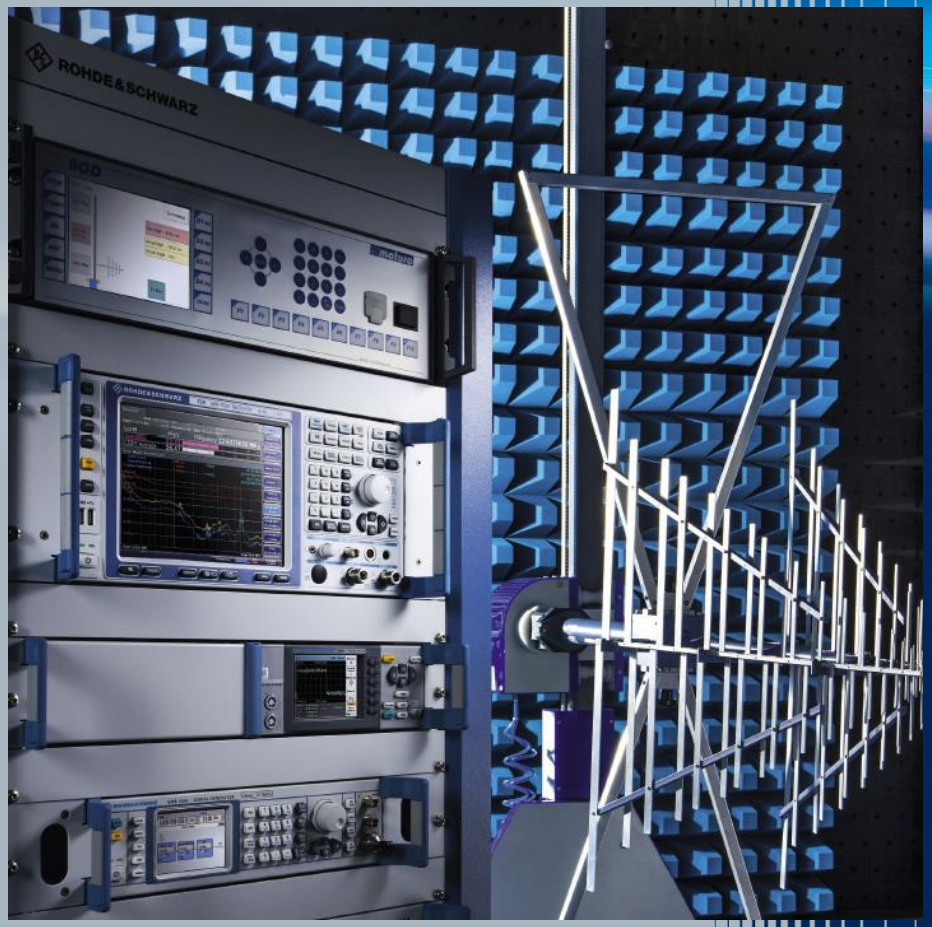
EMC-ESD in de Praktijk – 4/11/2014

Time-domain based EMI measurements



ROHDE&SCHWARZ

Agenda

- Time domain based EMI measurements
  - Introduction to EMI
  - FFT principles and possible causes for errors
  - Time Domain Scan in **EMI Receivers**
  - High speed FFT in **Oscilloscopes**

Annexes:

- Some links to YouTube
- Application Notes

Introduction to EMI

Today's Electronic Design & EMI

Nowadays electronic engineers are facing…

- Faster clock speeds & smaller form factors
- More data lines for communications
- Included RF technology (WLAN, Bluetooth, 3G/UMTS, 4G/LTE)
- Power has more impact on signals with smaller amplitude
- PCB Layout stacking – multilayer design
- Rise & fall times go down to fractions on nano-seconds
- So all this is **high frequency** up to …. GHz range

Introduction to EMI

Understand your electronic design

Clock rates, possible harmonics,
frequency of power supplies, shielding, grounding …

EMC Design TOOLS

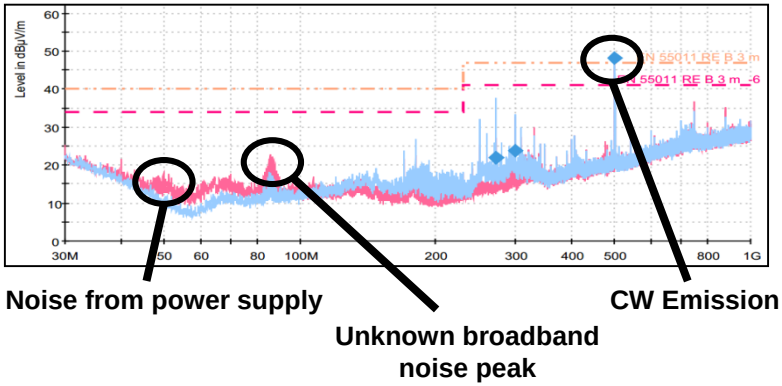
Software Prediction
Pre-scanning
Near field scanning

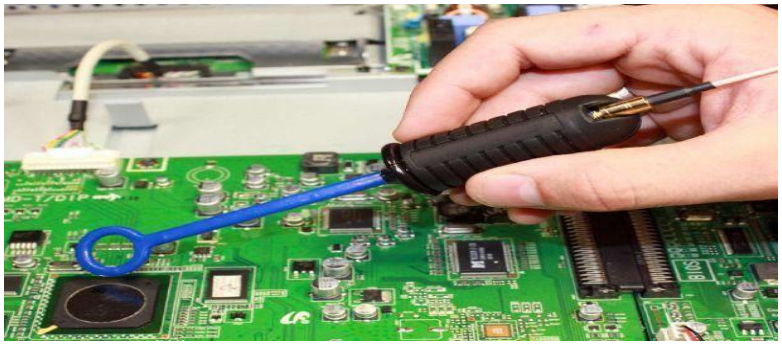
EMC Lab

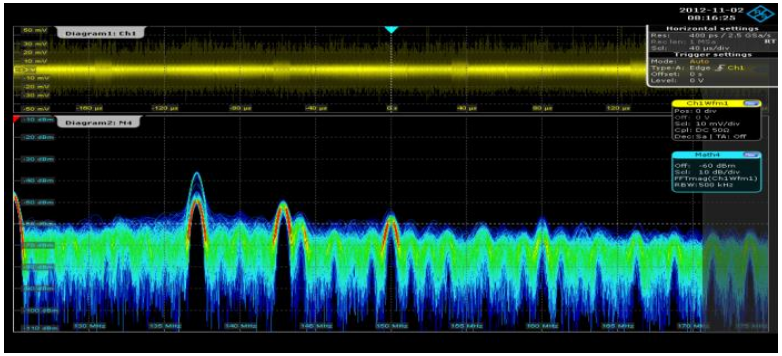
In-house testing
Outsourcing (EMC lab)
EMC Consultants

I know my system and can solve the EMI issues

By using fast and accurate EMI TOOLS



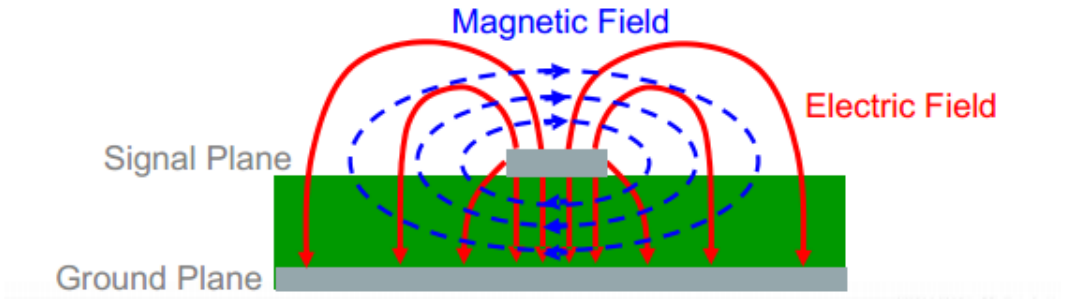




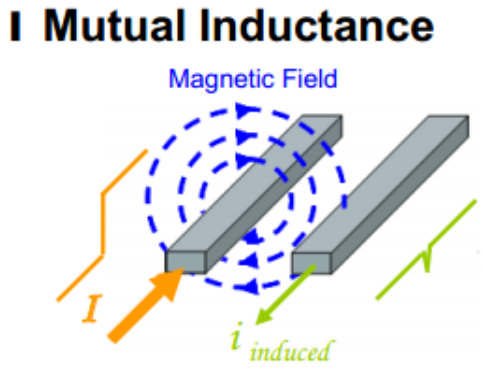
Introduction to EMI

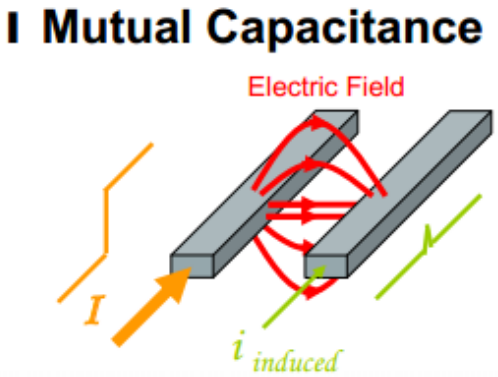
The impact of Electromagnetism

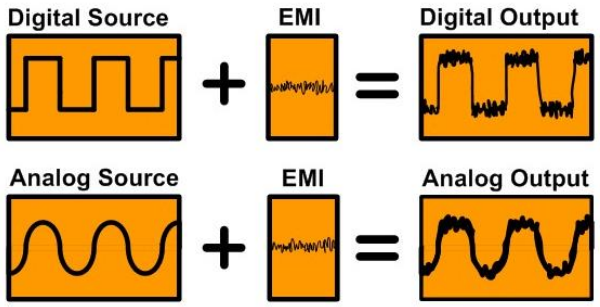
Even on a simple PCB circuit, Magnetic & Electric Fields are generated as long as current passes through the conducting medium



Both the E & H-field will penetrate adjacent conducting medium and induce noise on it



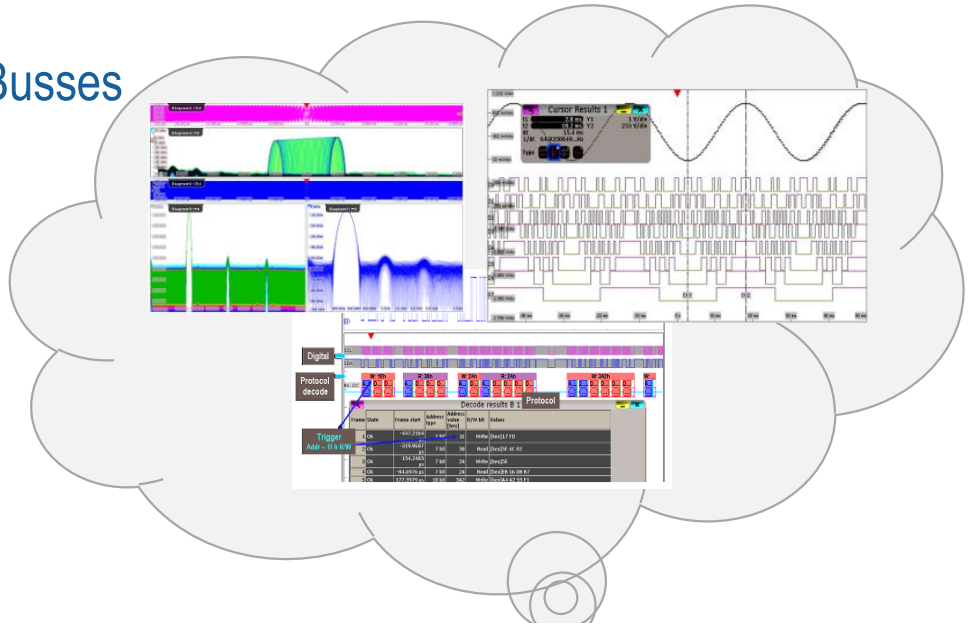




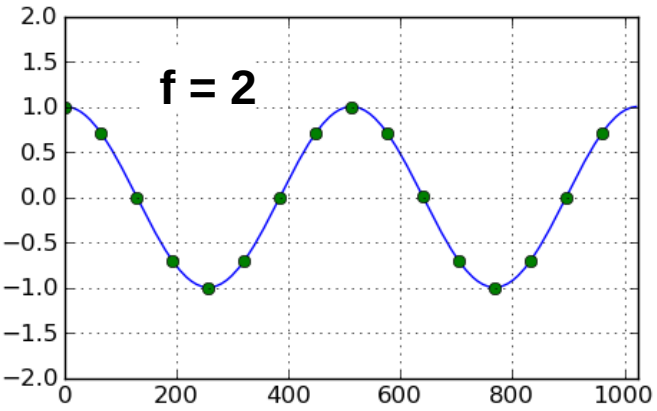
The EMI bubble… How to test efficiently?

EMC engineers are concerned about:

- Analog RF Signals, Digital High Speed Busses
- Parallel, Serial Bus Analysis & Decode
- Mix Signal Analysis
- FFT Analysis
- Triggering
- Time Correlated Events
- Acquisition rate (frequency range)
- Dead-time (missing intermittent faults)
- Dynamic Range (sensitivity)
- EMI Filters, Detectors, Windowing
- EMI Limit lines
- EMI transducer correction factors
- EMI appropriate accessories / infrastructure

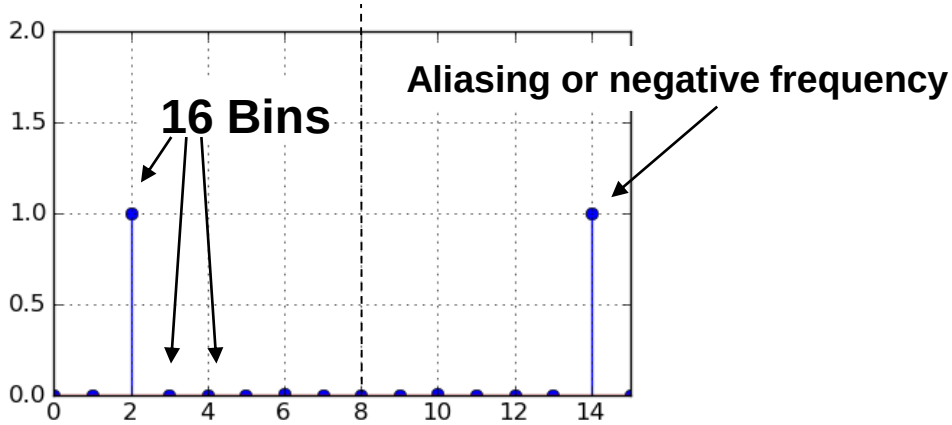


FFT Basics – Spectral Leakage



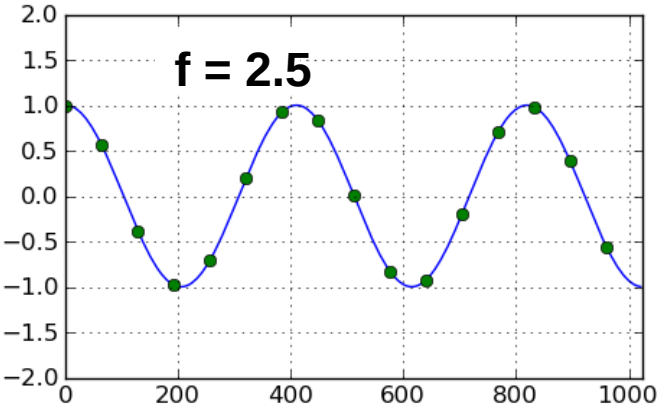
FFT

½ Fs = Nyquist frequency

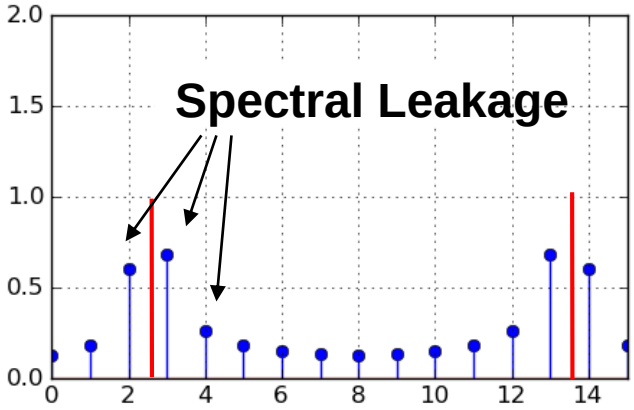


- **16 Discrete Samples in Time Domain**
- **Sample Frequency Fs**

- **16 Discrete Frequency points in FFT**
- **Frequency resolution = 1/16 * Fs**



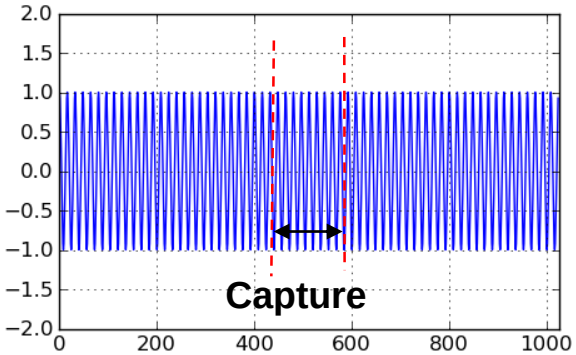
FFT

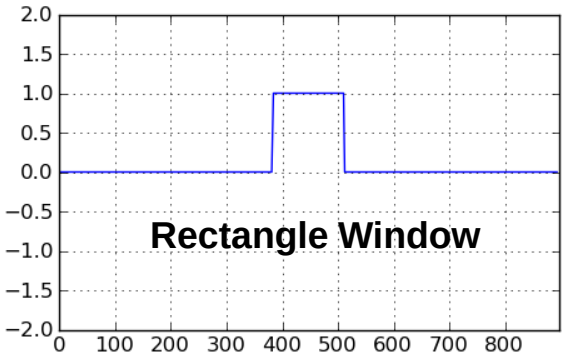


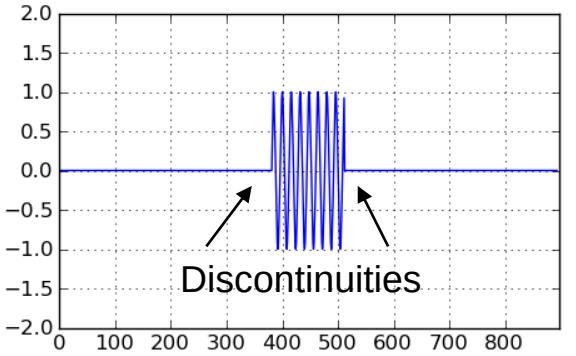
Spectral Leakage -> Signal Energy spreads over a lot of bins

FFT Basics – Solution: Windowing

Multiplication in Time Domain







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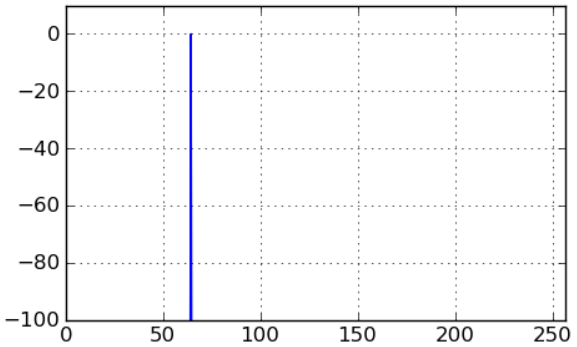
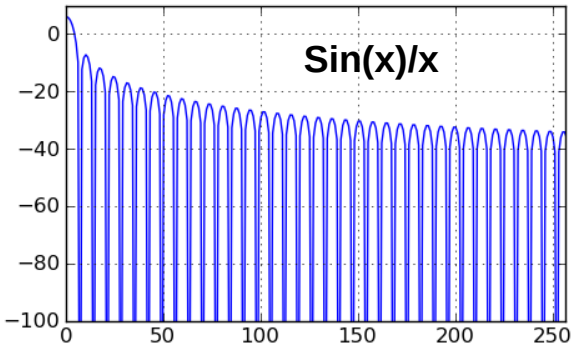
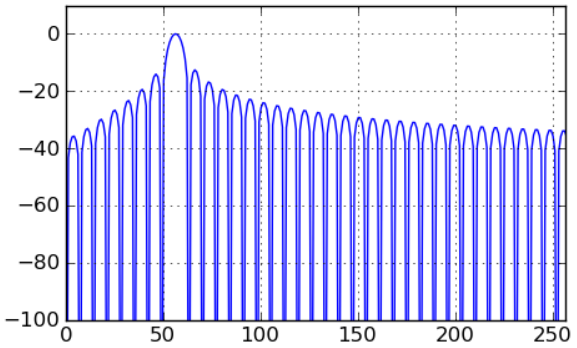


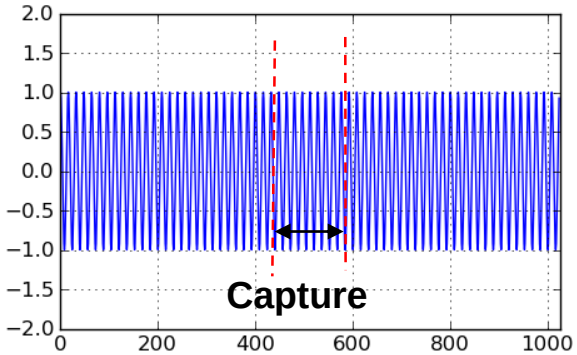


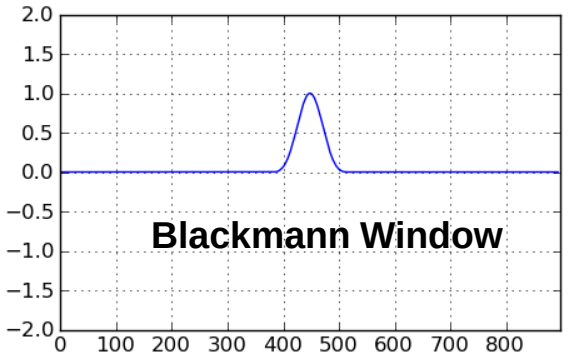


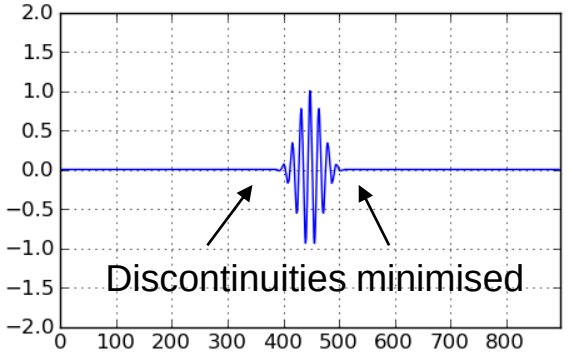
Convolution in Frequency Domain

FFT Basics - Windowing

Multiplication in Time Domain







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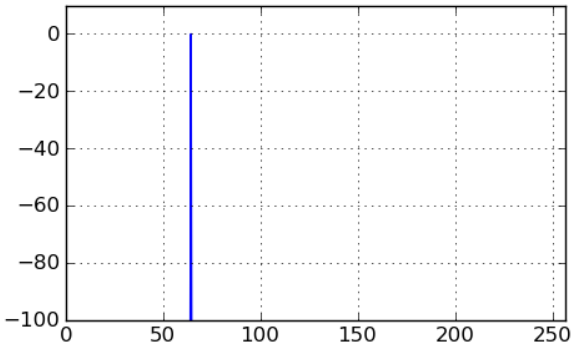
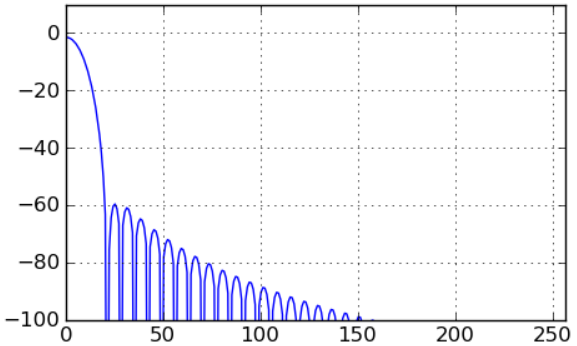
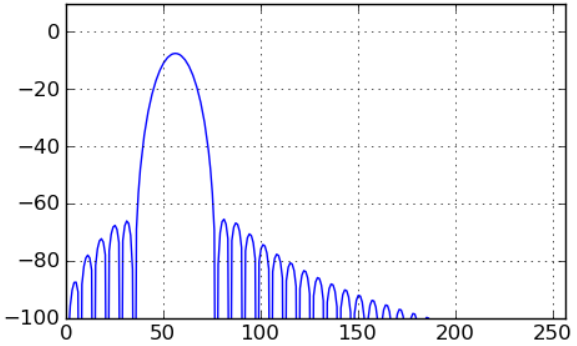
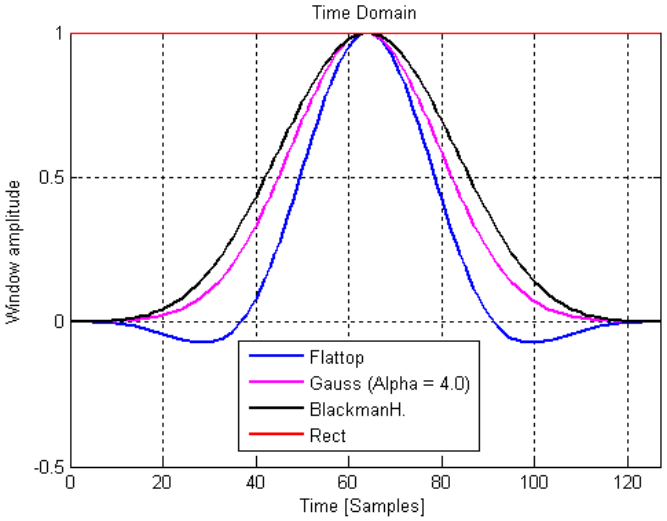


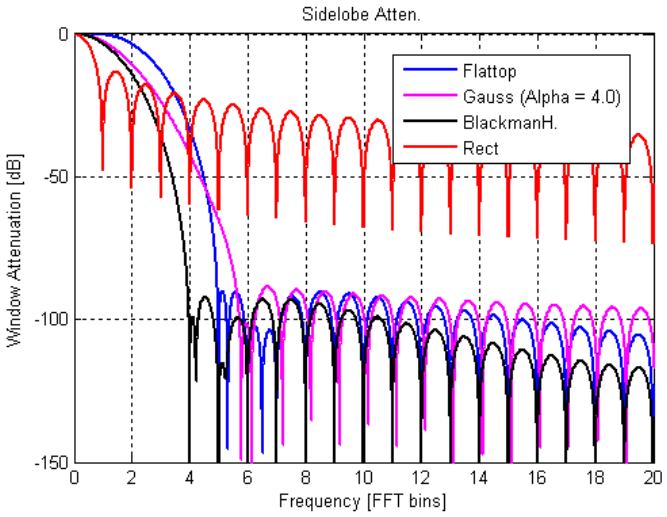


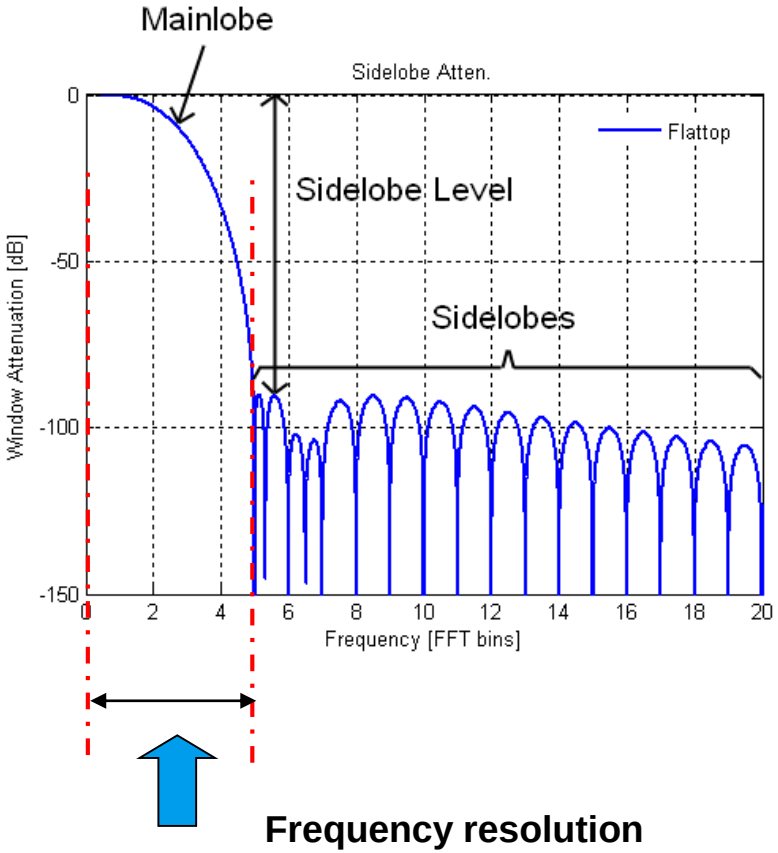


Convolution in Frequency Domain

FFT Basics – Window Properties



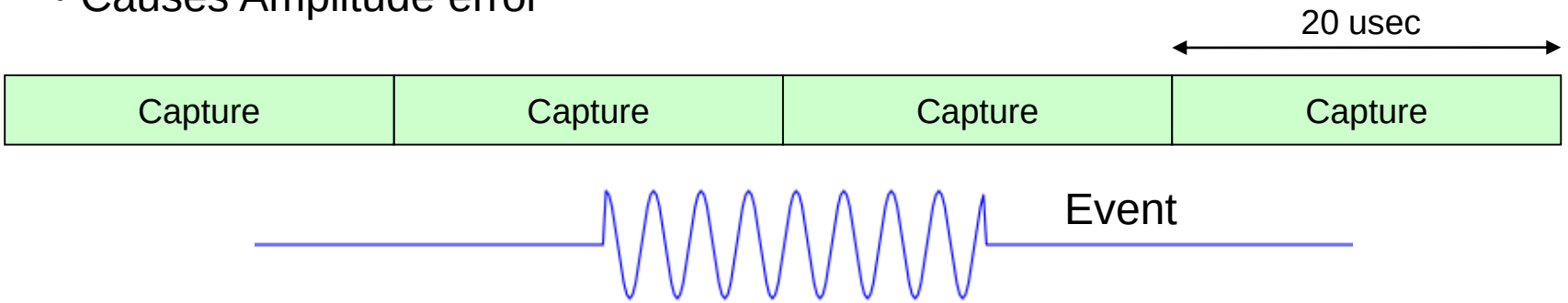




FFT Basics – 2 Problems

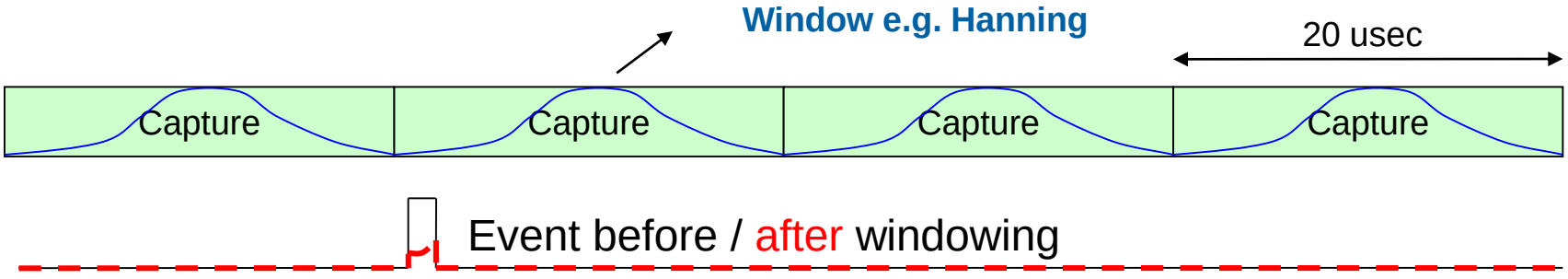
Problem 1:

- Event does not fully cover 1 Capture –> ‘incomplete’ FFT’s
- Causes Amplitude error

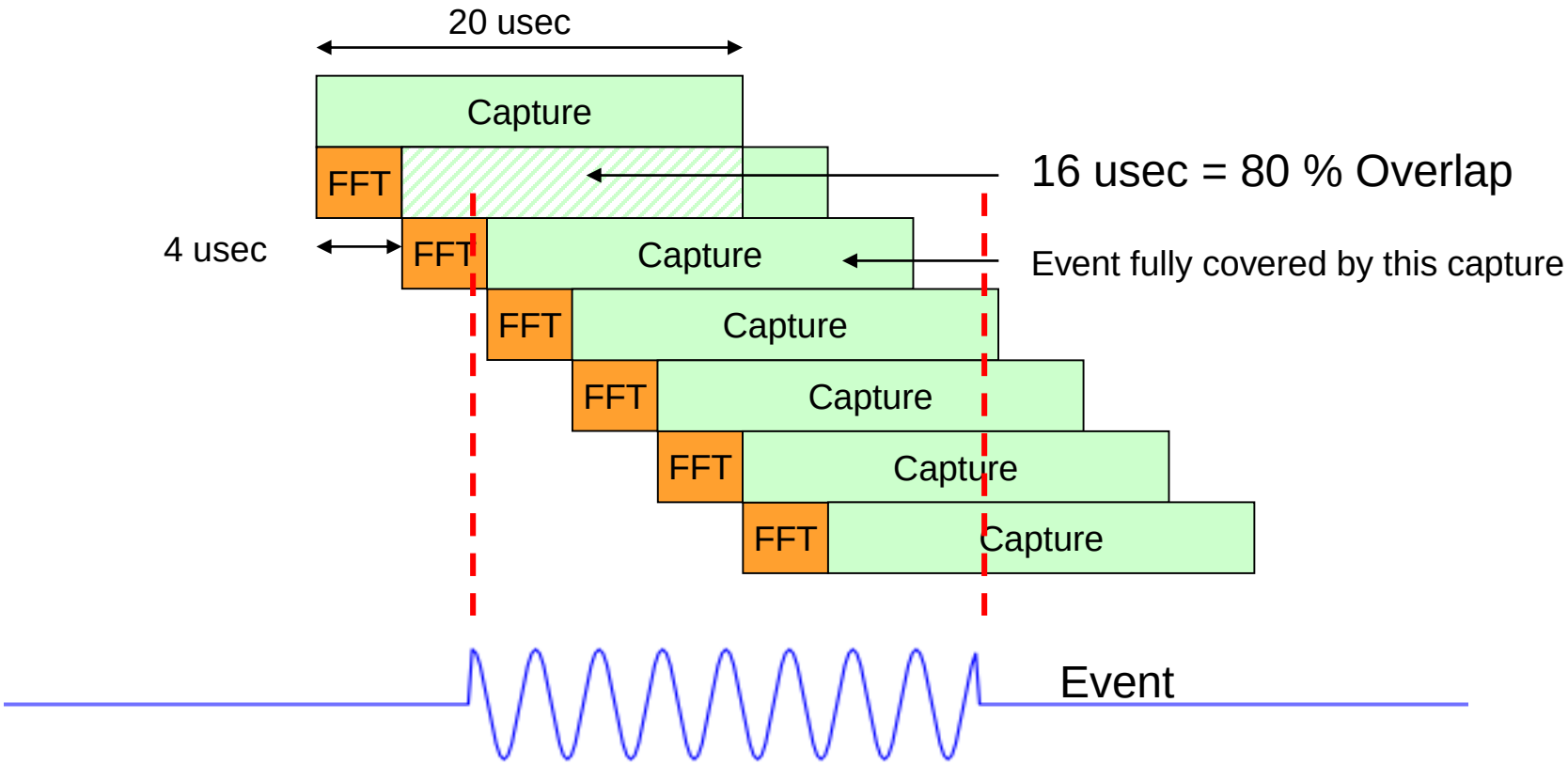


Problem 2:

- Very short Events at the edge of a window (other then Rectangle)
- Are almost not visible



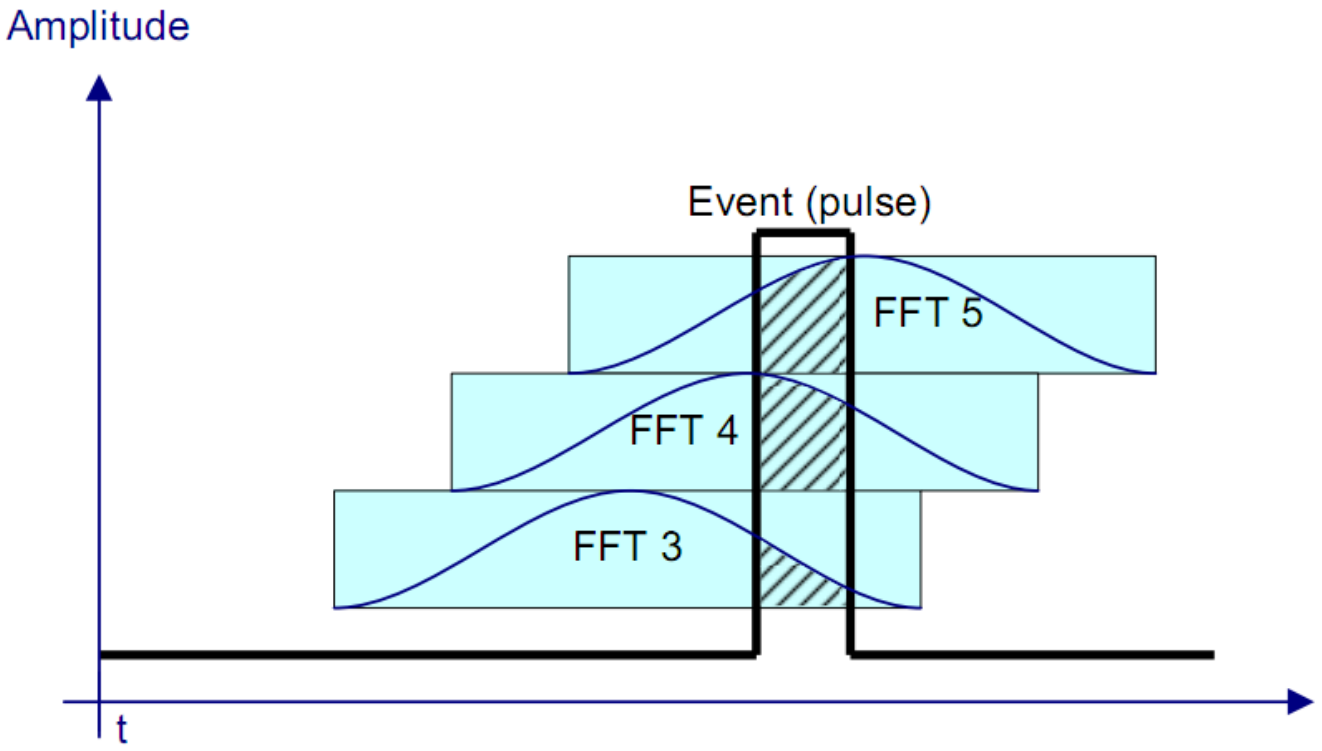
FFT Basics – Solution: Overlapping



- 80% overlap ensures amplitude accuracy for events > 24 usec
- Events < 24 usec will still be detected but with too low amplitude
- Shortest detectable event defined by e.g. BW 40 MHz -> 25 nsec

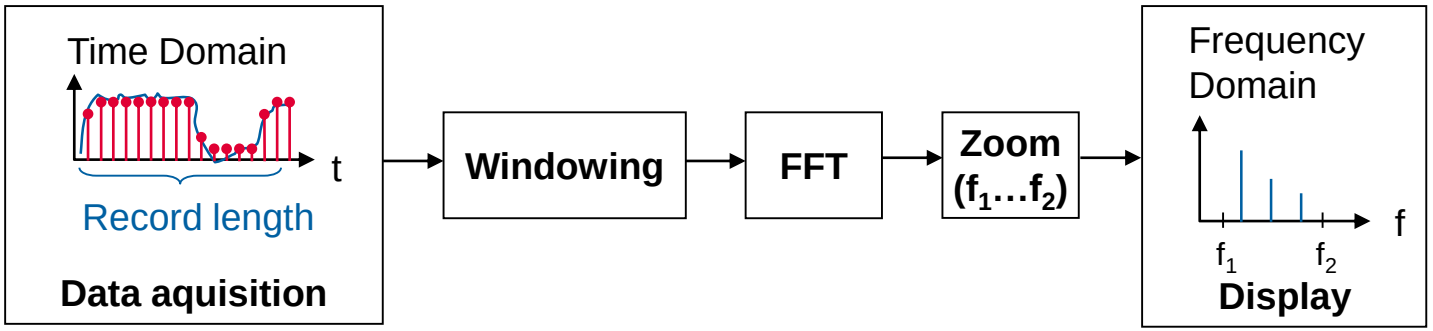
FFT Basics – Solution: Overlapping

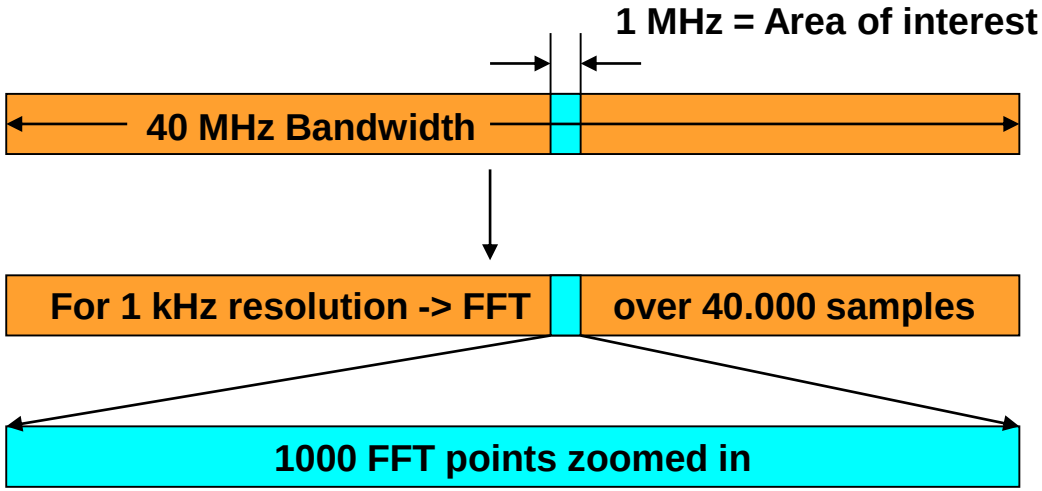
Overlapping is also a solution for problem 2



FFT Implementation - Traditional

FFT calculation on conventional instruments:

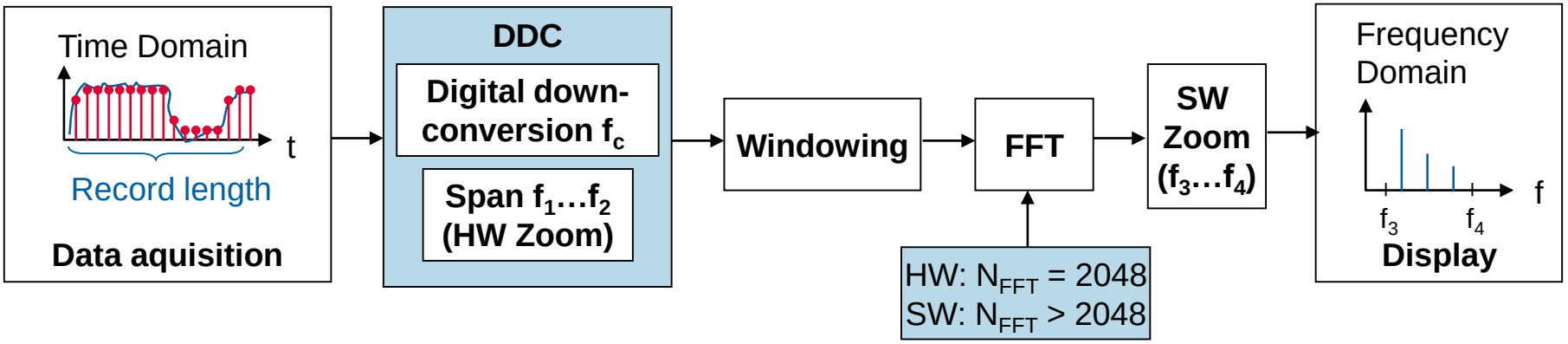


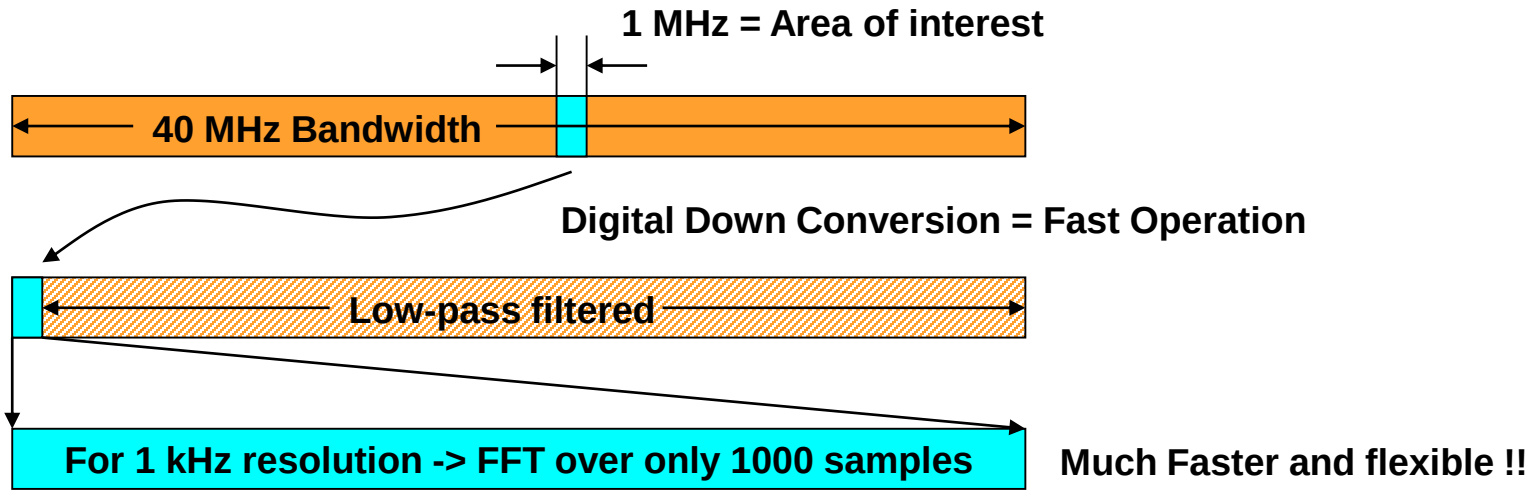


Time consuming operation !!

FFT Implementation – Digital Down-conversion

FFT calculation in R&S ESR(P)/RTE/RTO –with digital down-converter





R&S ESR EMI Test Receiver key features and benefits

- **EMI test receiver compliant to CISPR 16-1-1 Ed. 3 Amend. 1**
  - ⇨ **measurement of RFI emissions to commercial EMC standards (CISPR, EN, FCC, ETS, ANSI C63.4, VCCI, etc.)**

- **Time domain scan (option) alternatively to the standard stepped frequency scan**
  - ⇨ **among the fastest EMI test receivers in the marketplace**
  - ⇨ **direct comparison of both scan methods in one diagram**

- **Realtime capabilities (option) with up to 40 MHz span**
  - ⇨ **new insights in EMC diagnostics and analysis of disturbances**

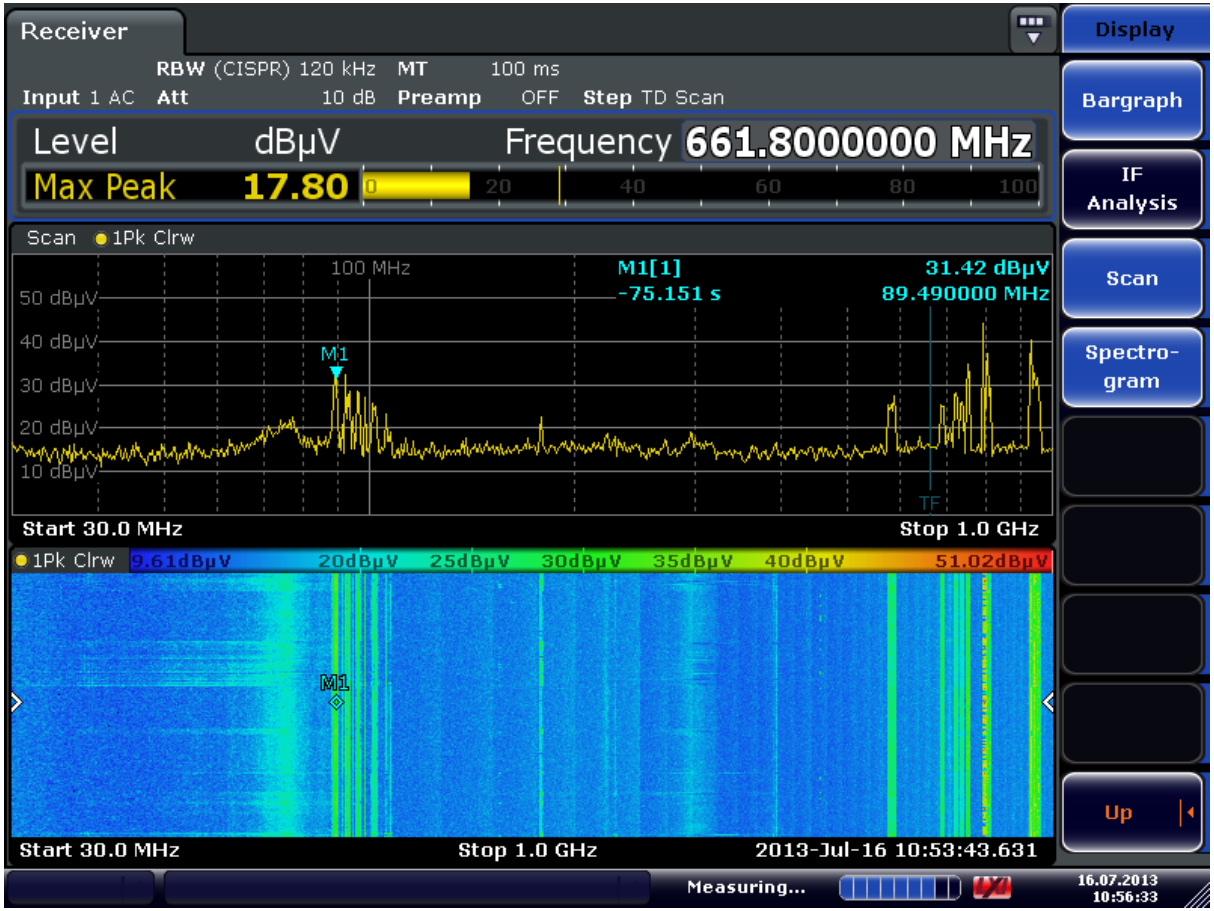
- **Spectrum analyzer mode with preselection & EMI application incl. 16 independent measurement markers**
  - ⇨ **CISPR-compliant EMI measurements also in analyzer mode**

ESR(P) – Std. Stepped Scan vs. Time-Domain Scan

Fig. 16: Measured signal spectra, quasi-peak detector, 150 MHz to 30 MHz.

Trace 1 (yellow) was measured with a time domain scan, trace 2 (green) with a stepped scan.

ESR Time Domain scan spectrogram



Spectrogram in receiver mode

Spectrogram in split screen mode can be combined with:

- **Time Domain scan**
- **Stepped Freq. scan**
- **IF analysis**
- **Bar-graph on/off**

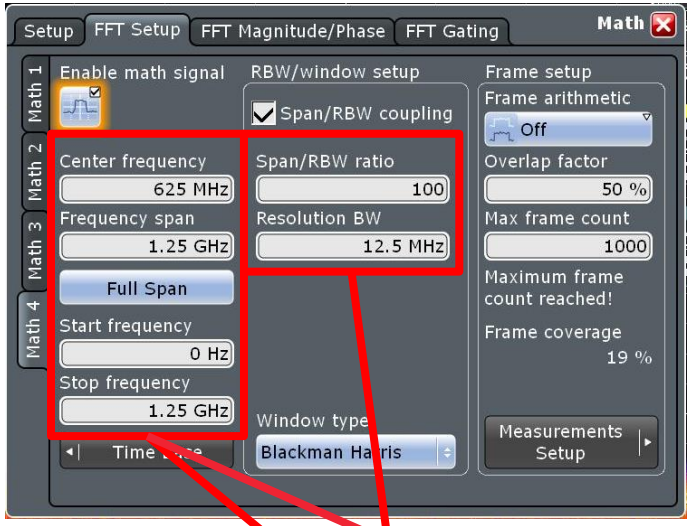
Marker evaluation

Measurement Speed EMI Receivers: Time domain scan vs. stepped scan

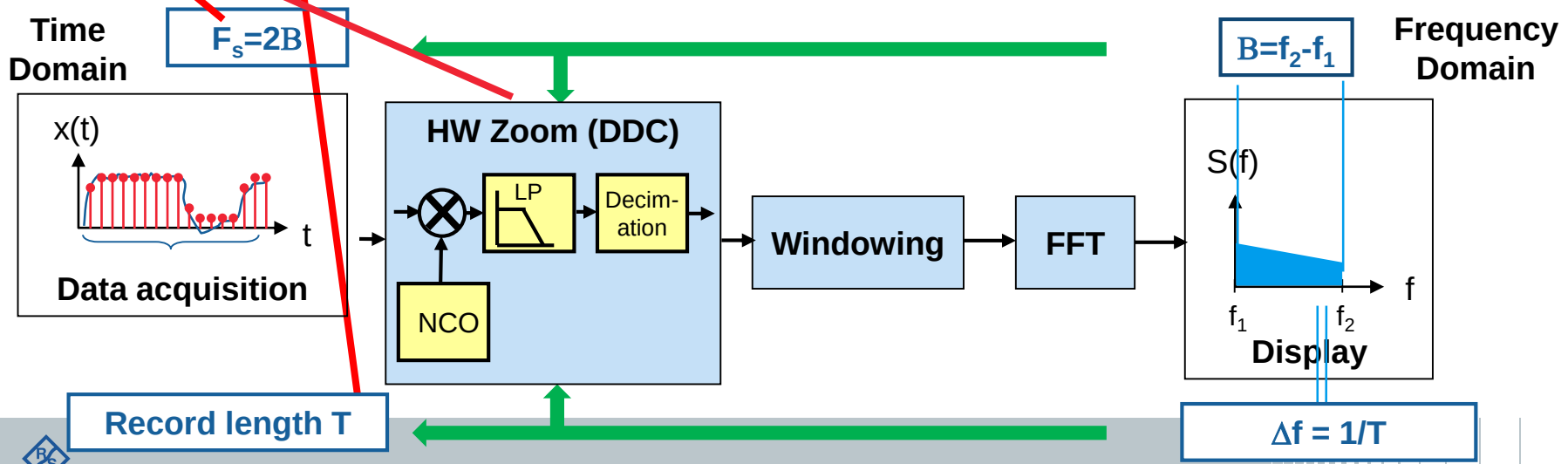
Frequency range	Weighting detector, measurement time, IF BW (no. of measurement points)	R&S ESRP		R&S ESR
		Stepped frequency scan	Time domain scan (option)	Time domain scan (option)
CISPR Band B 150 k to 30 MHz	Pk, 100 ms, 9 kHz (13.267)	1.326 s	2 s	0,11 s
CISPR Band B 150 k to 30 MHz	QP, 1 s, 9 kHz (13.267)	3.6 h	60 s	2 s
Band C/D 30 to 1000 MHz	Pk, 10 ms, 120 kHz (32.334)	323 s	6 s	0,52 s
Band C/D 30 to 1000 MHz	Pk, 10 ms, 9 kHz (431.000)	4.310 s	8 s	0,82 s
Band C/D 30 to 1000 MHz	QP, 1 s, 120 kHz (32.334)	approx. 9 h	1 980 s	80 s

FFT in R&S RTE/RTO Oscilloscopes

Spectrum Analyzer Look & Feel



- **Frequency domain controls time domain**
  - Time domain parameters (record-length / sampling rate) automatically changed as necessary
- **Down-conversion FFT (DDC) zooms into frequency range *before* FFT**
  - Largely reduced record length, much faster FFT



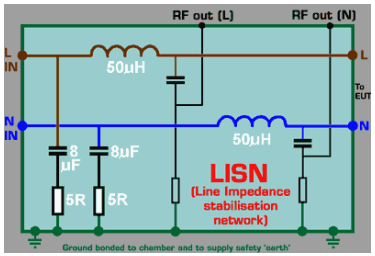
EMC Applications for Oscilloscopes

EMI

- **Radiated Interference**
  - EN55011, EN55012, EN55013, EN55014, EN55015, EN55022, CISPR
- **Conducted Interference**
  - EN55011, EN55012, EN55013, EN55014, EN55015, EN55022, CISPR
- **Power Quality**
  - EN61000-3-2
    EN60555-2
    EN61000-3-3
    EN60555-3

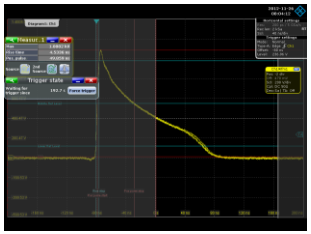
EMS

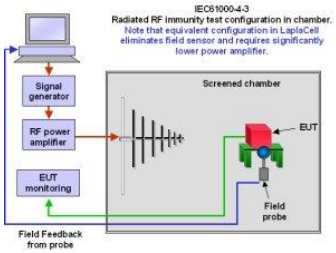
- **ESD, EFT and Burst Calibration**
  - EN61000-4-2
    EN61000-4-4
    EN61000-4-5
- **EUT Monitoring**
  - EN61000-4-3



Power Harmonics

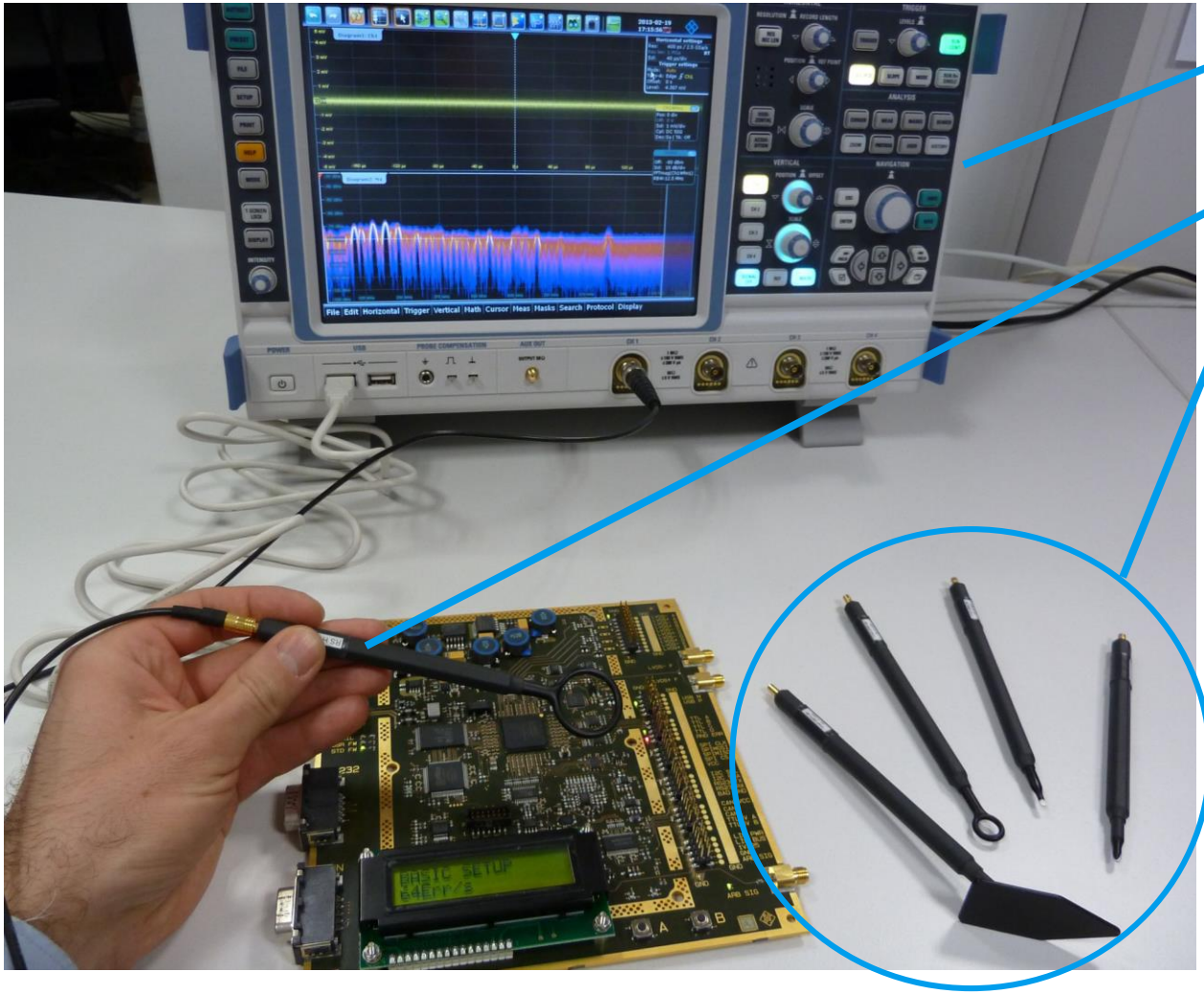
Flicker Measurement





RTE/RTO: A powerful tool for EMI/EMS debugging and precompl. applications

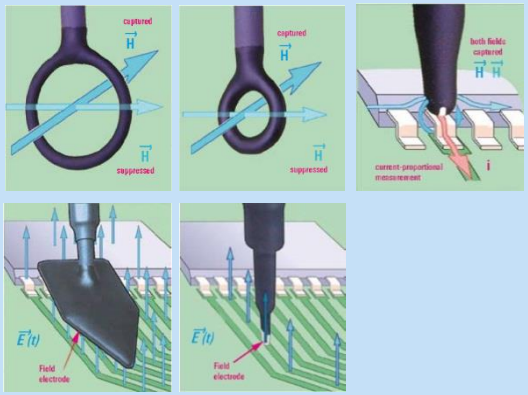
EMI Debugging with high-speed Oscilloscope



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

Pre-amplifier

EMC & RTE/RTO

www.rohde-schwarz.com or google on YouTube

Some useful links…:

- **R&S®RTO Oscilloscope Spectrum Sensitivity and FFT Capability**
  - http://www.youtube.com/watch?v=LHAdy9oo0Uo
- **R&S®RTO oscilloscope frequency analysis part 1 (3): The implementation**
  - http://www.youtube.com/watch?v=SrWFmL12RQc
- **R&S®RTO oscilloscope frequency analysis part 2 (3): AM and FM**
  - http://www.youtube.com/watch?v=SrWFmL12RQc
- **R&S®RTO oscilloscope frequency analysis part 3 (3): Frequency, time**
  - http://www.youtube.com/watch?v=HaWqSCapZwU
- **R&S®RTO Intuitive User Interface and Operation**
  - http://www.youtube.com/watch?v=xFO3rPHGGNY
- **R&S®RTO Family, the digital oscilloscopes from Rohde & Schwarz**
  - http://www.youtube.com/watch?v=rrYEFtgK_kg

Application Notes

Comparison of Time Domain Scans and Stepped Frequency Scans in EMI Test Receivers

http://www.rohde-schwarz.com/en/applications/comparison-of-time-domain-scans-and-stepped-frequency-scans-in-emi-test-receivers-application-note_56280-54019.html

EMI Debugging with the R&S®RTO and R&S®RTE Oscilloscopes

http://www.rohde-schwarz.com/en/applications/emi-debugging-with-the-r-s-rto-and-r-s-rte-oscilloscopes-application-note_56280-58049.html

Thank you for your attention !

Any questions

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