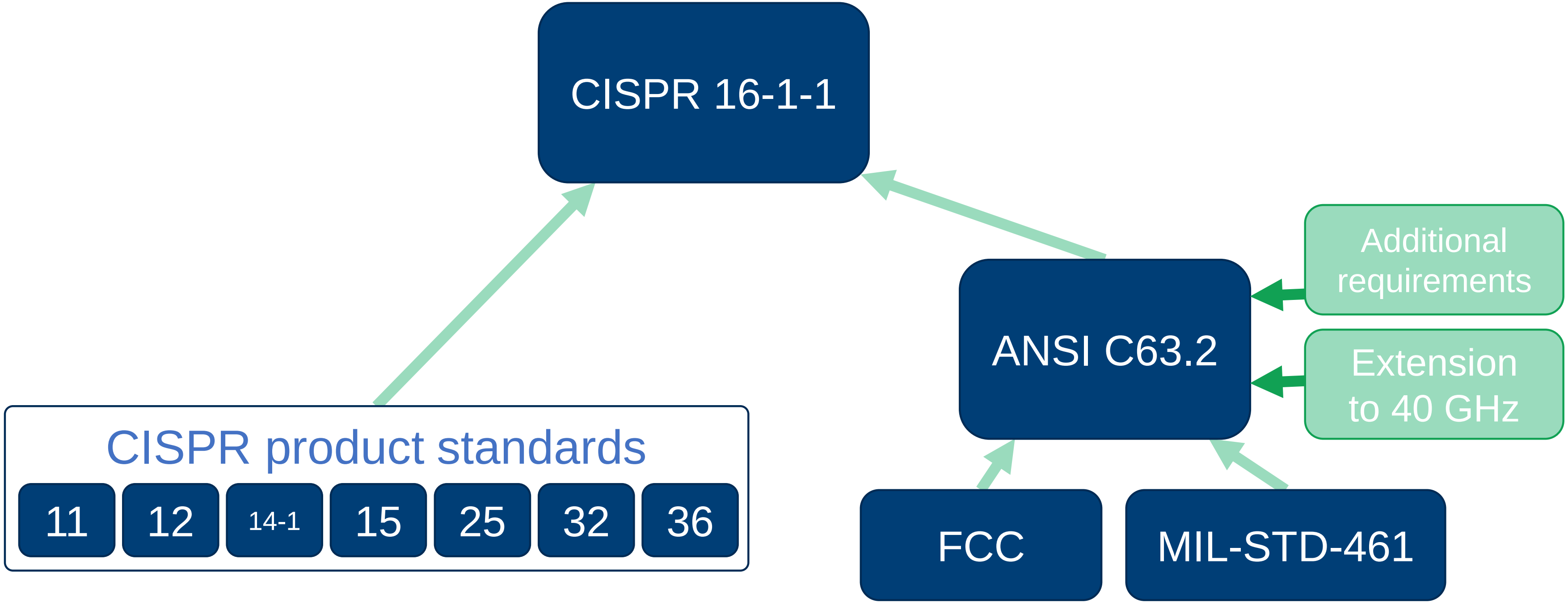
FROM STEPPED SCAN TO WIDEBAND TIME DOMAIN SCAN FOR COMMERCIAL TESTING

Tobias Groß

Product Management EMI Test Receiver

STANDARDIZATION

MEASUREMENT INSTRUMENTATION STANDARD



CISPR 16-1-1 FFT-BASED MEASURING RECEIVERS

- **Blackbox approach**

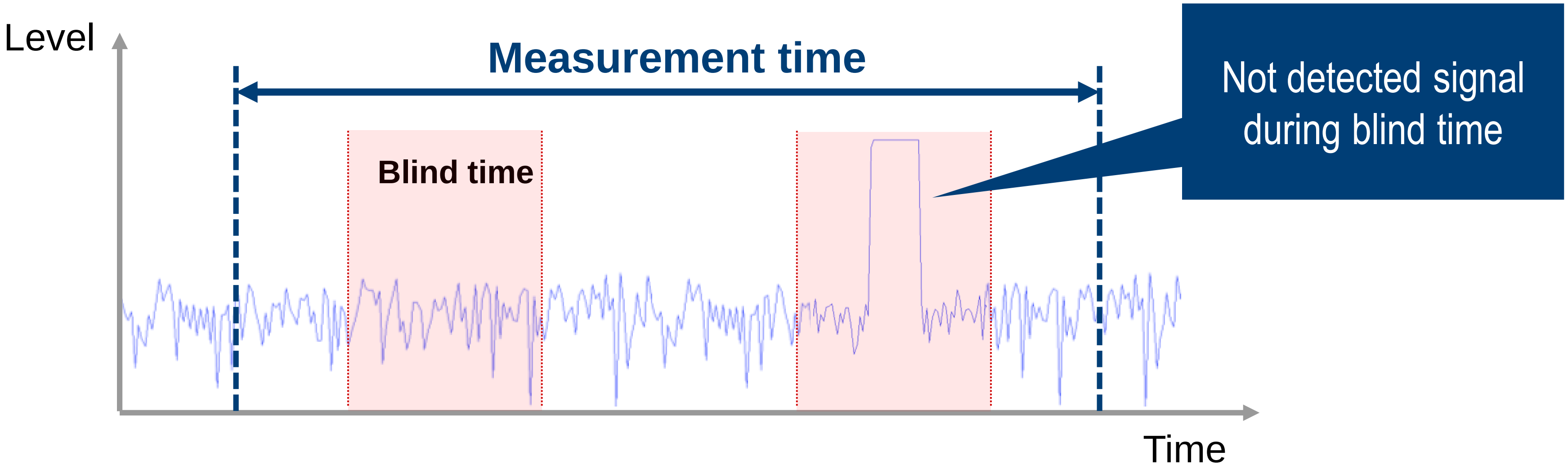
Specified input signal

- FFT-based **measurement receiver** for compliance testing

"instrument such as a tunable voltmeter, an EMI receiver, a spectrum analyzer or an FFT-based measuring instrument, with or without preselection, that meets the relevant parts of this standard"

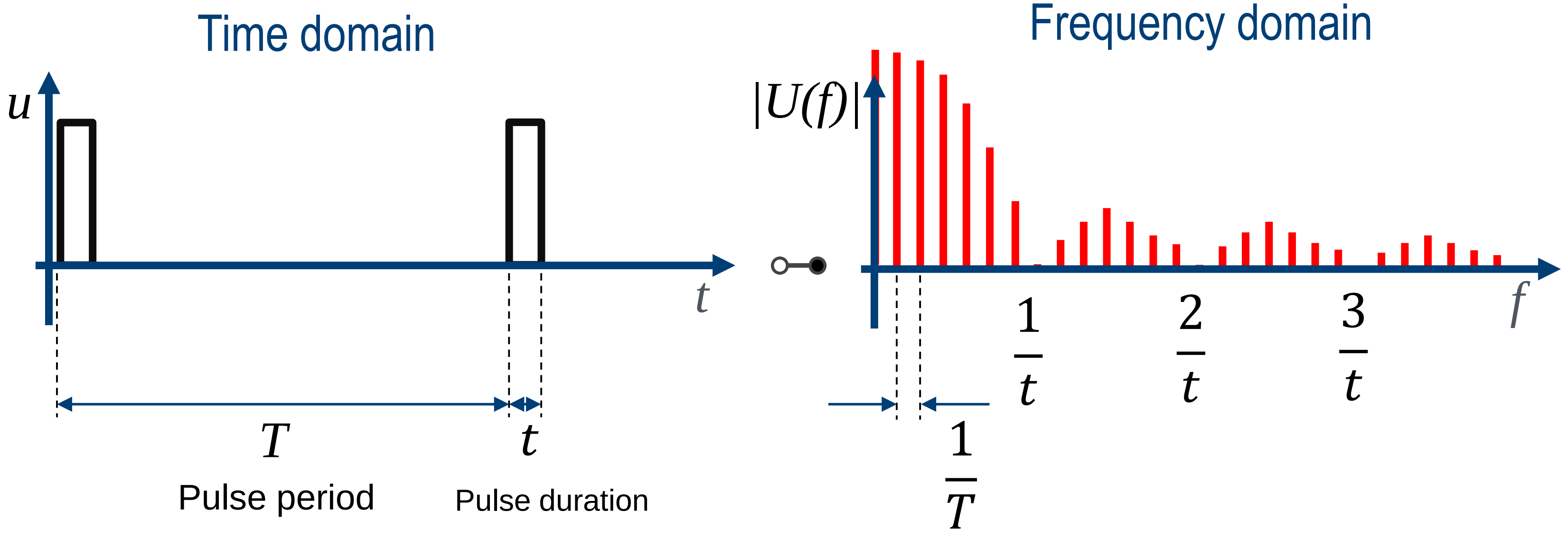
CISPR 16-1-1 – MEASURING APPARATUS

► Gapless measurement without blind time and signal loss



STEPPED SCAN ON PULSED SIGNAL

PULSE SPECTRUM

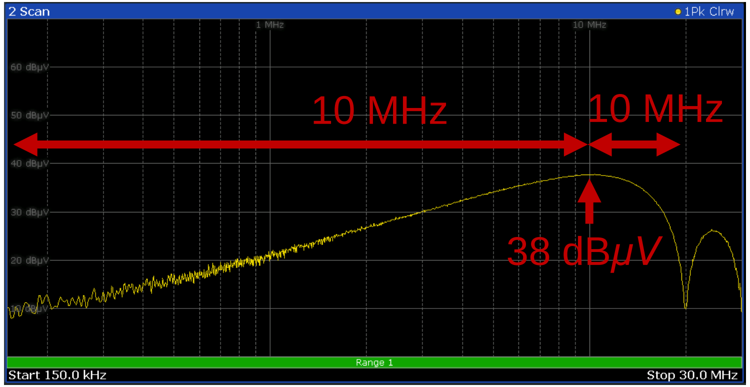


- Example: $t = 1\ \mu s \Rightarrow \frac{1}{t} = 1\ MHz$

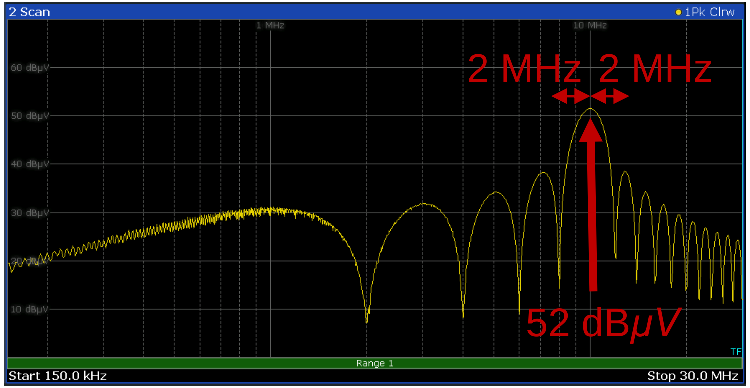
  $T = 100\ \mu s \Rightarrow \frac{1}{T} = 10\ kHz$

PULSE SPECTRUM (DURATION)

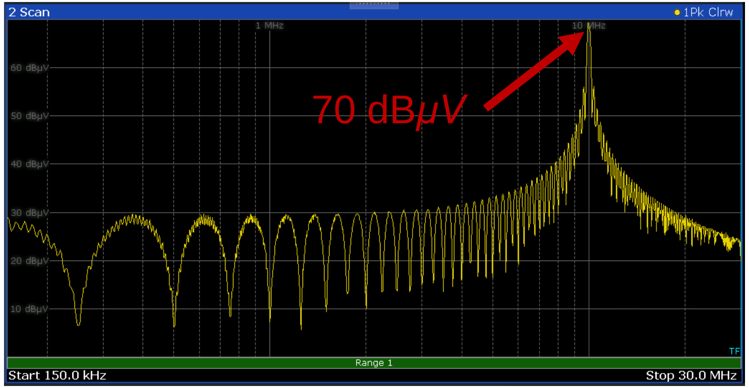
Period: *100 µs,* Duration: *100 ns*



Period: *100 µs,* Duration: *500 ns*



Period: *100 µs,* Duration: *4000 ns*



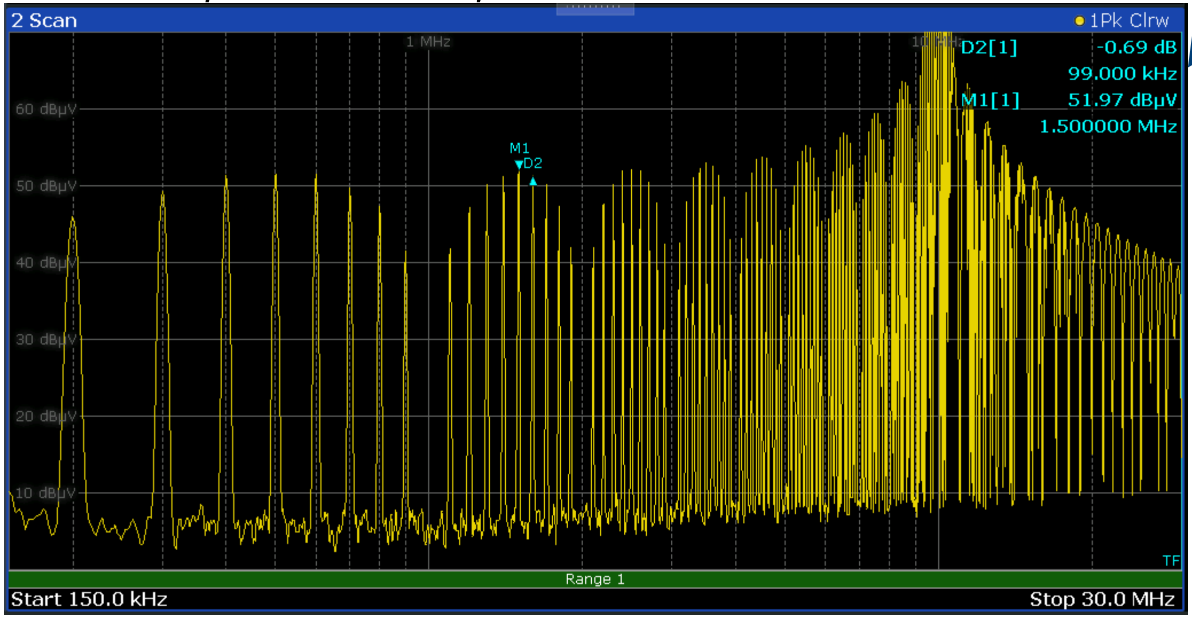
Level Difference: $20 \cdot \log_{10}\left(\frac{4000\ ns}{100\ ns}\right) \approx 32\ dB$

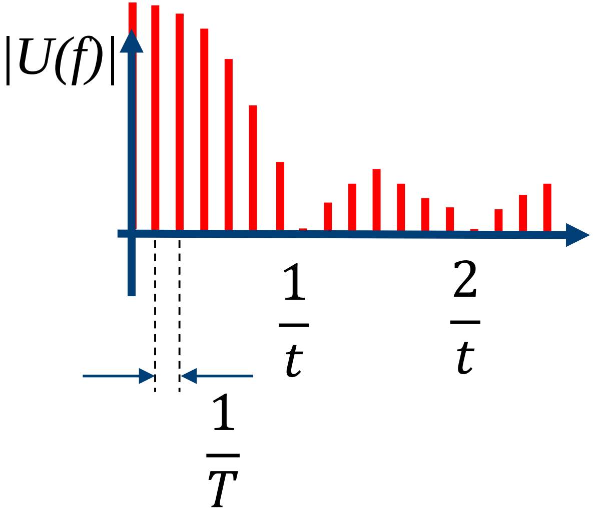
(changed Dutycycle)

PULSE SPECRUM

1/T ≈ 100 kHz
T = 10 μs

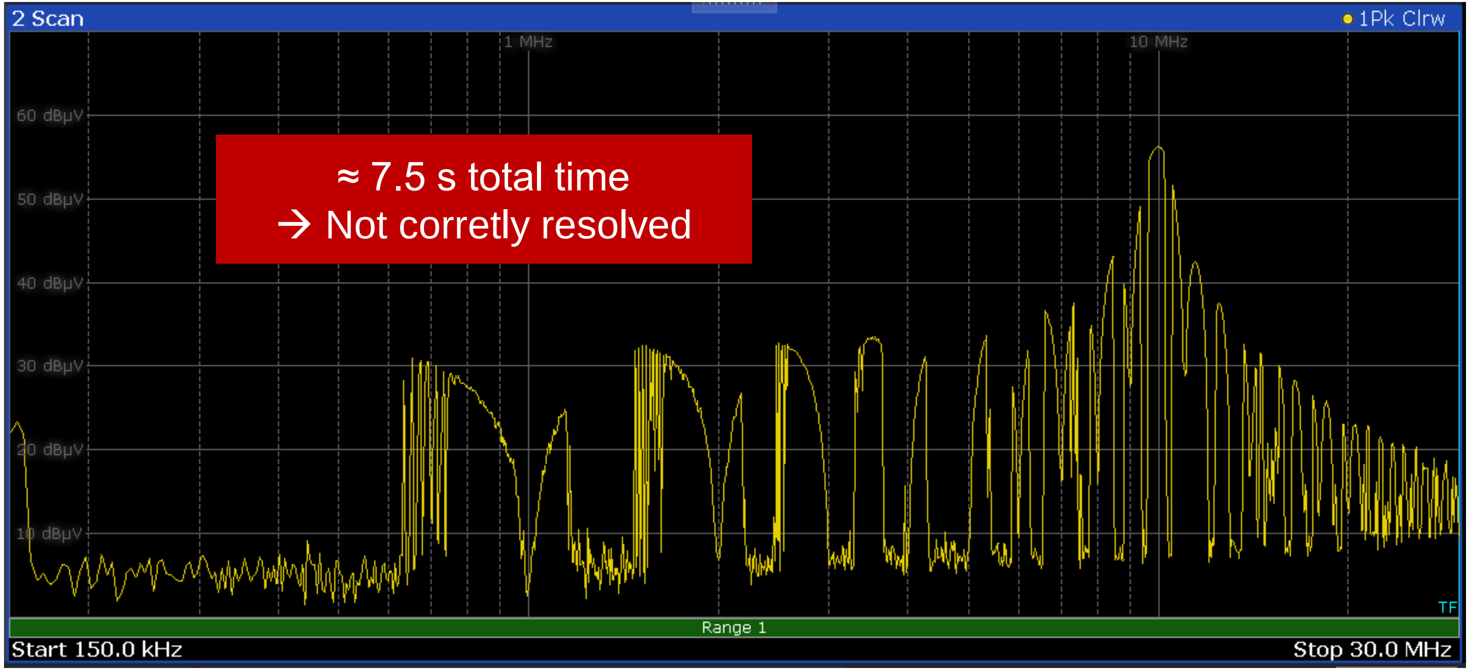
Period: *10 µs*, Duration: *1 µs*





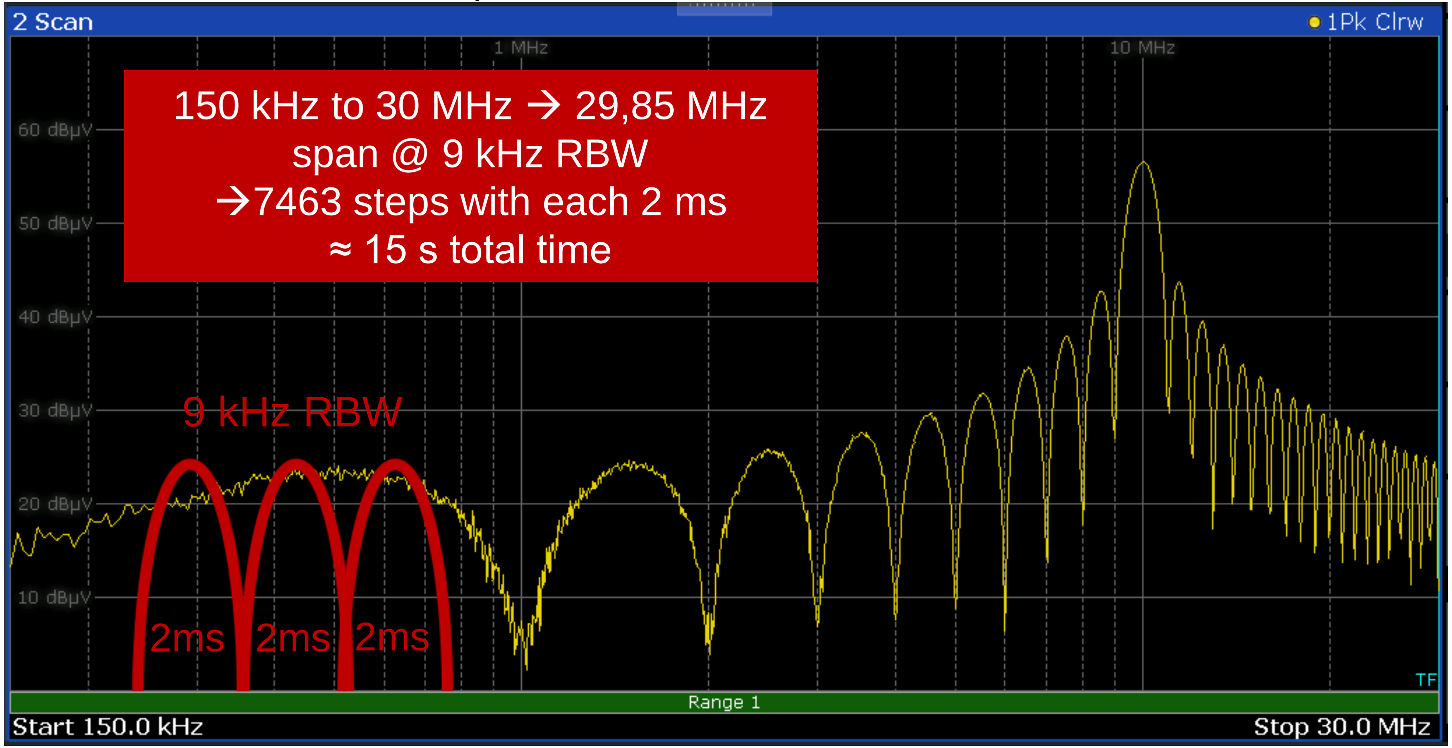
STEPPED SCAN @ 1 MS MEASUREMENT TIME

Period: *2 ms*, Duration: *1 µs*



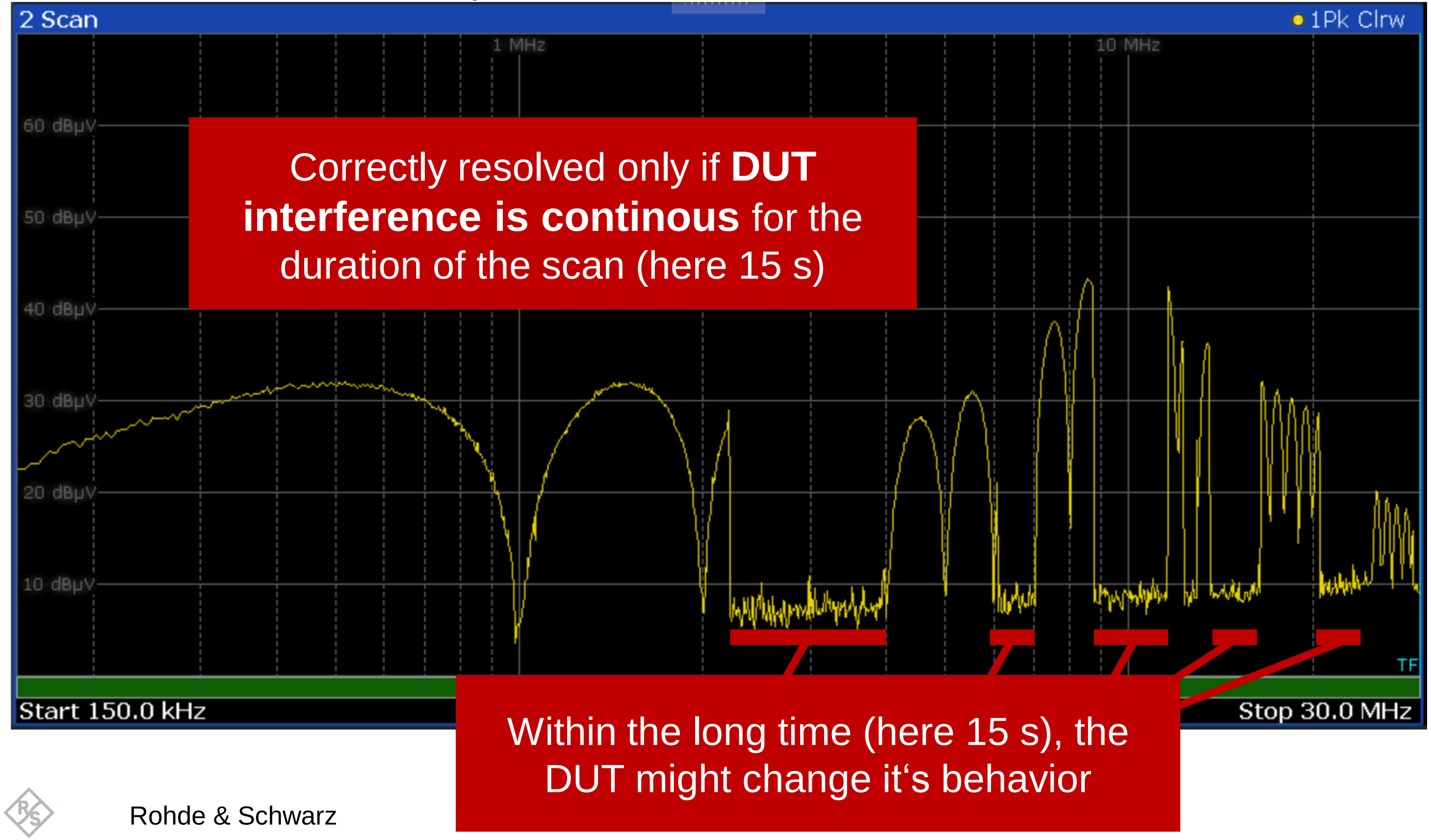
STEPPED SCAN @ 2 MS MEASUREMENT TIME

Period: *2 ms*, Duration: *1 µs*



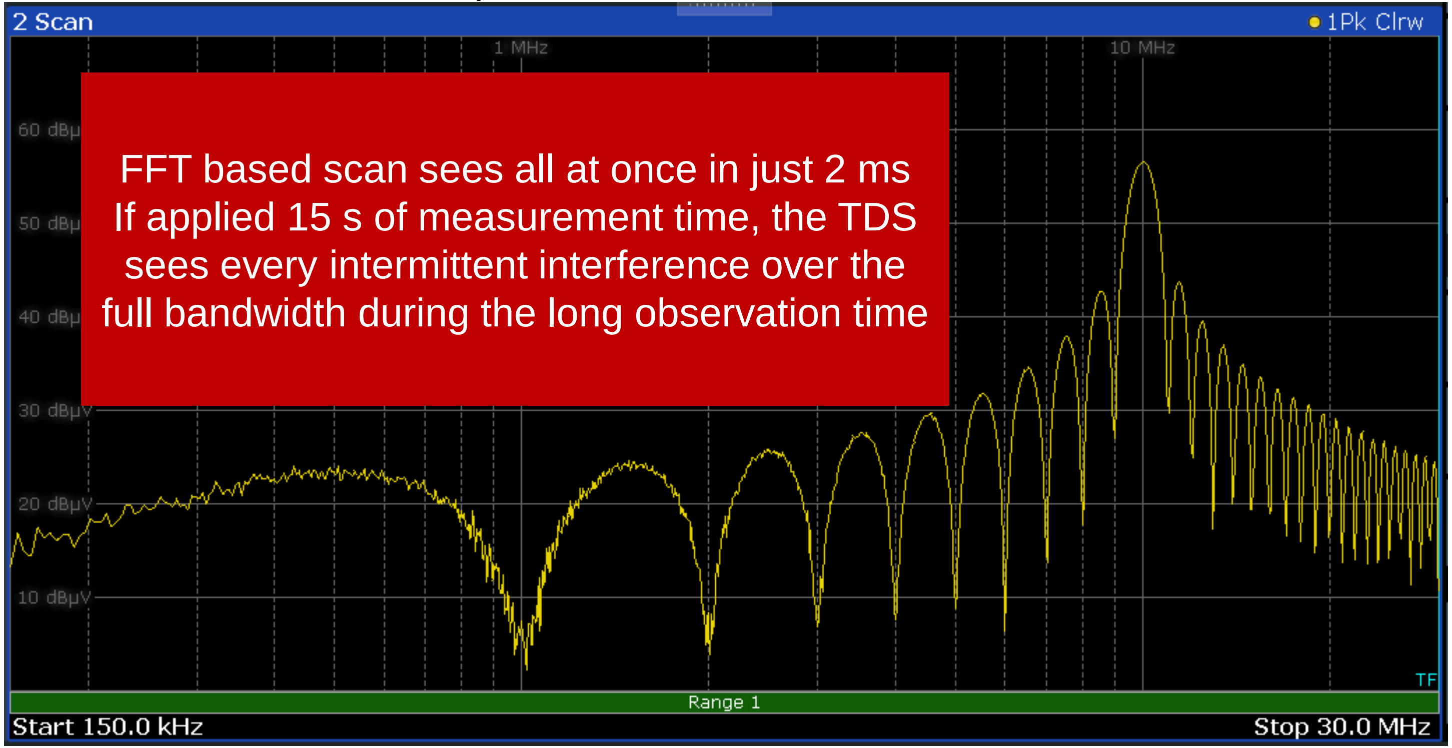
STEPPED SCAN @ 2 MS MEASUREMENT TIME

Period: *2 ms*, Duration: *1 µs*



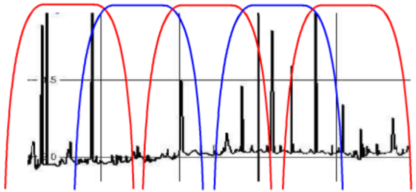
TIME DOMAIN SCAN @ 2 MS MEASUREMENT TIME

Period: *2 ms*, Duration: *1 µs*

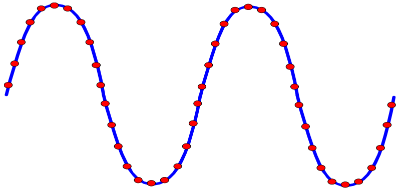


FFT BASED TIME DOMAIN SCAN

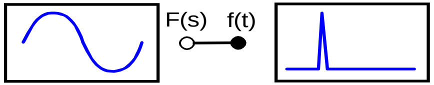
FFT-BASED TEST RECEIVER



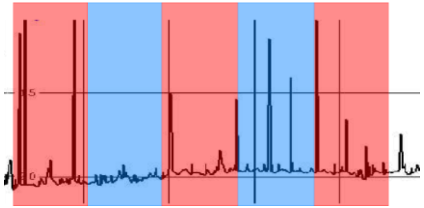
Frequency range
Split the measured frequency range in consecutive frequency intervals



Time-domain
Sampling of the filtered signals with high sampling rate/resolution and windowing



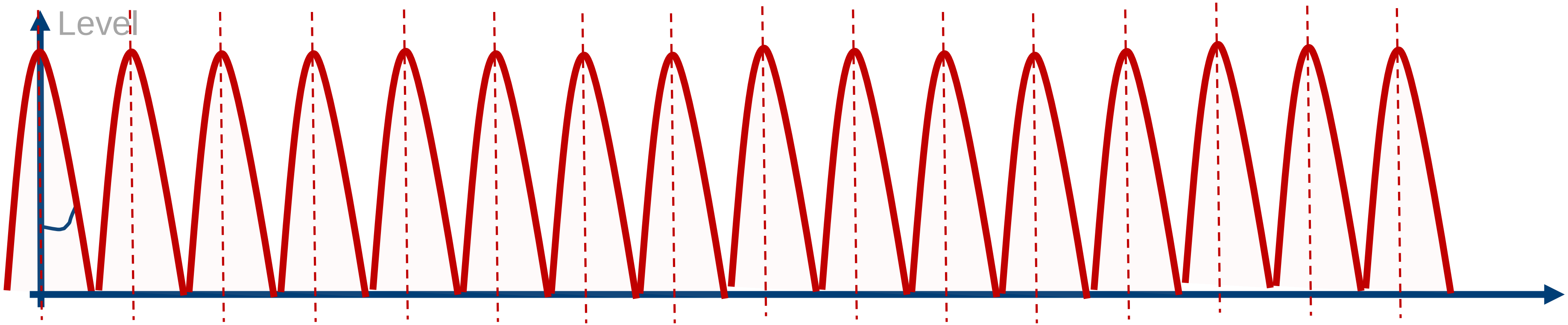
Fast-Fourier transform
Signal transformation of the filtered signals from time to frequency domain in blocks



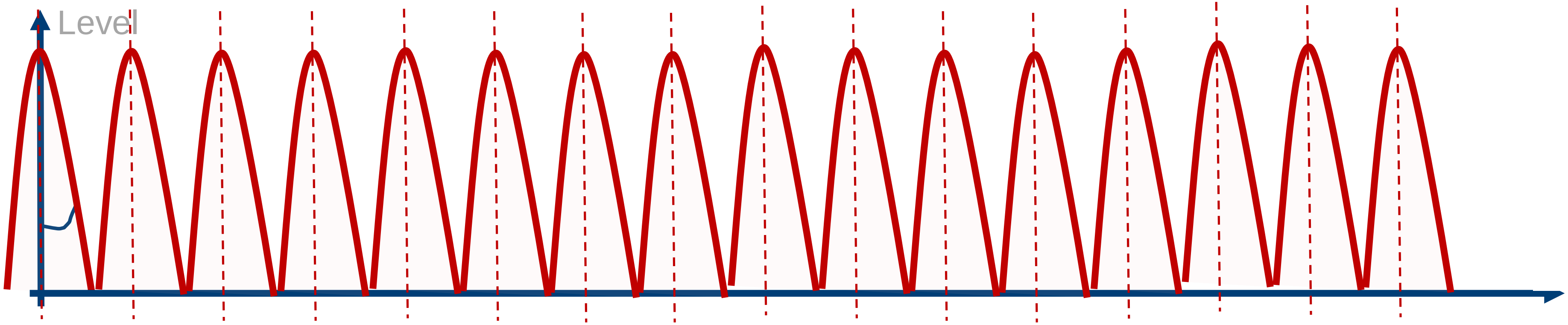
Frequency domain
Merging the spectral distributions of all frequency blocks

SWEEP

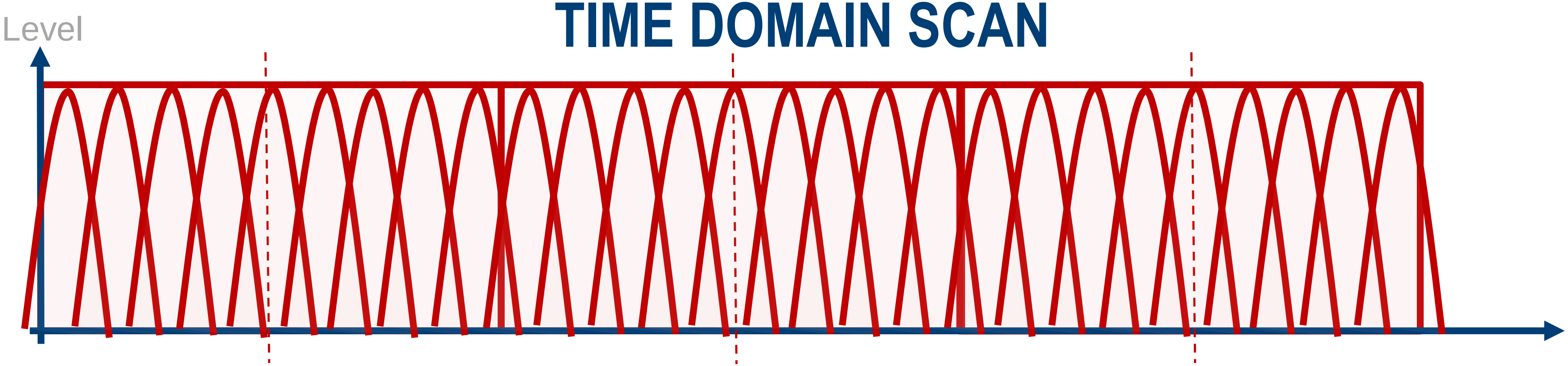
STEPPED SCAN



STEPPED SCAN



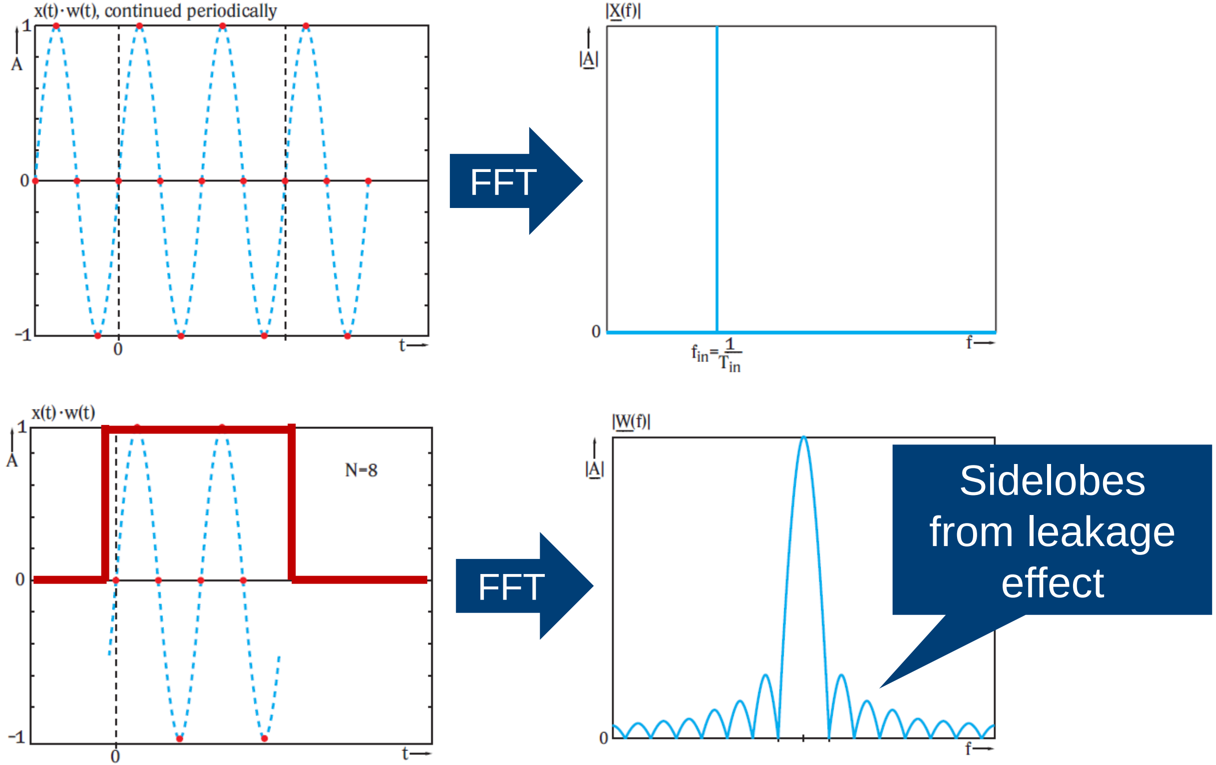
TIME DOMAIN SCAN



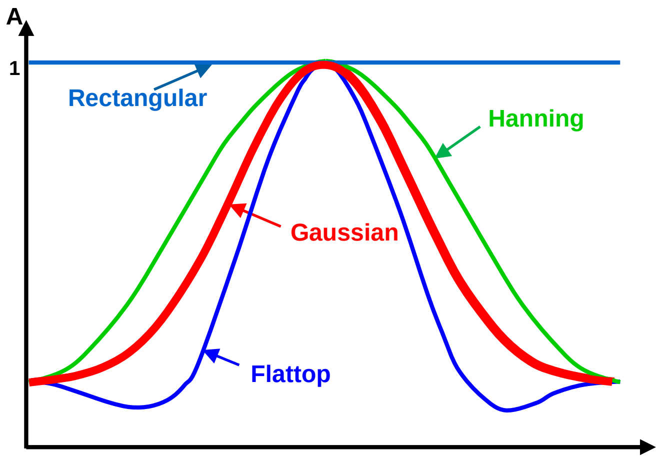
LEAKAGE EFFECT

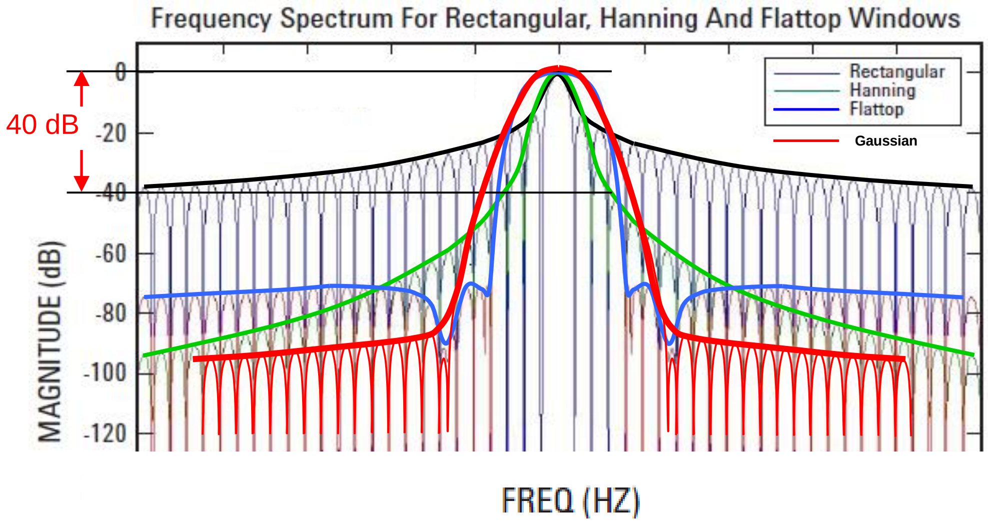
Continued periodical signal (infinite)

Windowed, finite time interval of signal



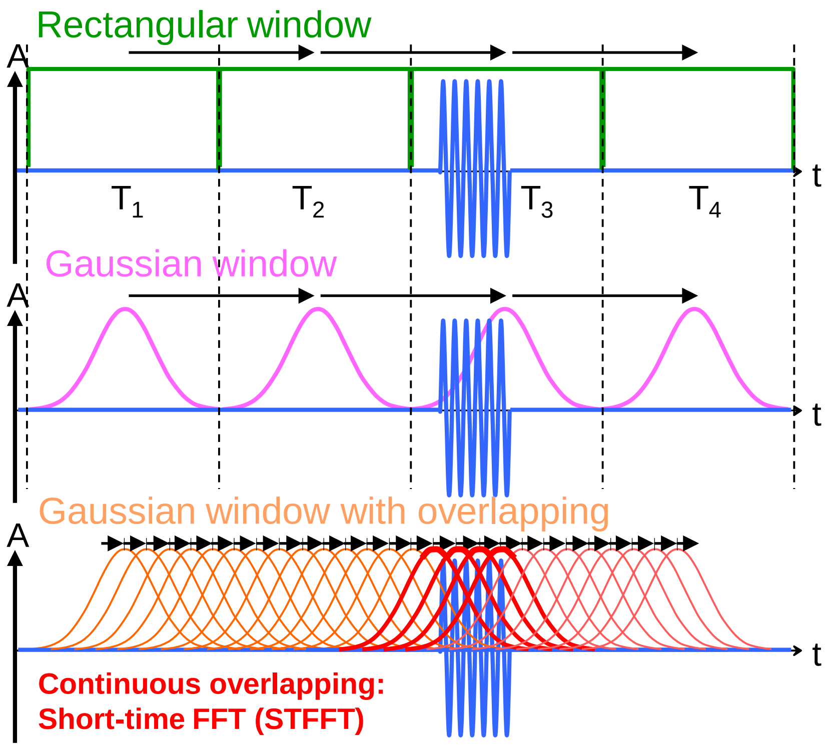
LEAKAGE EFFECT – WINDOWING

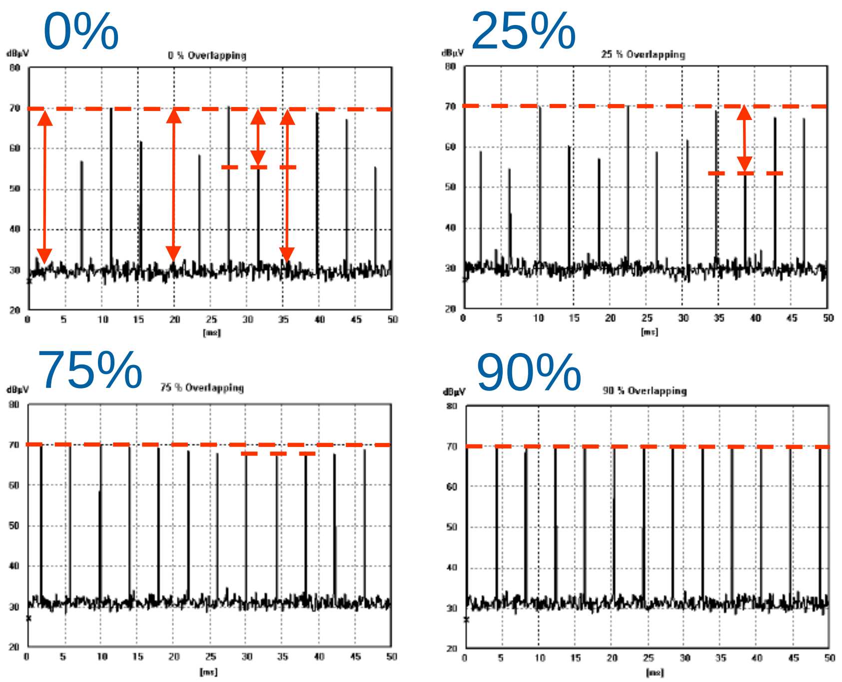




➔ Gaussian window suppresses the sidelobes the best to achieve optimal accuracy

FFT OF INTERMITTENT SIGNALS





Reference:

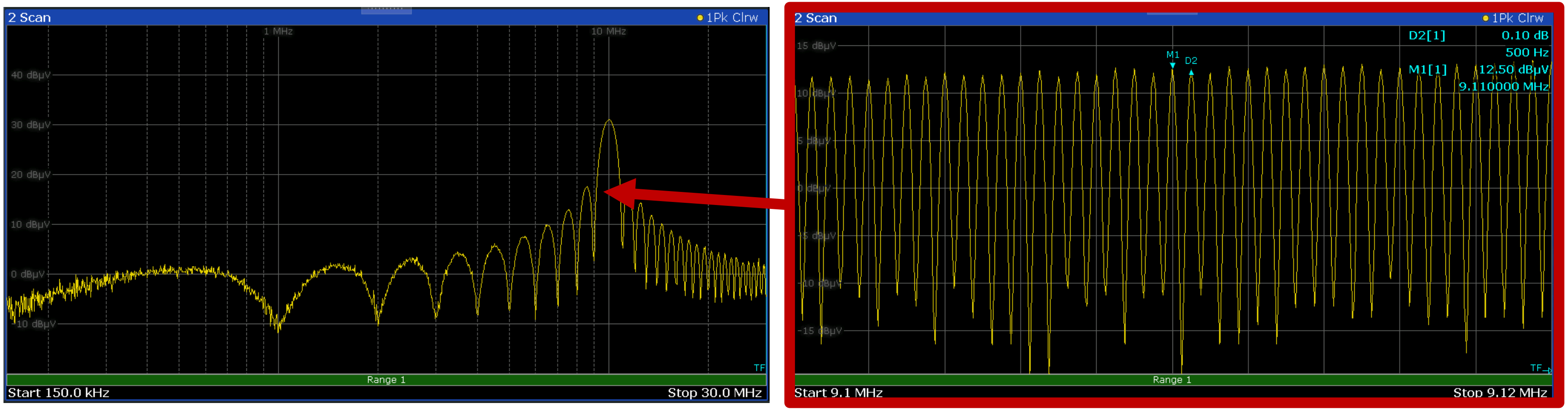
TR CISPR 16-3 © IEC:2010(E)

200 HZ RESOLUTION BANDWIDTH

- Trace points: $\frac{30\ MHz - 150\ kHz}{\frac{200\ Hz}{4}} = 597000$

More points than displayable on screen (~ 1000)

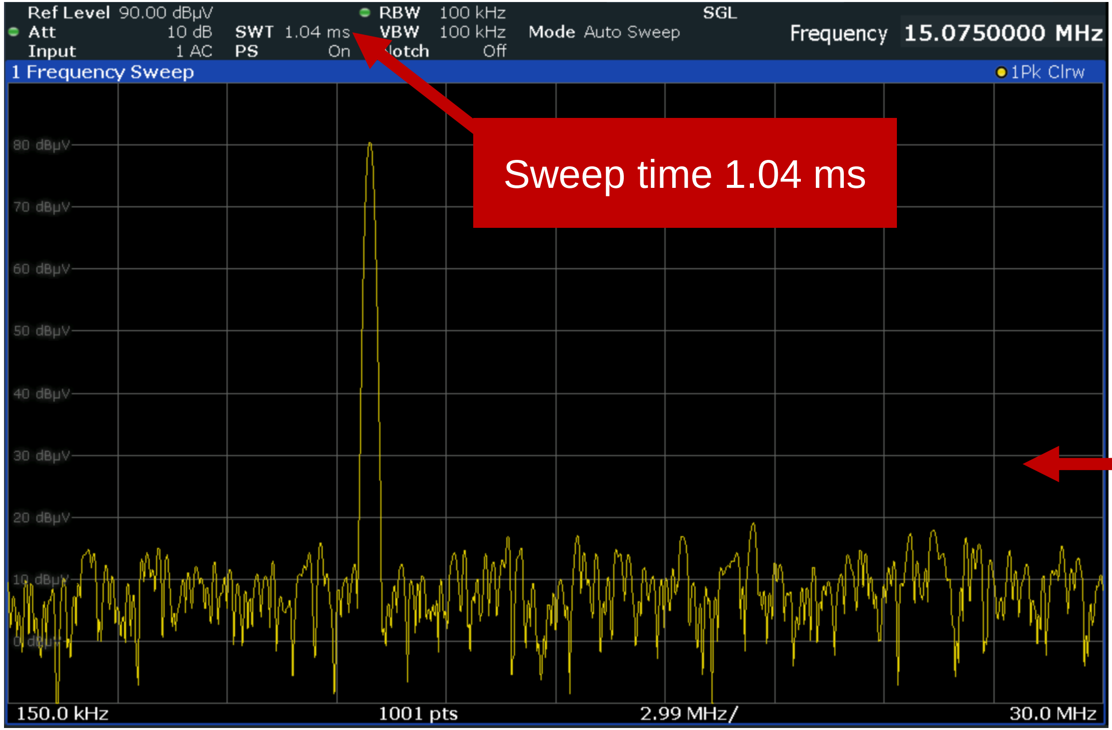
Zoom to 9.1 MHz … 9.12 MHz



COMPARISON WITH SPECTRUM ANALYZER SWEEP

MEASUREMENT WITH SPECTRUM ANALYZER

Period: *2 ms*, Duration: *1 µs*

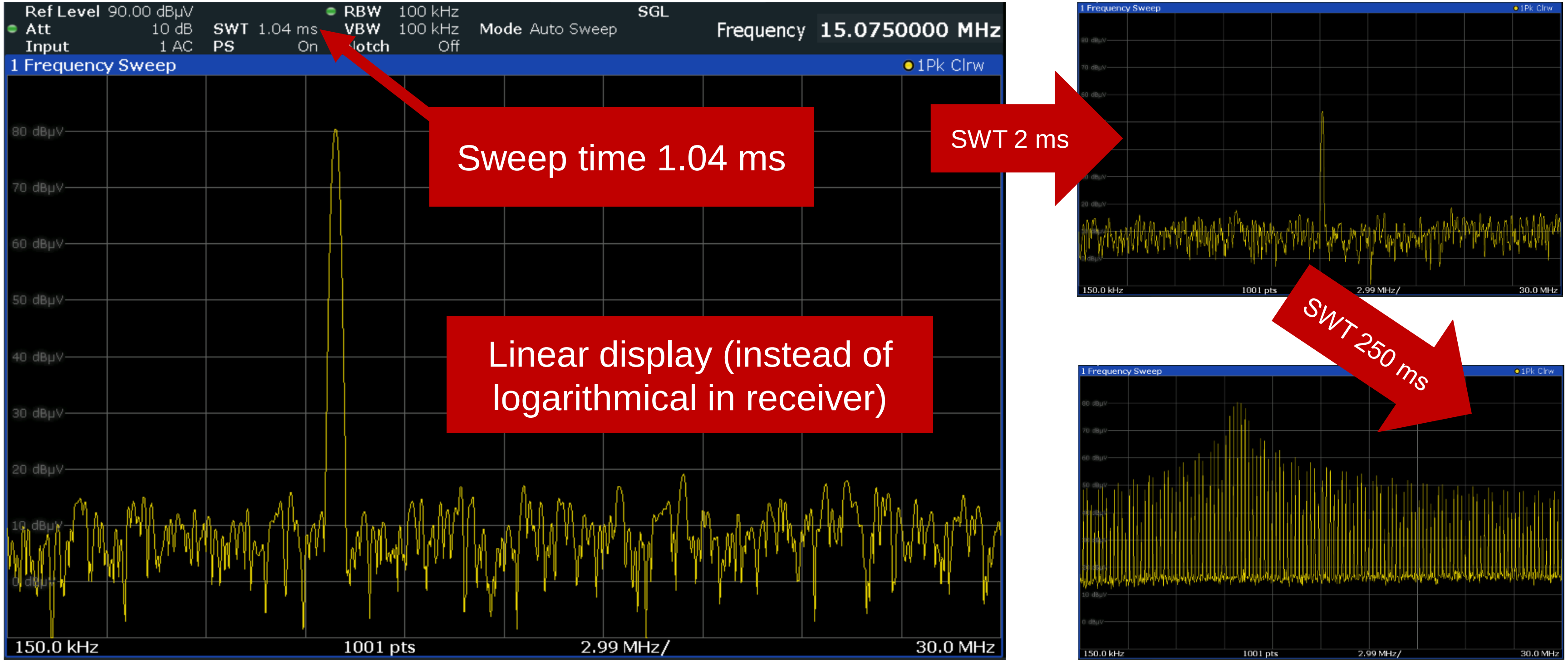


Sweep time 1.04 ms

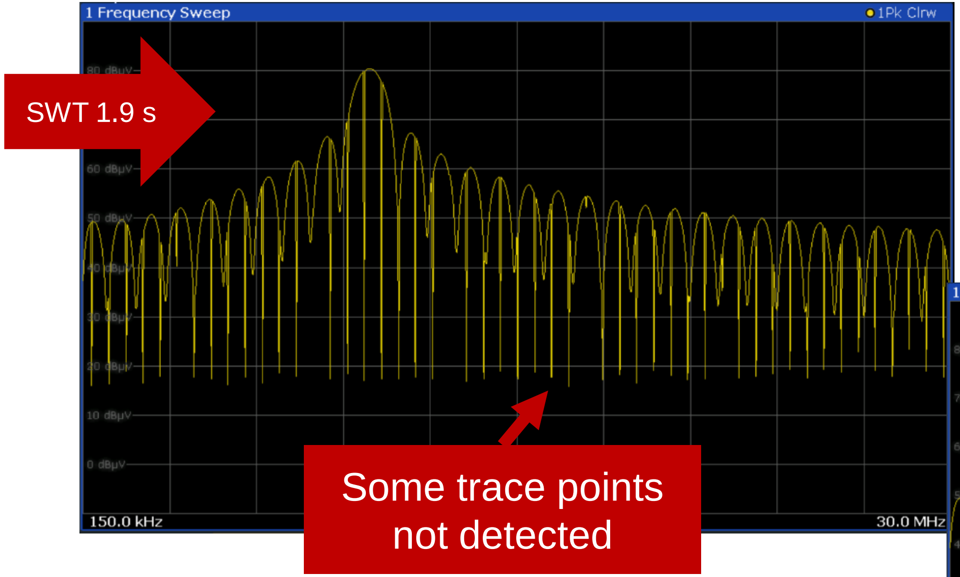
Linear display (instead of logarithmical in receiver)

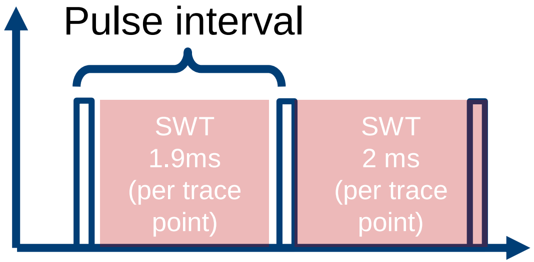
MEASUREMENT WITH SPECTRUM ANALYZER

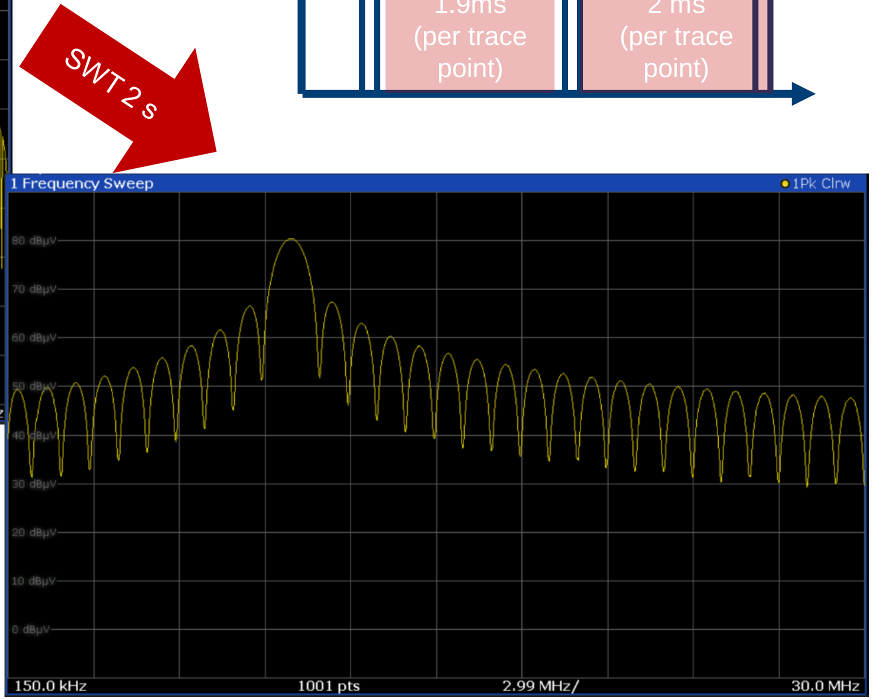
Period: *2 ms*, Duration: *1 µs*



MEASUREMENT WITH SPECTRUM ANALYZER

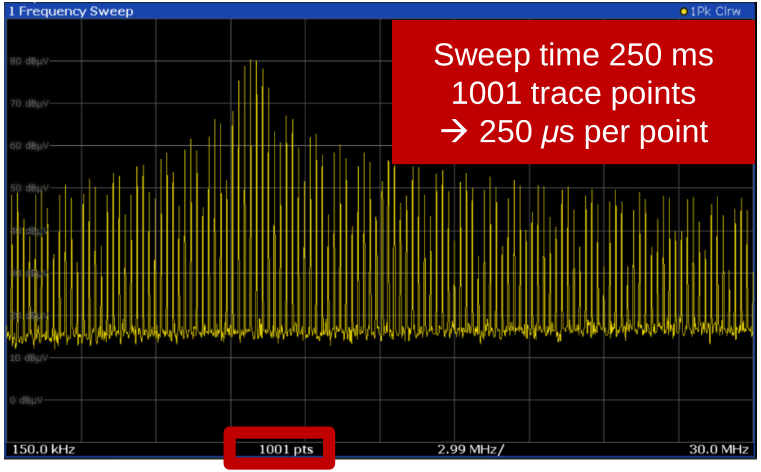


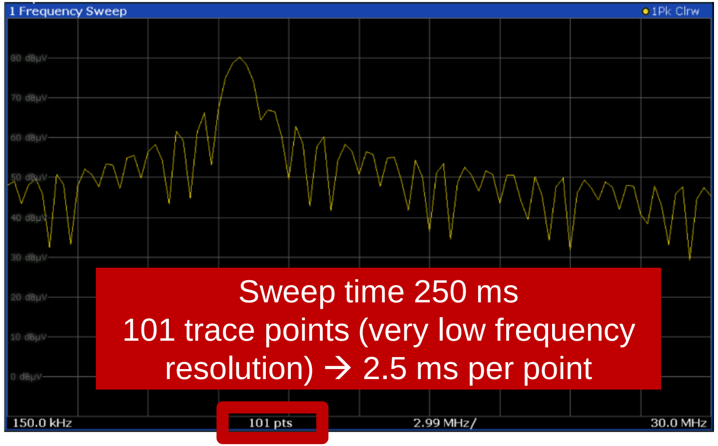


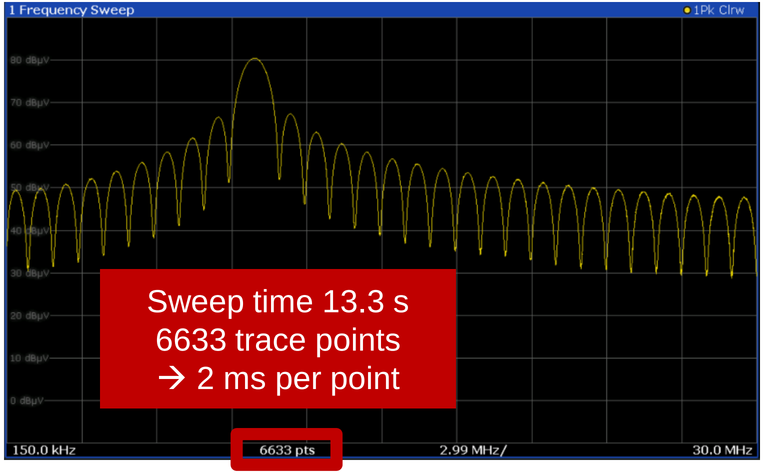


MEASUREMENT WITH SPECTRUM ANALYZER

Period: *2 ms*, Duration: *1 µs*



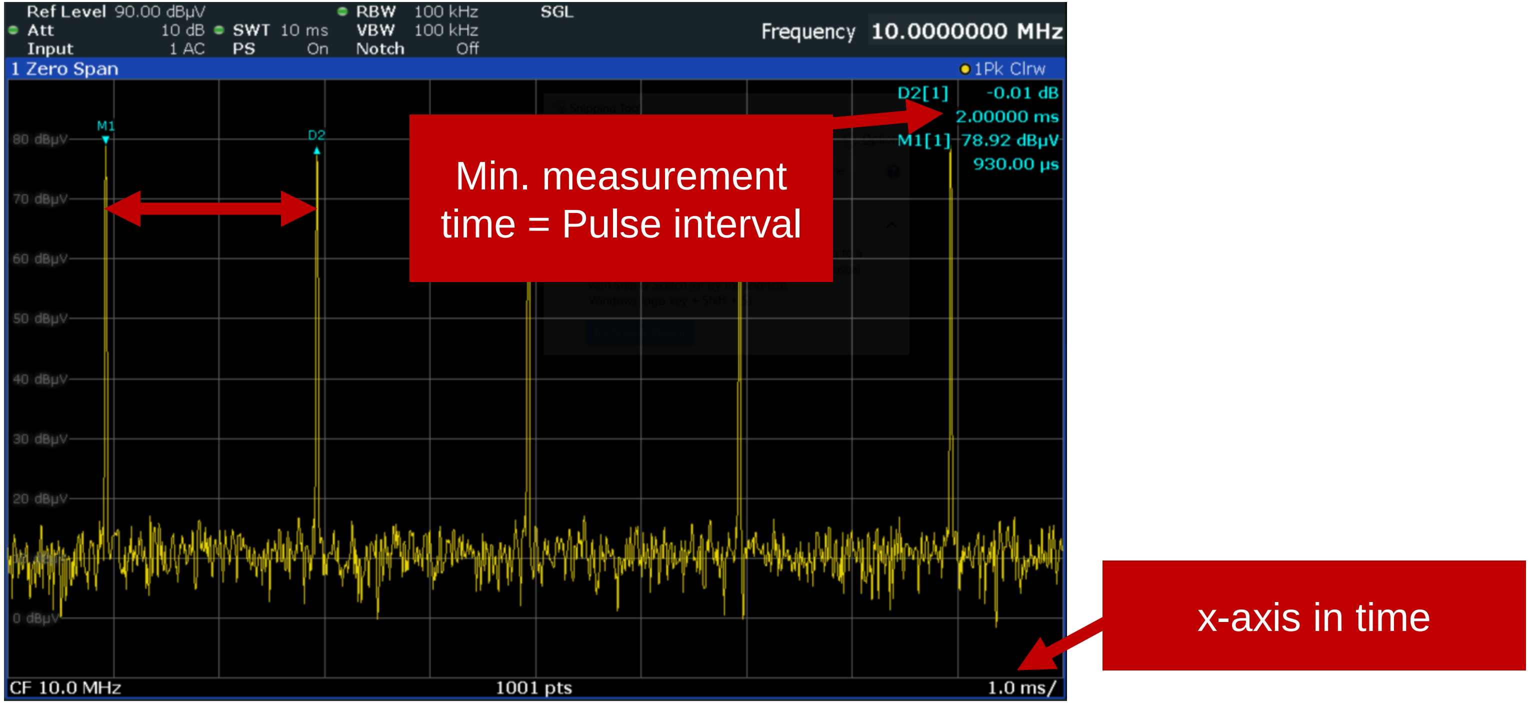




- Trace points: $\frac{30\ MHz - 150\ kHz}{\frac{9\ kHz}{2}} \approx 6633$
  (Minimum requirement by CISPR 16-2)
- Measurement time: $6633 \cdot 2\ ms \approx 13.27\ s$

FIND PULSE PERIOD IN ZERO SPAN MODE

- Single frequency displayed over time



WIDEBAND TIME DOMAIN SCAN

KEY FEATURES OF NEW ESW WIDEBAND OPTION

970 MHz
FFT bandwidth

- 100/120 kHz RBW
- 30 MHz – 1 GHz

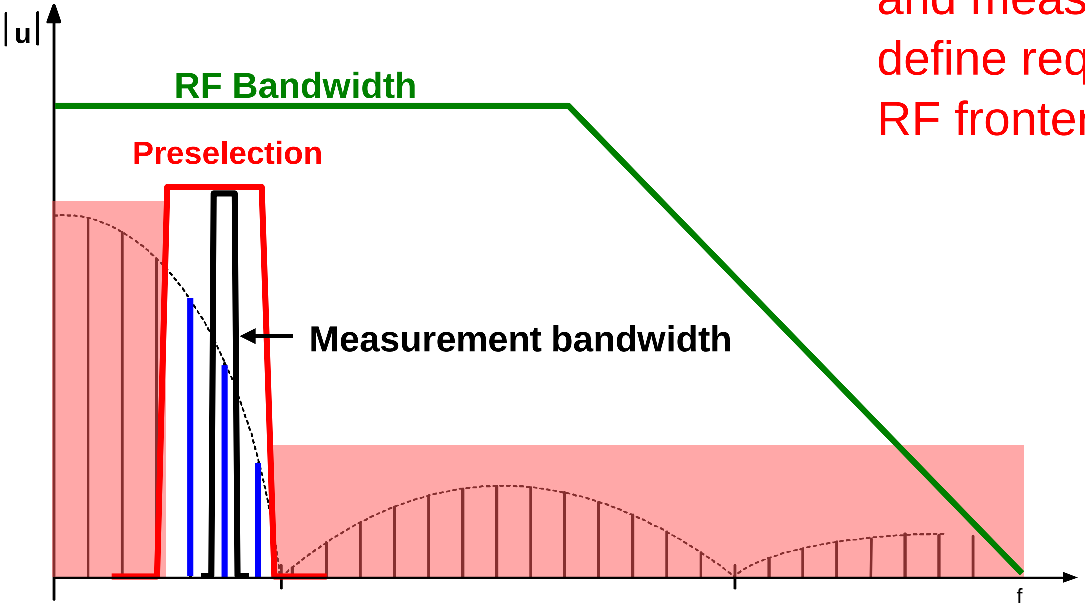
Real-time
Gapless measurements in receiver spectrogram

CISPR detectors
Simultaneous measurement of CISPR detectors at full bandwidth

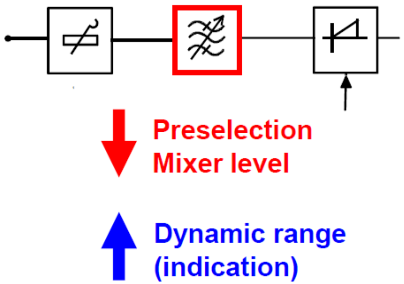
Pulse resolution 5 Hz - Fully compliant in CISPR Band D (300 MHz - 1 GHz)

PRESELECTION FILTER

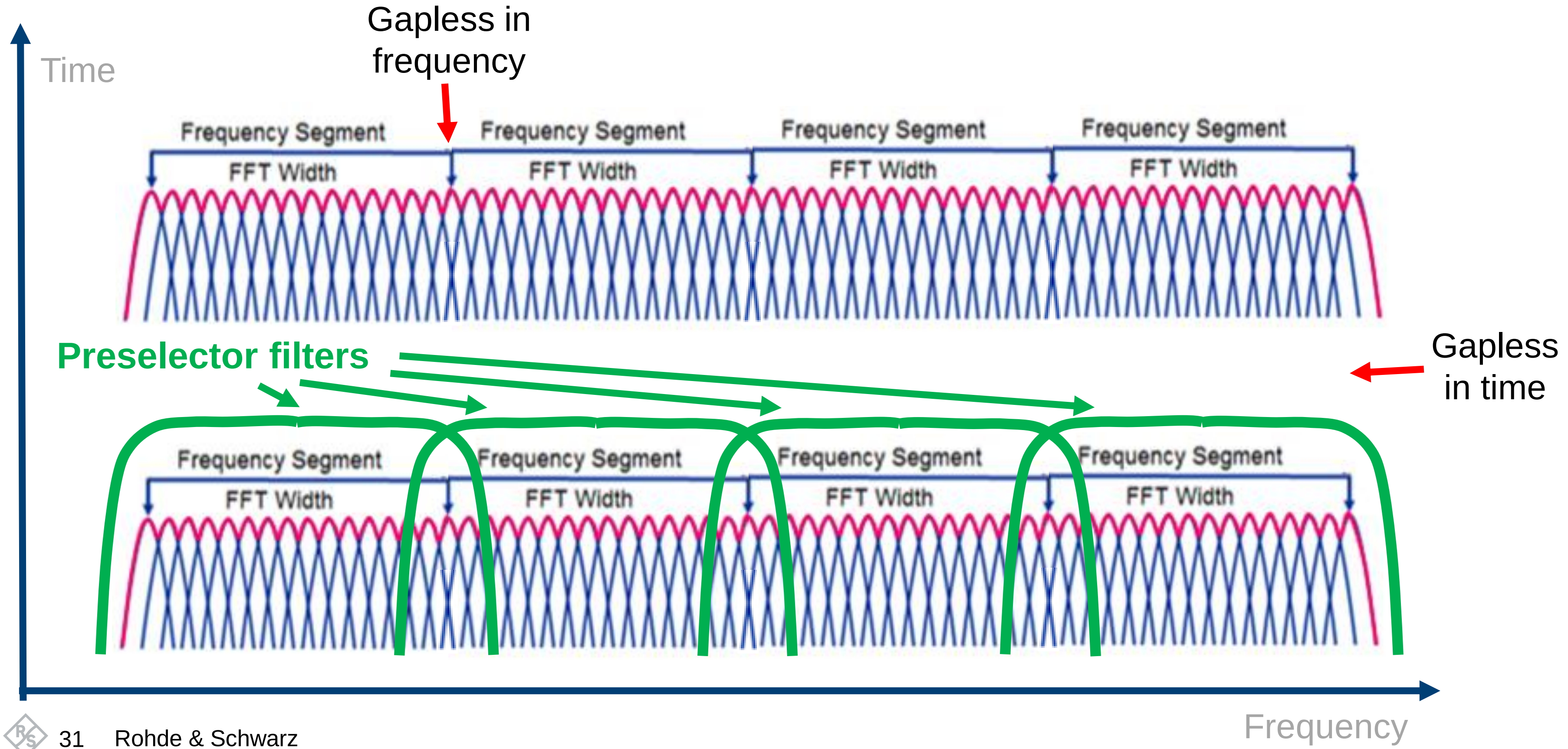
Pulse in frequency domain



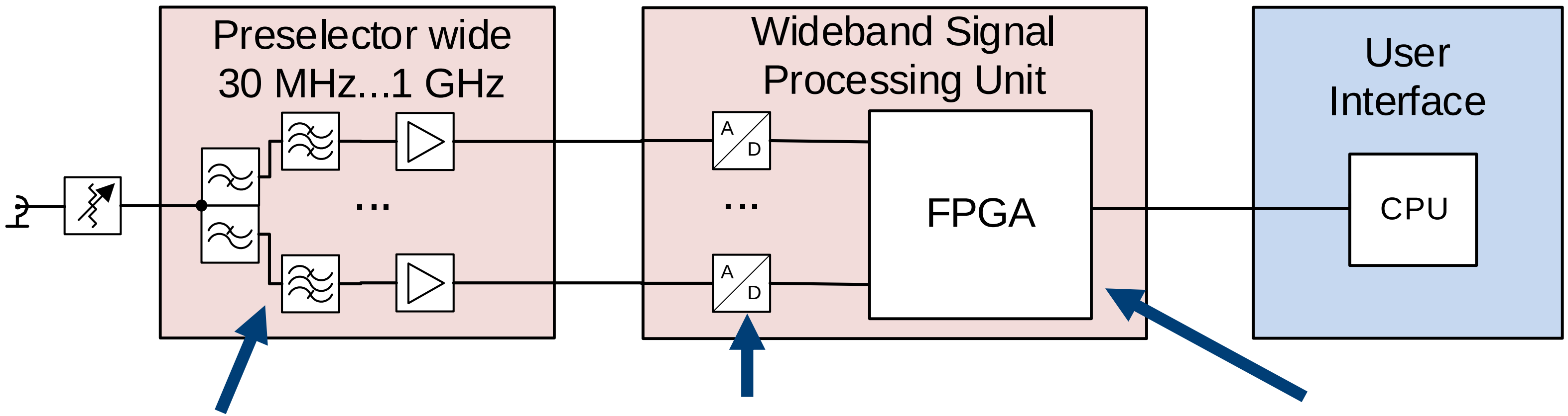
Ratio of Preselector bandwidth and measurement bandwidth define required dynamic range of RF frontend and ADC



PARALLEL MEASURED FFT-SEGMENTS



CONCEPT OF NEW ESW WIDEBAND OPTION



Parallel signal paths cover
CISPR bands C and D

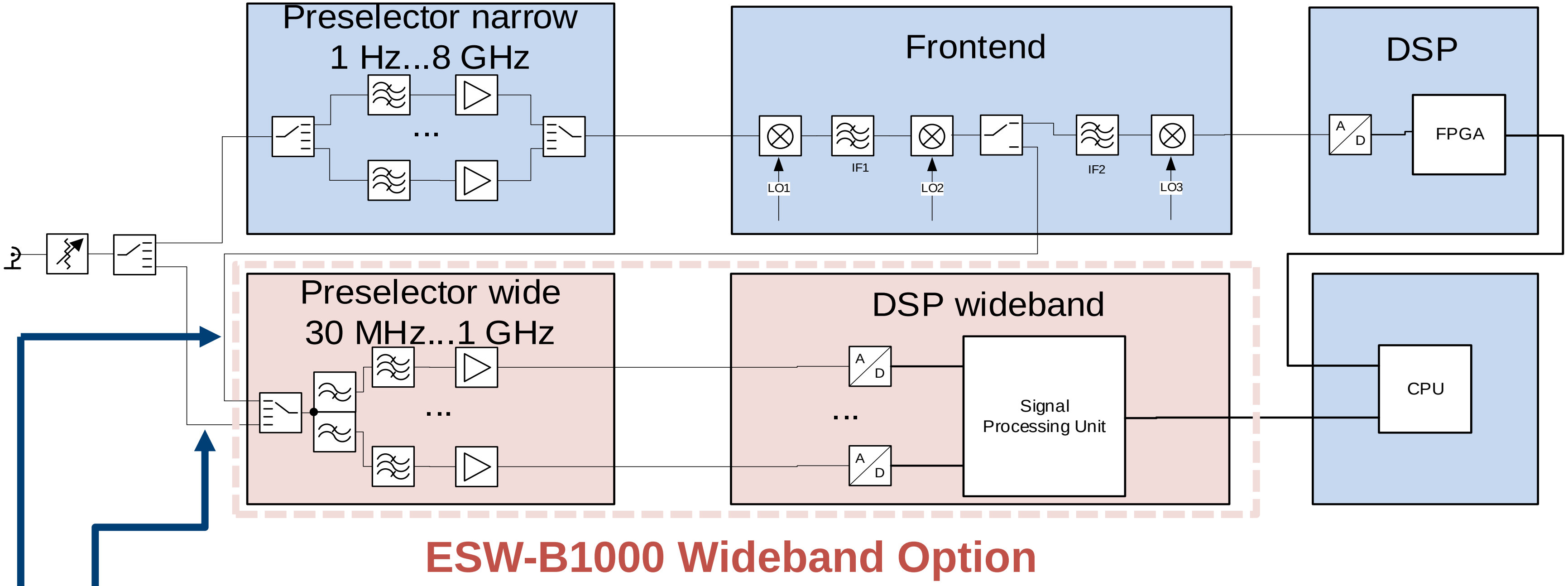
All eight paths have their own preselection and preamplifier to achieve **maximum dynamic range**

Parallel A/D converters

Split signal path increases dynamic range for pulses

Massive computing power to calculate the spectrum in **real-time**

ESW EQUIPPED WITH NEW WIDEBAND OPTION



- Direct path up to 1 GHz (full 970 MHz FFT bandwidth)
- Connection to IF2 @ > 1 GHz (450 MHz FFT bandwidth)

ADVANTAGES OF WIDEBAND TESTING

Commercial

- Direct QP measurement
- Higher speed
- Better insight for debugging

MIL

- Longer Meas Time
- Probability of intercept
- Wide spectrogram for analysis

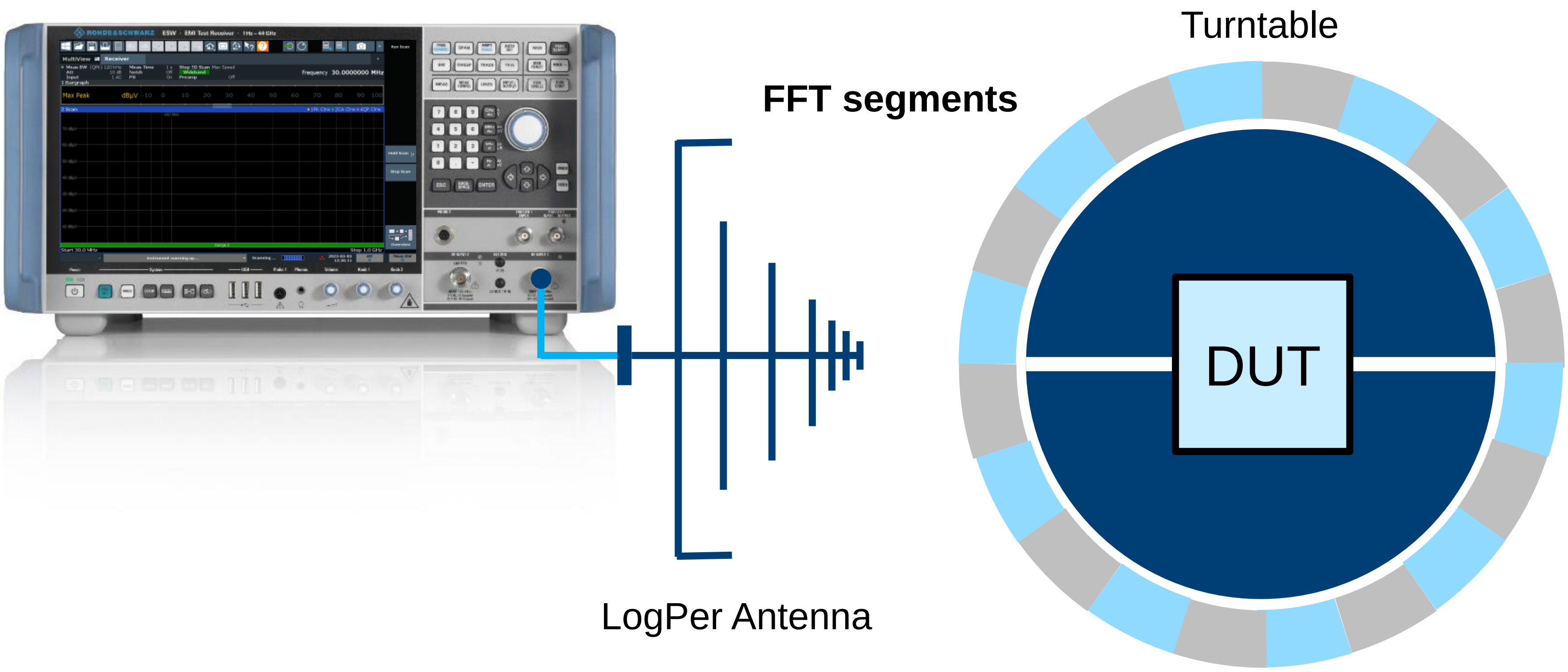
Automotive

- Greater insight for debugging
- Higher speed

COMMERCIAL TESTING

- ▶ Challenging DUT‘s
  - – Short operating modes
  - – High complexity
- ▶ Direct QP measurement
  - – CISPR Band C+D at one shot

CONSTANT TURNTABLE ROTATION



IN-SITU COMMERCIAL TESTING

- CISPR 37
  - Direct QP measurement recommended (instead of prescan → critical frequency selection → final scan)

  - High variability in ambient noise
  - Reproducability
  - Constant operating mode

WIDEBAND FFT

► Evolution towards very wide FFT bandwidth for faster measurement