Merjenje EMC

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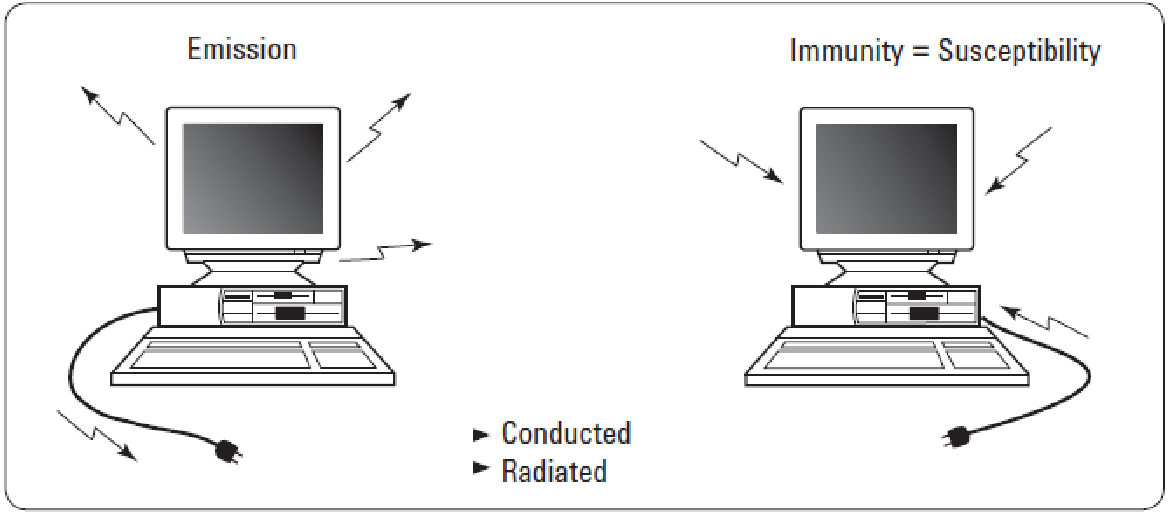
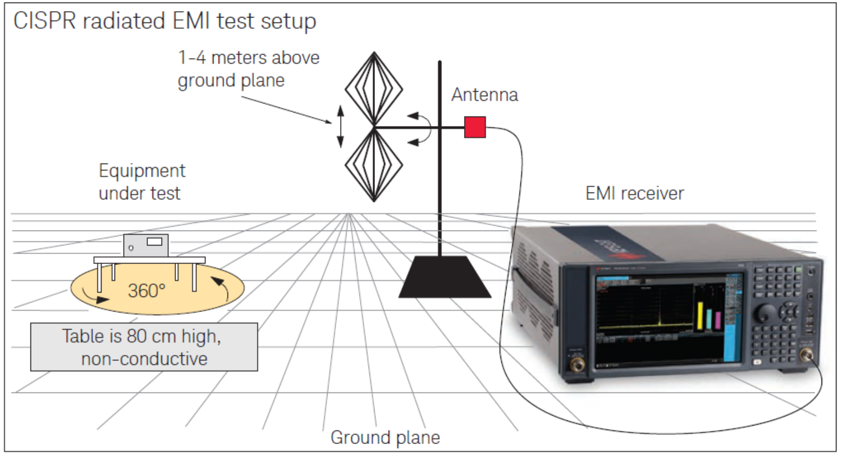
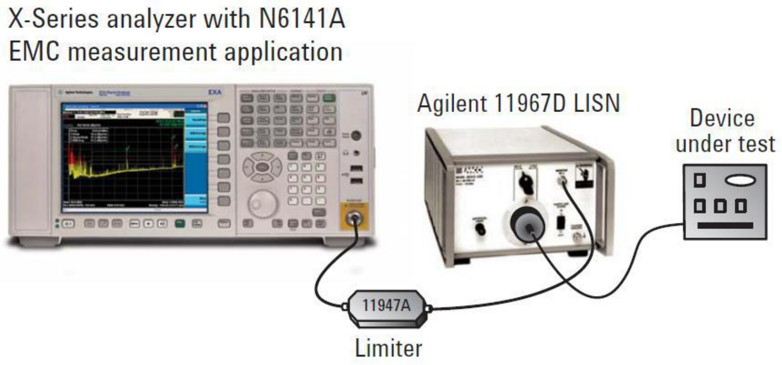
Amiteh d.o.o.

EMC

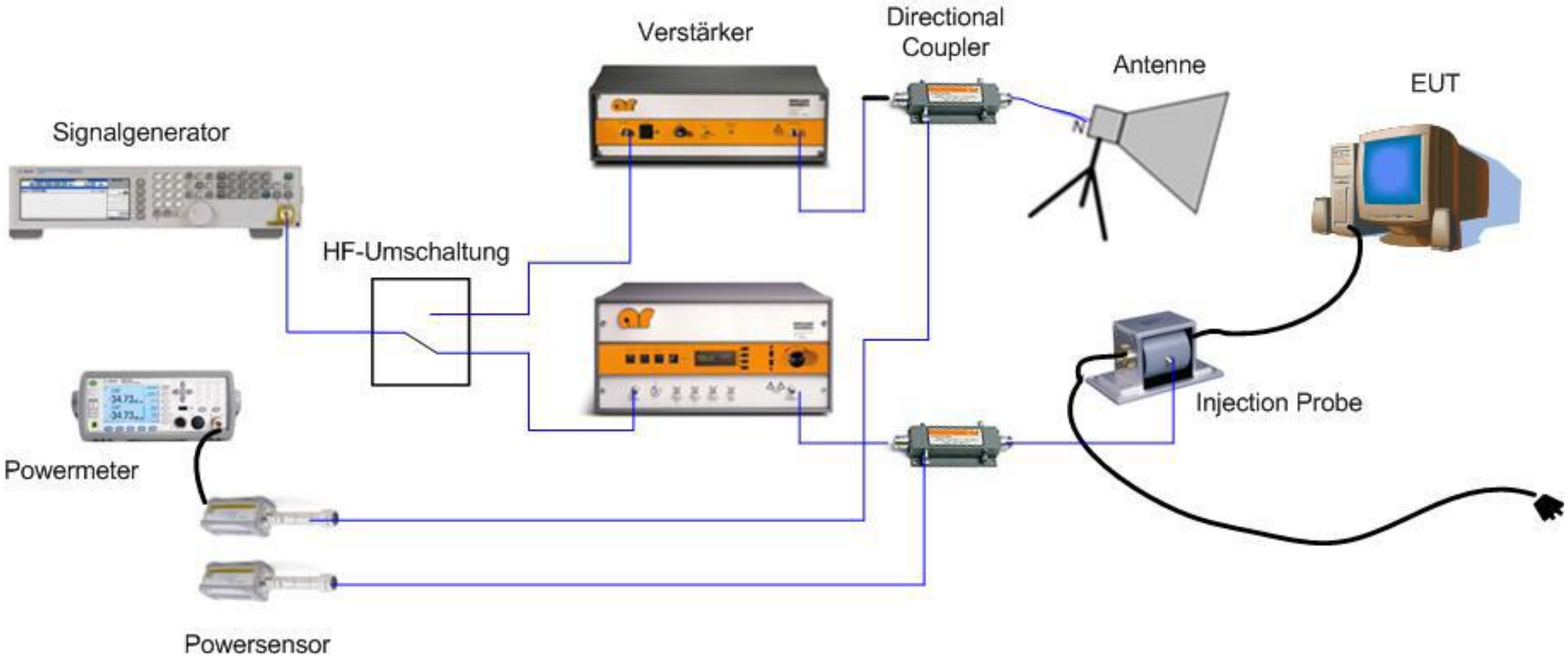


EMC – emisije


CISPR radiated EMI test setup
1-4 meters above
ground plane
Antenna
Equipment
under test
EMI receiver
360°
Table is 80 cm high,
non-conductive
Ground plane

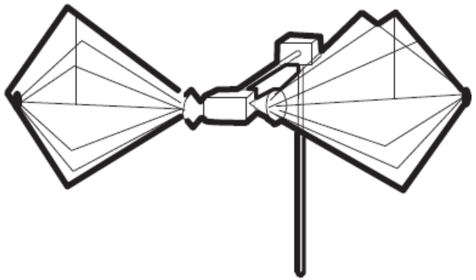

X-Series analyzer with N6141A
EMC measurement application
Agilent 11967D LISN
Device
under test
11947A
Limiter

EMC - odpornost

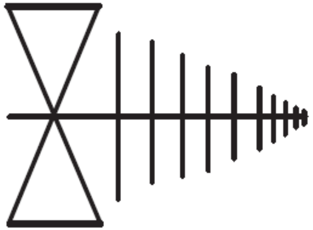


EMC – antene

Biconical antenna
(30 - 300 MHz)

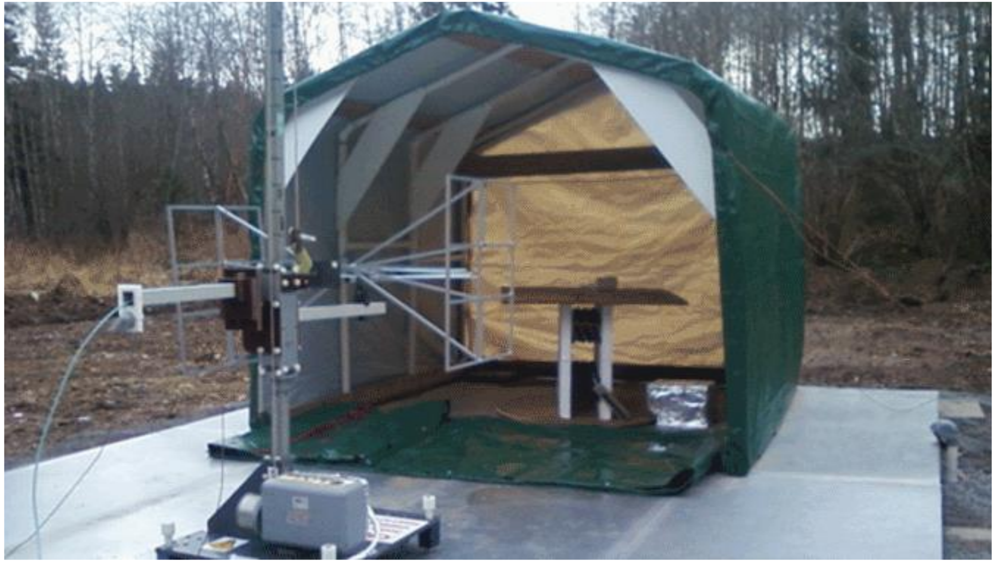


Broadband antenna
(30 - 1000 MHz)

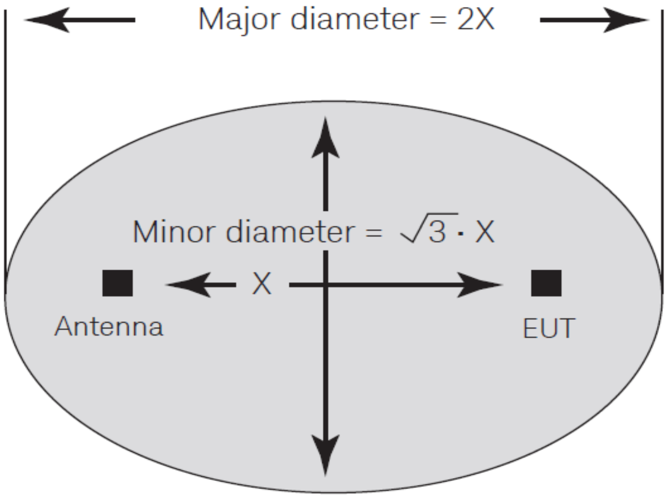


Log periodic antenna
(200 - 1000 MHz)

EMC – merilno okolje

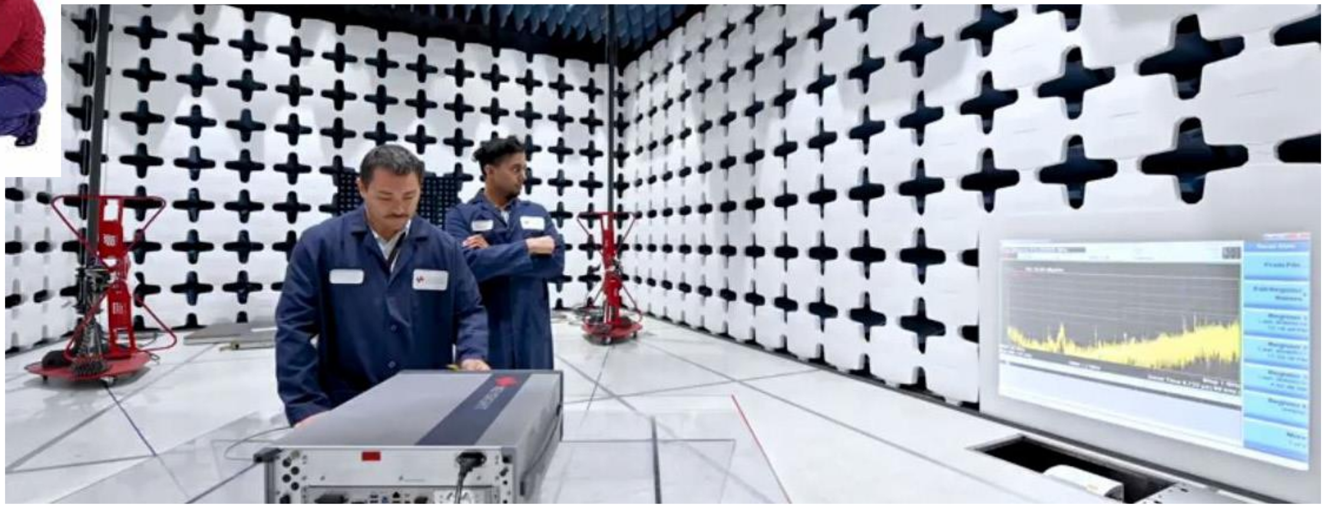


Open Area Test Site (OATS)



EMC – merilno okolje

GTEM celica



Gluha soba

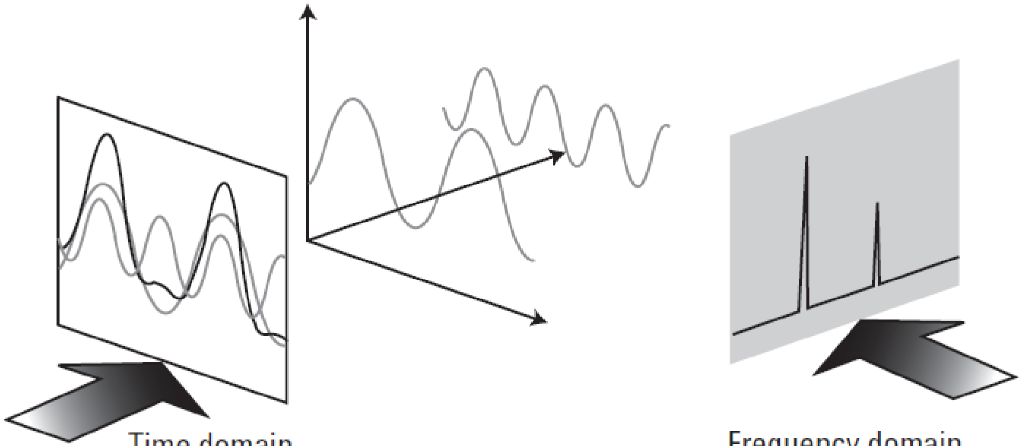
AMITEH

Time-domain measurements

Time-domain measurements include:

- Pulse rise and fall times,
- Overshoot
- Ringing
- Period and frequency
- Positive and negative width
- Tmin, Tmax, Tvolt
- Channel-to-channel phase
- …

What is a spectrum?

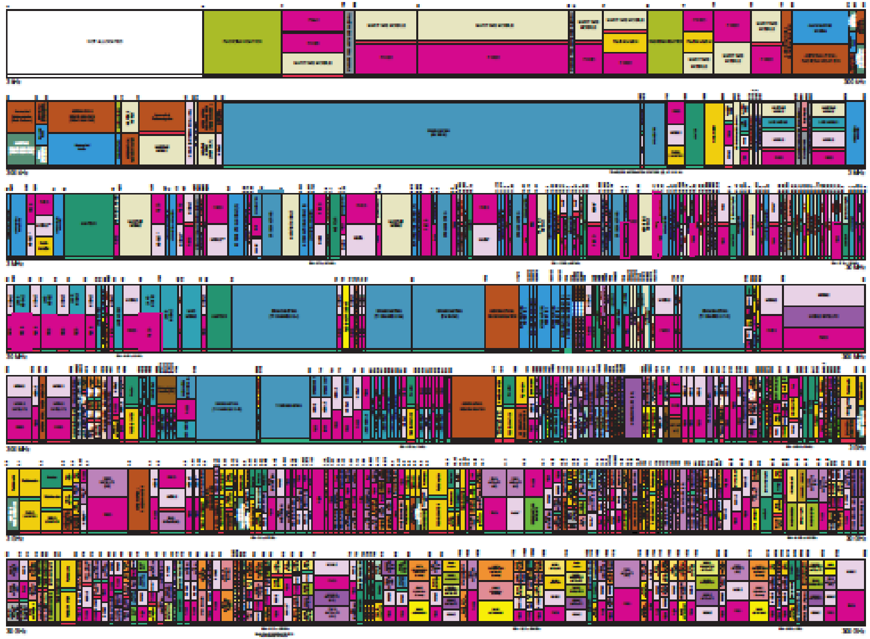


A spectrum is a collection of sine waves that, when combined properly, produce the time-domain signal under examination.

Types of signal analyzers

- Swept-tuned, superheterodyne analyzers (measuring receivers, spectrum analyzers)
- Fourier analyzers
- Vector signal analyzers

Why measure spectra?



Spectrum monitoring

- Government regulatory agencies
- Security

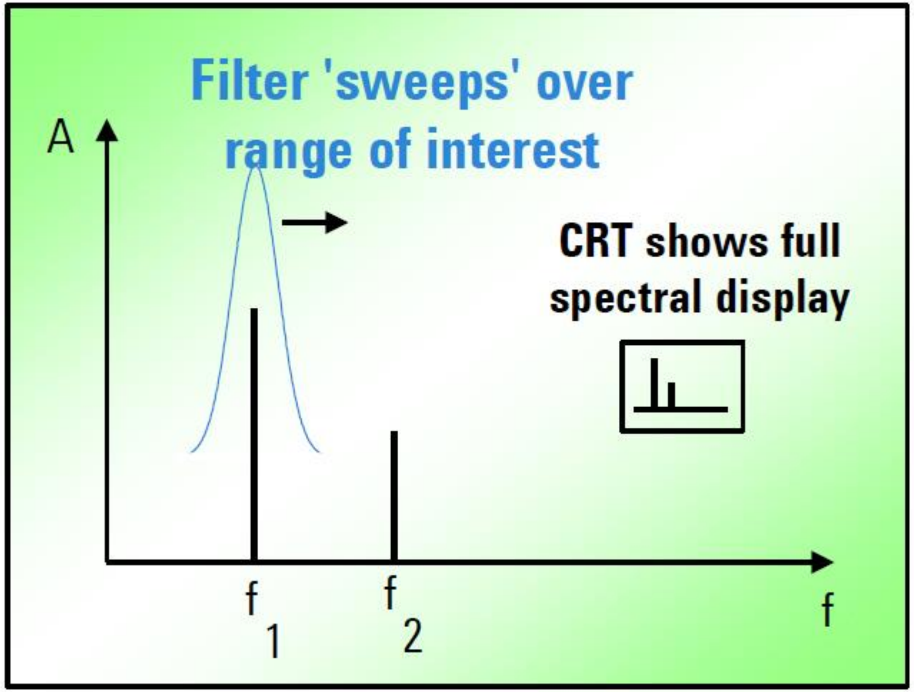
Electromagnetic interference

- radiated or
- conducted

unwanted emissions

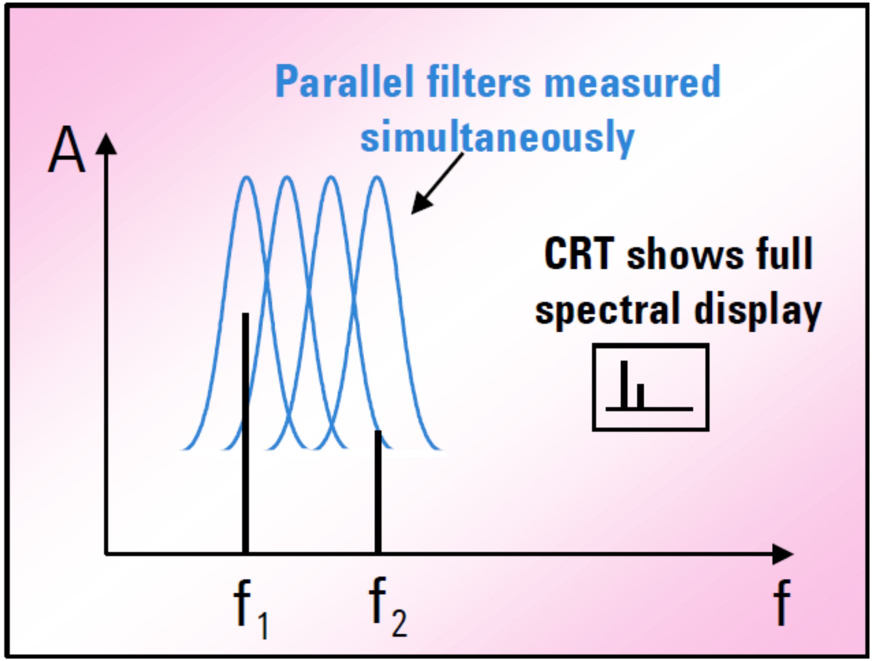
TEMPEST

Swept-tuned receiver



These analyzers "sweep" across the frequency range of interest, displaying all the frequency components present.

Fourier analyzers



Fourier analyzers take the time domain information, digitize it, and then perform the mathematics required to convert to the frequency domain, and display it. The concept is as if there were a bank of parallel filters measuring the range of frequencies simultaneously.

Measuring receivers

Measuring receivers are widely used in metrology and calibration lab environments, spectrum monitoring and electromagnetic-compatibility facilities.

Measuring receivers are used **with calibrated antennas** to

- determine the signal-strength and standards-compliance of broadcast signals,
- investigate and quantify radio-frequency interference,
- determine compliance of a device with electromagnetic interference and TEMPEST standards and regulations.

Measuring receivers are also used **without antennas** to

- Calibrate RF attenuators and signal generators.

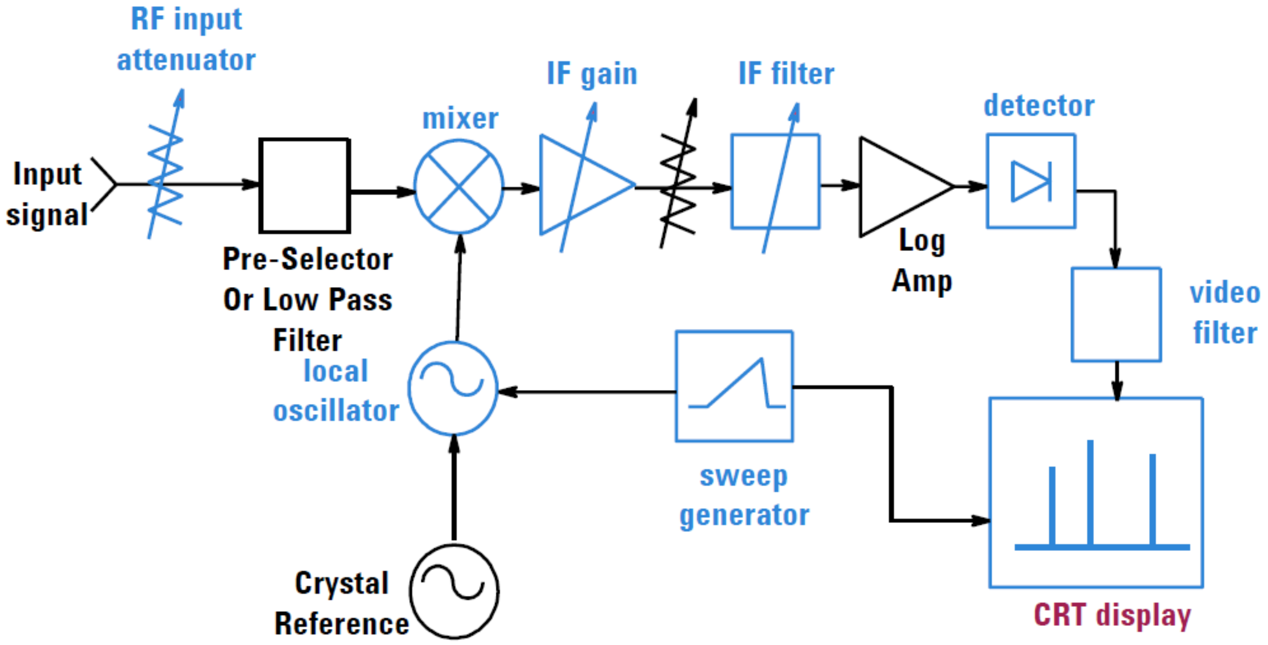
Measuring receivers

Frequencies up to 110 GHz
Maximum information bandwidth 11 GHz

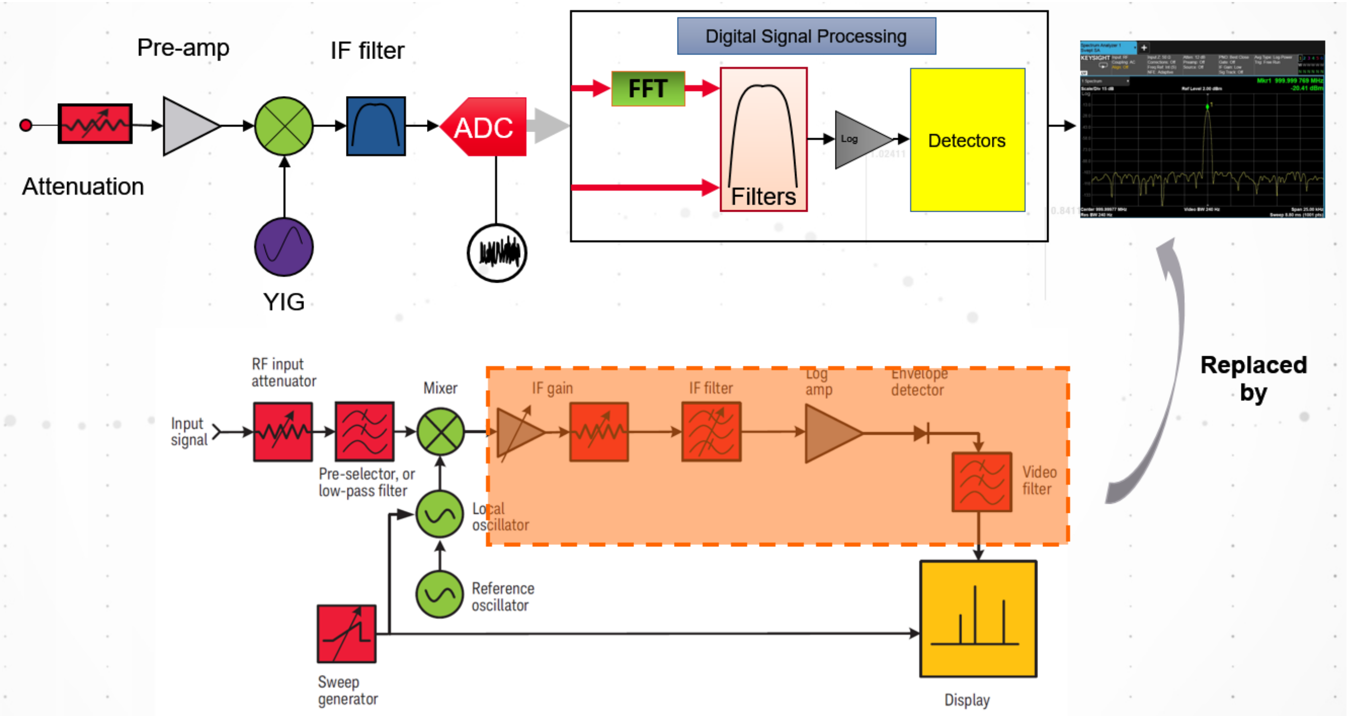
Key measurements include:

Frequency counter
Absolute RF power
Tuned RF level
TRFL with tracking
AM depth, FM deviation, PM deviation
Modulation rate, Modulation distortion
Modulation SINAD
Audio frequency
Audio AC level
Audio distortion
Audio SINAD
Auto carrier triggering
CCITT filters

Theory of Operation

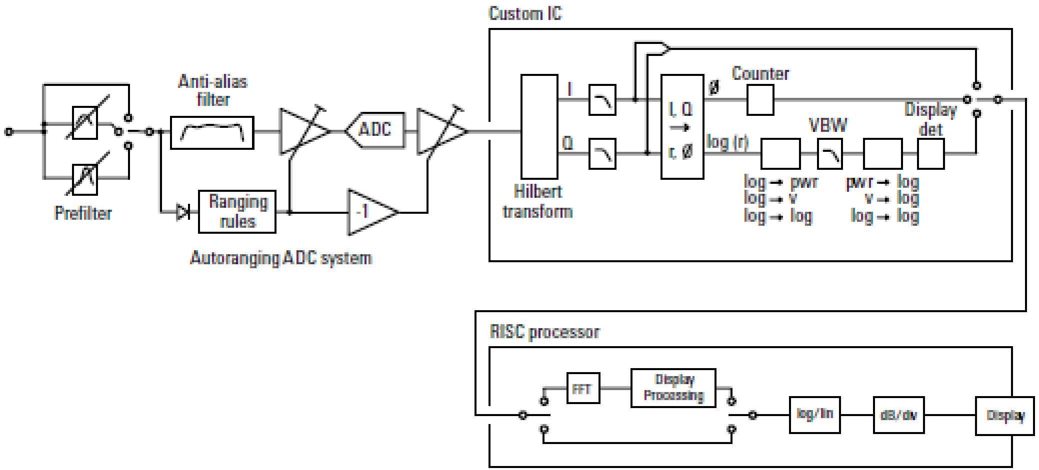


Theory of Operation
Modern Spectrum Analyzer



Digital IF Overview

The All-digital IF



Advantages:

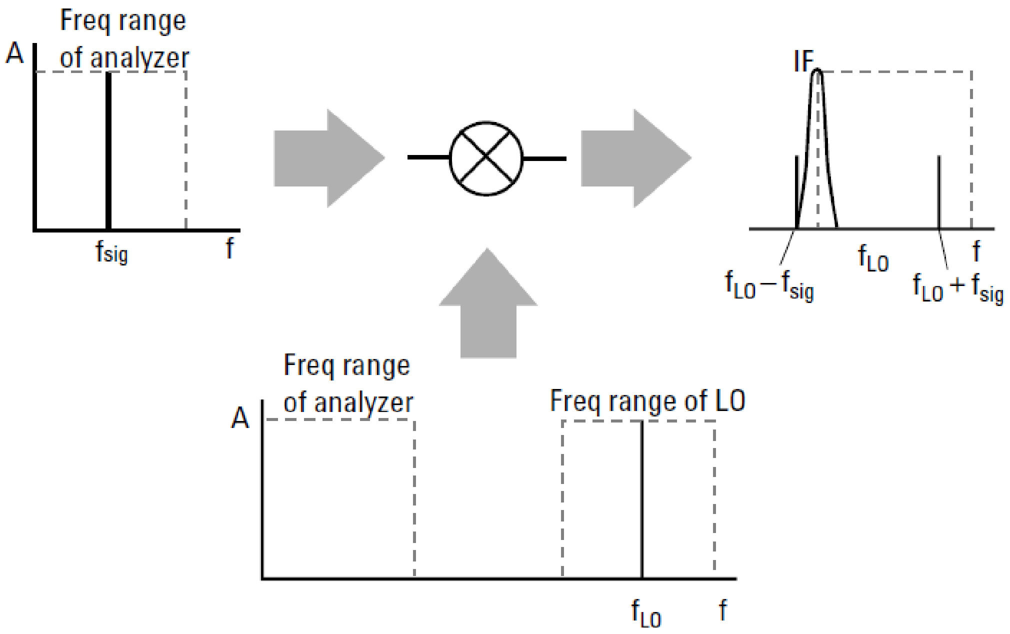
Faster response/shorter sweep times
Better selectivity
Better bandwidth accuracy
Smaller gain vairation between RWBs
Preserves amplitude and phase info
FFT possible
Advanced display posibilities
Frequency counter
More accurate log amplifier

Theory of Operation

Time Domain Scan

CISPR band C / D	Stepped scan	TDS	Accelerated TDS
30 MHz to 1 GHz Quasi-peak detector, one second dwell time; 120 kHz resolution bandwidth	9 hours	46 seconds	6 seconds
Four antenna positions (Left and right sides / vertical and horizontal orientations)	36 hours	184 seconds	24 seconds

Theory of Operation

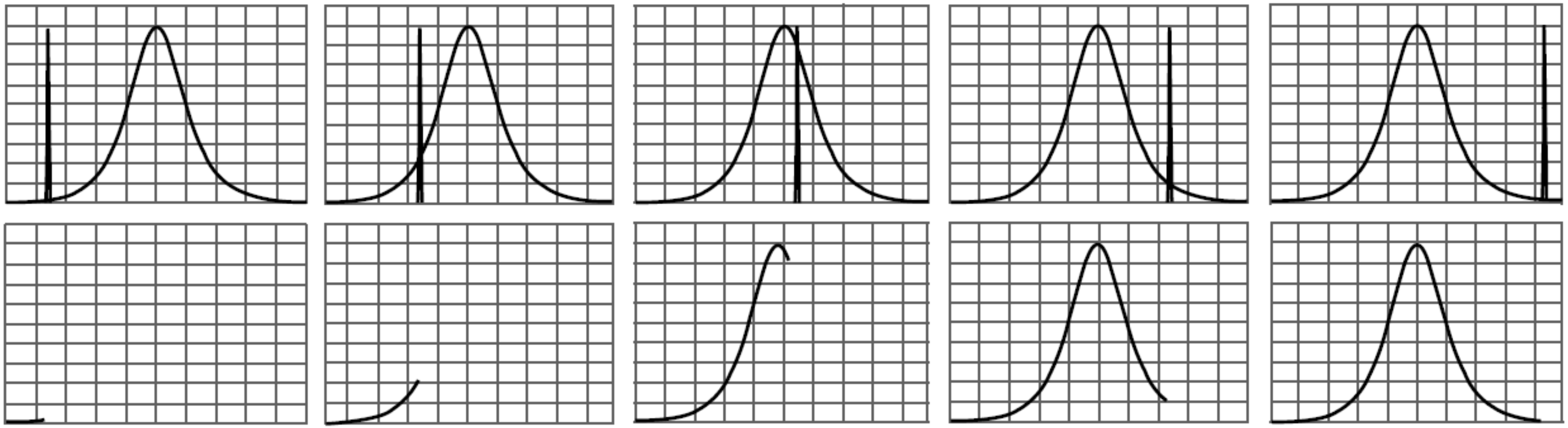


$$f_{LO} = f_{sig} + f_{IF}$$

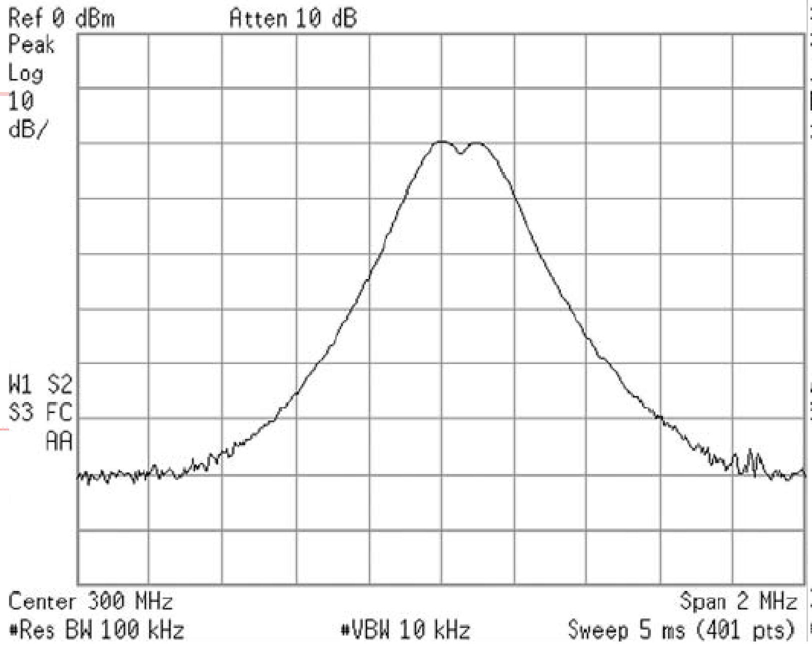
f_{sig} = signal frequency
f_{LO} = local oscillator frequency, and
f_{IF} = intermediate frequency (IF)

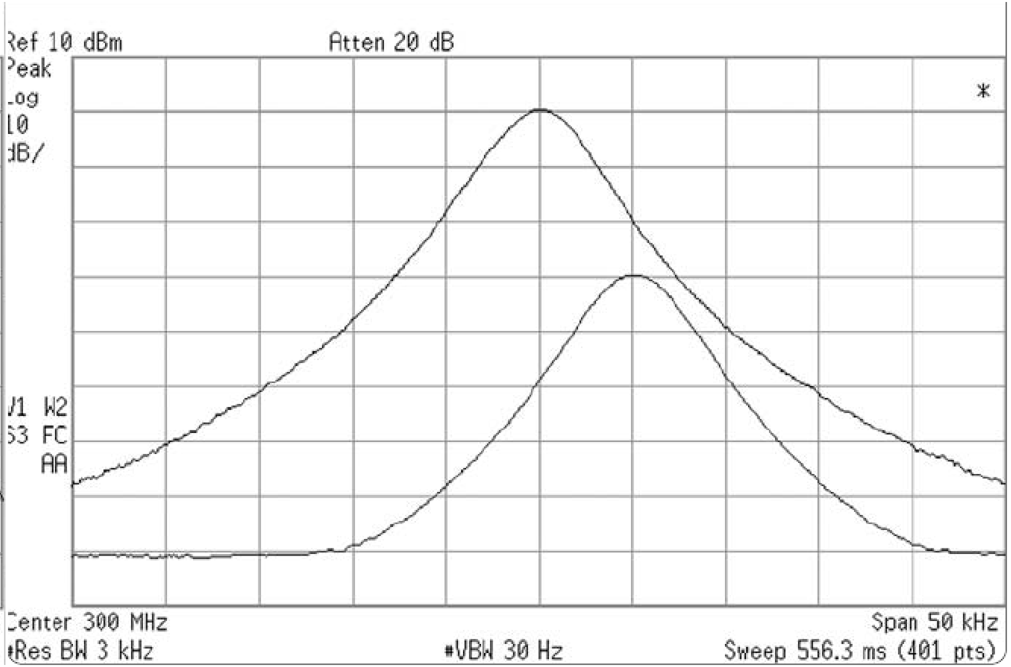
Theory of Operation

Resolving signals – Resolution bandwidth filter shape



Theory of Operation

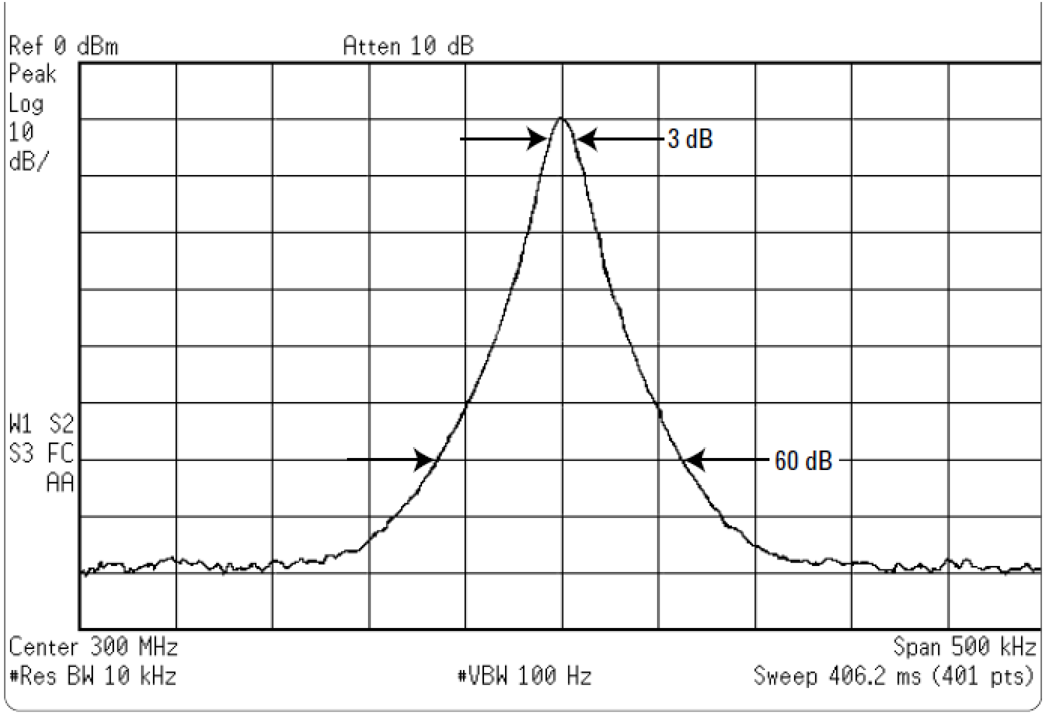




Resolving equal-amplitude signals

Resolving non equal-amplitude signals

Theory of Operation



Bandwidth selectivity:
ratio of the 60 dB bandwidth to the 3 dB bandwidth.

Analog filters: 12,7:1

Digital filters: 4,1:1

Theory of Operation

Bandwidth selectivity

Filter skirt at a given offset is calculated as:

$$H(\Delta f) = -10(N) \log 10 [(\Delta f/f_0)2 + 1]$$

Where: $H(\Delta f)$ is the filter skirt rejection in dB

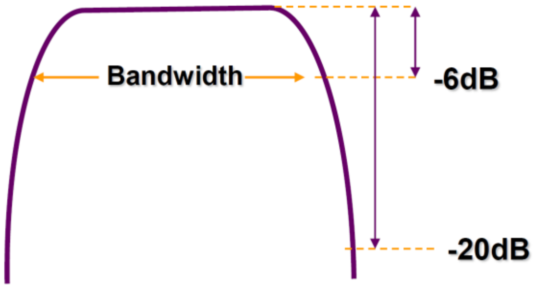
N is the number of filter poles

Δf is the frequency offset from the center in Hz, and

$$f_0 = \frac{\mathrm{RBW}}{2\sqrt{2^{1/N}-1}}$$

Theory of Operation

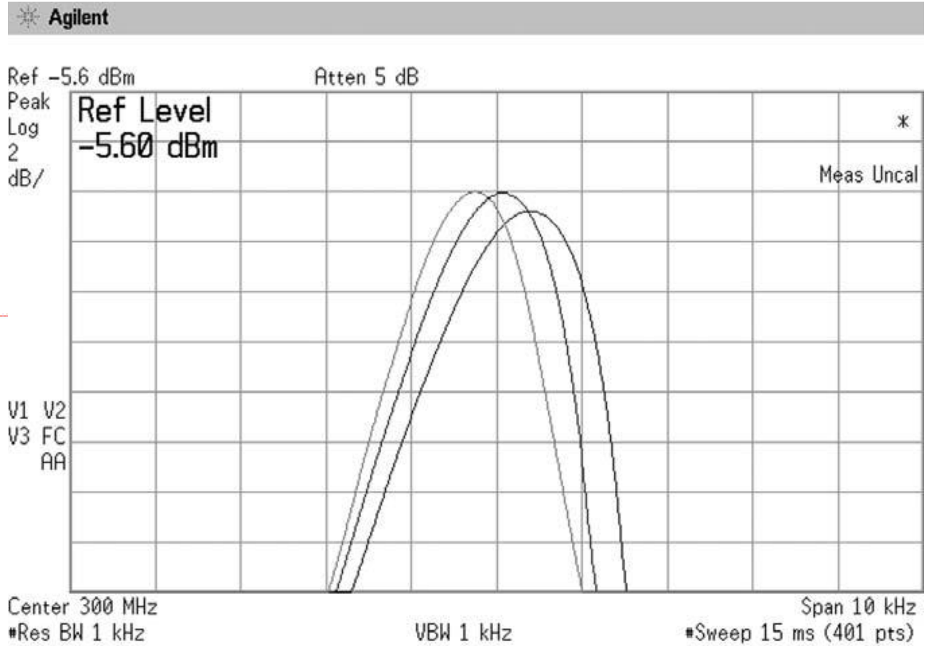
CISPR Bandwidth Requirements



Measurement Range	CISPR Band	CISPR Bandwidth
9 KHz – 150KHz	A	200 Hz
150 KHz – 30 MHz	B	9 KHz
30 MHz – 1 GHz	C/D	120 KHz
> 1GHz	E	1 MHz

Theory of Operation

Sweep time



Analog resolution filters

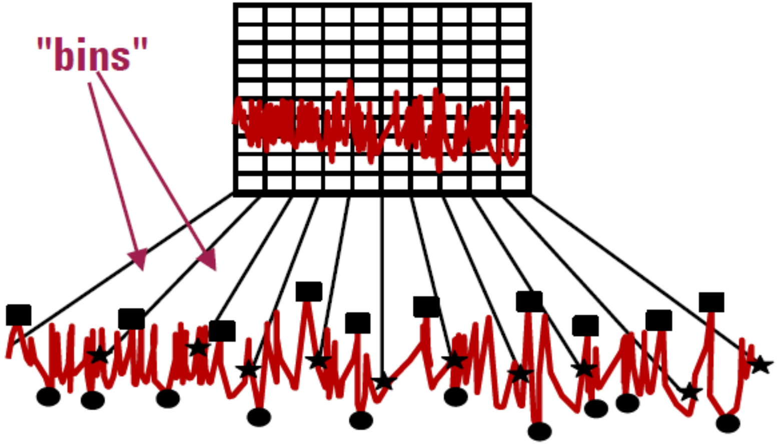
IF filters require finite times to charge and discharge:

Time in passband = (RBW)(ST)/Span

Sweeping an analyzer too fast causes a drop in displayed amplitude and a shift in indicated frequency.

Theory of Operation

Detector types



■ Positive detection:
largest value in bin displayed;
best for sinusoidal signal

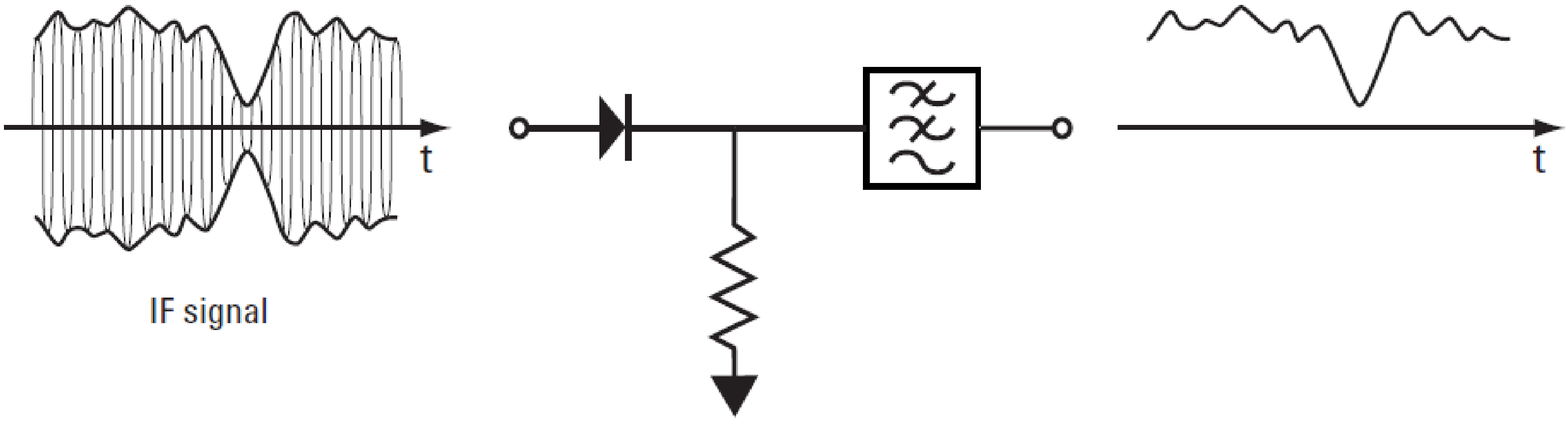
● Negative detection:
smallest value in bin displayed;
differentiates CW from impulsive signals

★ Sample detection:
value in the centre of bin displayed;
best for noise

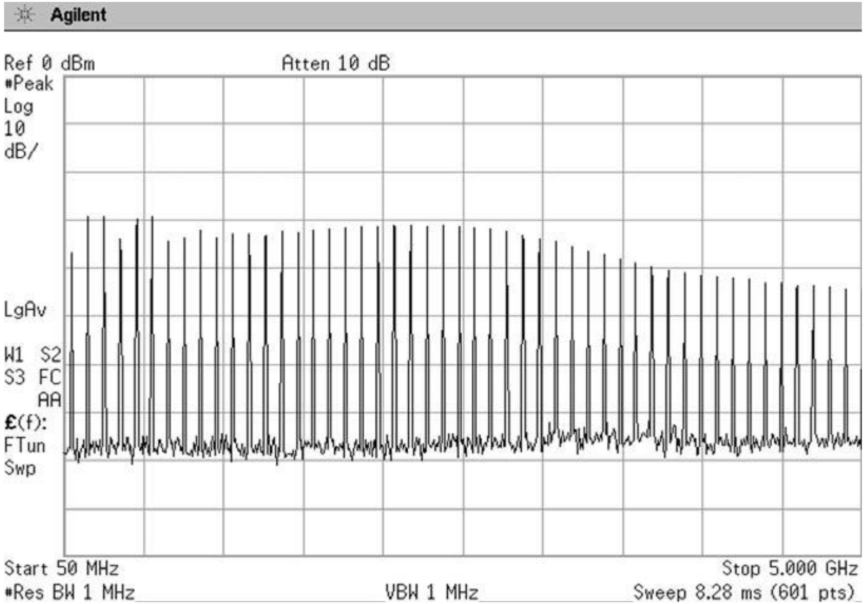
Theory of Operation

Envelope detector

converts the IF signal to video (DC):



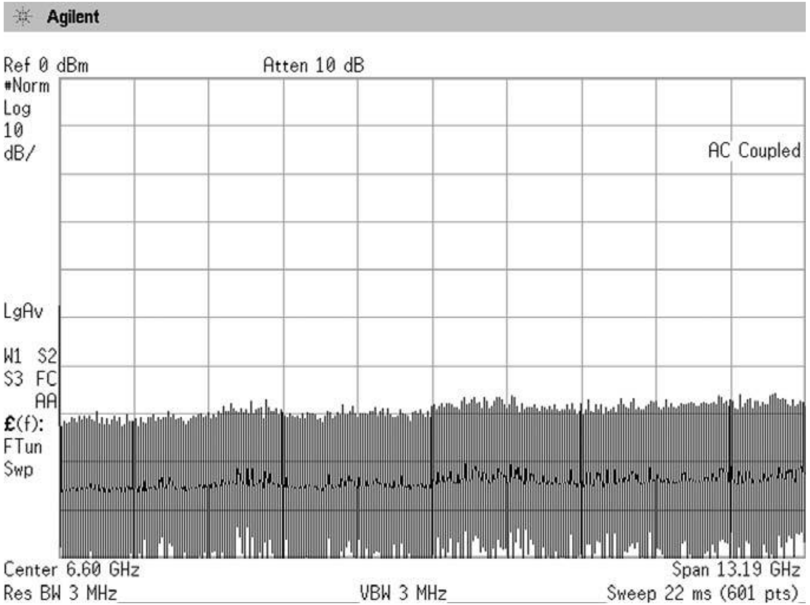
Theory of Operation



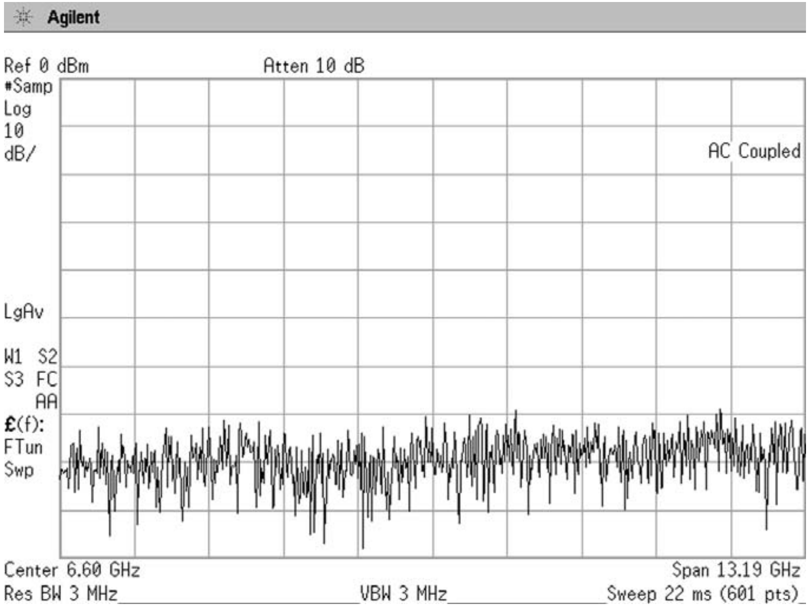
Peak detector used

Theory of Operation

Normal („rosenfell“) detection – „smart“ detection



Normal mode



Sample mode

Theory of Operation

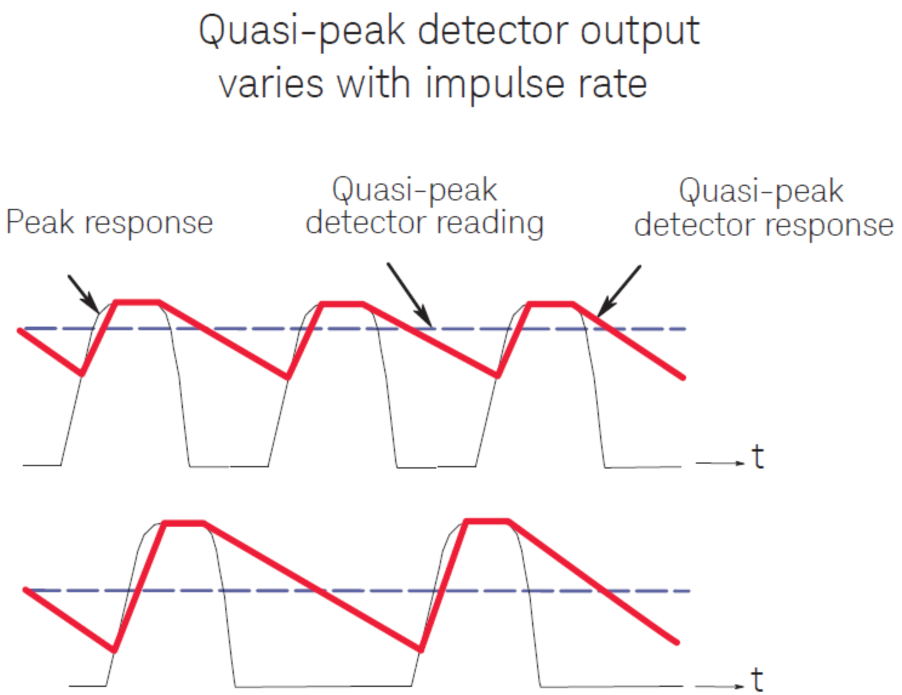
Average detection

- *Power (rms) averaging* averages rms levels
- *Voltage averaging* averages the linear voltage data of the envelope signal
- *Log-power (video) averaging* averages the logarithmic amplitude values (dB)

EMI detectors: average and quasi-peak detection (QPD)

- *envelope-detected signal passes through a low-pass filter with a bandwidth much less than the RBW; the filter integrates (averages) the higher frequency components such as noise.*
- *The measured value of the QPD drops as the repetition rate of the measured signal decreases.*

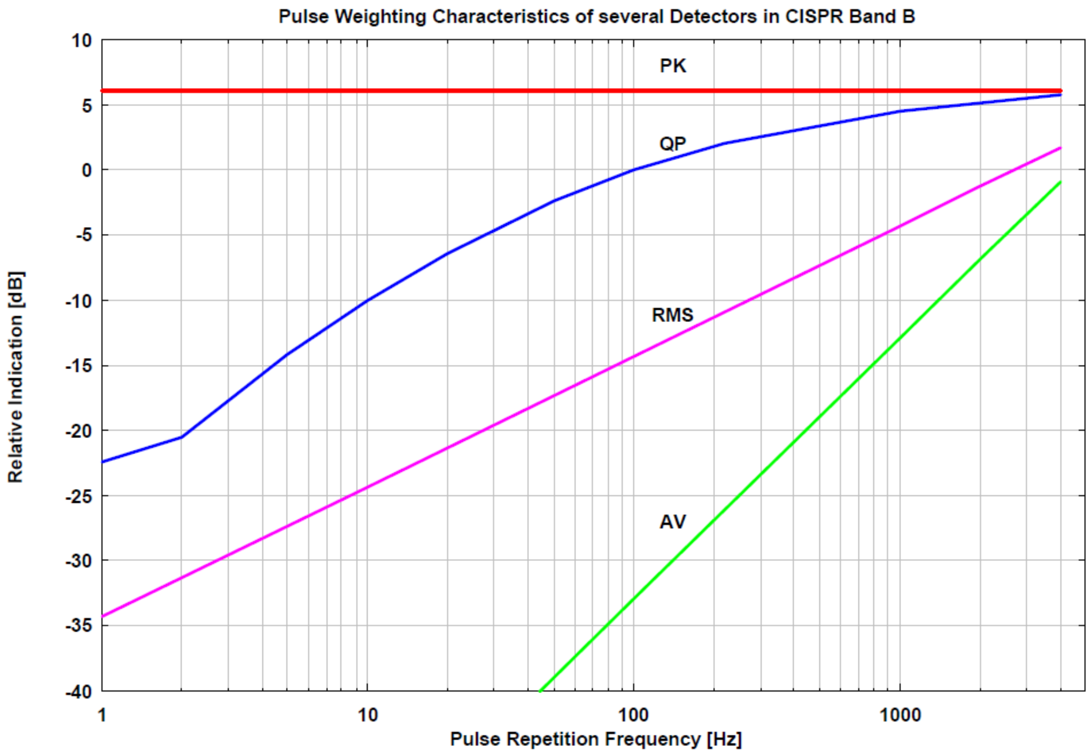
Theory of Operation



Quasi-peak detection

As the impulse repetition rate increases, the quasi-peak detector does not have time to discharge as much, resulting in a higher voltage output

Theory of Operation



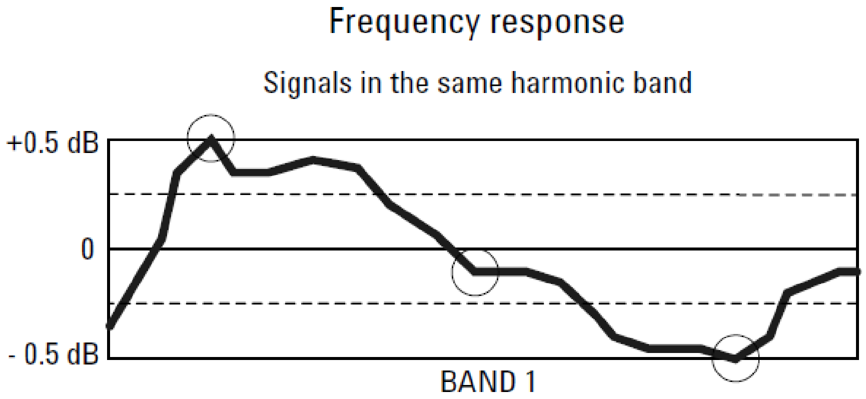
Amplitude and Frequency Accuracy

- Input filter/preselector

Preselector – a tunable band pass filter – is used in the higher frequency bands has a larger *frequency response variation*, ranging from 1.5 dB to 3 dB.

- Mixer and the local oscillator

- both add to the *frequency response uncertainty.* Some spectrum analyzers have a *band switching uncertainty*



Amplitude and Frequency Accuracy

- **Absolute amplitude accuracy**

Absolute frequency response specification is referenced to built-in calibrator amplitude and frequency.
Specifications of a variety of different spectrum analyzers:

Amplitude uncertainties (±dB)

Relative		
	RF attenuator switching uncertainty	0.18 to 0.7
	Frequency response	0.38 to 2.5
	Reference level accuracy (IF attenuator/gain change)	0.0 to 0.7
	Resolution bandwidth switching uncertainty	0.03 to 1.0
	Display scale fidelity	0.07 to 1.15
Absolute		
	Calibrator accuracy	0.24 to 0.34

Amplitude and Frequency Accuracy

Improving overall uncertainty

- Sources of uncertainty can be considered independent variables – calculate the root sum of squares (RSS) error.
- Do the measurement without changing unecessary setting.
- Use a power meter and compare the reading of the spectrum analyzer at the desired frequencies with the reading of the power meter.
- Use more accurate calibrator, or one closer to the frequency of interest.

Amplitude and Frequency Accuracy

Specifications, typical performance, and nominal values

Specifications – 100% of the units tested will meet the specification.

"2 sigma" or 95% confidence value – not all units meet the specification.

Typical performance – 80% of the units exhibit with a 95% confidence level.

Nominal values – generaly are not tested during the manufacturing process.

Amplitude and Frequency Accuracy

The digital IF section

- Digital IF architecture eliminates or minimizes many of the uncertainties experienced in analog spectrum analyzers:
- Reference level accuracy (IF gain uncertainty)
- Display scale fidelity – no log amplifier; however, other factors, such as RF compression (especially for input signals above –20 dBm), ADC range gain alignment accuracy, and ADC linearity (or quantization error) contribute to display scale uncertainty.
- RBW switching uncertainty – minimized with excelent repetability and error compensation.

Amplitude and Frequency Accuracy

Frequency accuracy

For **absolute frequency measuremens** a typical readout accuracy might be stated as follows:

±[(freq readout x freq ref error) + A% of span + B% of RBW + C Hz]

When making **relative measurements**, span accuracy comes into play, e.g. 0,5% of span.

Marker count accuracy might be stated as:

±[(marker freq x freq ref error) + counter resolution]

Sensitivity

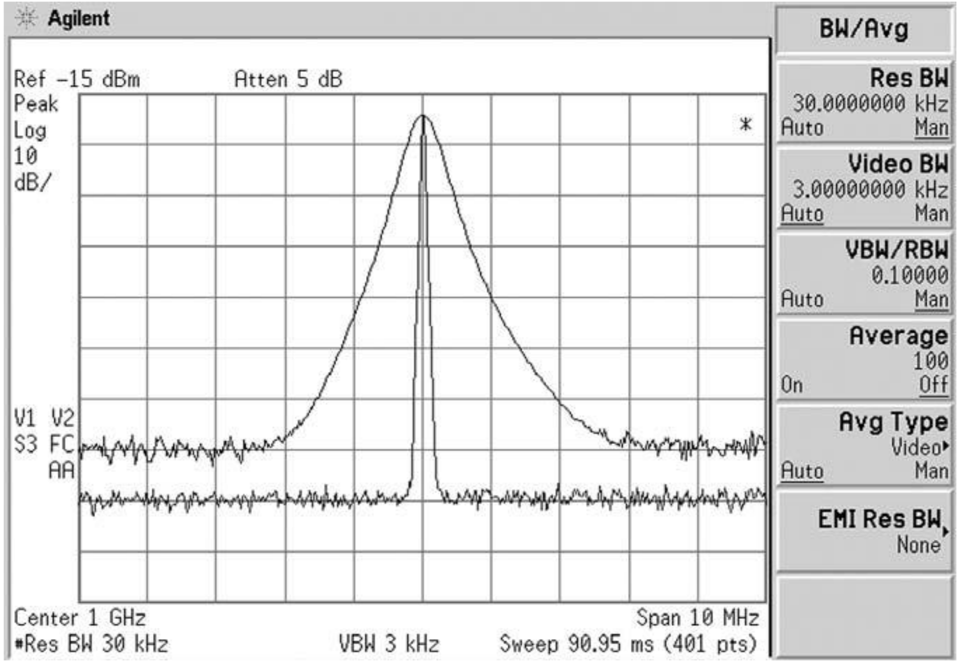
The limitation in search out and measure low-level signalsis the noise generated within the spectrum analyzer itself, commonly referred to as the *Displayed Average Noise Level, or DANL*

noise energy = kTB

At room temperature, the noise power density normalized to 1 Hz BW is –174 dBm/Hz.

We get the lowest DANL by selecting minimum (zero) RF attenuation.

Sensitivity



Displayed level changes with RBW:

10 log (BW2/BW1)

BW1 = starting resolution bandwidth
BW2 = ending resolution bandwidth

Video filter does not affect the average noise level and so does not affect the sensitivity of an analyzer.

Preamplifiers

With appropriate preamplifier in front of the spectrum analyzer, we can obtain a system noise figure that is lower than that of the spectrum analyzer alone and we can improve system sensitivity.

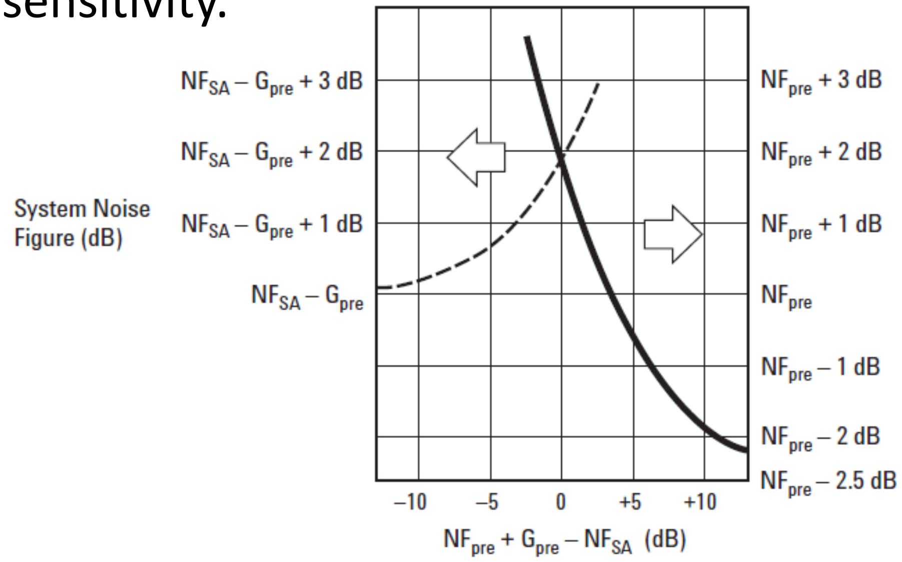
If NFpre + Gpre ≥ NFsa + 15 dB,

Then NFsys = NFpre – 2.5 dB

And

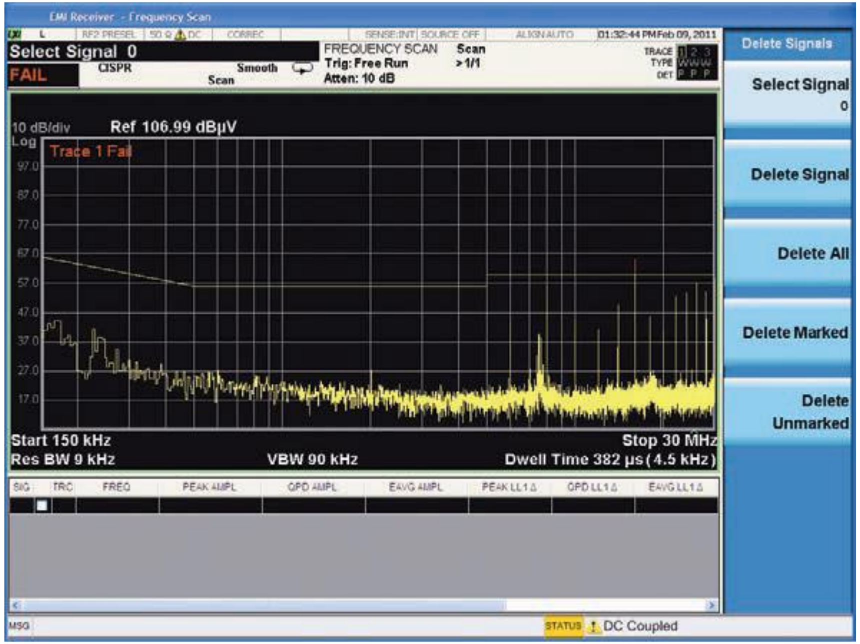
If NFpre + Gpre ≤ NFsa – 10 dB,

Then NFsys = NFsa – Gpre



Možne rešitve za EMC merjene

Programska oprema olajša nastavljenje merilne opreme



PXE - Vrhunski merilni sprejemnik s TDS

Hvala za pozornost!