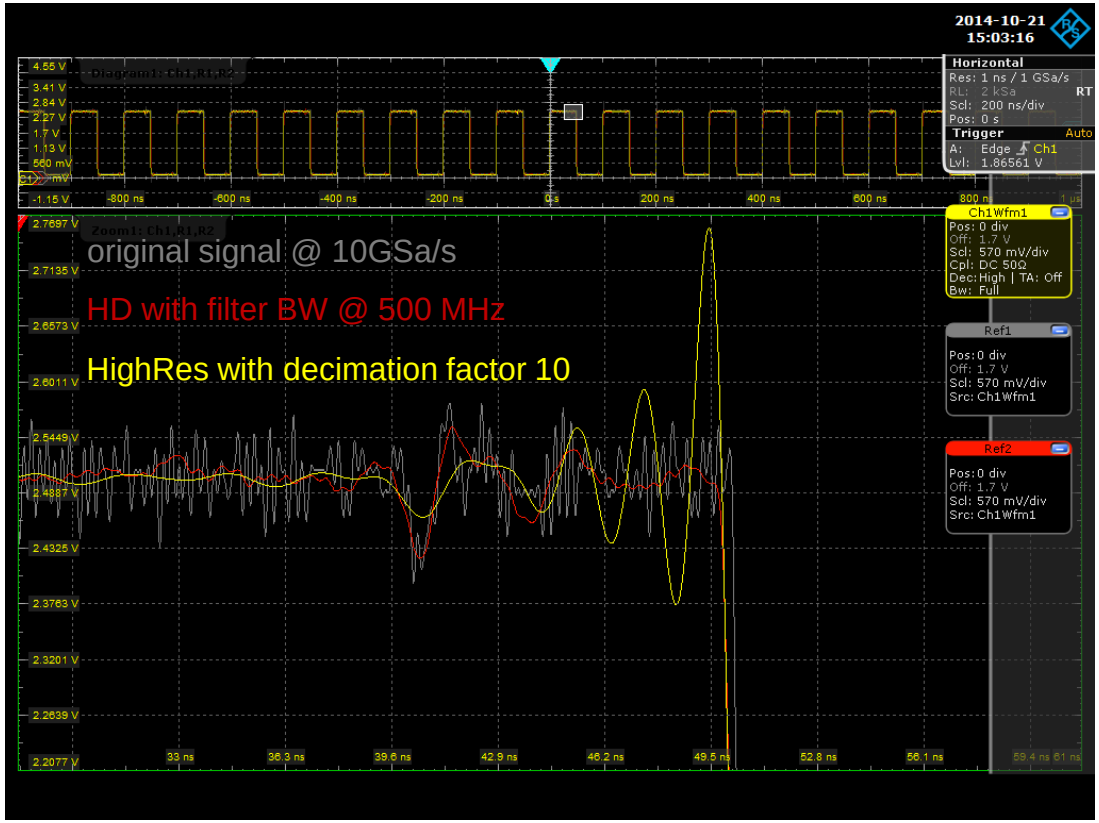
Peak is just a fraction of one division and Digital trigger can still trigger on the peak

HighRes Decimation vs HD mode

Flexible bandwidth adjustment

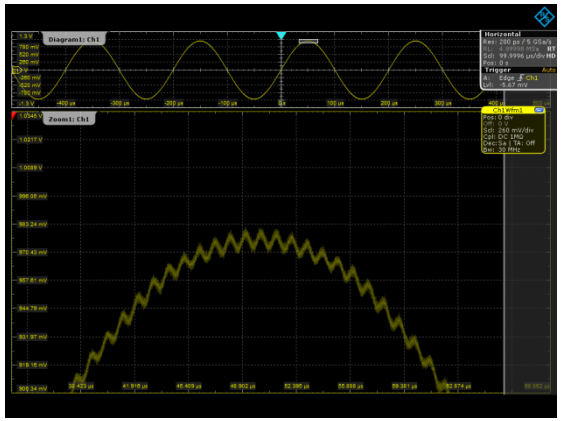
Vertical Resolution	R&S®RTO Filtered BW in HD	R&S®RTE Filtered BW in HD
8 bit	Full (HD inactive)	Full (HD inactive)
10 bit	1 GHz	500 MHz
11 bit	-	300 MHz
12 bit	500 MHz	-
12 bit	300 MHz	200 MHz
13 bit	200 MHz	100 MHz
14 bit	100 MHz	50 MHz
16 bit	50 MHz to 10 kHz	30 MHz to 10 kHz

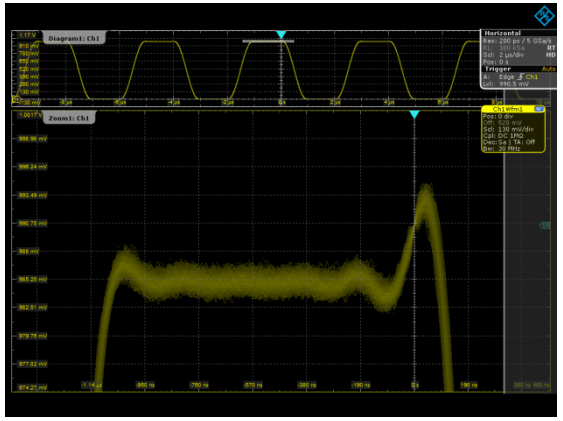
Drawbacks of HighRes



Benefits of High Definition Mode

- **More signal details and more precise analysis results**
  - Sharper waveforms
  - Signal details are made visible otherwise masked by noise
  - More precise analysis results
  - 500 uV/div available w/ HD active (software based)
- **Real-time triggering on smallest signal details**
  - Unique for R&S digital trigger: every 16-bit sample is checked against the trigger condition → enough trigger sensitivity
- **Full sample rate and high time resolution available**
  - No decimation





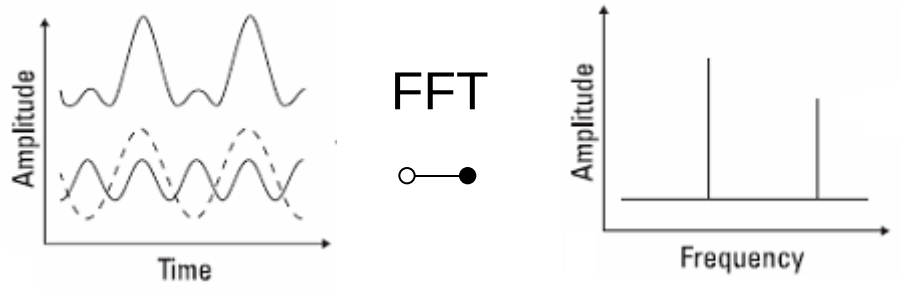
Truly uncompromised
FFT: the easy way to analyze the signal spectrum

- FFT-based spectrum analysis: powerful and user-friendly
  - Easy to use and flexible: first results with only two clicks
  - Spectrum analyzer look-and-feel
  - High measurement speed and fast display
  - High dynamic range
  - Gated FFT
  - Cursors
  - Mask test
- Application examples
  - EMI debugging
  - VCO testing
  - Spectral measurements

Fast Fourier Transform Concept

Definition FFT

- Fast Fourier Transform
- Algorithm for transforming data from time domain to frequency domain

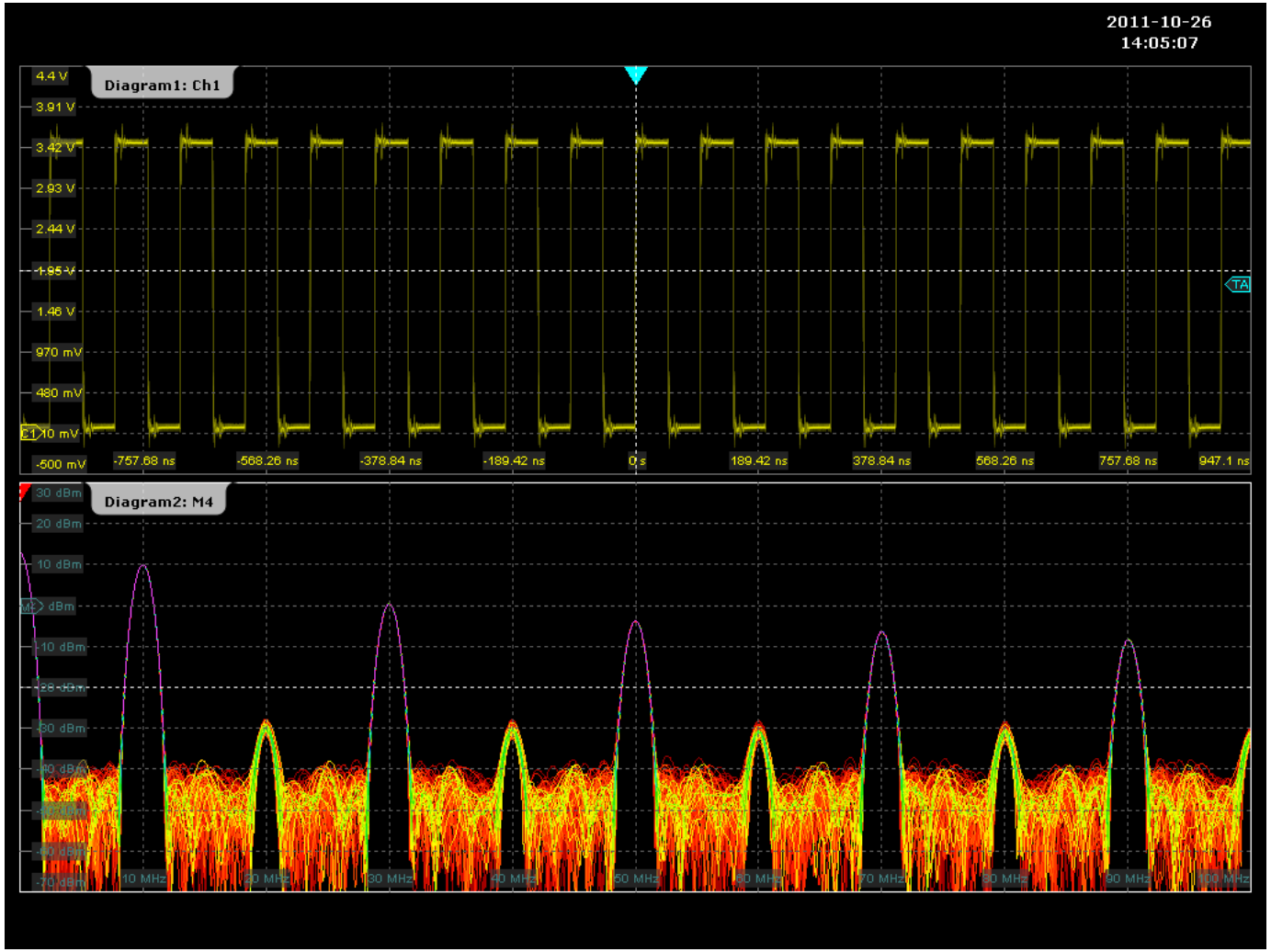


$$X_k = \sum_{n=0}^{N-1} x_n \cdot e^{-i 2\pi \frac{k}{N} n} \qquad k = 0, \ldots, N-1$$

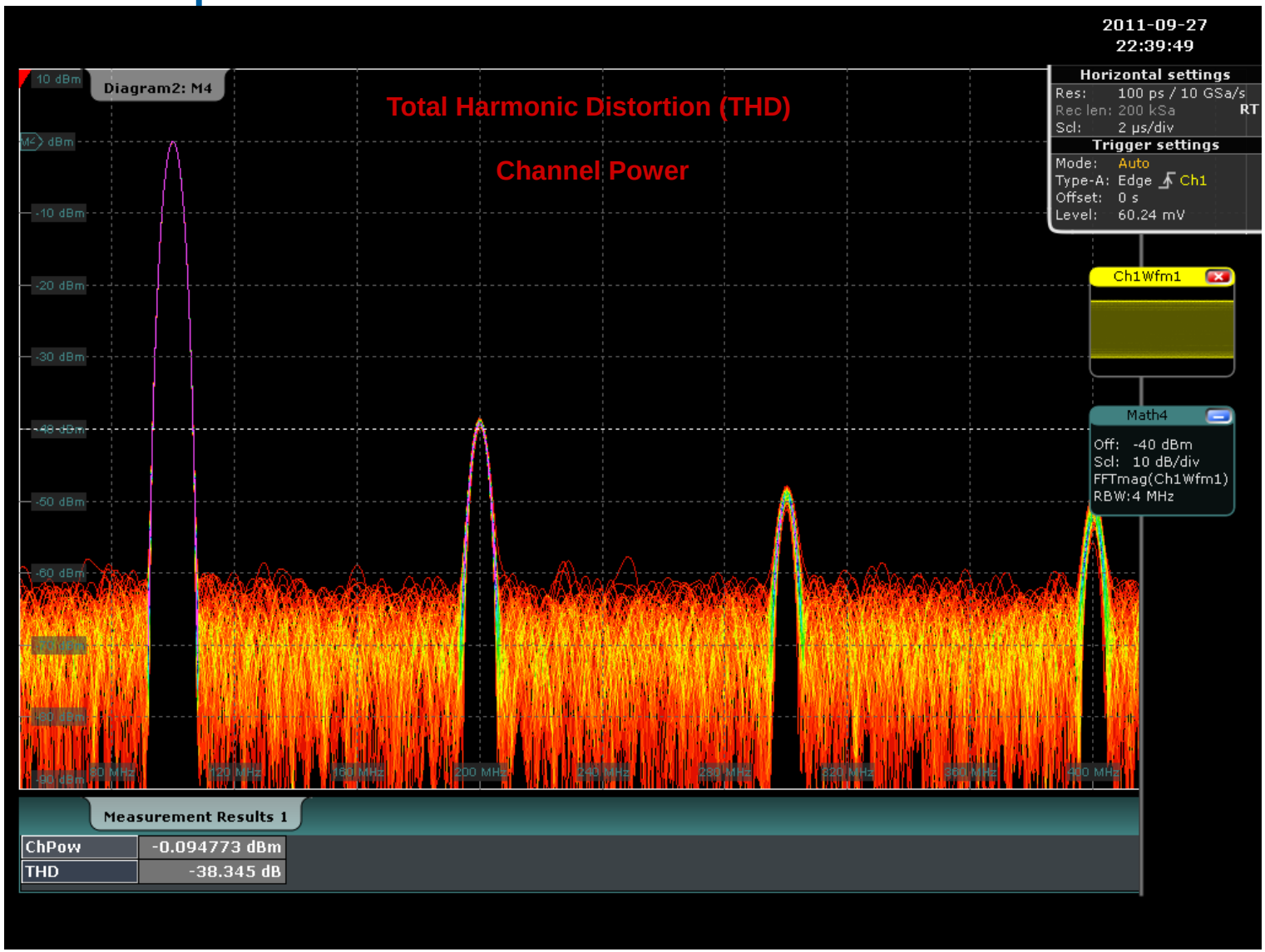
Examples for applications

- Testing the impulse response of filters and systems
- Measuring harmonic content and distortion in systems
- Identifying and locating noise and interference sources
- Analyzing harmonics in 50 and 60 Hz power lines

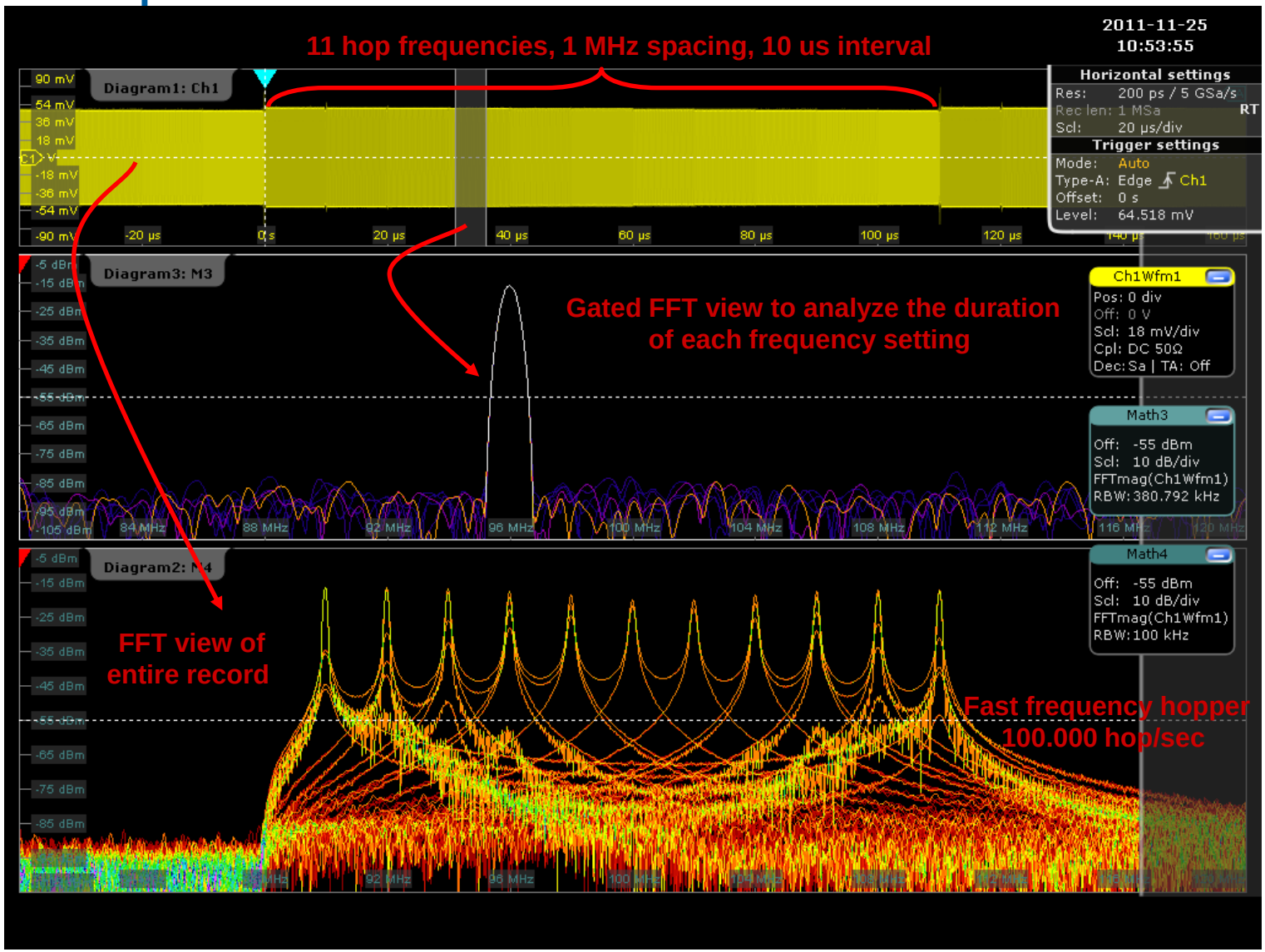
FFT in Oscilloscopes



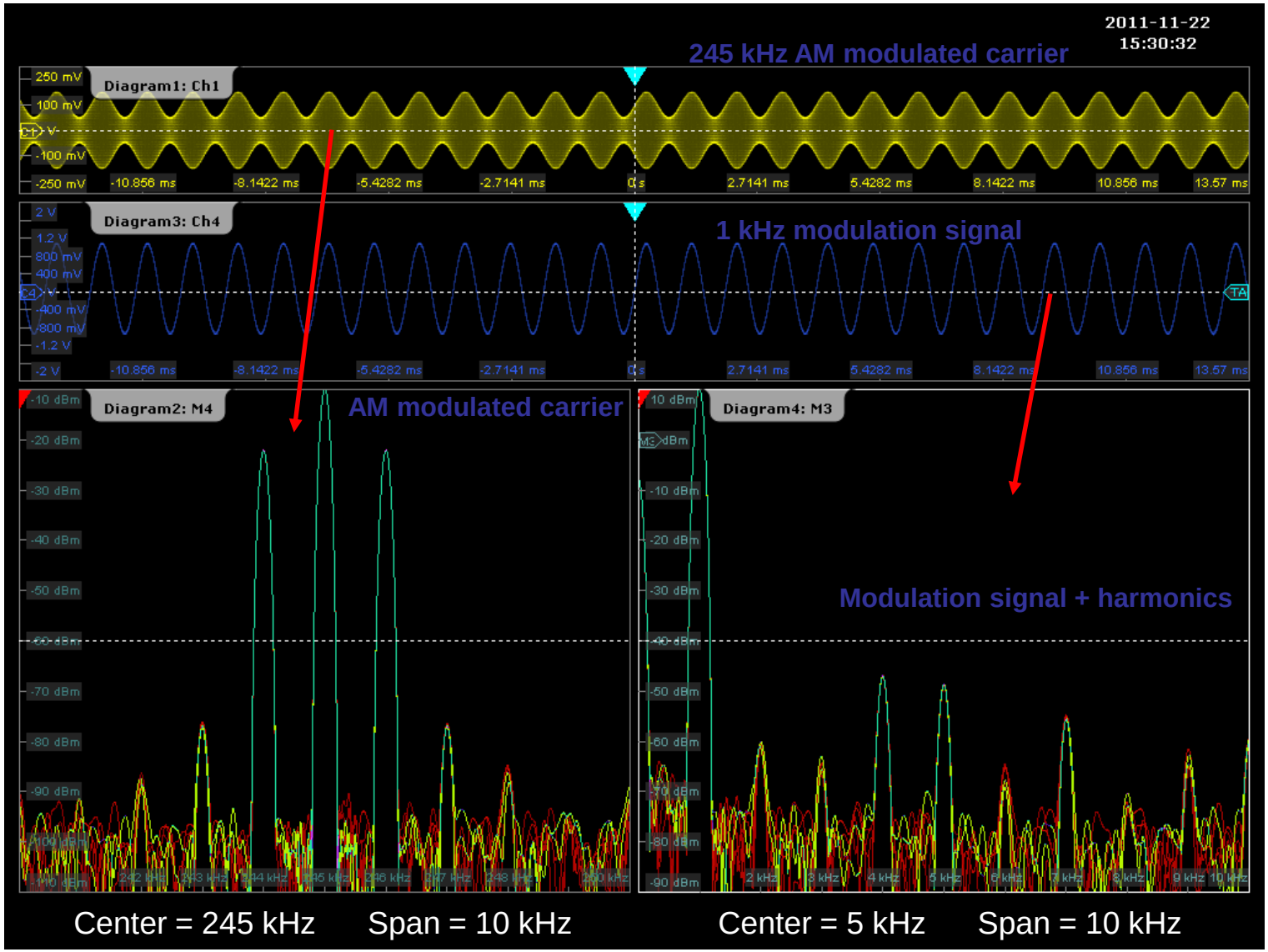
General Spectrum Measurements



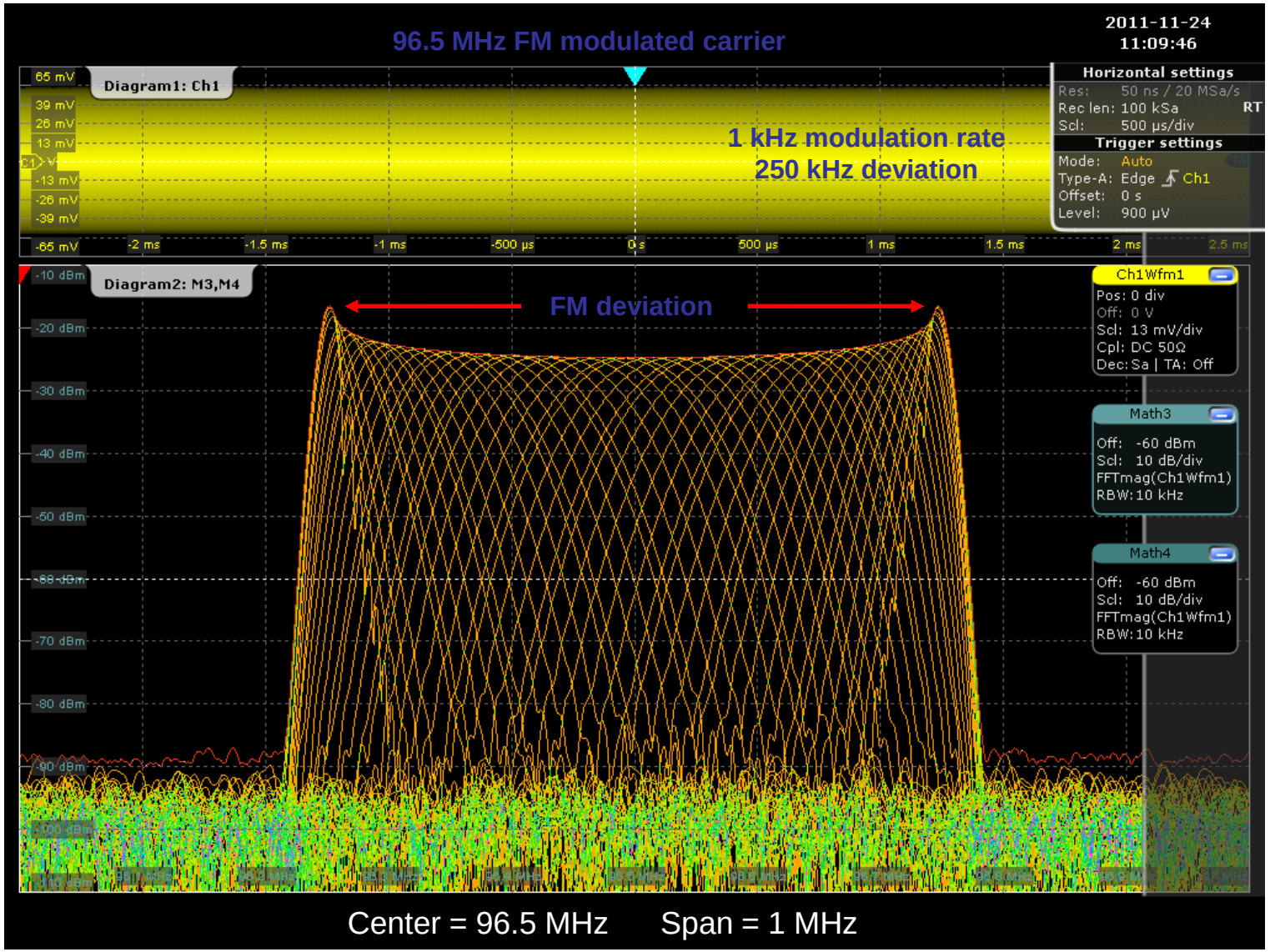
Gated Spectrum Measurements



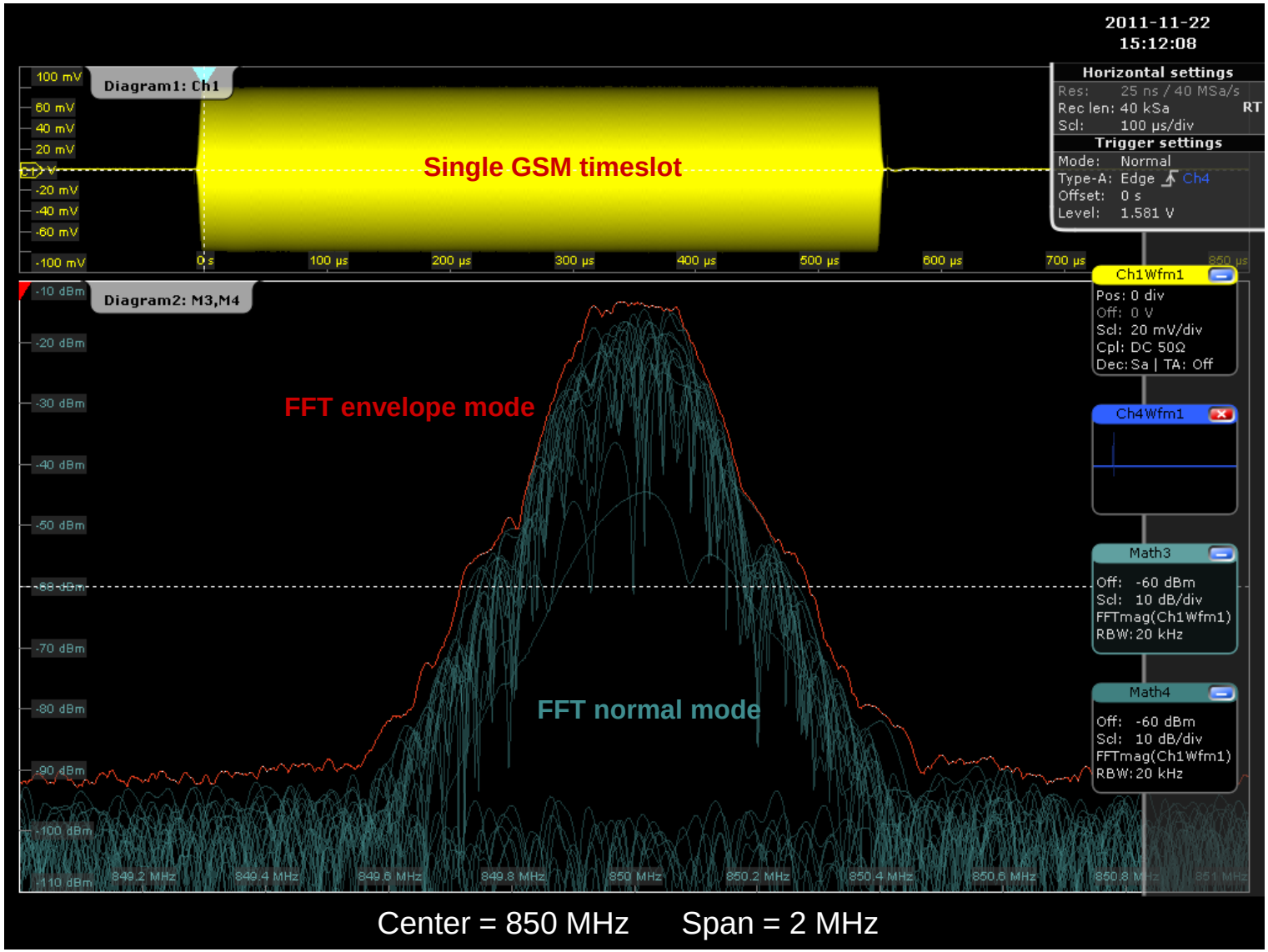
Modulation Measurements – AM



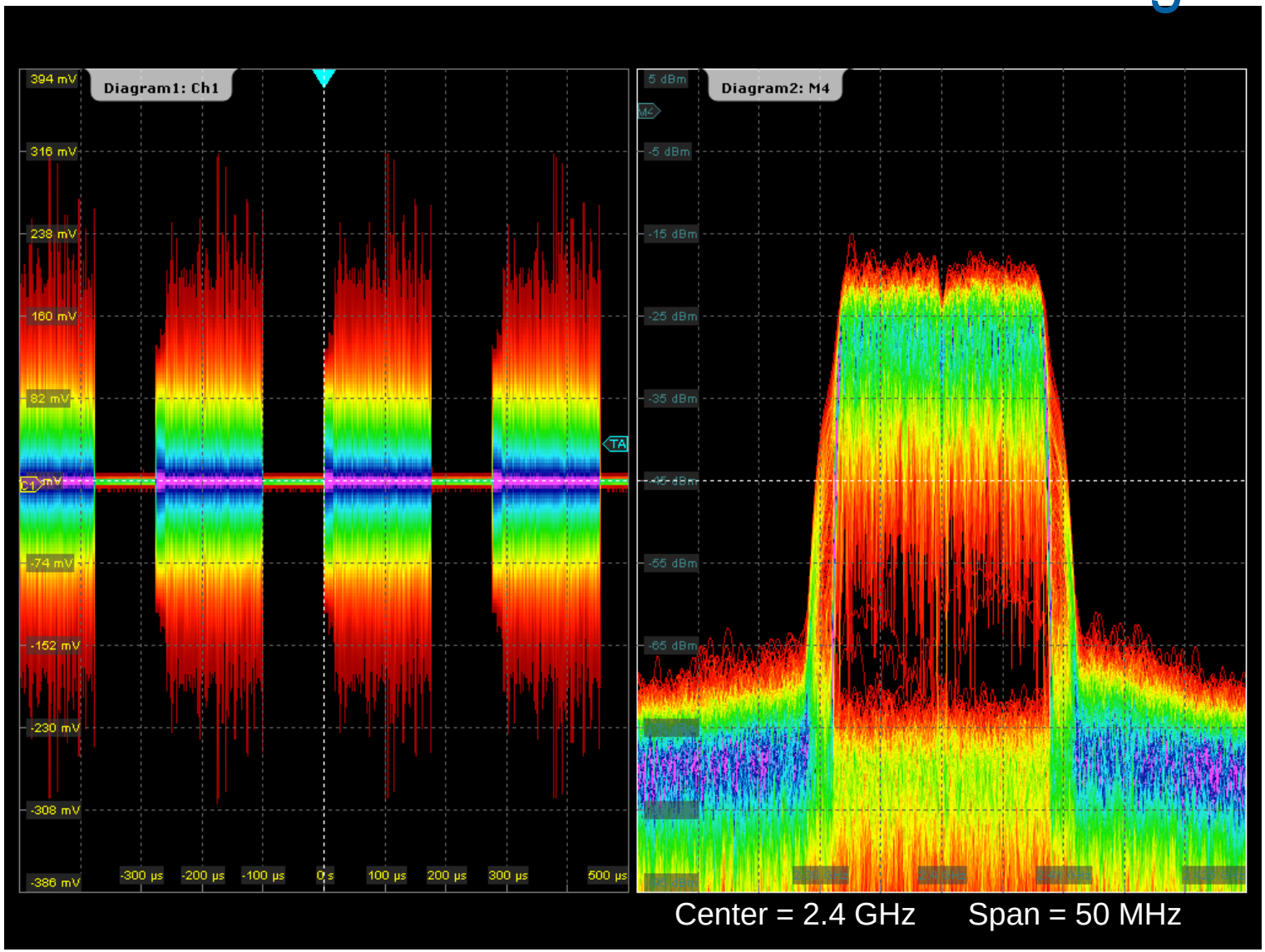
Modulation Measurements – FM



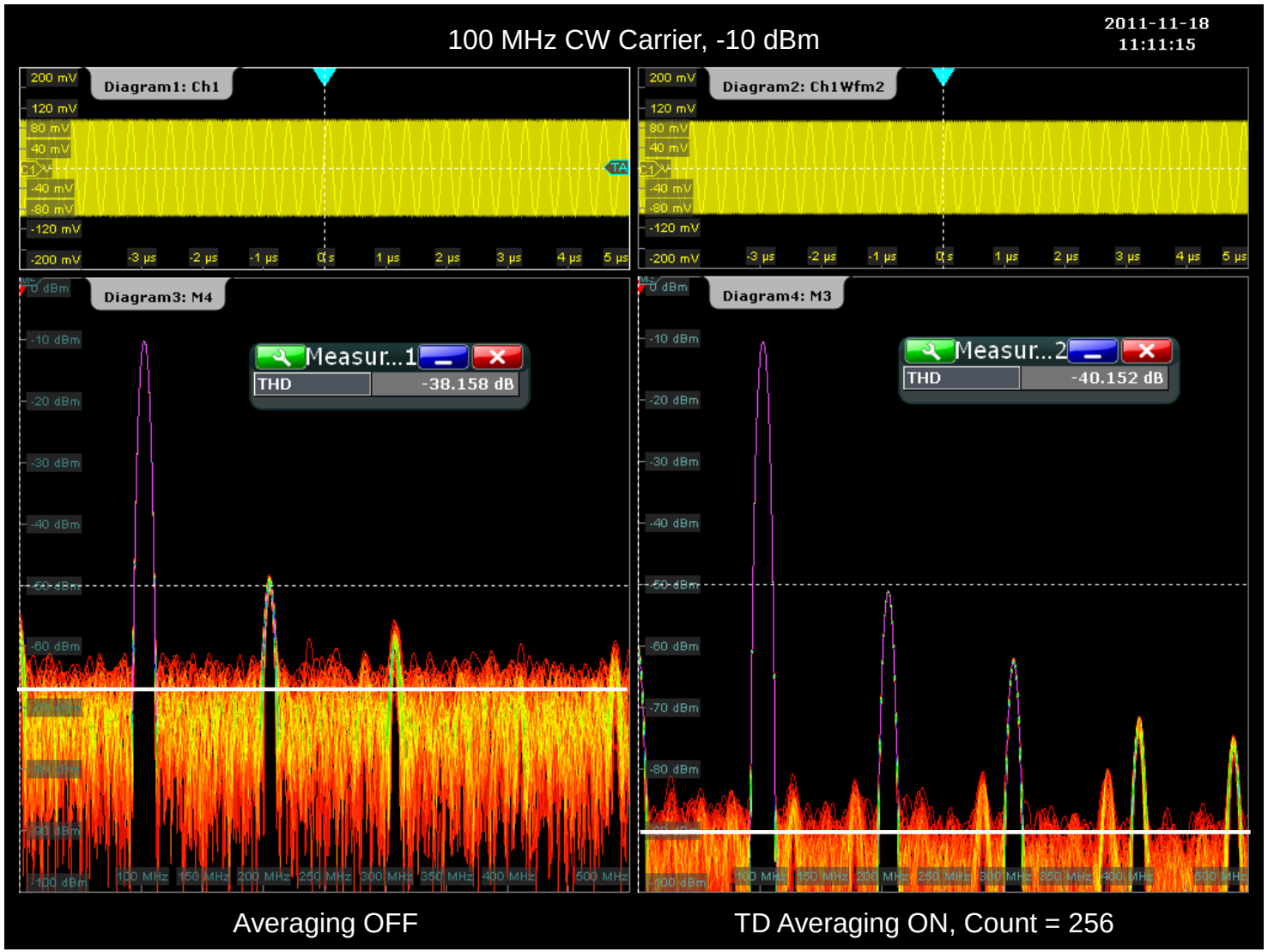
Modulation Measurements – GSM burst



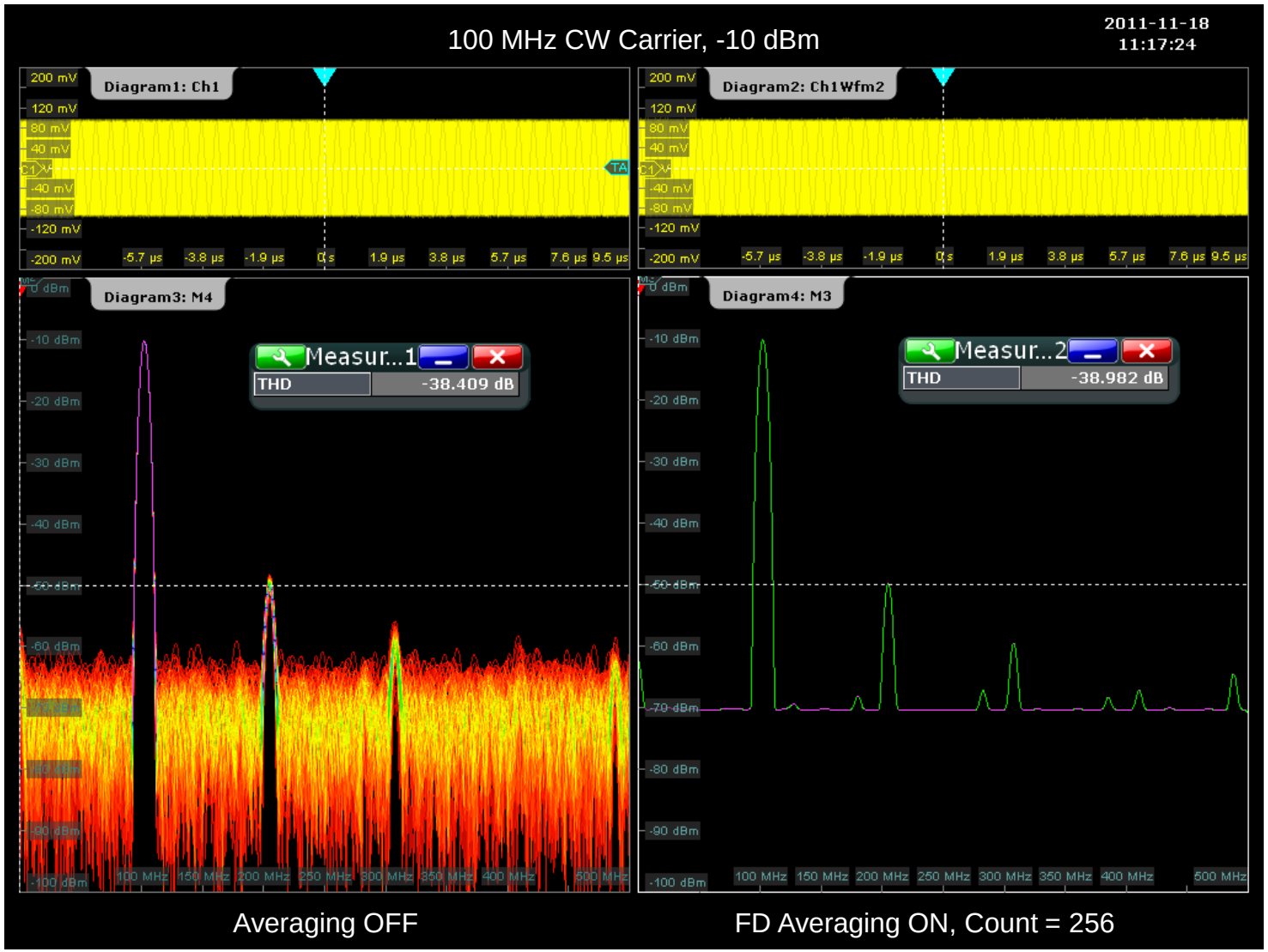
Modulation measurements – WLAN 802.11g



Maximum possible Dynamic Range – Averaging

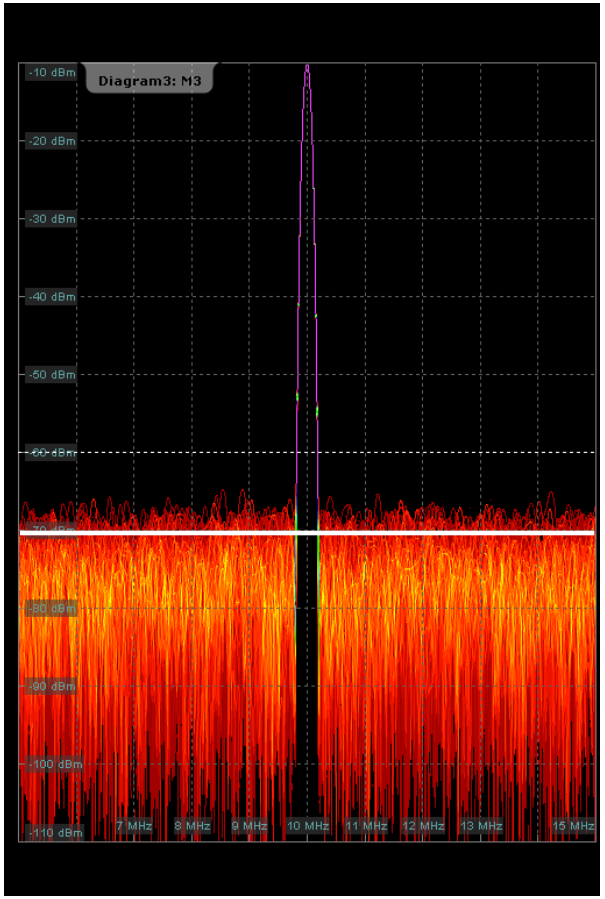


Maximum possible Dynamic Range – Averaging

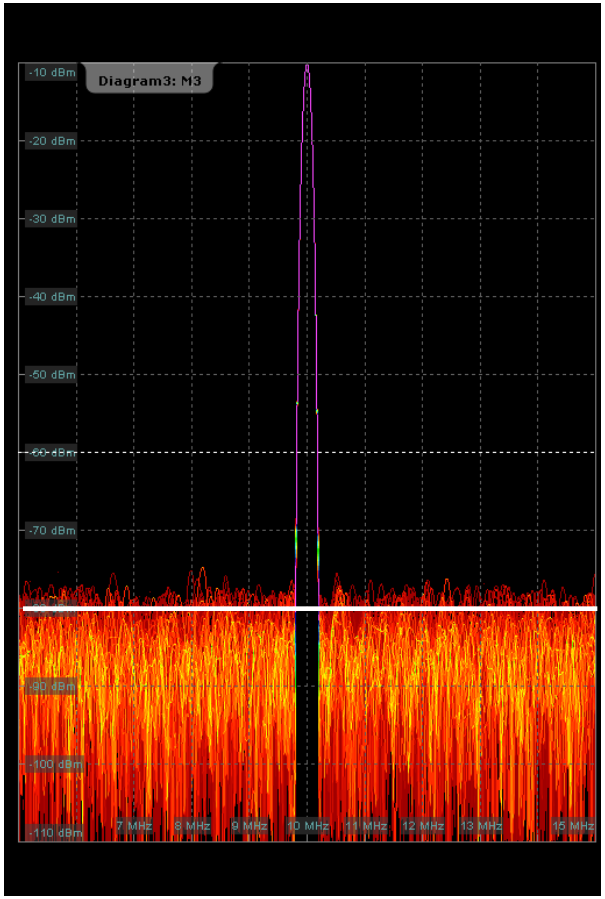


Maximum possible Dynamic Range – Memory Depth

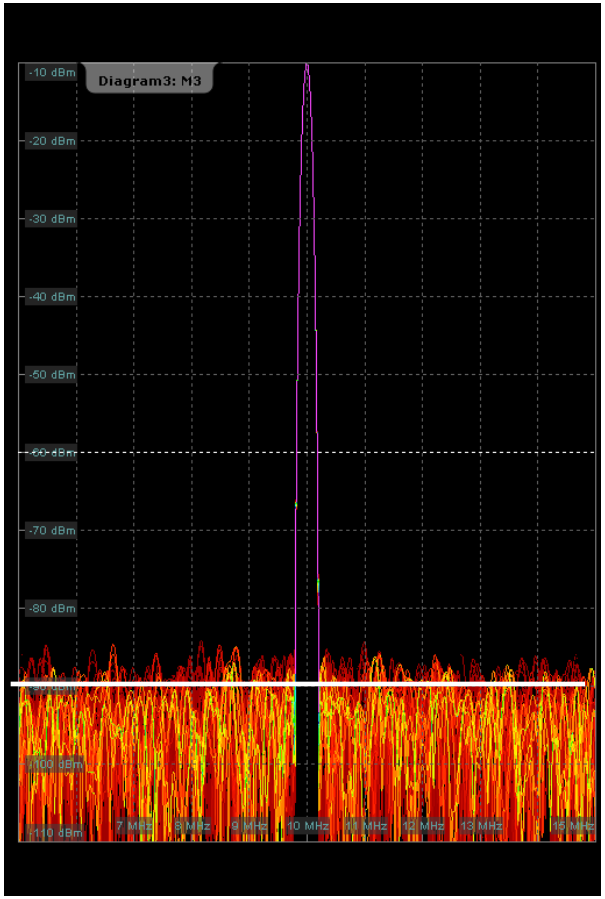
10 MHz CW Carrier, -10 dBm



Record Length: 1 kSa

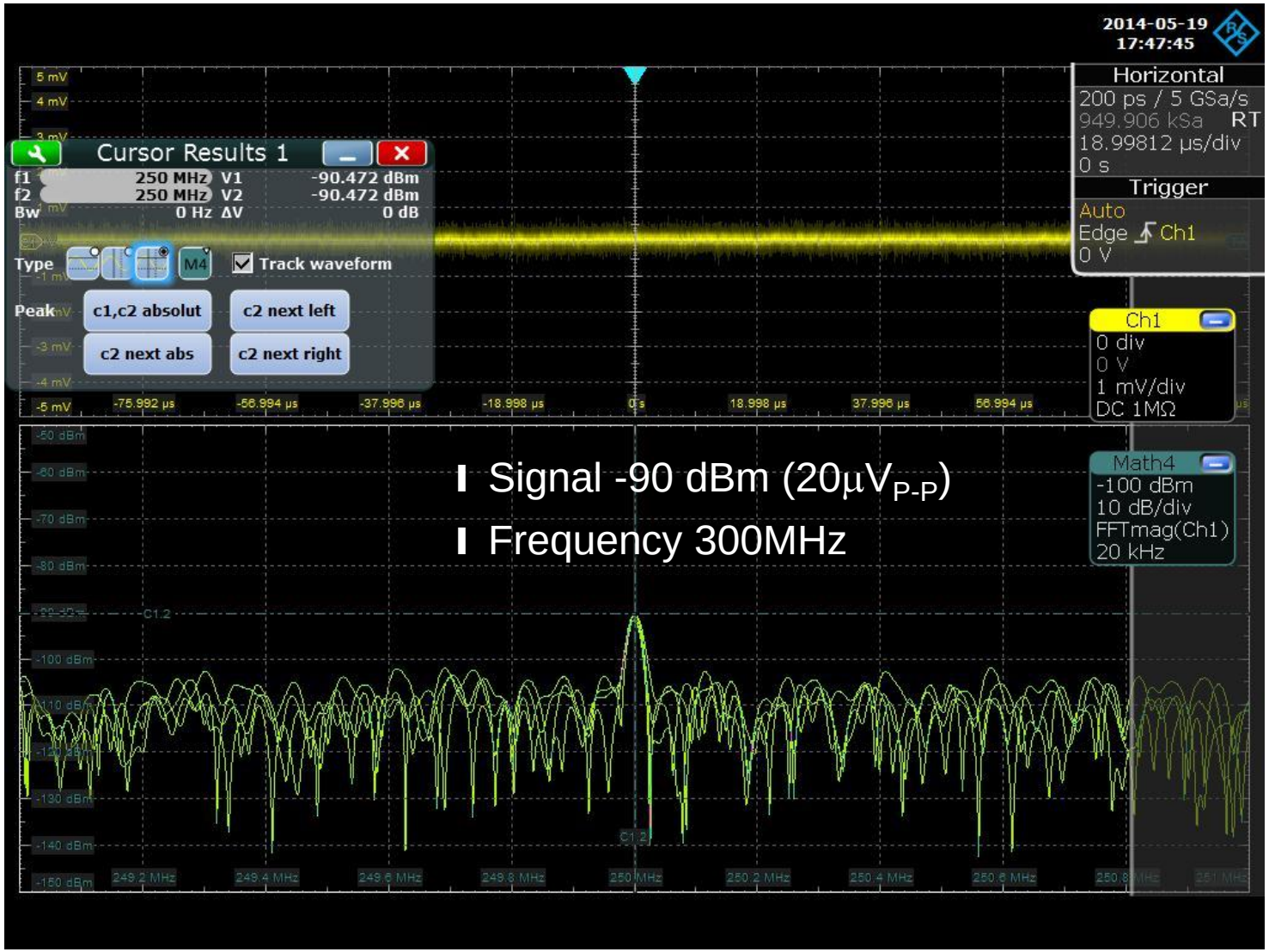


Record Length: 10 kSa

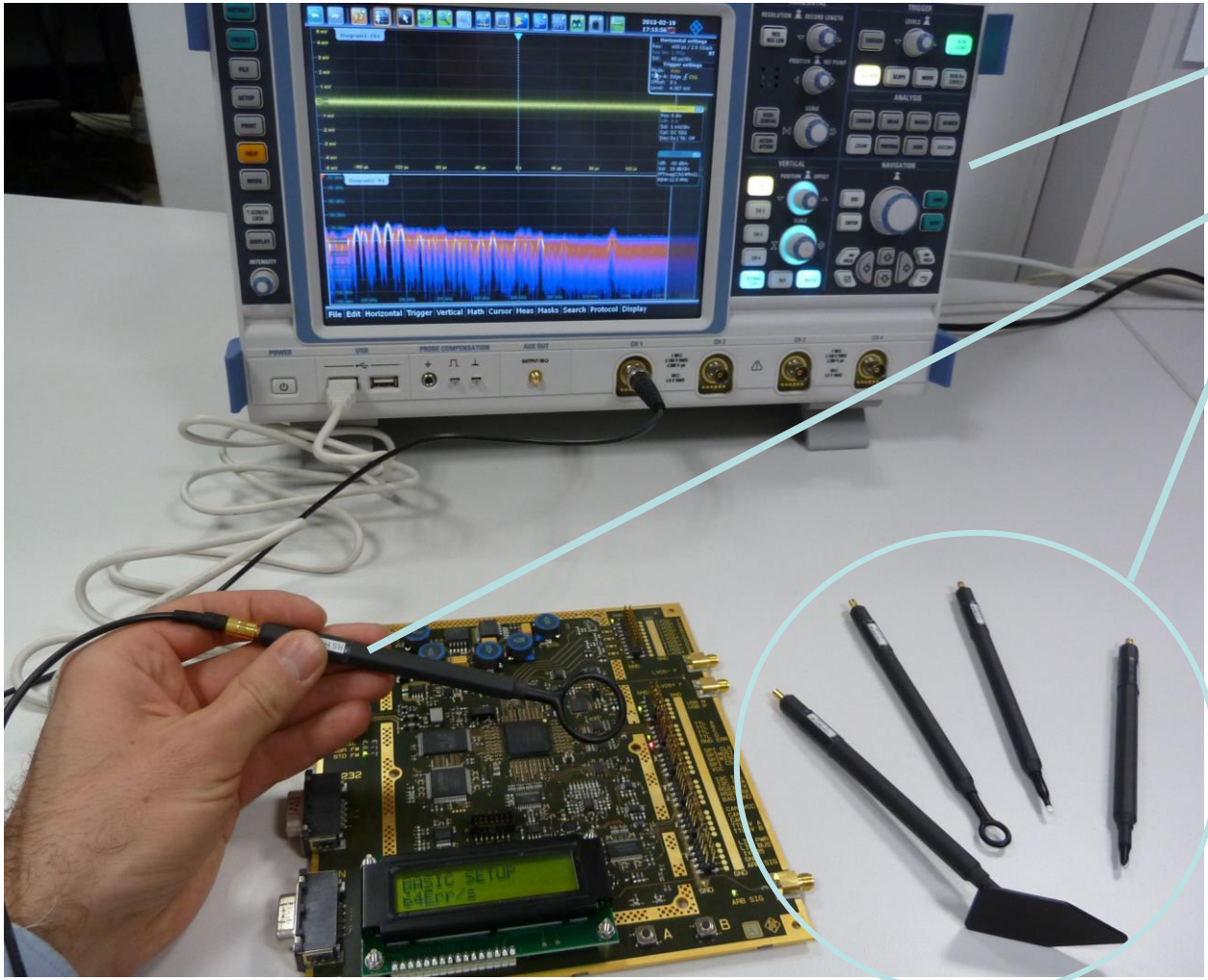


Record Length: 100 kSa

FFT detection of low signals



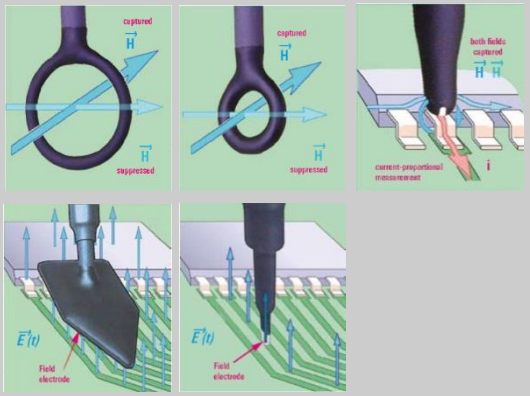
EMI Debugging with the oscilloscope



R&S ® RTO

Near-field sniffer Probes R&S ® HZ-15

E- and H-field



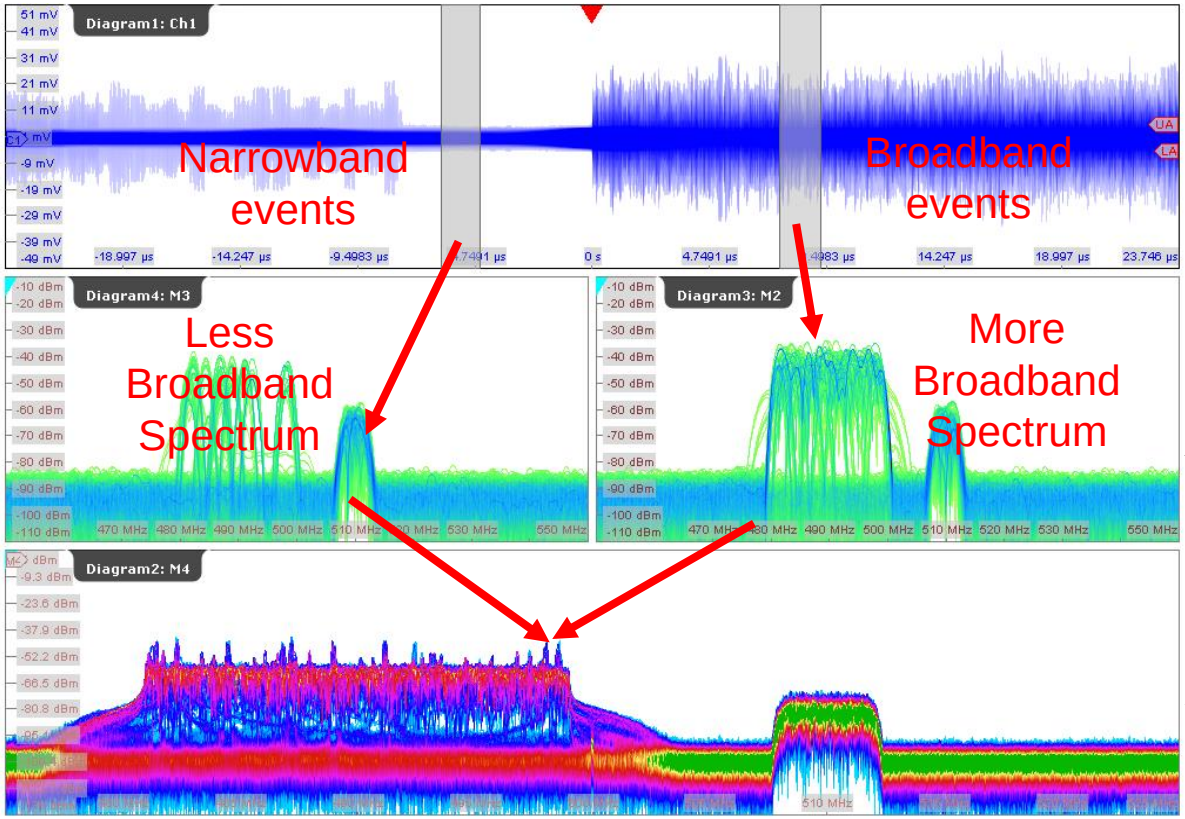
30 MHz – 1 GHz

Can be used down to 100 kHz

Optional:
R&S ® HZ-16
Preamplifier

Time Domain Gated FFT

- **Time domain gating is inversely proportional to the RBW**
- **Broader gate => Smaller RBW (higher freq resolution)**
- **RTO is capable of displaying FFT from different gate area to help in identifying spectral source**



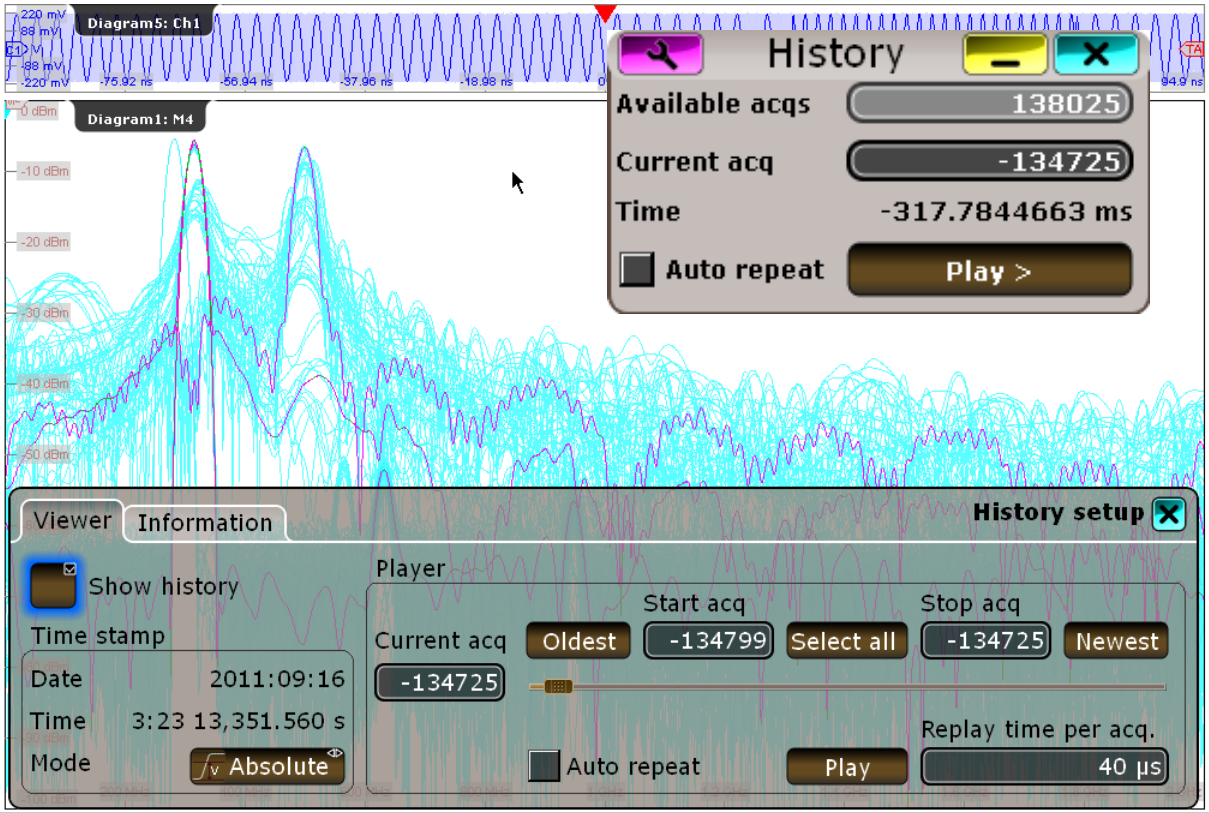
Mixed broadband and narrowband signal with 500MHz carrier at 10MHz spectral distance

Gated FFT view on time domain triggered signals

Non-gated FFT view on full time domain captures

History Mode with FFT

- Data acquired in the memory can be retrieve and analyze in FFT
- Data captured in Ultra-Segmentation when view in History mode can also be analyze in FFT



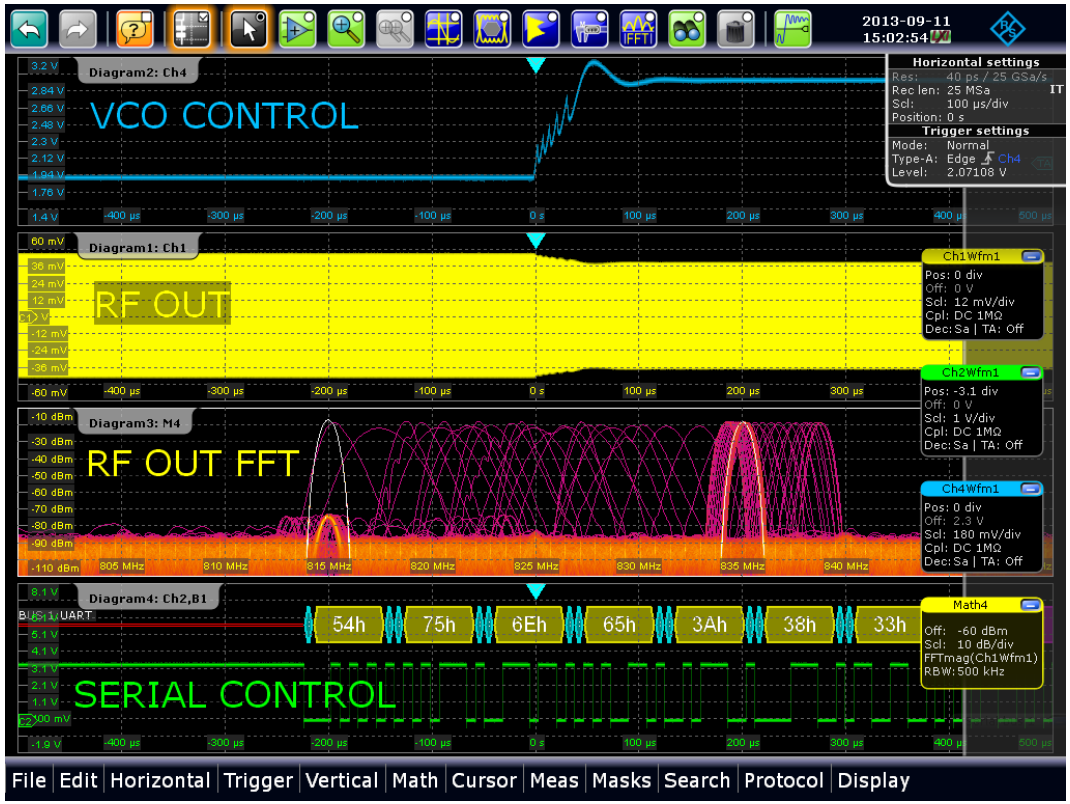
Since data is already acquired in memory, there is a limitation in manipulating the resolution and frequency span.

Spectral Mask Testing

- **User can also make use of mask testing to “capture” spectral violation**

RTO/RTE - Multiple domain instruments

- Time domain analysis
- Logic analysis with MSO option
- Serial protocol analysis with low-speed serial bus trigger and decode options
- Frequency analysis with built-in FFT on four channels from DC to 4/2 GHz
- R&S®ProbeMeter: Integrated voltmeter in the R&S active probes for precise DC measurements



Time for questions…