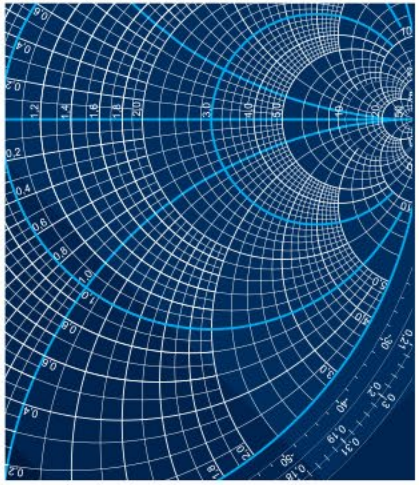


Measurement Techniques

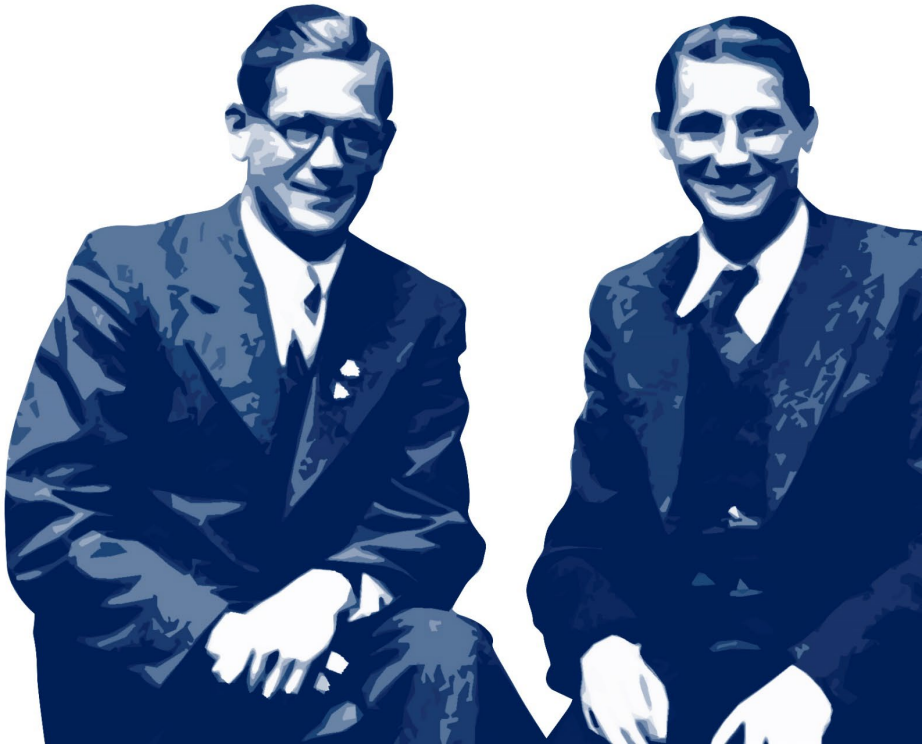
Design Verification & Evaluation

EVERYTHING TEST

Instrument Selection & Optimization

FROM A TWO-MAN LAB
TO A PRIVATELY OWNED GLOBAL COMPANY

- Founded 90 years ago by university friends Dr. Lothar Rohde and Dr. Hermann Schwarz as "Physikalisch-technisches Entwicklungslabor" ("Physical and Engineering Development Lab")
- Still fully owned by the founding families
- Financial independence, as well as long-term, sustainable planning and acting, ensure stability and resilience.
- Since its founding, an enabler and innovator of a safer and connected world



FACTS & FIGURES

History

Established 1933 in Munich, Germany

Type of enterprise

Independent family-owned company

Net revenue

EUR 2,78 billion (FY 22/23)

Global presence

In over 70 countries

Employees

14,000 worldwide

Success

A leading international supplier in all of its fields of business

ONE COMPANY, THREE DIVISIONS, DIVERSE MARKETS: WE ARE A RELIABLE TECHNOLOGY PARTNER

TEST & MEASUREMENT

Wireless I Industry, Components & Research I Aerospace & Defense Testing I Automotive

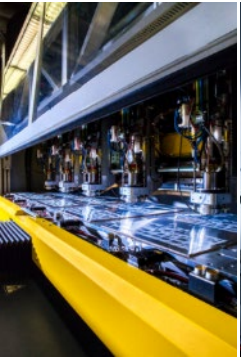
TECHNOLOGY SYSTEMS

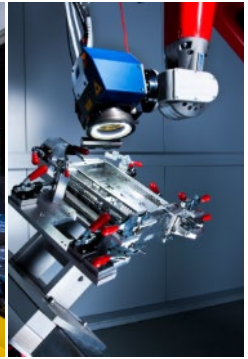
Secure Communications I Critical Infrastructure & Networks I Government I IP Network Analytics I Broadcast, Amplifiers & Media

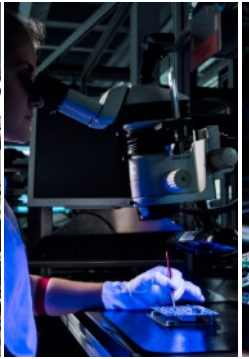
NETWORKS & CYBERSECURITY

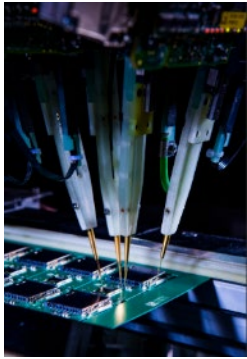
Endpoint Security I Secure Networks I Certified & High-Grade Crypto Solutions

PRODUCTION SITES









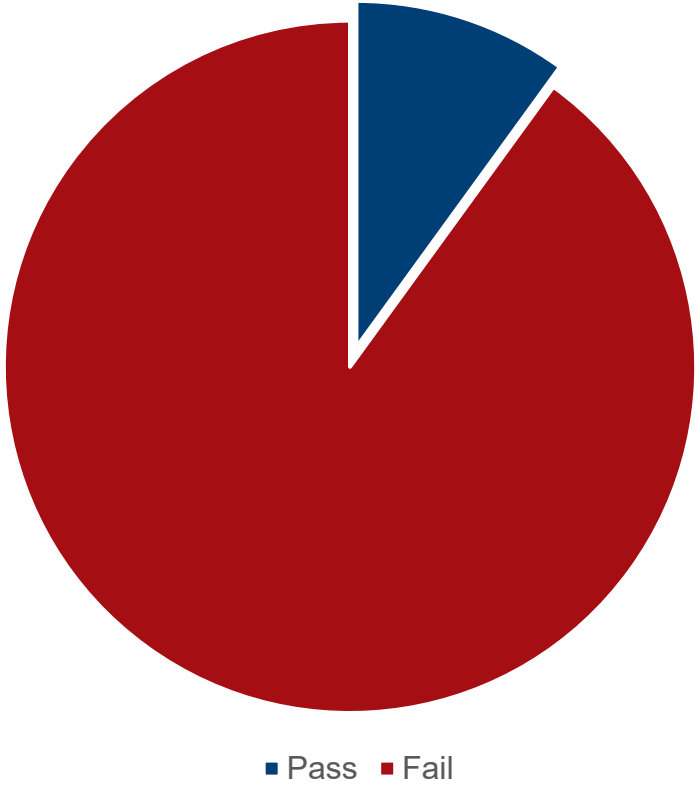
EMI Debug and Pre-Compliance

Tatiana Nishikawa
Application Engineer
ROHDE&SCHWARZ
Make ideas real

EMI Agenda

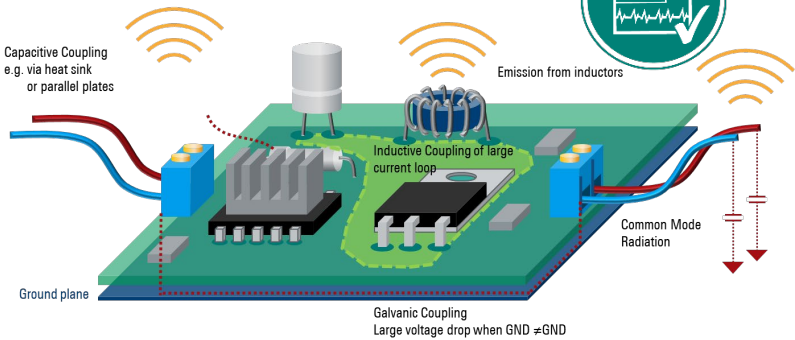
- EMC Standards Overview
- Traditional EMI Test
  - Compliance test with a spectrum analyzer
- EMI Debug and Troubleshooting
  - Troubleshooting with a spectrum analyzer
  - Troubleshooting with a oscilloscope
- Measurement solution comparison

First pass compliance test:
Devices can have a
90% failure rate!



Source: EEtimes.com, “IoT Devices: Most initially Fail EMI testing”

EMI Considerations for Your Design



Causes of EMI

EMI is often caused by switching of signals:

- Power Supply
- Clocks
- DDR memory interface
- etc.

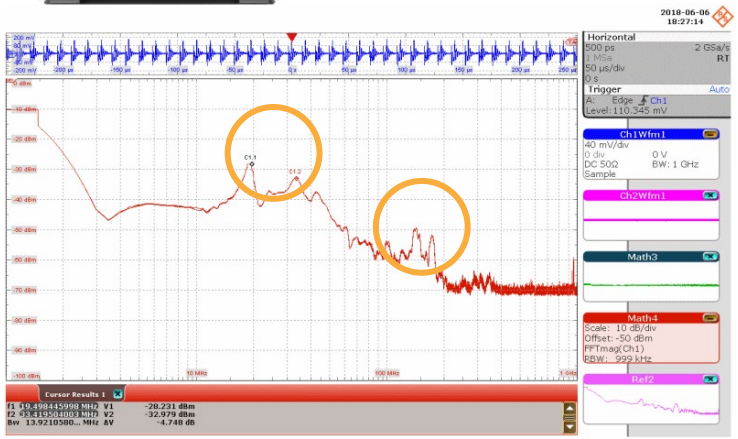
Know your EUT

- Specify known frequency source (clock and etc.)
- Generate a list of possible harmonic frequencies
- Determine the frequency of switching powers supplies
- Identify miscellaneous periodic waves

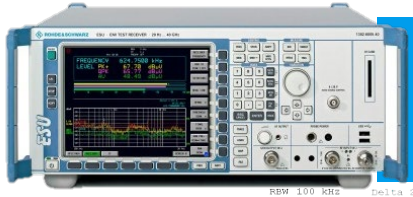
These are referred to as narrowband interference and generally occurs at very specific frequencies related to components on your board.

EMI Testing
Comparing Equipment

Real-Time
Oscilloscope



Debug or Pre-Compliance

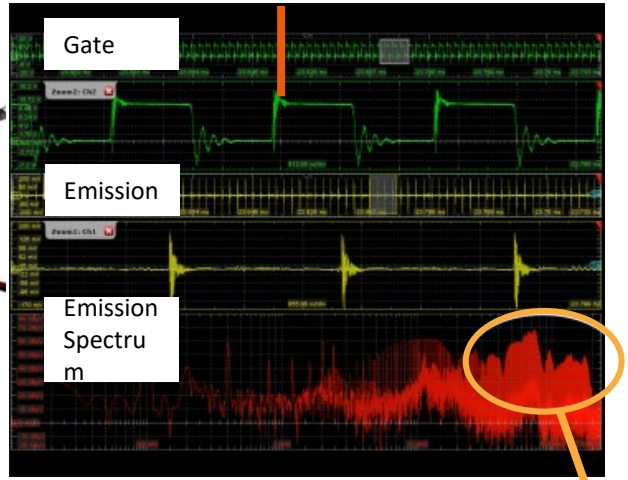


Receiver
or
Spectrum Analyzer

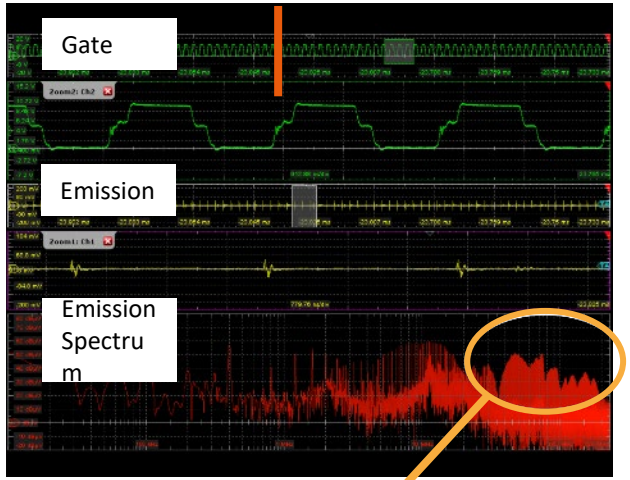
Pre-Compliance or Compliance

Application Example:
Optimizing Wide Band-Gap Switching

Fast gate driver signal



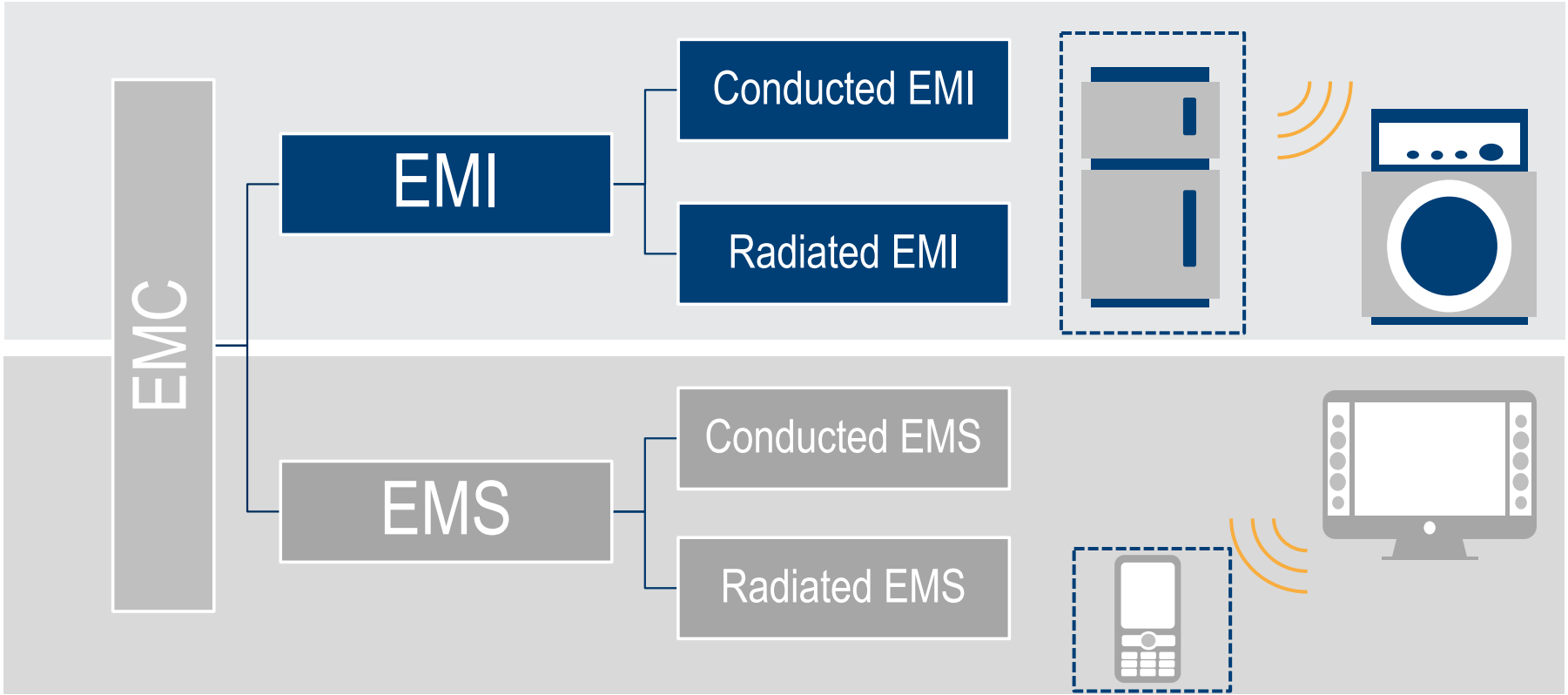
Shaped gate driver signal



Significantly reduced emissions

EMC Standards and background

What is EMC?


EMC
EMI
Conducted EMI
Radiated EMI
EMS
Conducted EMS
Radiated EMS

Standards

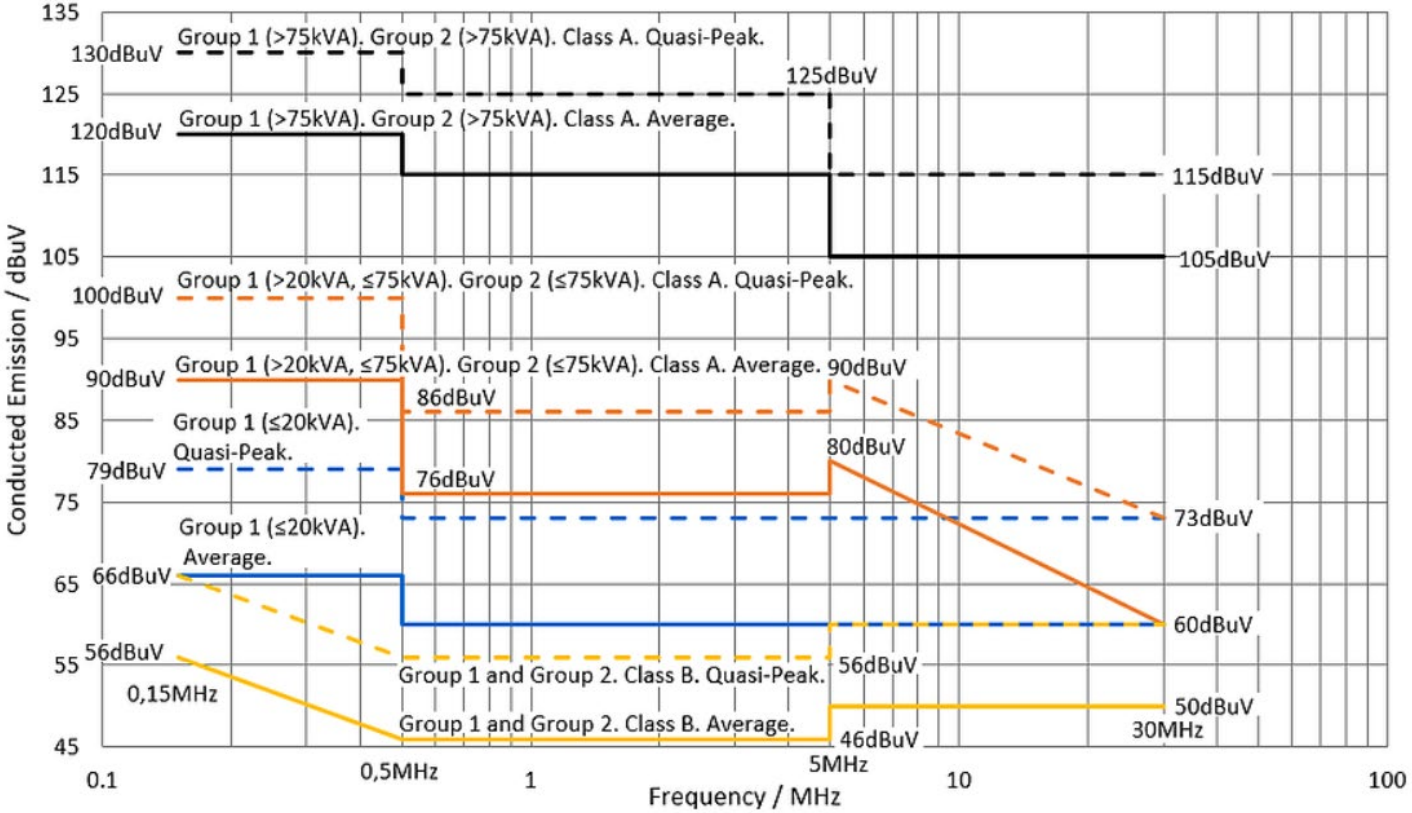
International Electrotechnical Commission (IEC)

Comité **I**nternational **S**pécial des **P**erturbations **R**adio (CISPR)

CISPR 11.

Group 1 and **Group 2**. **Class A** and **Class B.**

Conducted Emission Limits **[Mains Ports]**

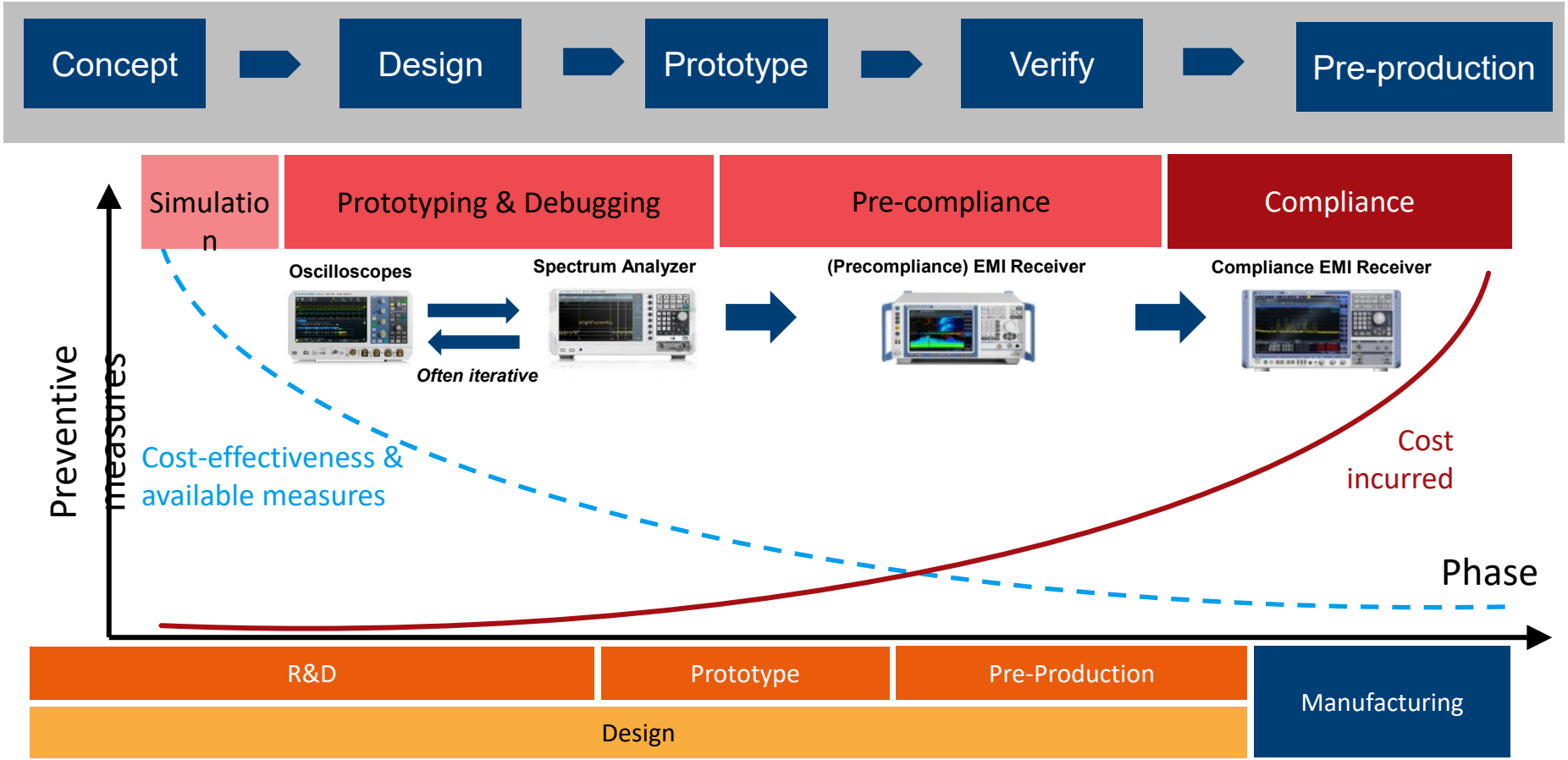


CISPR 11, ISM

CISPR 14-1, Appliances

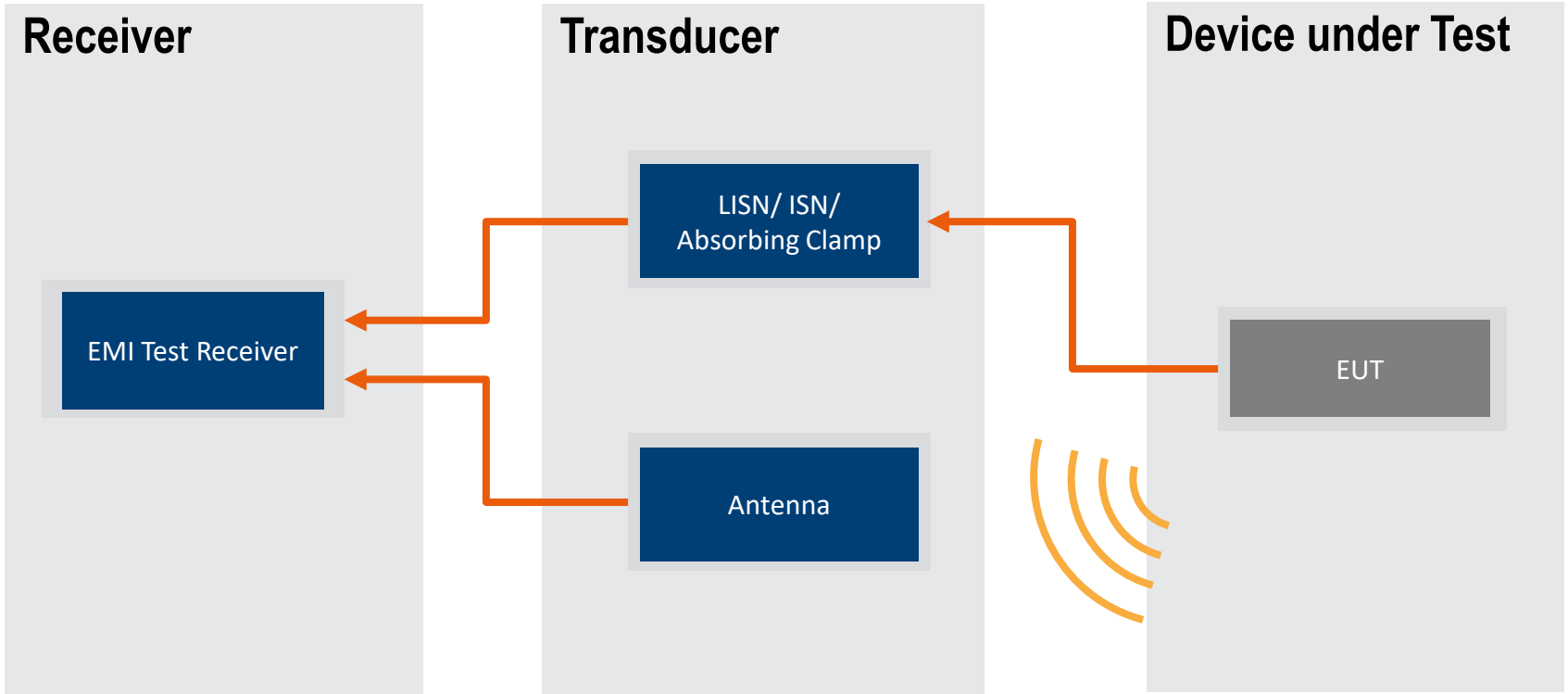
CISPR 15, Lighting

CISPR 32, Multimedia

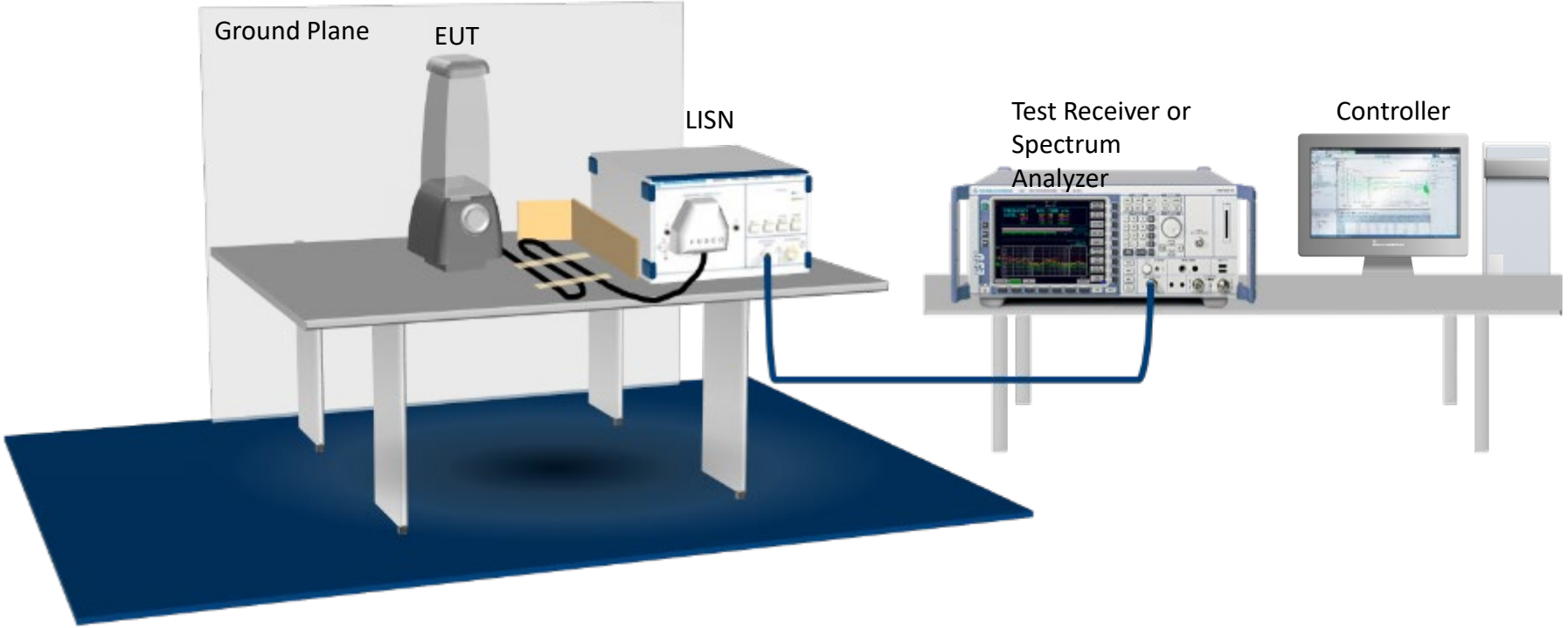

Concept
Design
Prototype
Verify
Pre-production
Simulation
Prototyping & Debugging
Pre-compliance
Compliance
Oscilloscopes
Spectrum Analyzer
(Precompliance) EMI Receiver
Compliance EMI Receiver
Often iterative
Preventive measures
Cost-effectiveness & available measures
Cost incurred
Phase
R&D
Prototype
Pre-Production
Manufacturing
Design

EMI Testing
Traditional Approach

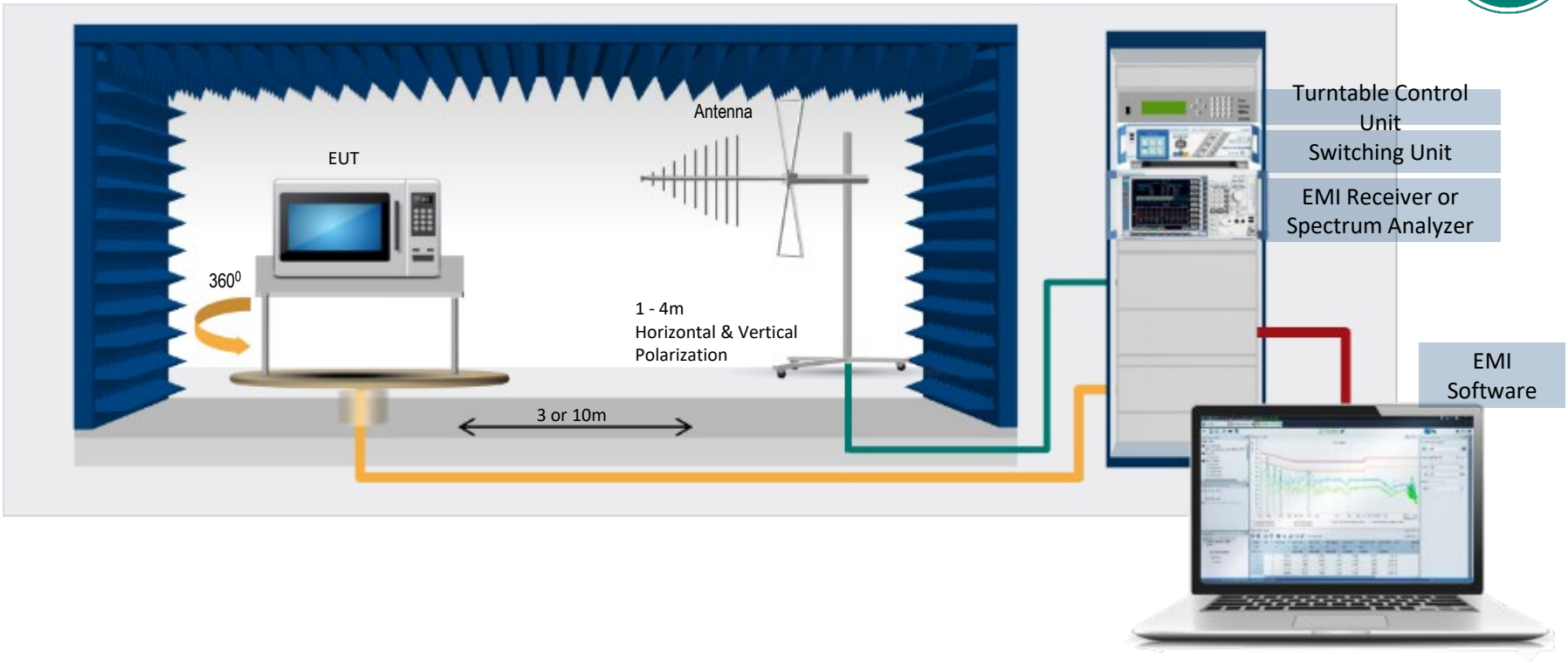
System Configuration



Conducted emissions test (AC Mains)



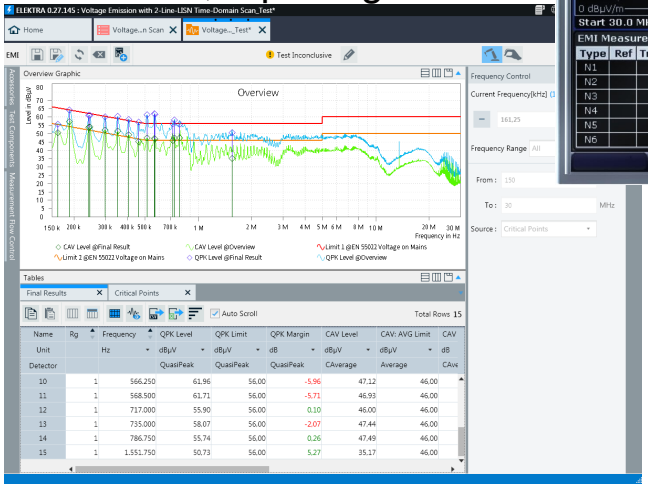
Radiated Emissions Test

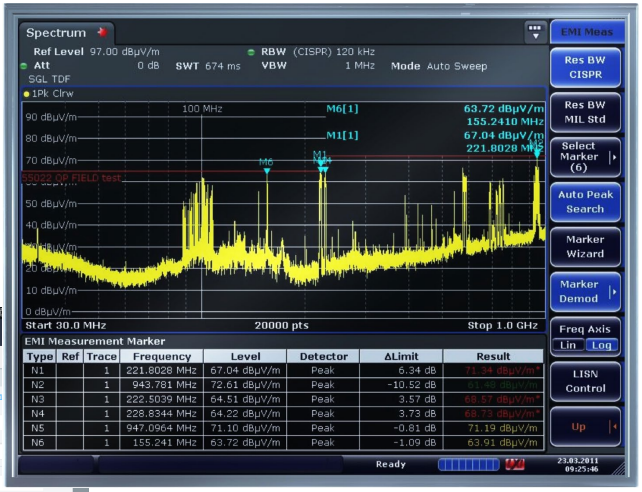


EMI Scan with a Spectrum Analyzer

- Full compliance means full chamber, CISPR 16 compliant receiver
- Want results that will match these
- Start with the limit lines for the standard you are testing against
- Finding a quiet area is more and more challenging
- Consider use of a full compliance chamber

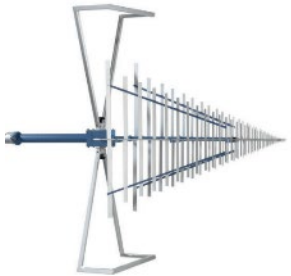
PC Software for better automation, reporting





EMI Measurement Application

Compliance EMC Testing: Measuring Equipment
Transducers



Antenna – electric radiated emission

Antenna – magnetic radiated emission

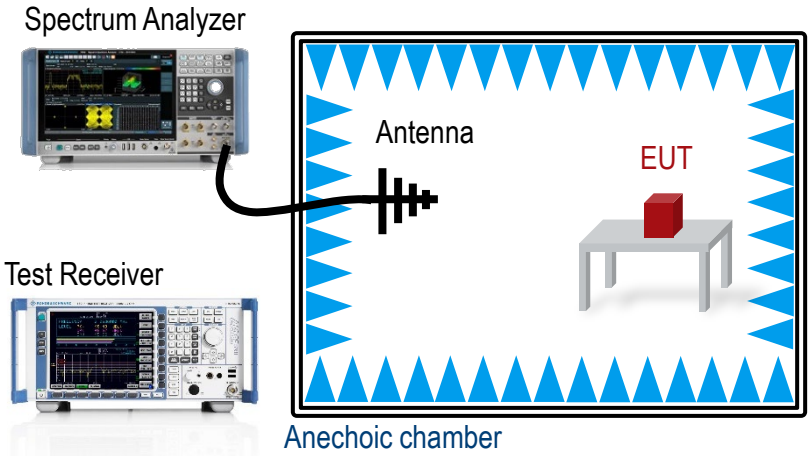
Artificial Network – Conducted voltage

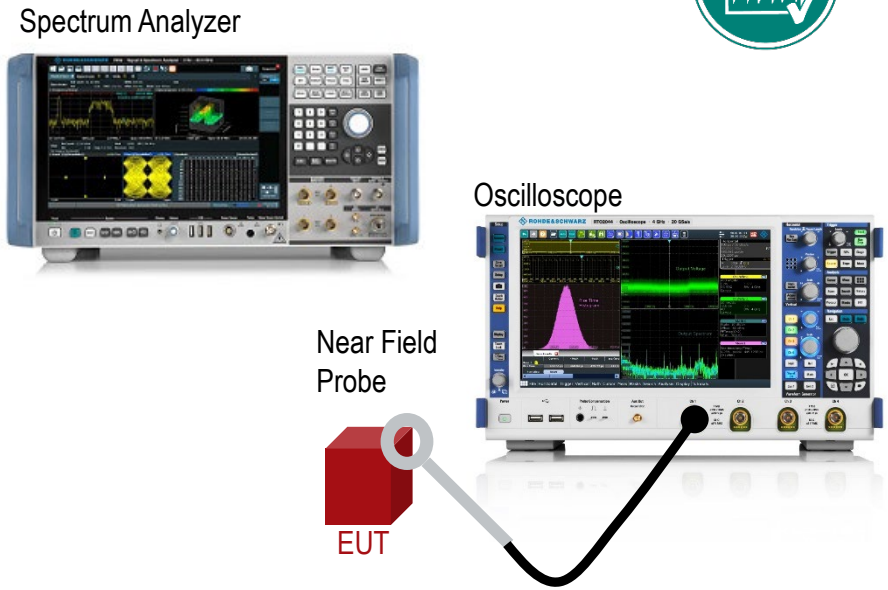
ISN - Conducted voltage

Current probe – conducted current

Absorbing clamp – disturbance power

EMC Standards vs EMI Measurements





Typical EMC Measurement

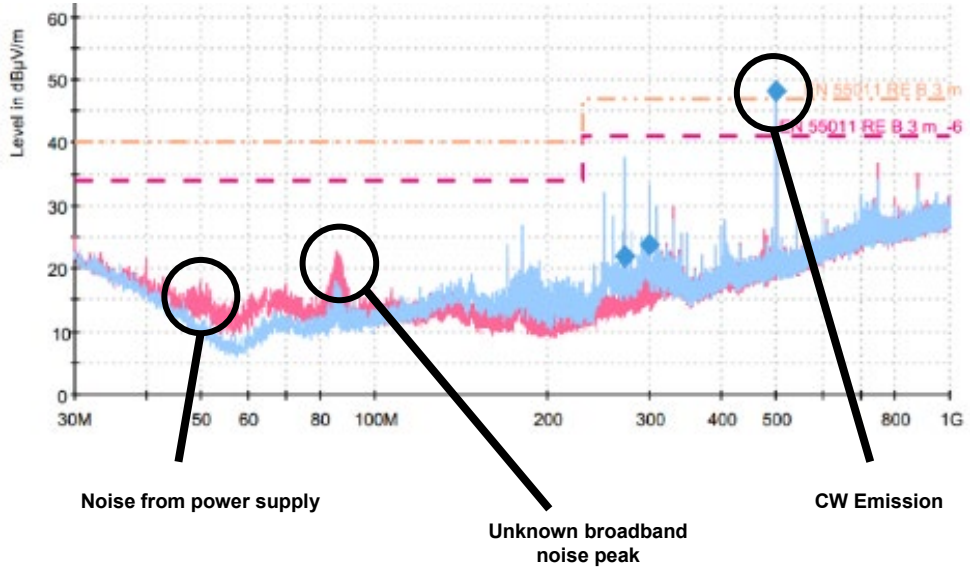
- Mostly far field in nature
- More accurate with less ambience noise
- More expensive to setup

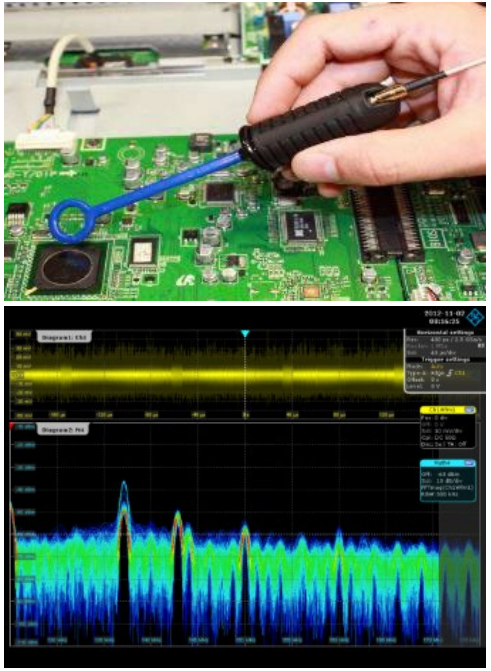
EMI Measurement with Scope or Spectrum Analyzer

- Near field measurements
- More noise and less accurate
- Cheap and flexible

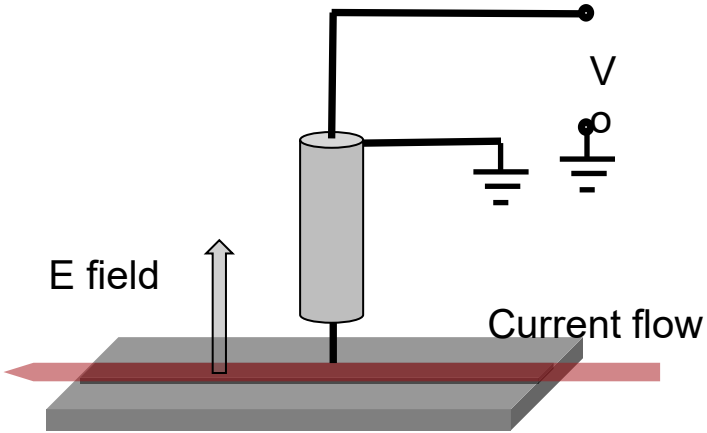
EMI Testing
Debugging and troubleshooting

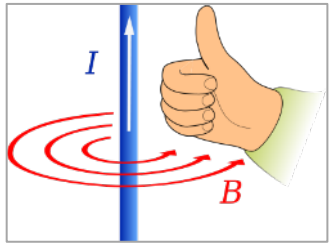
Basic EMI Debug Process

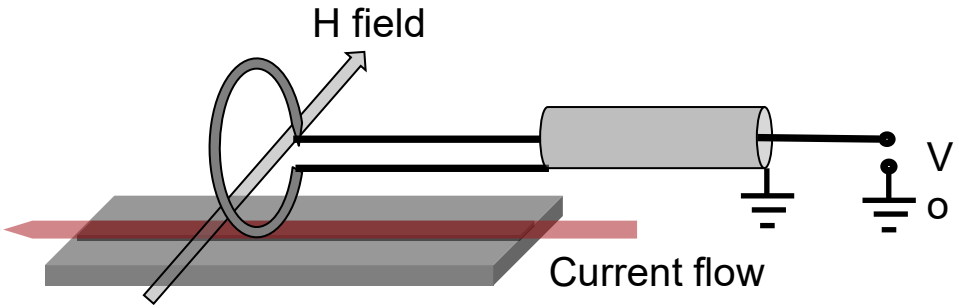




Near Field Probe Types







Near Field Probing

- Check for EMI issues periodically to make sure no obvious issues
- Can use a Spectrum Analyzer or Scope with 50 Ohm Input
- Scopes with 1 mV/div settings do not need pre-amplifier

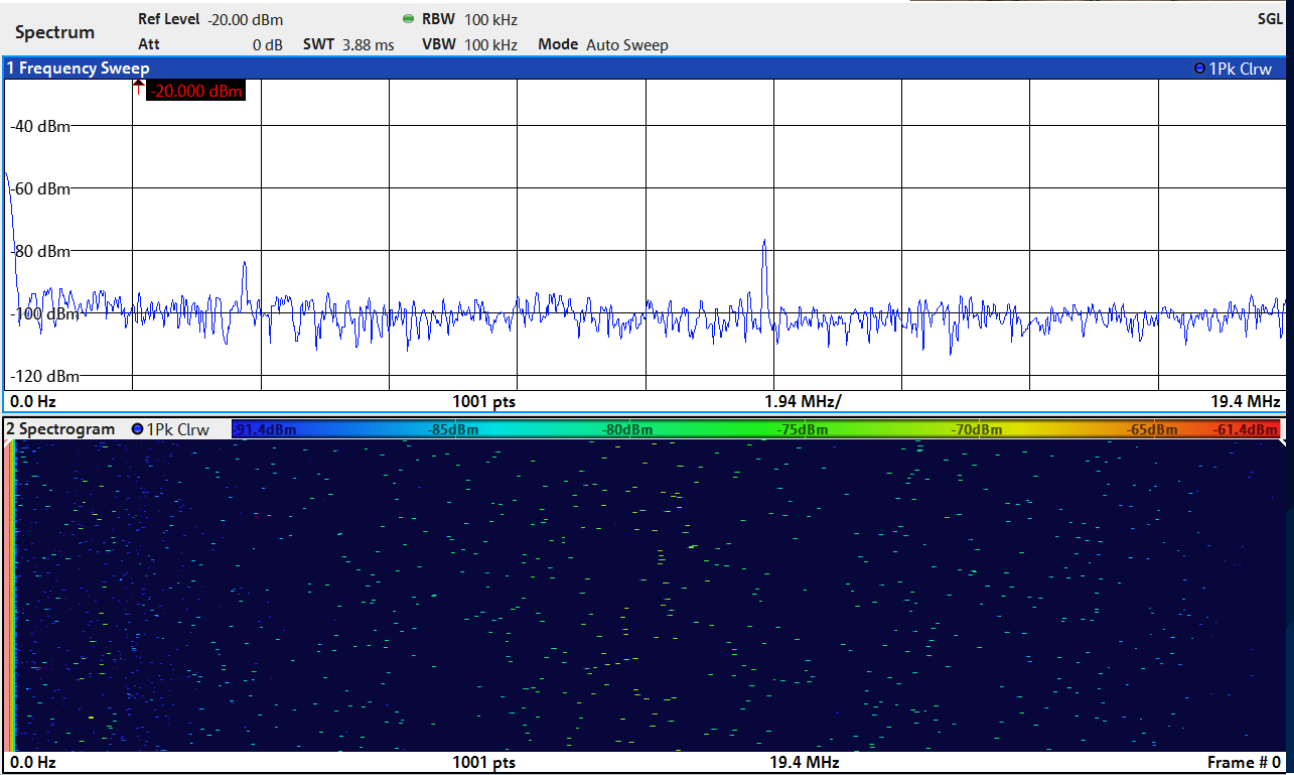
Choosing an approach

Spectrum Analyzer or Oscilloscope for EMI debugging

?

Troubleshoot with a Spectrum Analyzer

Laptop Power Supply

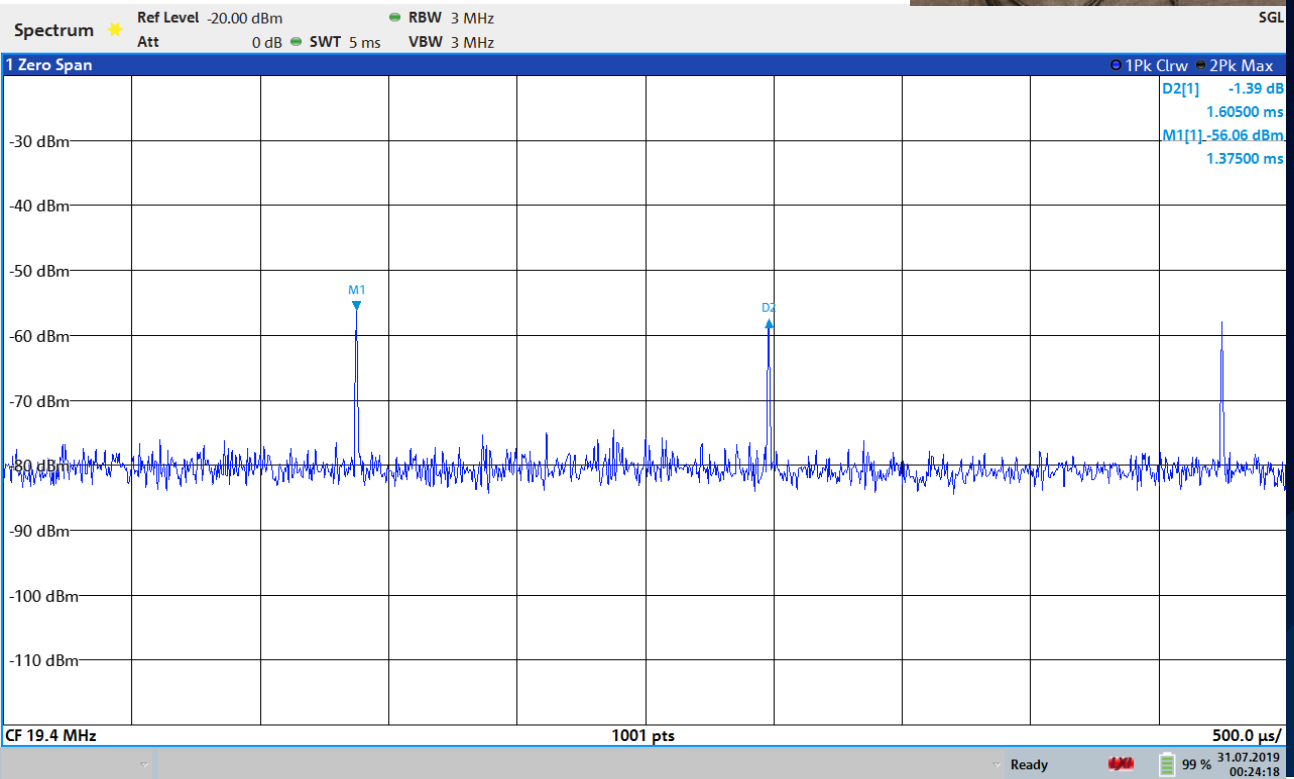


- DUT is a switching power supply
- Looking for “offending” signals that would fail a standards based limit line

- **Step 1**:
  Hunt for the offending signals – use markers to find the highest power levels in the spectrogram (lower display)

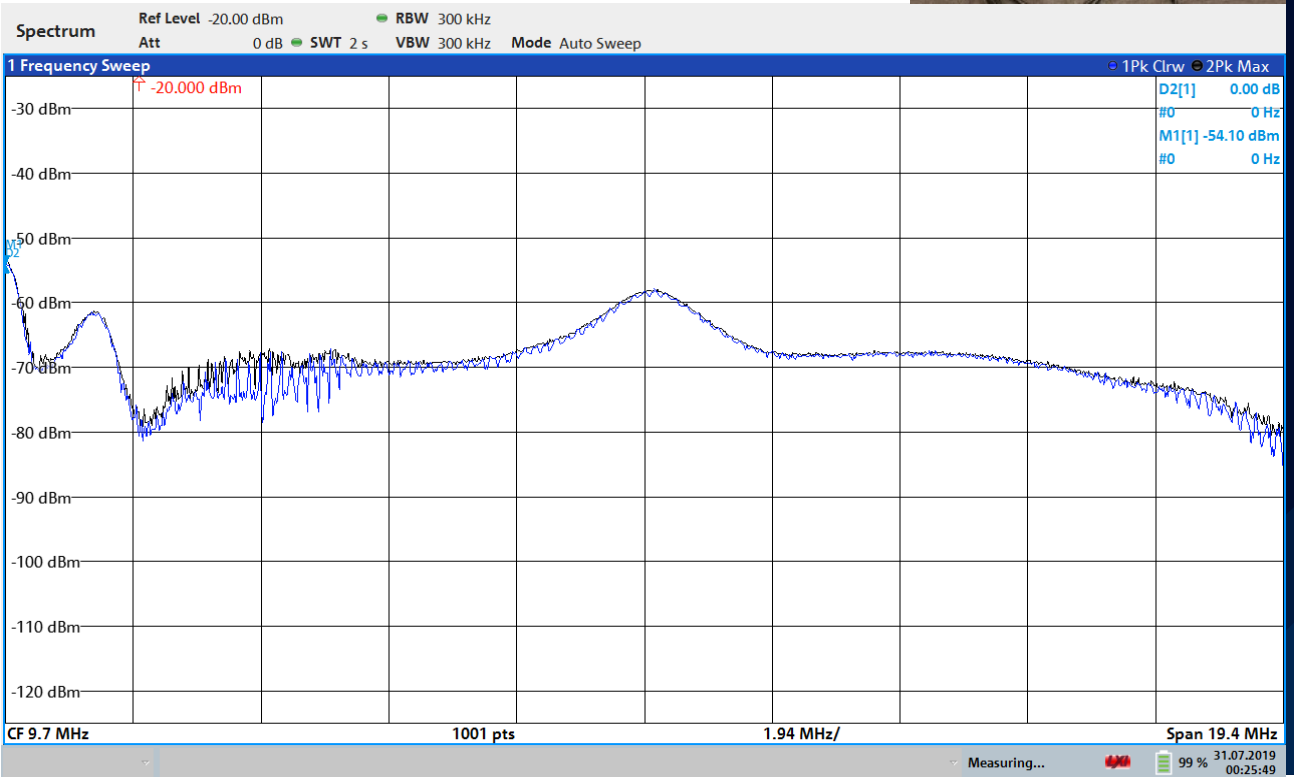
Troubleshoot with a Spectrum Analyzer

Laptop Power Supply



- **Step 2**:
  Use Zero Span at the same frequency the offending signal occurs
  - 19.4 MHz in this case
- Zero span shows the RF envelope power
- Use markers to measure the time between pulses (clock signal) – 1.6 msec in this case

Laptop Power Supply

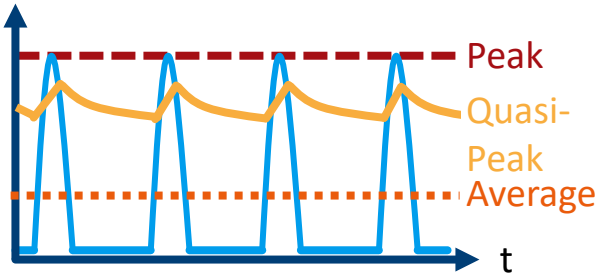


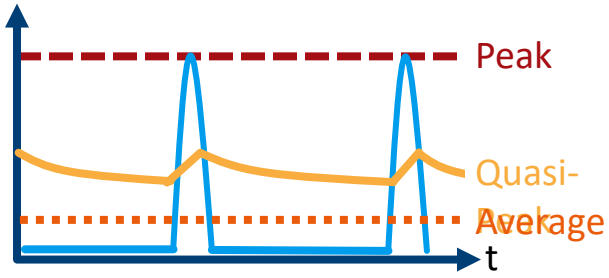
Troubleshoot with a Spectrum Analyzer

- **Step 3**:
  Spectrum display
  Set Sweep time to >1000x the measured time interval (1.6 msec)
- 1000x ensures enough points in the spectrum trace display to see the “pulse”
- (Or use a real time spectrum analyzer)
- This is the worst case signal: actual quasi-peak detector might show a lower level
- Work to address this offending emission

Quasi Peak

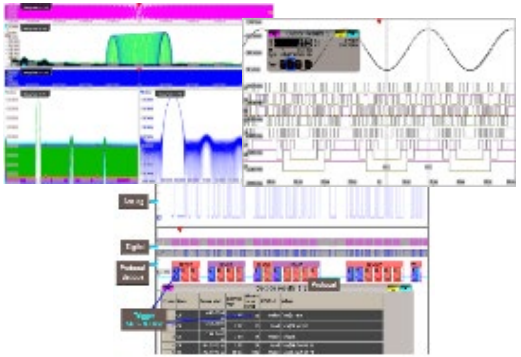
- Quasi-peak means 'not quite peak', or 'aiming towards peak but not actually peak'
- Quasi-peak detector was believed to better indicate the subjective annoyance level experienced by a listener hearing impulsive interference to an AM radio station





Spectrum analyzers and **EMI receivers**
both have a quasi-peak detector

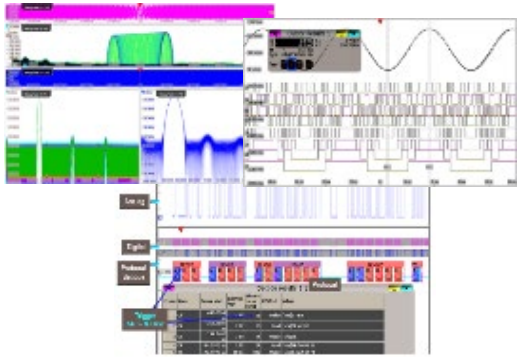
Important Scope-Parameters for EMI Debugging



Important Scope-Parameters for EMI Debugging

Bandwidth	100 MHz to 4 GHz	Analog capture range of the EMI signals
Sample rate	> 2X Analog BW	Max FFT Frequency is half the sample rate
Coupling	50 Ohm	Near Field Probes are designed for 50 Ohm systems
Vertical sensitivity	1 – 5 mV/div	Check HW settings, larger requires a pre-amplifier

FFT Span / RBW	Span to Resolution bandwidth factor (100 – 1000)
FFT gating	Easily isolate spurious spectral components in time domain
FFT Zone Trigger	Draw a mask or area on an FFT to trigger the oscilloscope

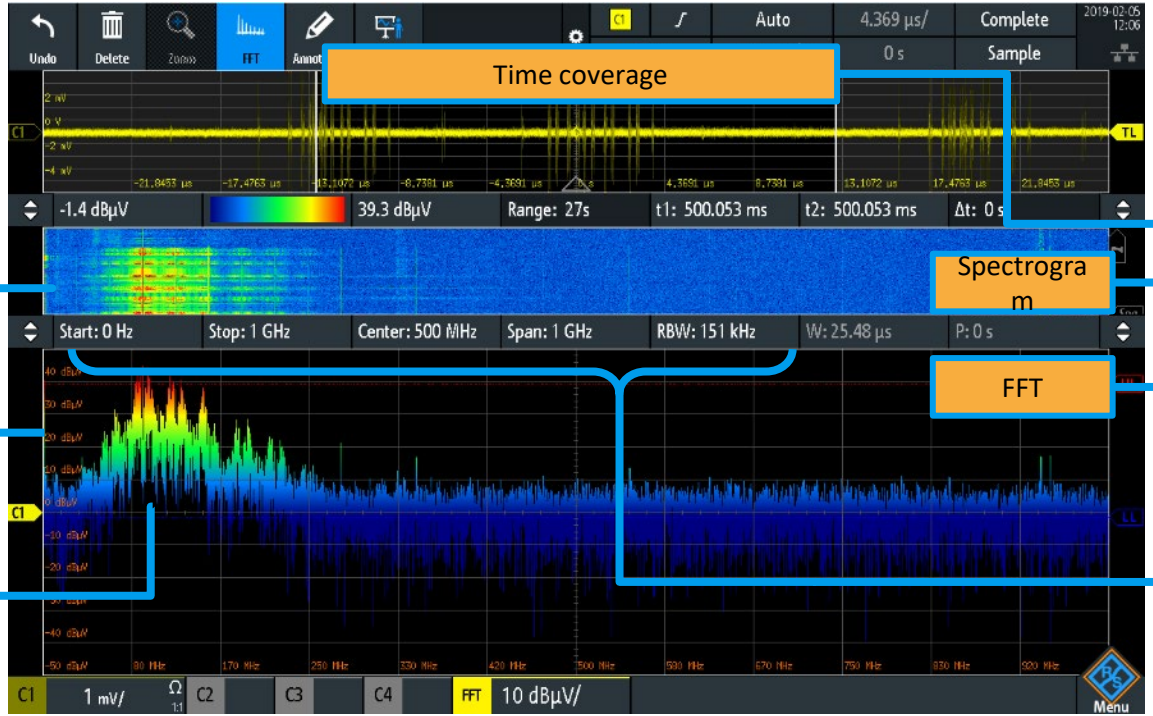


Frequency and Time Domain Correlation

Waterfall diagram helps to show short emissions

dBuV scaling like in EMI measurements

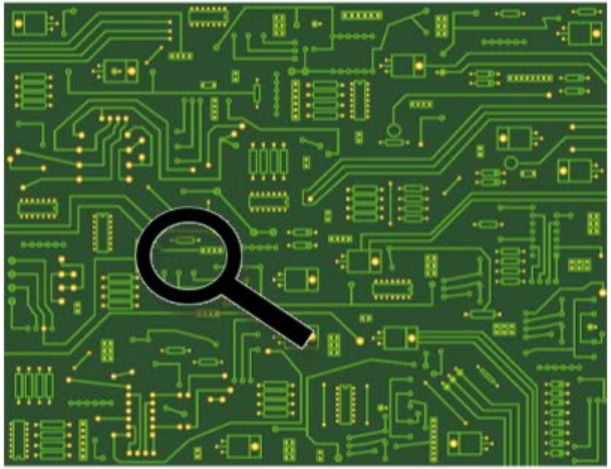
Color coding display for better visibility

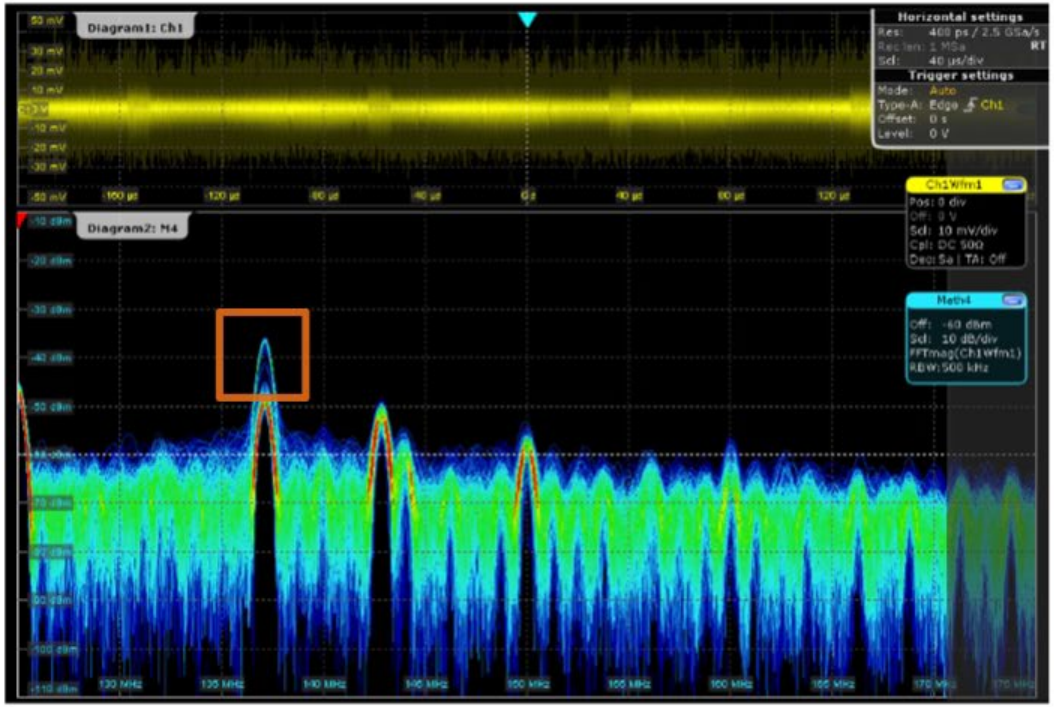


Time-frequency correlation of emissions

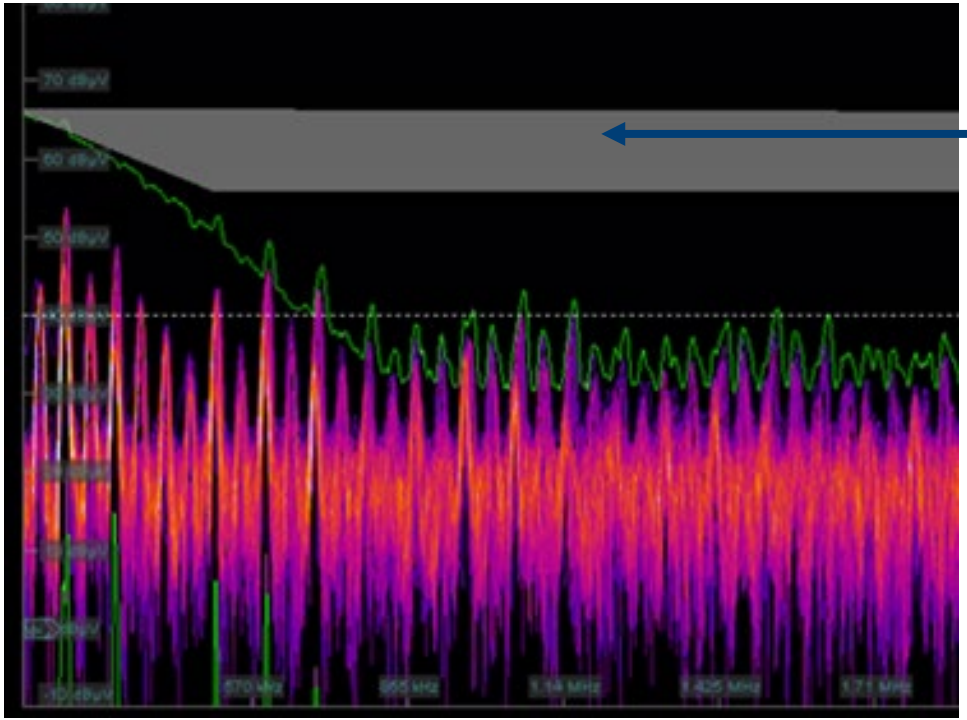
Directly set start, stop and resolution bandwidth

Near-Field Probe with an Oscilloscope





Modern Scope FFT Capabilities
Mask Test / Zone Trigger

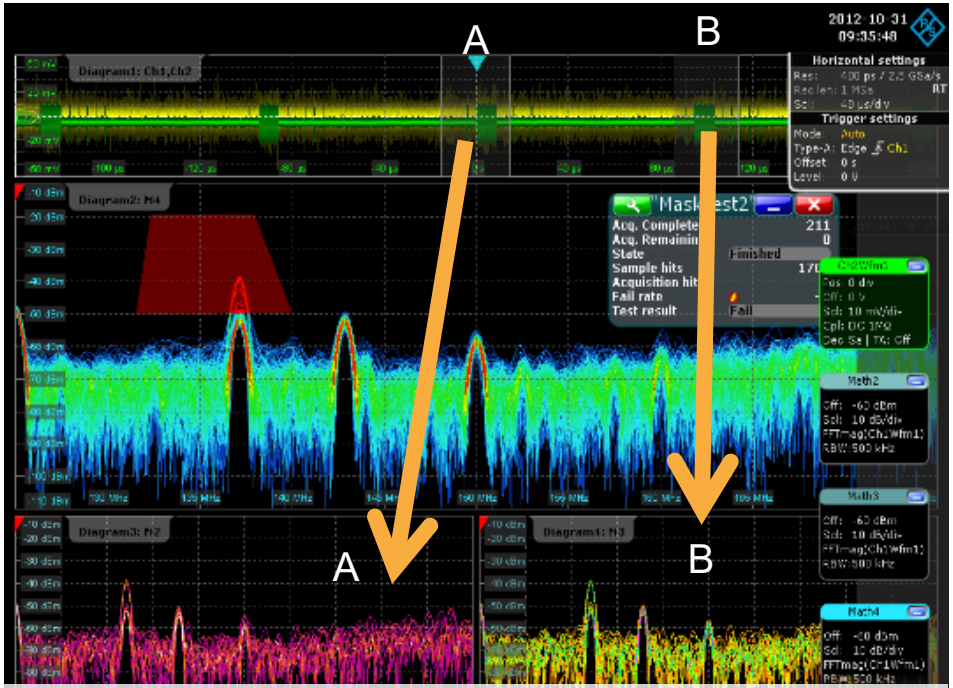


User-defined spectrum mask

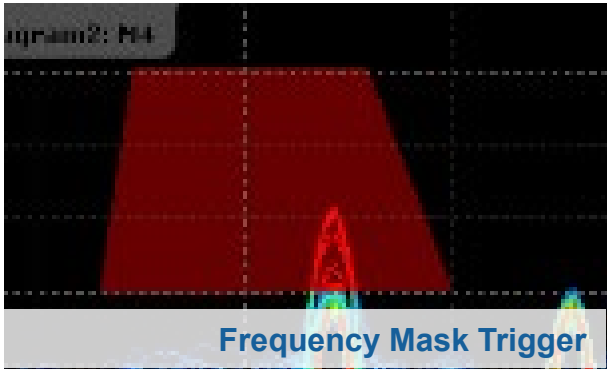
“Stop-on-violation” function

Analyze underlying source

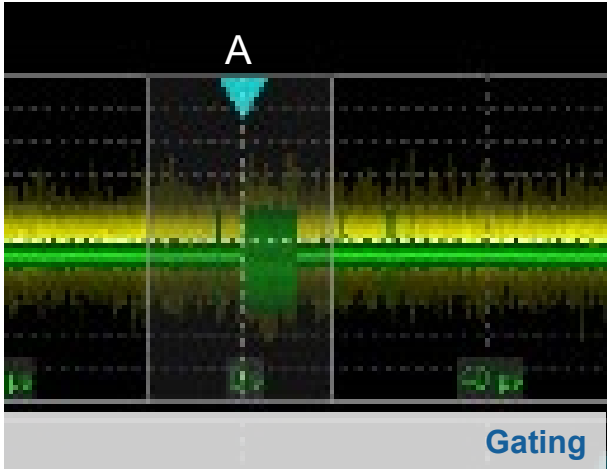
FFT Gate specific moments in time



FFT Gating isolates the spectrum of a time event



Frequency Mask Trigger



Gating

Conclusion

EMI Receiver, Spectrum Analyzer and Oscilloscope

Feature	EMI Receiver	Spectrum Analyzer	Oscilloscope
General purpose RF			
Wireless standards WLAN, IOT, Cellular			
Serial data bus decode			
EMI detectors / bandwidths (incl. QP)			
EMI Meas. Dynamic Range & Sensitivity			
Log-scale & limit lines			
Scan Types			
Time/frequency correlation possible			
Gapless recording			
Auto ranging			

EMI Receiver, Spectrum Analyzer and Oscilloscope

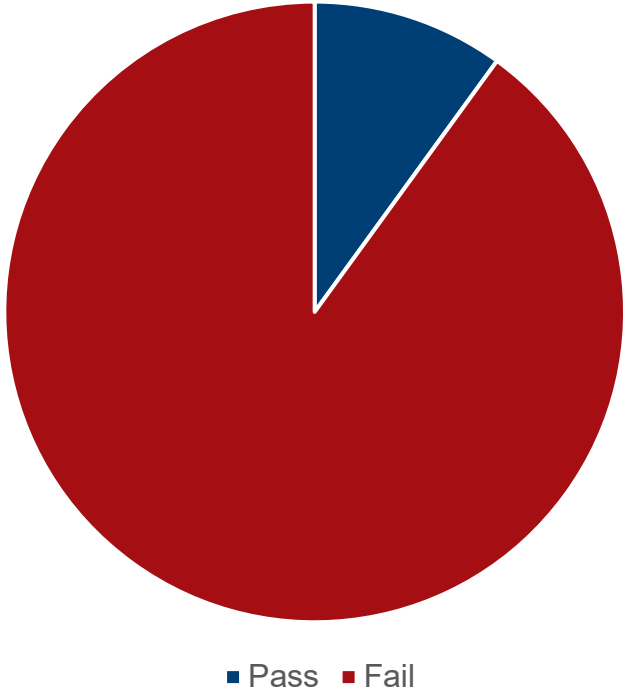
Feature	EMI Receiver	Spectrum Analyzer	Oscilloscope
General purpose RF	-	✓	✓
Wireless standards WLAN, IOT, Cellular	-	✓	✓
Serial data bus decode	-	-	✓
EMI detectors / bandwidths (incl. QP)	✓	✓	-
EMI Meas. Dynamic Range & Sensitivity	Very high / Very high	High / Very high	Medium
Log-scale & limit lines	✓	✓	(✓)
Scan Types	All (Sweep, step, time-domain, zero-span)	Some (Sweep, zero-span)	No scan
Time/frequency correlation possible	✓	✓	✓
Gapless recording	Very long	Long	Medium
Auto ranging	✓	-	-

Summary

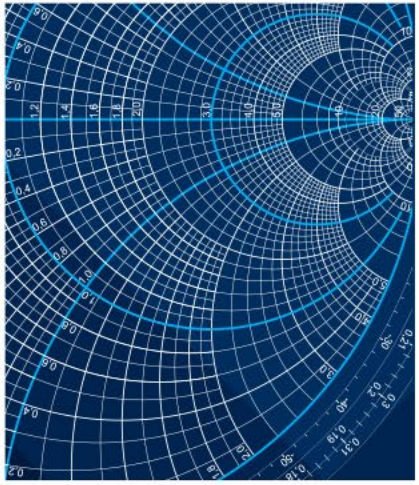
1. EMI is complex but can be tested easily
2. Test EMI early in the design process
3. Oscilloscopes and Spectrum Analyzers can be used for EMI

R&S has full product portfolio from probes to chambers with technical experts to help!

First pass compliance test:
Low cost IOT device
90% failure rate



Source: EEtimes.com, “IoT Devices: Most initially Fail EMI testing”



Measurement Techniques

Design Verification & Evaluation

EVERYTHING TEST

Instrument Selection & Optimization

Presentation Feedback