車聯網時代汽車零部件EMC規範的新要求

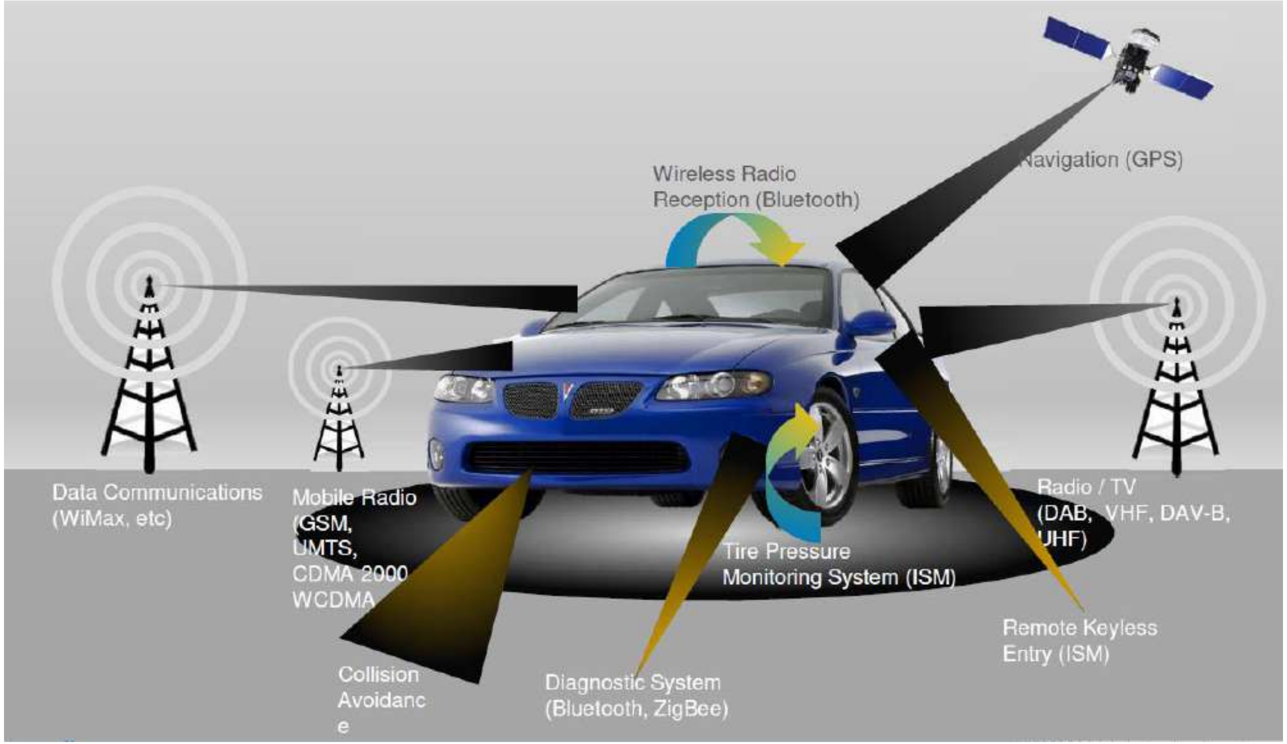
RSTW
AE Edmund Yen

ROHDE & SCHWARZ
Make ideas real

AGENDA

- Introduction
- Automotive EMC Testing
- Trends in Automotive EMC
- EMI Test Receiver ESx Product Feature and Function information
- R&S System Capability
- Conclusion

SAFE TO DRIVE IN THIS HOSTILE ENVIRONMENT?



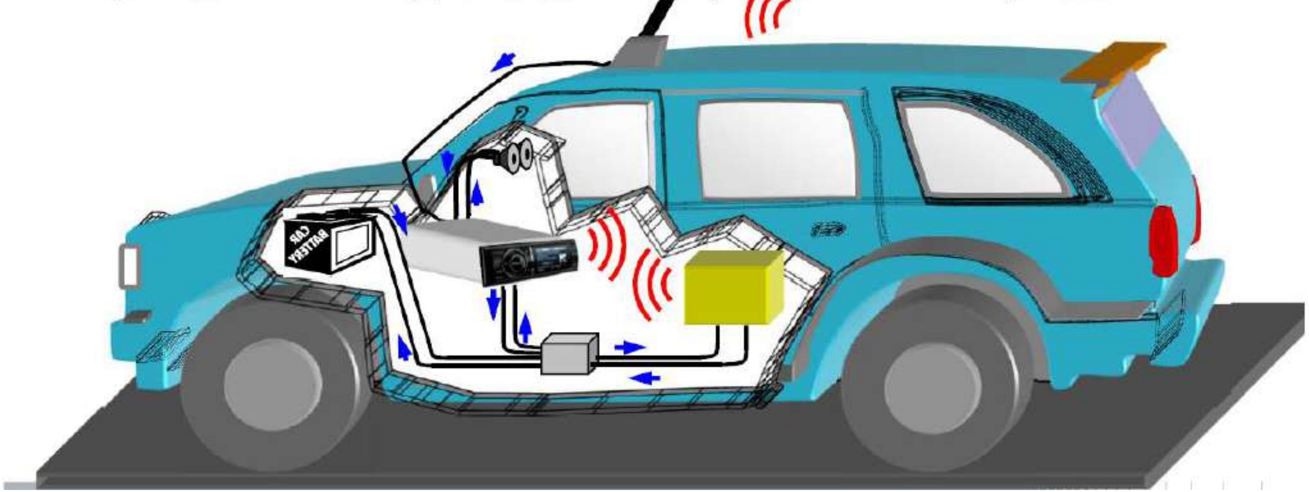
THE NEED FOR AUTOMOTIVE EMC

- Infotainment Systems

- Mobile Applications

- Navigation systems

- Safety systems



TESTING IN AUTOMOTIVE EMC: ECE R10

ECE-R10 EMC					
EMI			EMS		
RF		Power Frequency	Transient	RF	
Conducted	Radiated	Harmonics/Flic ker	EFT， Surge	Conducted	Radiated
CISPR 12 CISPR 25	CISPR 12 CISPR 25	IEC 61000-3-2 IEC 61000-3-12/ IEC 61000-3-3 IEC 61000-3-11	ISO 7637-2 IEC 61000-4-4 IEC 61000-4-5	ISO 11451-4 ISO 11452-4	ISO 11451-2 ISO 11452-2 ISO 11452-3 ISO 11452-5

STANDARD OVERVIEW: AUTOMOTIVE IN EMI STANDARD

Emission Standards

CISPR 25

Limits and Methods of Measurement of radio disturbance characteristics for the protection of receivers used on board vehicles

CISPR 12

Limits and methods of measurement for the protection of off-board receivers (Vehicles, boats and internal combustion engines)

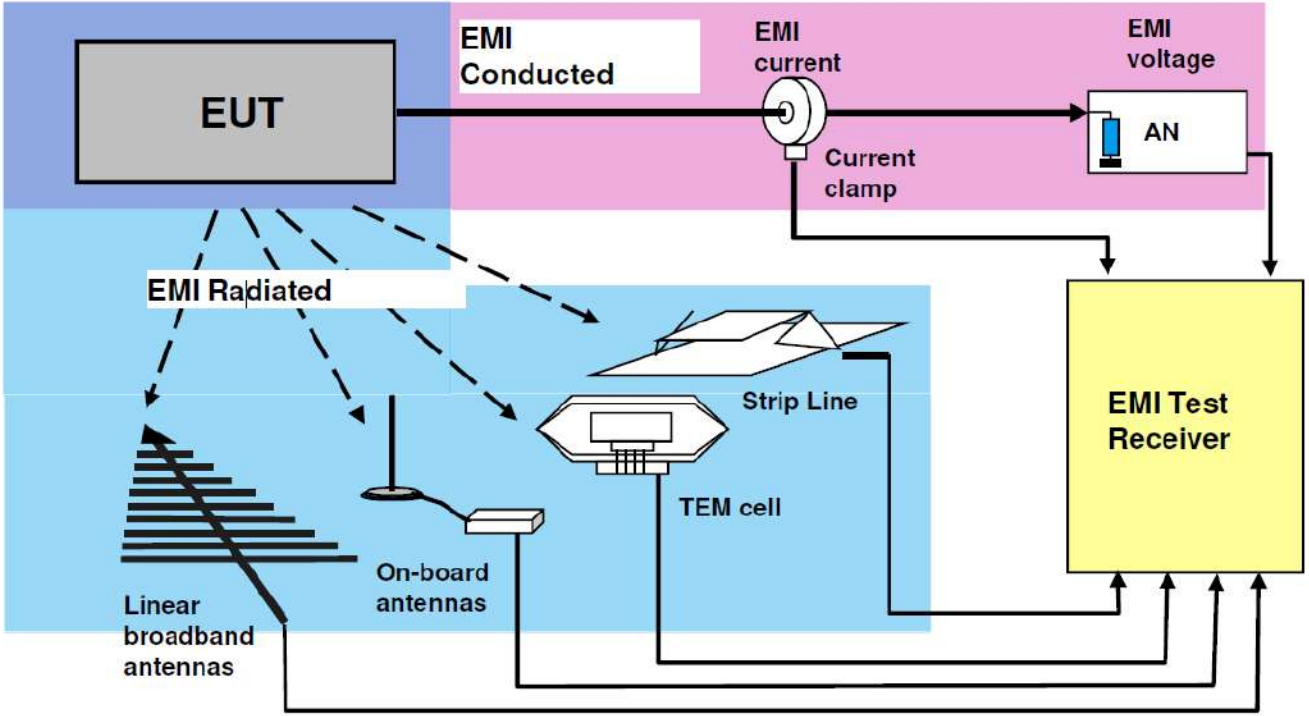
STANDARD OVERVIEW: AUTOMOTIVE IN EMS STANDARD

STANDARD OVERVIEW

International	Manufacturer	Europe	India
CISPR 12 VEHICLE EMI	GM 3097 ESA EMC	2004/104/EEC VEHICLE & ESA EMC	AS004 VEHICLE & ESA EMC
ISO 11451 VEHICLE EMS	BMW GS95002 VEHICLE & ESA EMC	ECE R10 VEHICLE & ESA EMC	
ISO 10605 VEHICLE & ESA ESD	VW-TL ESA EMC		
CISPR 25 ESA EMI	FORD EMC ESA EMC		
ISO 11452 ESA EMS	⋮		
ISO 7637 Conducted Pulse	FLAT 9.90110 VEHICLE & ESA EMC		

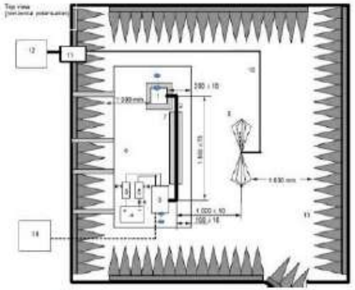
CISPR 25 AUTOMOTIVE COMPONENT EMI

- Limits and **Methods** of Measurement of radio disturbance characteristics for the protection of receivers used on board vehicles

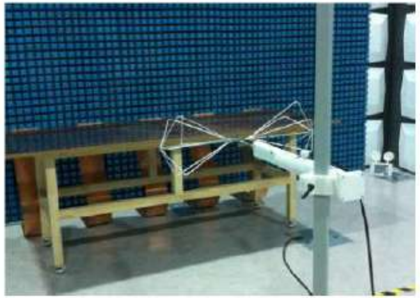


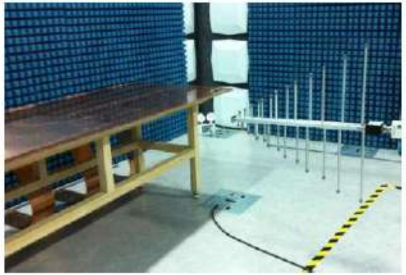
CISPR 25: TEST SETUP & ENVIRONMENT

Example of Setup & Chamber:

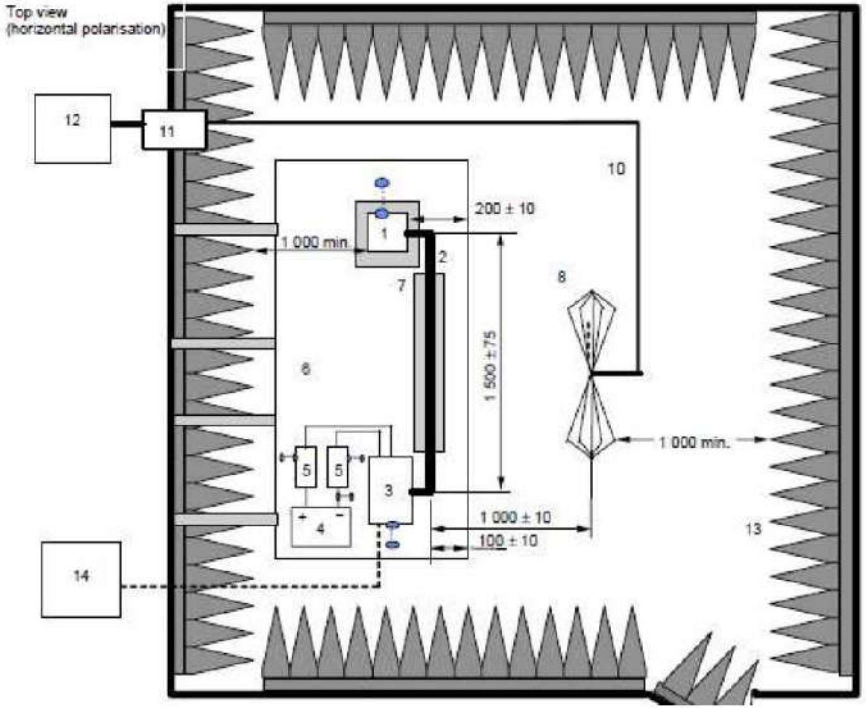


Example: Setup & Environment:

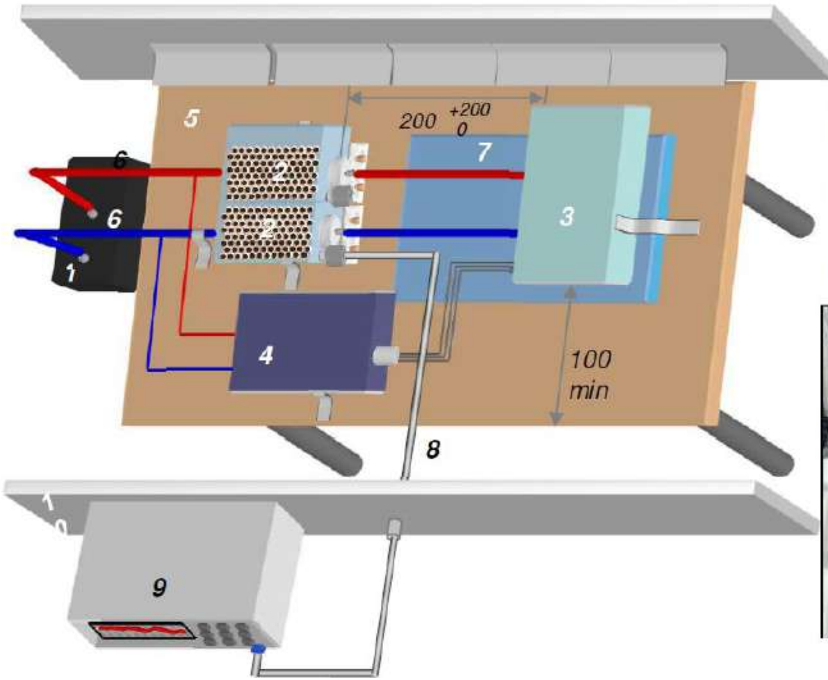




CISPR 25: RADIATED TEST SETUP

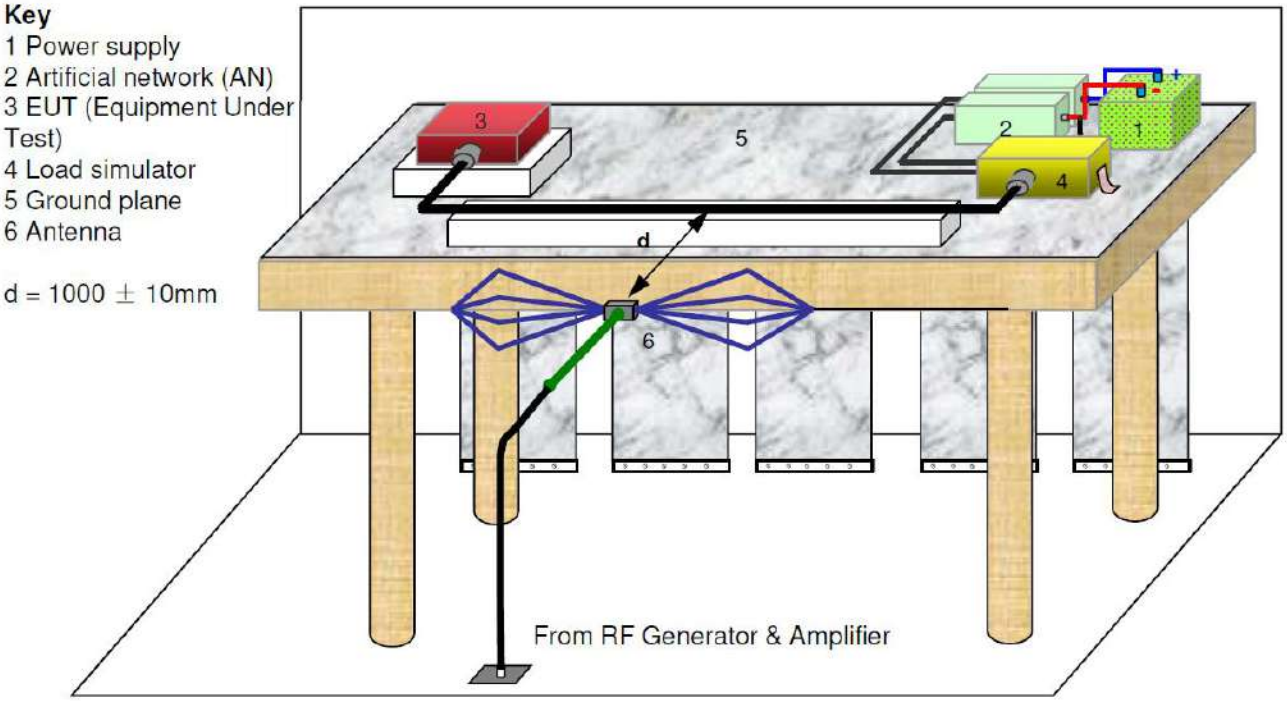


CISPR 25: RADIATED TEST SETUP

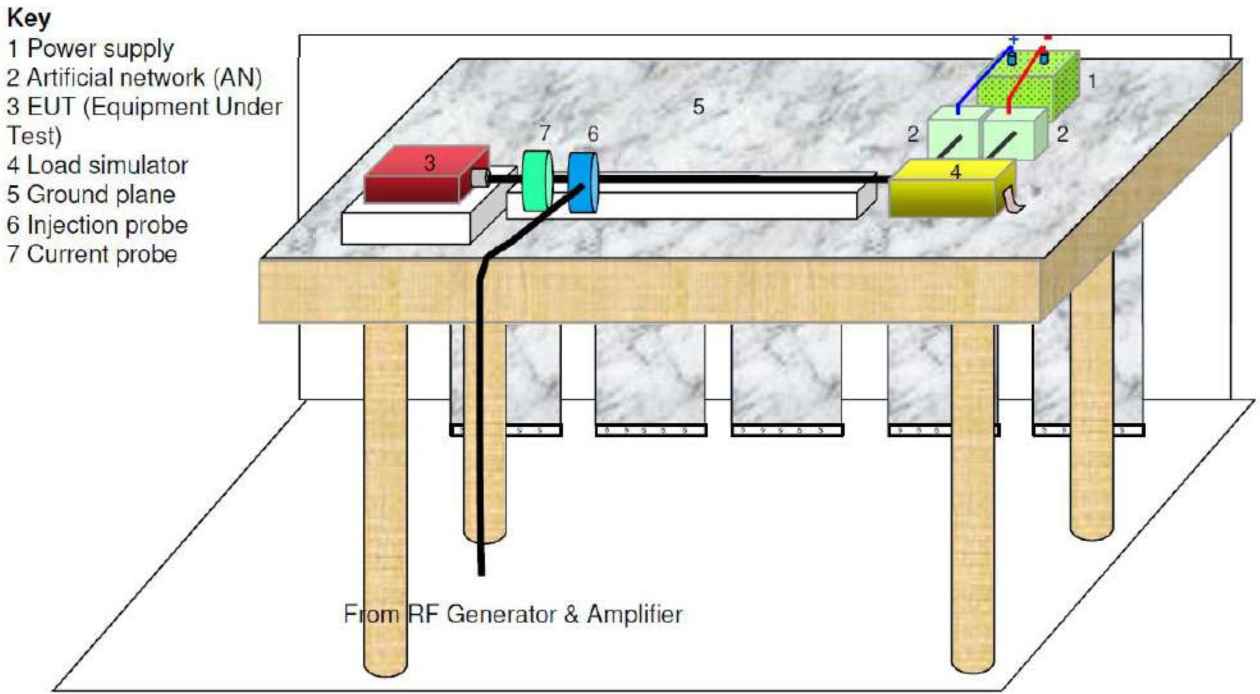


Key
1 Power supply
2 Artificial network
3 EUT
4 Load simulator
5 Ground plane
6 Power supply lines
7 Low relative permittivity support
8 RF Cable (50 Ω)
9 Measuring instrument
10 Shielded enclosure

ISO 11452-2: RADIATED IMMUNITY TEST SETUP

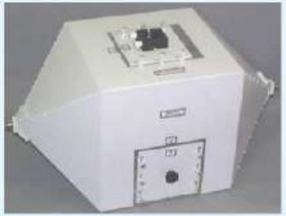


ISO 11452-4 CONDUCTED IMMUNITY TEST SETUP

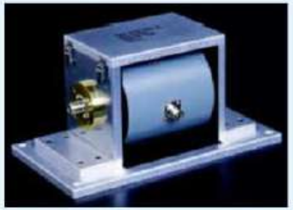


ISO 11452: TEST METHODS

ISO 11452-2
ALSE Antennas
Electric field strength



ISO 11452-3
TEM-Cell
Electric field strength



ISO 11452-4
Injection probe
Current injection

ISO 11452-5
Stripline
Electric field strength

ISO 11452-7
Broadband Artificial Network
Direct power injection

ISO 11452-8
Radiating loop
Magnetic field strength

ISO 11452-8
Helmholtz coil
Magnetic field strength

ISO 11452-9
Portable transmitter
Radiated power

ISO 11452: SUMMARY OF TESTS

Standard	Test	Transducer	Freq (Hz)	Level
ISO 11452-2	Radiated Immunity	Antenna / TLS	80M ~ 18G	100V/m
ISO 11452-4	Bulk current injection	Injection Probe & TWC	1M ~ 3000M	200mA / 33W
ISO 11452-3	Radiated immunity	TEM Cell	10k ~ 200M	200V/m
ISO 11452-5	Radiated immunity	Stripline	10k ~ 400M	200V/m
ISO 11452-8	Magnetic field immunity	Helmholtz coil / radiating loop	DC & 15 ~ 150k	Up 3000A/m
ISO 11452-9	Portable transmitter	Antenna	26M ~ 5.85G	0.5W ~ 16W
ISO 11452-10	Immunity in audio freq	Isolation transformer	15 ~ 250k	3V
……				

CISPR 25 – AUTOMOTIVE EQUIPMENT PROTECTION OF ON-BOARD RECEIVERS

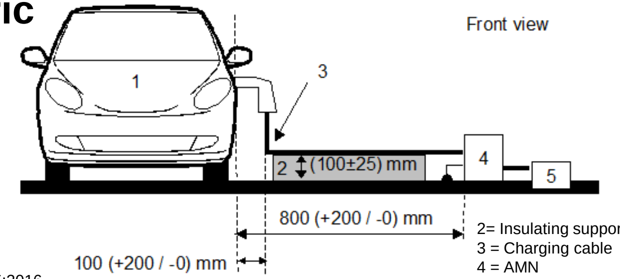
► **Developed by CISPR sub-committee D**

- **4th Edition was published on 27 October 2016 and Corrigendum COR1:2017**
- **In Europe published on national level only, e.g. BS EN 55025:2017 (UK), DIN EN 55025:2018 (Germany)**
- **EN 55025 is not listed in the Official Journal of the EU and has no legal status**

  Therefore, the car component manufacturer has to apply the specific company standards of the car manufacturer, which are usually based on CISPR 25 or EN 55025 respectively

CISPR 25 – AUTOMOTIVE EQUIPMENT PROTECTION OF ON-BOARD RECEIVERS

- **What's New in Edition 4?**
  - **The reference to CISPR 16-1-1 was updated to make FFT-based receivers like the R&S®ESW, R&S®ESR and R&S®ESU applicable for EMI compliance measurements**
  - **The appropriate average detector is the CISPR-AV detector with meter time constant, the alternative use of the pure linear AV detector was deleted**
  - **Frequency range was not extended, maximum = 2.5 GHz**
  - **Dielectric material is not used any more between cable harness and table in the component measurement setup for alternators and generators (Figure 8)**
  - **Disturbance measurements in charging mode of electric and hybrid vehicles if the charger is part of the vehicle**
    - Vehicle test – Voltage at internal antenna
    - The measurements are made without the engine running and all other equipment shall be switched off
    - AMN/AN-HV same as for CISPR 12



Source: CISPR 25:2016

CISPR 25 – AUTOMOTIVE EQUIPMENT PROTECTION OF ON-BOARD RECEIVERS

- **What's New in Edition 4? (continued)**
  - **Apply correction factor for the AN, it is available from the manufacturer of the AN and can easily added as transducer factor in the receiver or system software**
  - **A new informative Annex on chamber validation was added, it contains two alternative validation methods ("long wire" and "reference site method")**
  - **Disturbance measurements on the high voltage (HV) propulsion system of electric vehicles**
    - Disturbance voltage and current, voltage measurement requires specific 5 µH//50 Ω HV-AN, i.e. in shielded box, adaption for shielded cables and additional resistor for discharging to <50 V within 60 s
    - RE for components, ALSE method (150 kHz to 2500 MHz)
    - Coupling between HV and LV system by direct S-parameter measurements (decoupling factor) or based on existing CISPR 25 test set-up (voltage, current and electric field)

CISPR 25 – AUTOMOTIVE EQUIPMENT PROTECTION OF ON-BOARD RECEIVERS

- **What's New in Edition 4? (continued)**
  - **Using the minimum dwell time as defined in Table 2 with a measuring receiver can result in enormous measurement result errors**
  - **In a worst case the receiver will not capture the disturbance signal at all if the dwell time is shorter than the pulse repetition interval of the disturbance signal**
  - **Not suitable for measuring intermittent narrowband signals with CISPR-AV detector! Should be at least:**
    - **160 ms in AM Band (<30 MHz)**
    - **100 ms in Bands >30 MHz**

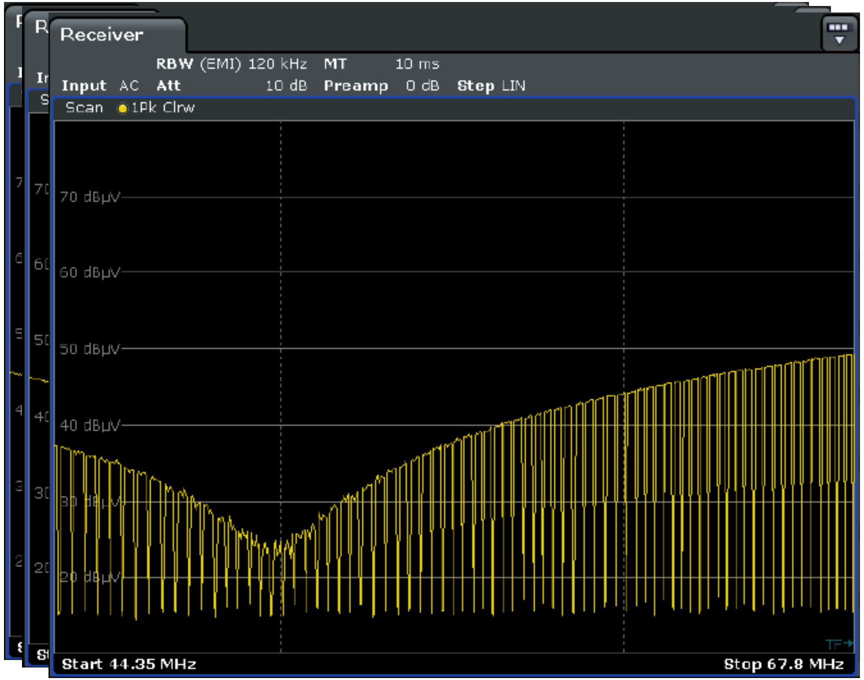
Table 2 – Scanning receiver parameters

Service / Frequency range	MHz	Peak detection			Quasi-peak detection			Average detection		
		BW at -6 dB	Step size	Dwell time	BW at -6 dB	Step size	Dwell time	BW at -6 dB	Step size	Dwell time
AM broadcast and mobile services	0,15 - 30	9 kHz	5 kHz	50 ms	9 kHz	5 kHz	1 s	9 kHz	5 kHz	50 ms
FM broadcast	76 - 108	120 kHz	50 kHz	5 ms	120 kHz	50 kHz	1 s	120 kHz	50 kHz	5 ms
Mobile services	30 to 1 000									
TV Band I	41 – 88									
TV Band III	174 – 230									
TV Band IV/V	470 – 890									
DAB	171 - 245									
DTTV	470 - 770	120 kHz	50 kHz	5 ms	Does not apply	Does not apply	Does not apply	120 kHz	50 kHz	5 ms
Mobile service	1 000 - 2 500	120 kHz	50 kHz	5 ms	Does not apply	Does not apply	Does not apply	120 kHz	50 kHz	5 ms
GPS L1 civil	1 567 – 1 583	Does not apply	Does not apply	Does not apply	Does not apply	Does not apply	Does not apply	9 kHz	5 kHz	5 ms

NOTE For emissions generated by brush commutator motors without an electronic control unit, the maximum step size may be increased up to 5 times the bandwidth.

CISPR 25 – AUTOMOTIVE EQUIPMENT PROTECTION OF ON-BOARD RECEIVERS

- **Wrong measurement time can result in enormous errors!**
  - **Pulse modulated carrier with 12 ms pulse period, Time Domain Scan shows closed trace with 12 ms measurement time**
  - **Gaps in TD Scan trace with 10 ms measurement time**
  - **Even when 10 ms yields a closed trace in Stepped Scan, zooming in reveals gaps in the trace**
  - **Important Measurement time ≥ signal period!**



CISPR 25 – AUTOMOTIVE EQUIPMENT PROTECTION OF ON-BOARD RECEIVERS

- **What's Coming in Edition 5?**
  - **Maximum frequency will be extended beyond 2500 MHz for both component (ALSE method) and vehicle (voltage at internal antenna) testing, this will add new frequency bands up to 6 GHz:**
    - 4G: 2496 to 2690 MHz, 3300 to 3800 MHz and 5150 to 5925 MHz
    - WiFi: 5150 to 5350 MHz and 5470 to 5725 MHz
    - C2X (Car-to-X Communication): 5850 to 5925 MHz
  - **Adds new GNSS band: BDS (BeiDou System)**
  - **Revision of measurement methods in charging mode of electric and hybrid vehicles based on charging mode concept in IEC 61851-1 (Mode 1 to 4)**
  - **New Annexes will be added on the consideration of measurement instrumentation uncertainty (MIU), also uncertainty budget is given (sample calculation)**

ELECTRO-MAGNETIC ENVIRONMENT (EME) TESTING

NEW INTEREST TOPICS WITHIN ISO AUTOMOTIVE WORKING GROUP

ADAS	C2X	EMC & ISO 26262	Automotive EMC Environment	Vehicle EMS	Virtual Testing
					
Human machine interface to provide assistance in driving	Communication from vehicle-to-everything	ISO 26262 addresses functional safety requirements for electrical & electronic systems	Specific conditions required for automotive EMC testing	Alternative vehicular test methods, e.g. Intentional EMI, Magnetic Field & Reverberating Chamber	Virtual testing for safety analysis
To study the ADAS functionality during immunity	To study C2X functionality during EMC testing	To study the functionality tests under EMC testing environments	To consider requirements specifically for testing in automotive EMC	Consideration of newer EMC test methods.	To consider future virtual testing for safety assessment

RISING UP TO THE CHALLENGE

EME

C-V2X

Advise

RDS

E-call

ELECTRO-MAGNETIC ENVIRONMENT (EME) TESTING

ELECTRO-MAGNETIC ENVIRONMENT (EME) TESTING

ELECTRO-MAGNETIC ENVIRONMENT (EME) TESTING

► **EME Effects test** is putting the DUT/SUT under the sum of

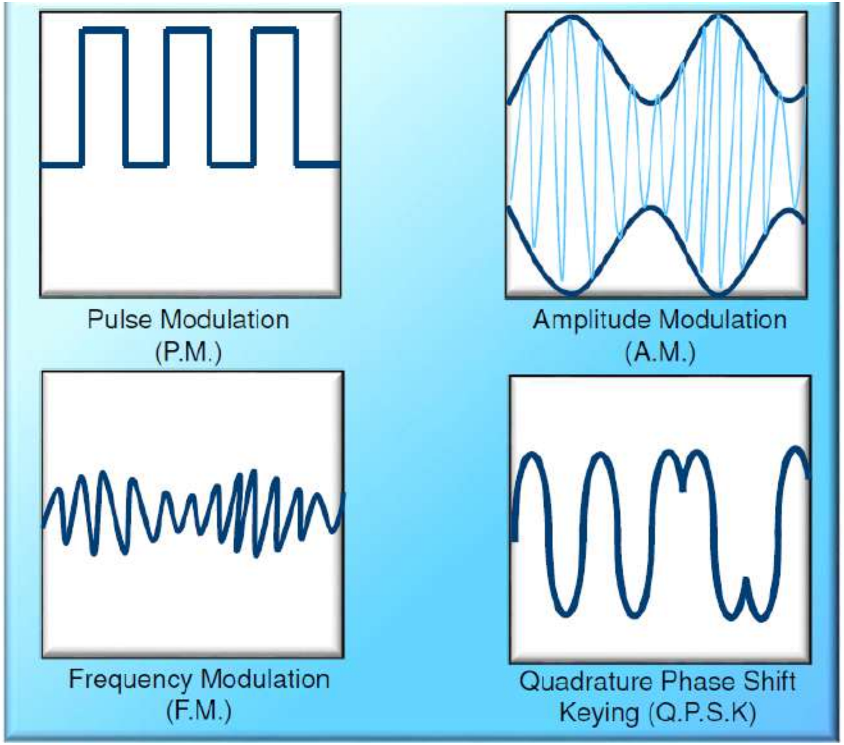
- **EMC** tests which directly tests for safety and reliability of electrical & electronic devices;

- **Radio coexistence** which evaluates performance and functionality in the presence of known radio and wireless communication signals;

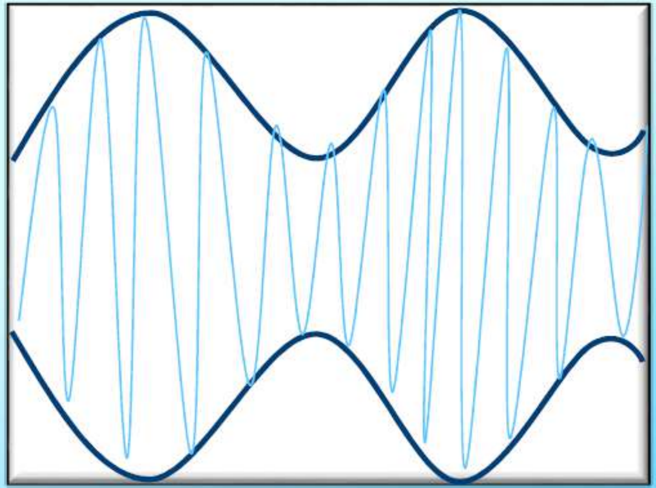
- **Scenarios** that introduce diverse operational environments; in order to know the **Worst-case Effects** and evaluate the **Safety Integrity** of the DUT/SUT by advance analysis methods

ELECTRO-MAGNETIC ENVIRONMENT (EME) TESTING

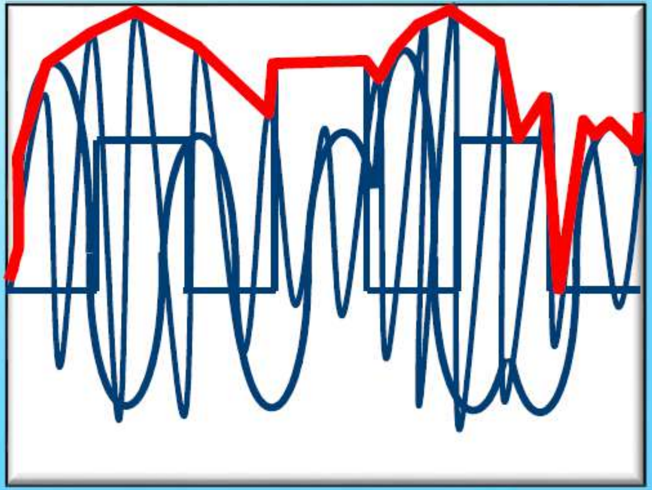
FIXED MODULATION FOR CONVENTIONAL EMS



CONVENTIONAL EMS SIGNAL VS EME SIGNAL

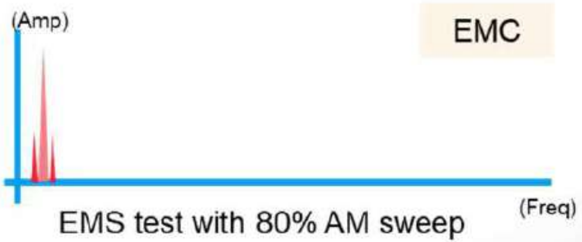


Amplitude Modulation
(A.M.)



Example of EME Signal

CONVENTIONAL EMS SIGNAL VS EME SIGNAL



- Military test method vs Pulse radar interferences
- EME test covers and focuses multi-domains of interference signals, which is closer to real-world environment during wartime
- It is Reliability, Adaptability and Safety Tests

EMC STANDARDS

Commercial Equipment:

- ISM Equipment
- Consumer Electronics Equipment
- IT / Household Equipment
- Lighting Equipment

Applicable Standards:

- CISPR 11 - 35
- IEC61000-X-X series
- Product Specific Standards

Military Equipment:

- Aircraft Equipment
- Ship & Submarine Equipment
- Land Based Equipment

Applicable Standards:

- Mil-Std 461
- Mil-Std 464C
- GJB151A/152A-97

Automotive Equipment:

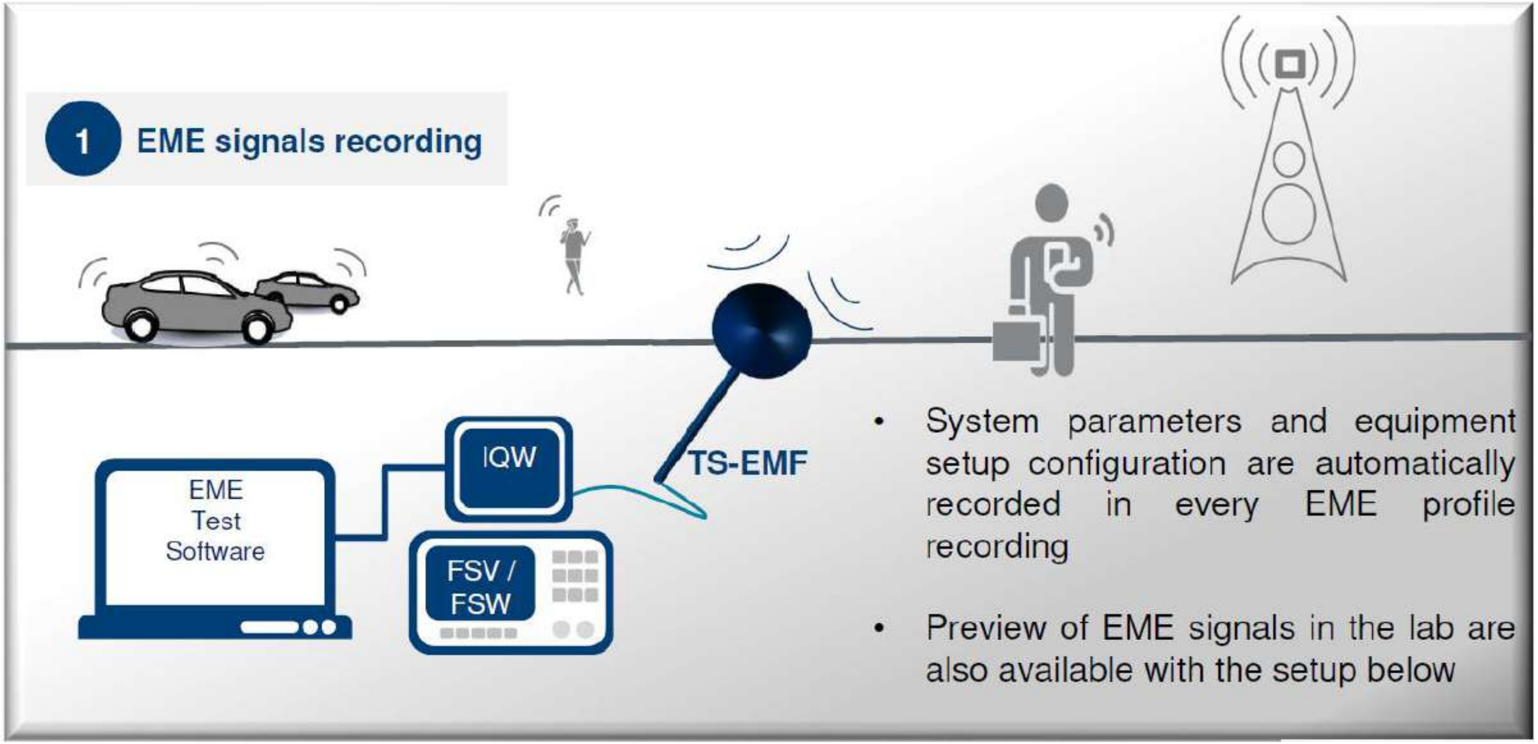
- Control Equipment
- Infotainment Equipment
- Communication Equipment

Applicable Standards:

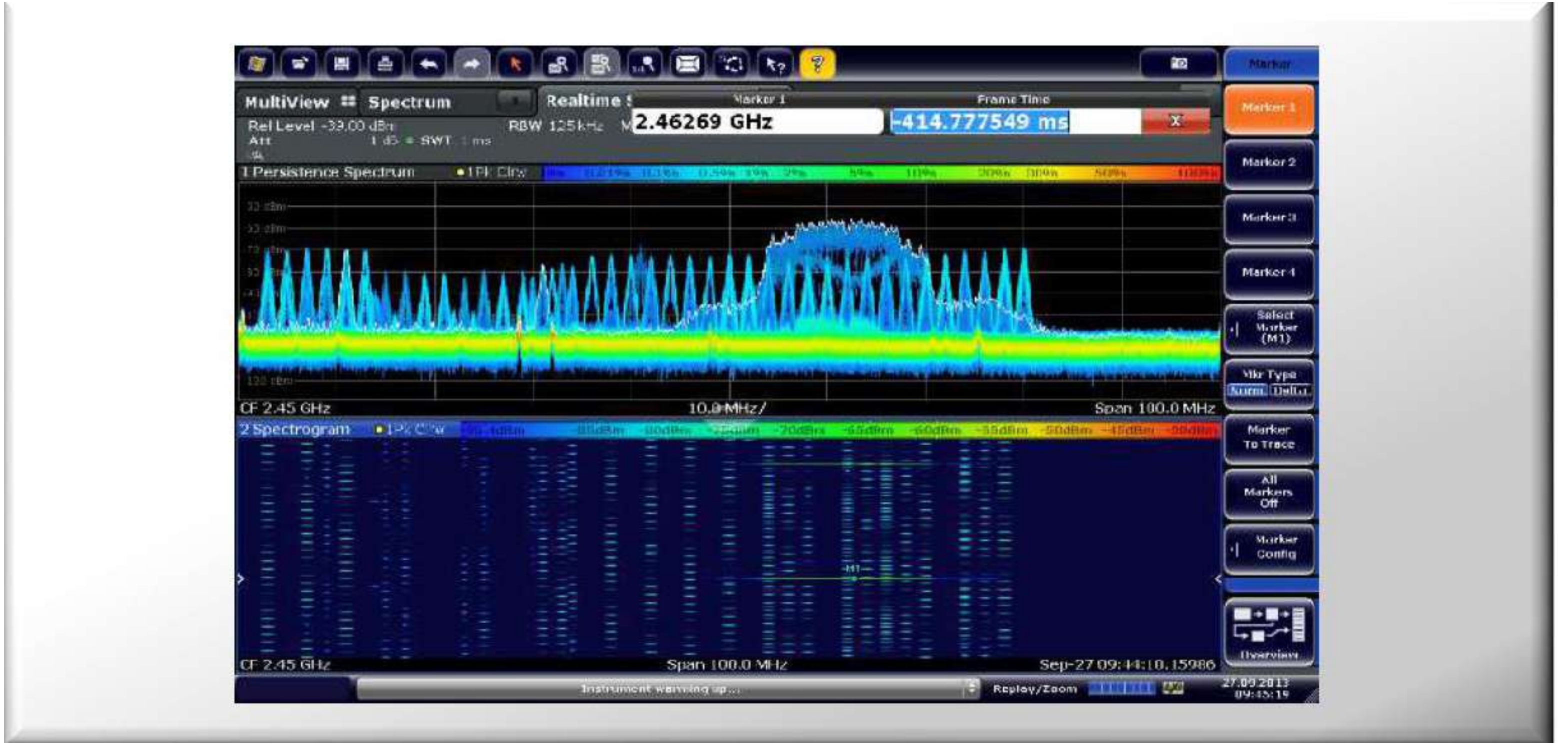
- CISPR 12, 25
- ISO11451, ISO11452
- Product Specific Standards

RELEVANT TEST STANDARD DOCUMENTS

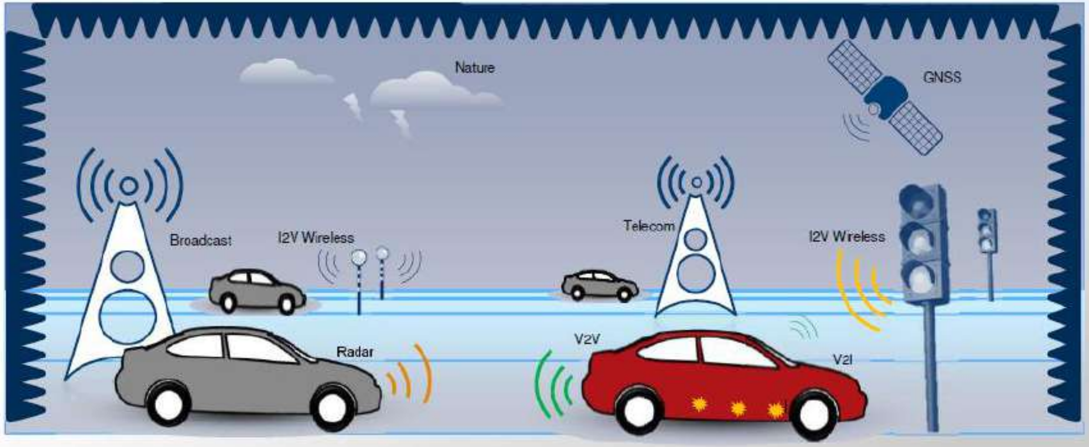
EME SIGNAL COLLECTION AND RECORDING ON ROAD



EME SIGNAL COLLECTION AND RECORDING ON ROAD



TESTING EME IN CHAMBER



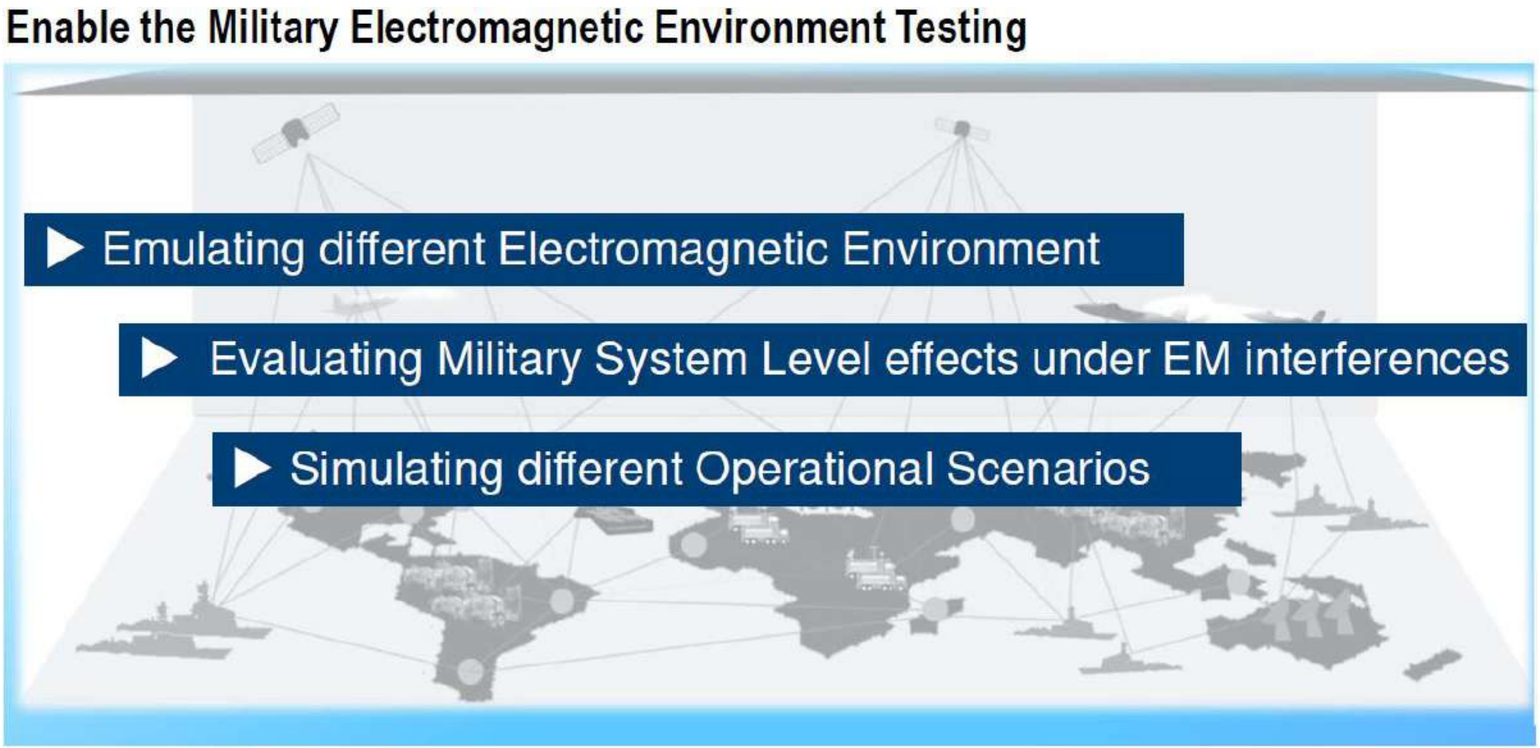
EMULATE COMPLEX EME SIGNALS

Enable the Road Electromagnetic Environment Testing

- **Radio coexistence** which evaluates performance and functionality in the presence of known radio and wireless communication signals;

- **Scenarios** that introduce diverse operational environments

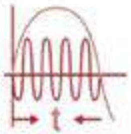
EMULATE COMPLEX EME SIGNALS



BRING REAL-WORLD EME TO LAB

EME FEATURE

Recommended Specification



FREQUENCY AND BANDWIDTH

Carrier Frequency < 6 Ghz

Baseband BW 160Mhz

ARB BW 160 Mhz

Analysis BW 160Mhz

FIDELITY & FIELDSTRENGTH

Subjected to recording and system calibration

Max-Pk field-strength may limited existing EMC system

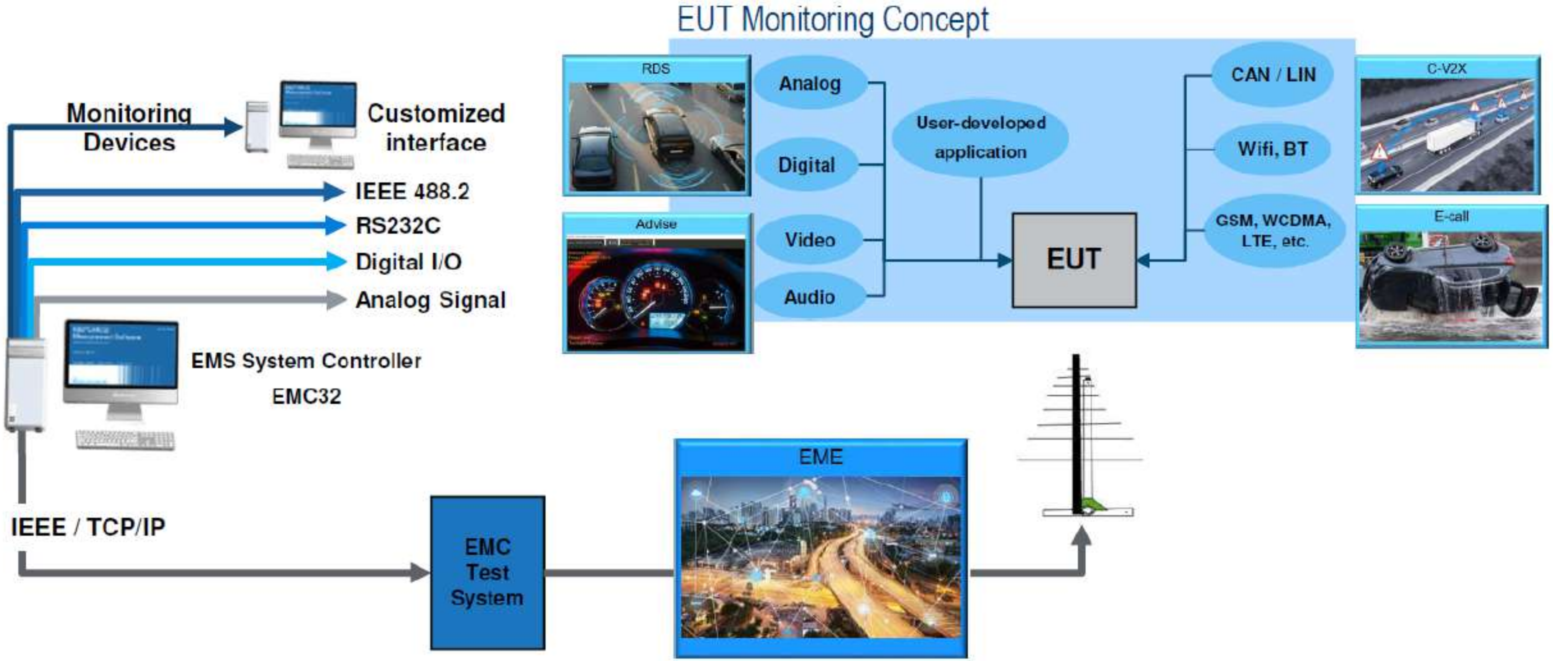
AMPLIFIER SPECIFICATION

Subjected to waveform characteristics and field strength levelling method

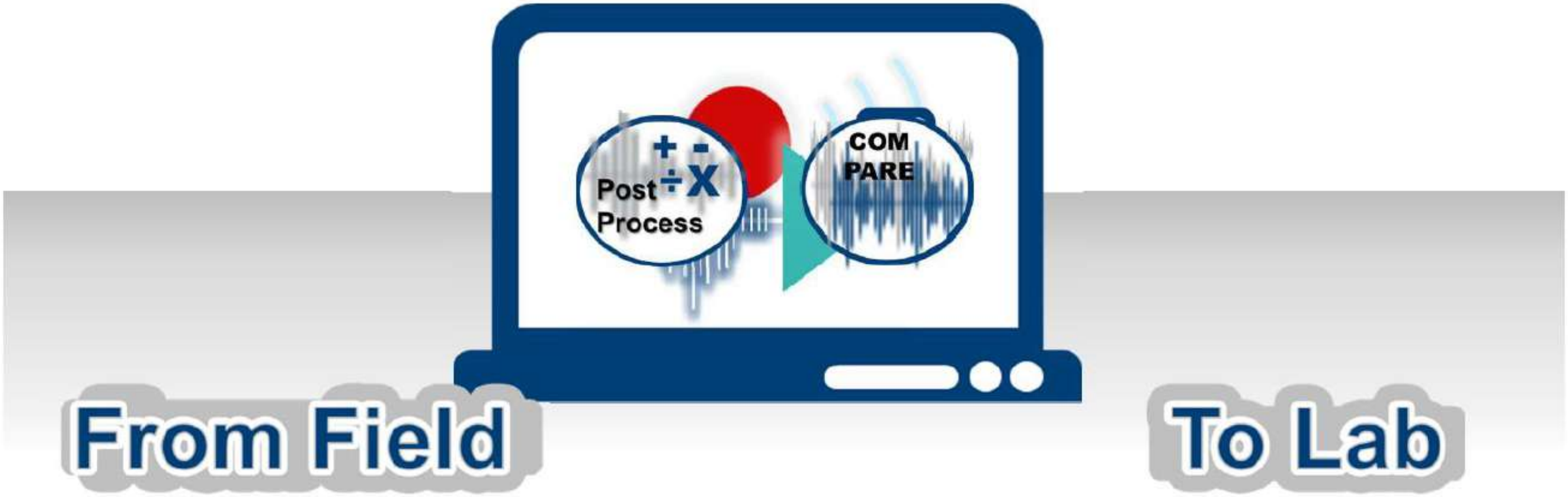
VALIDATION

TA-EME are designed according to CSAE recommended method and requirements

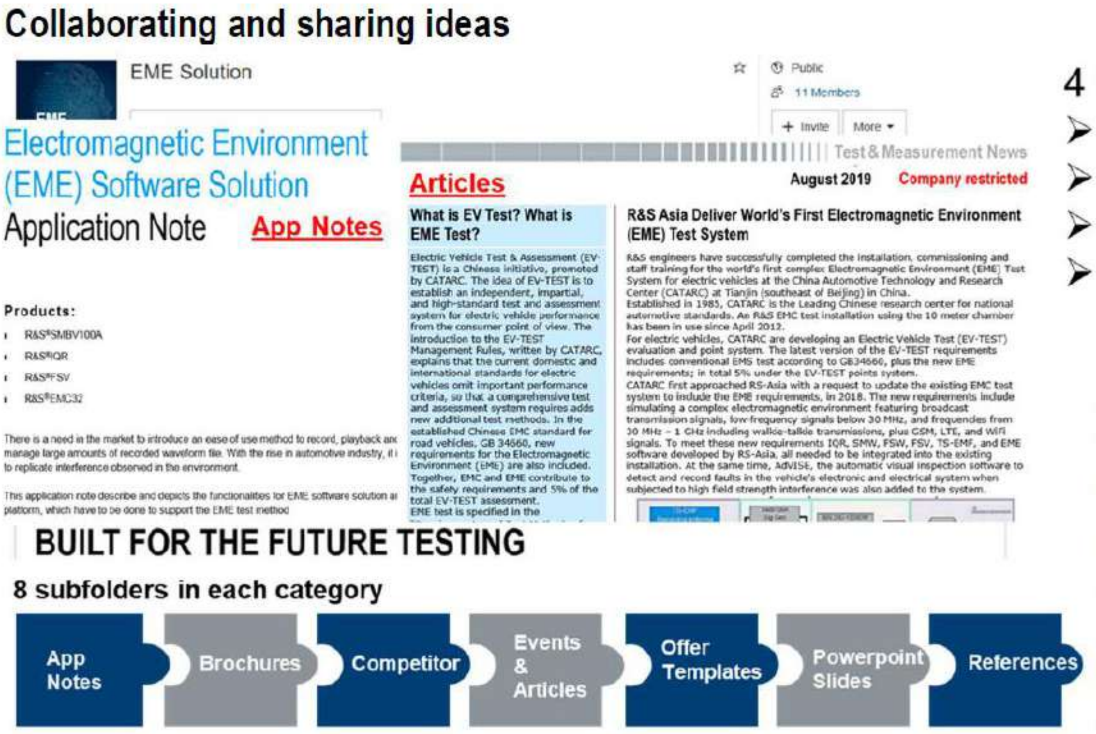
EME MONITORING SYSTEM



TAS-EME SOFTWARE FEATURES



VISIT EME SOLUTION



4 Categories

- Automotive
- Medical
- Military
- Wireless

Scan Me

R&S®ESW EMI TEST RECEIVER

High-end compliance receiver based on proven FSW platform

- ► 1 Hz to 8 / 26.5 / 44 GHz
- ► All relevant standards from commercial to military
- ► Best HF performance receiver and spectrum analyzer in one device

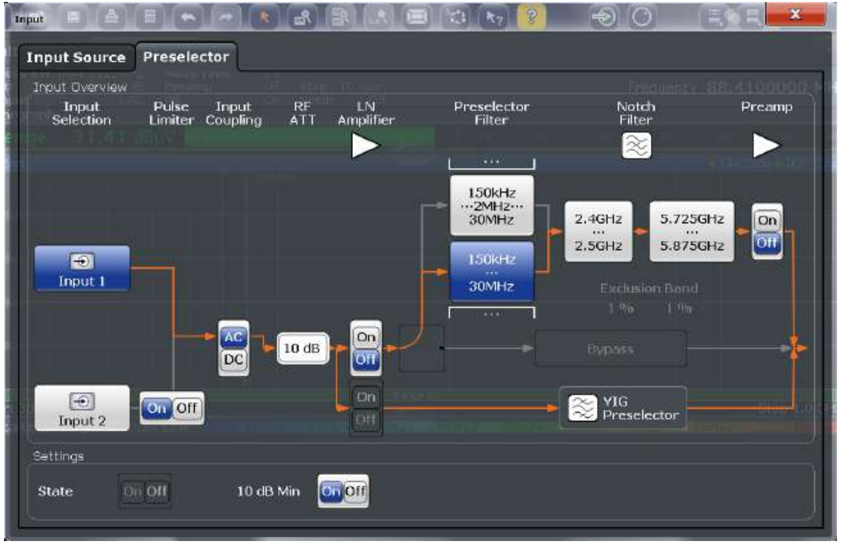
Highlights

- ► Sensitivity: Built-in preamplifier, optional LNA and notch filters
- ► Speed: Unique time-domain scan with parallel CISPR detectors
- ► Usability: Big high resolution touch screen
- ► MultiView: All needed measurements in one display

COMPANY RESTRICTED

R&S®ESW HF PERFORMANCE

- ► High dynamic range and sensitivity
  - – 1 dB compression point: +15 dBm
    (< 3 GHz, Presel., Preamp and LNA off)
  - – Third-order intercept point (TOI): > 20 dBm
    (< 1 GHz, Presel., Preamp and LNA off)
  - – Displayed average noise level (DANL): < -149 dBm
    (Between 1 MHz and 1 GHz, Presel., Preamp and LNA off)
  - – Very low spurious responses: < -110 dBm
    (1 MHz - 8.9 GHz)
- ► Preselection and notch filters
  - – 2.4 - 2.5 GHz and 5.725 - 5.875 GHz for ISM band suppression



Configurable input signal path of ESW

R&S®ESW MEASUREMENTS BEYOND 44 GHZ

- ► **Automotive radar** testing
  - – e.g. 77 GHz
- ► **A&D applications** analyzing interferer
  - – 110 GHz or higher

ESW-B21

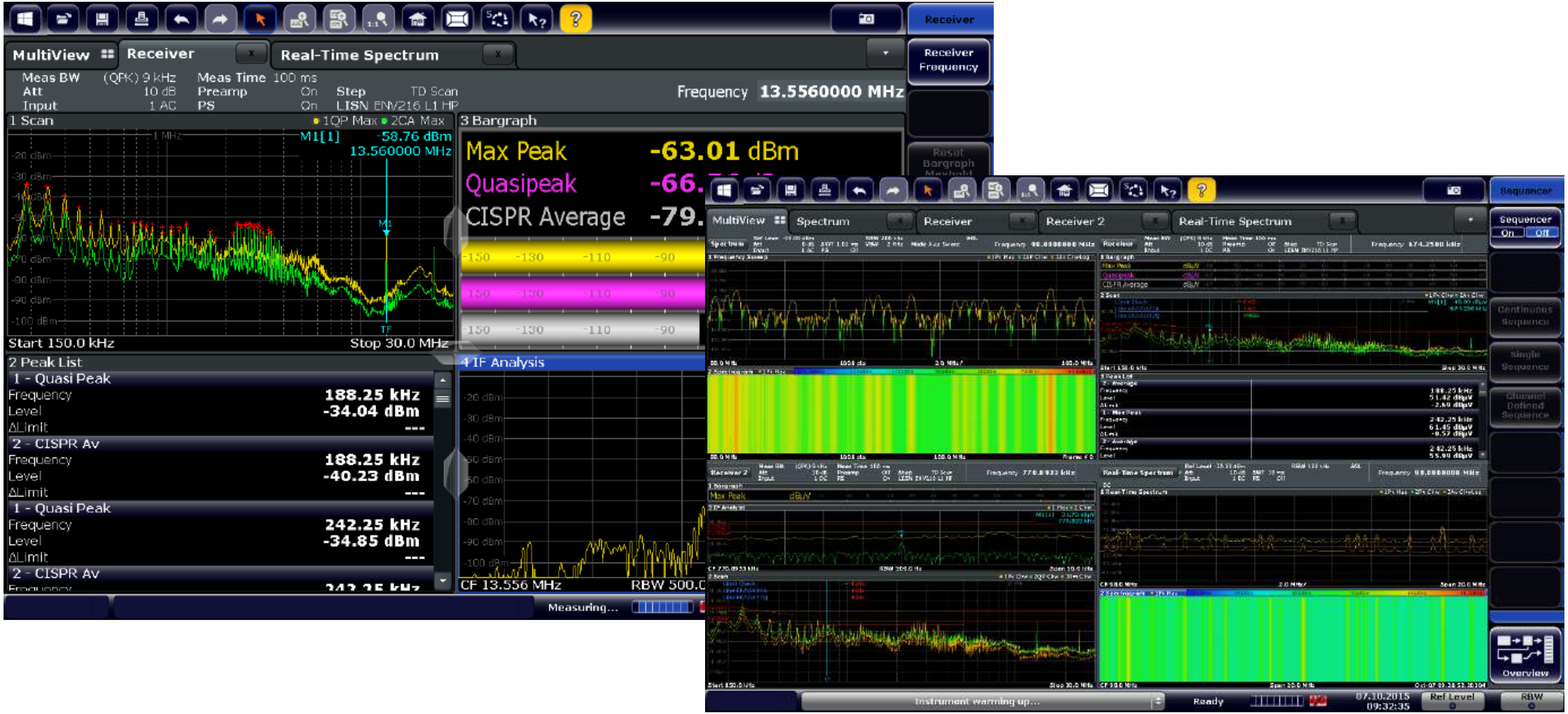
EMI Test Receiver ESW26/44

FS-Zxx

- ► FCC compliance test
  - – Measurement up to 5^{th} order harmonics
  - – Up to 200 GHz for carrier frequency above 30 GHz
- ► R&S ESW-B21 & FS-Zxx harmonic mixers extend

  the frequency coverage of the ESW26 / 44 up to 500 GHz.

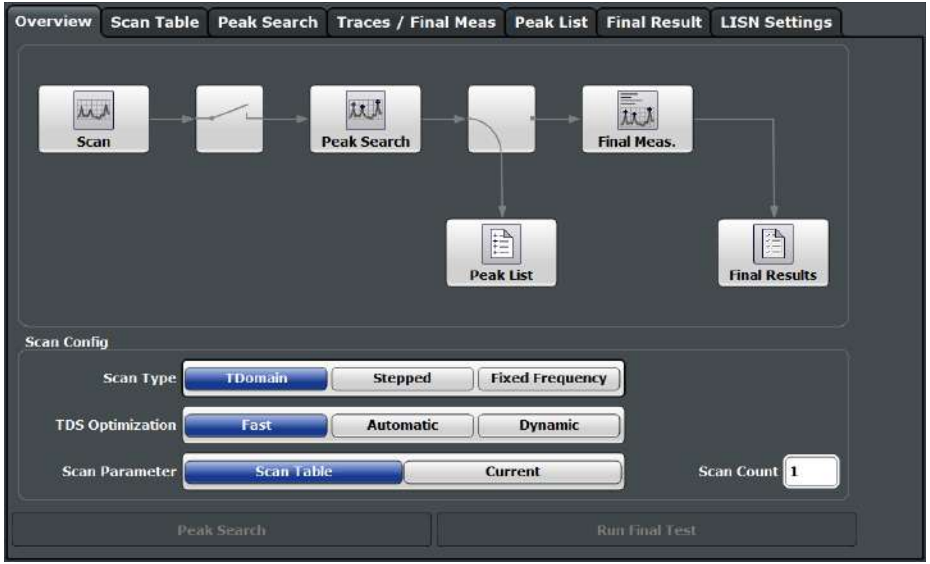
R&S®ESW CUSTOMIZABLE MULTI-VIEW



R&S®ESW INTUITIVE GRAPHICAL USER INTERFACE

► Test Automation Overview Block Diagram

1. **Scan table**
   – Customizable frequency ranges
   – Measurement time
   – Resolution Bandwidths (RBW)
2. **Peak Search**
   – Record to Peak List
   – Choose Limit Line according to standard
3. **Final Measurement**
   – Interactive Mode
4. **Final Results**
   – Report generation



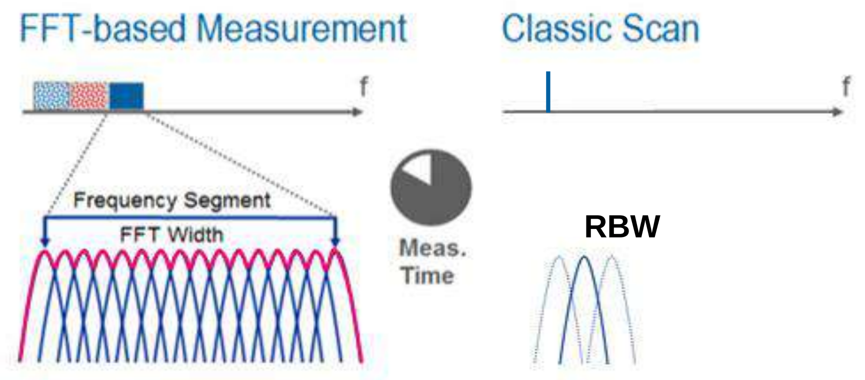
R&S®ESW TIME DOMAIN SCAN FOR MIL-STD & COMMERCIAL

- Rohde & Schwarz was the lead manufacturer in the Tri Services Working Group on the integration of Time Domain Scan within MIL-STD-461G

FFT is faster by numbers of magnitude than the classic scan

- Conducted band (150 kHz – 30 MHz) fits in **one** FFT analysis BW

- Perform QP & CISPR Avg in real-time on the conducted band



R&S®ESW MEASUREMENT SPEED

- Time domain scan with 3 optimization modes
  - **Automatic**
    full compliant to CISPR 16-1-1
  - **Fast**
    Compliant to CISPR 16-1-1 for pulses with a repetition frequency ≥ 10 Hz
  - **Dynamic**
    Enhanced dynamic in CISPR band D for applications with requirements beyond CISPR 16-1-1

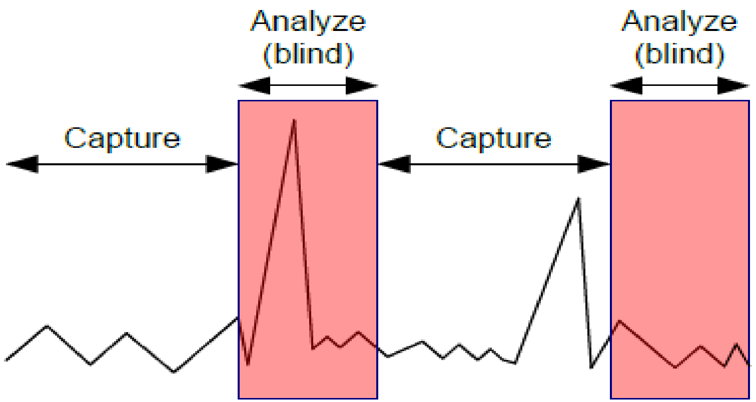
	Measurement times	R&S ESW		
		Automatic TDS (full compliant)		Fast TDS
	150 kHz – 30 MHz 9 kHz, QP + CAV, 1 s	2 s		2 s
	150 kHz – 30 MHz 9 kHz, Peak, 100 ms	110 ms		110 ms
	30 MHz – 1000 MHz 120 kHz, Peak, 10 ms	380 ms		380 ms
CISPR 25 Automotive	**30 MHz – 1000 MHz** 9 kHz, QP + CAV, 1 s	64 s	- 37 %	40 s
	30 MHz – 1000 MHz 120 kHz, QP + CAV, 1 s	50 s	- 20 %	40 s
CISPR 11 Microwave oven	**1 GHz – 6 GHz** 1 MHz, Peak + CAV, 100 ms	216 s	- 51 %	111 s
	1 GHz – 18 GHz 1 MHz, Peak, 10 ms	8 s		8 s
FCC	1 GHz – 26.5 GHz 1 MHz, Peak + AV, 10 ms	13 s		13 s
MIL	**1 GHz – 40 GHz** 1 MHz, Peak, 10 ms	21 s		21 s

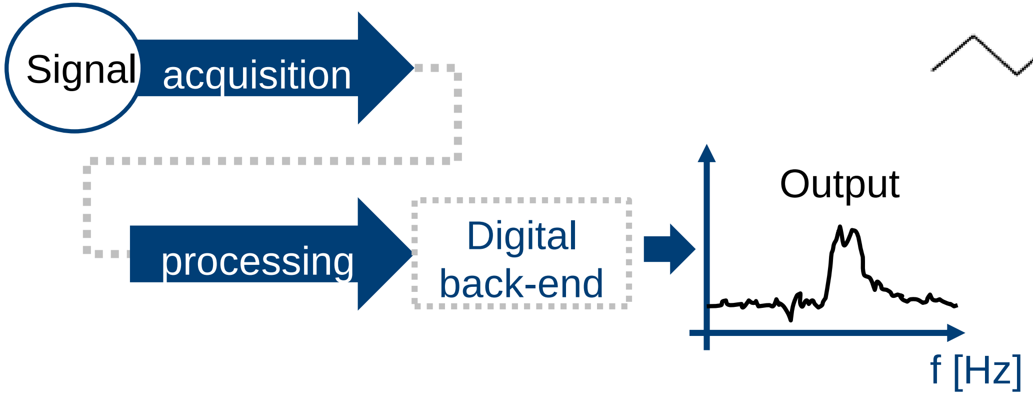
FFT-BASED RECEIVER FOR EMI COMPLIANCE MEAS.
TIME DOMAIN SCAN VS STEP SCAN TIME:

Frequency range	Weighting detector; measurement time; IF bandwidth; step width for stepped scan (SS) and Time Domain Scan (TD)	FFT-based measuring instrument R&S ESW 	
		Stepped Scan	Time-domain Scan
CISPR Band B 150 kHz to 30 MHz	Pk; 100 ms; 9 kHz; SS: 4 kHz, TD: 2.25 kHz	12.35 mins	0.11 s
CISPR Band B 150 kHz to 30 MHz	QP + CAV, 1 s, 9 kHz SS: 4 kHz, TD: 2.25 kHz	approx. 3.8 h	2 s
CISPR Bands C/D 30 to 1000 MHz	Pk, 10 ms, 120 kHz SS: 40 kHz, TD: 30 kHz	4.15 mins	0.62 s
CISPR Bands C/D 30 to 1000 MHz	Pk, 10 ms, 9 kHz SS: 4 kHz, TD: 2.25 kHz	approx. 1 h	0.84 s
CISPR Bands C/D 30 to 1000 MHz	QP, 1 s, 120 kHz SS: 40 kHz, TD: 30 kHz	approx. 10 h	80 s
CISPR Bands C/D 30 to 1000 MHz	QP + CAV, 1 s, 9 kHz SS: 4 kHz, TD: 2.25 kHz	approx. 100 h	67 s

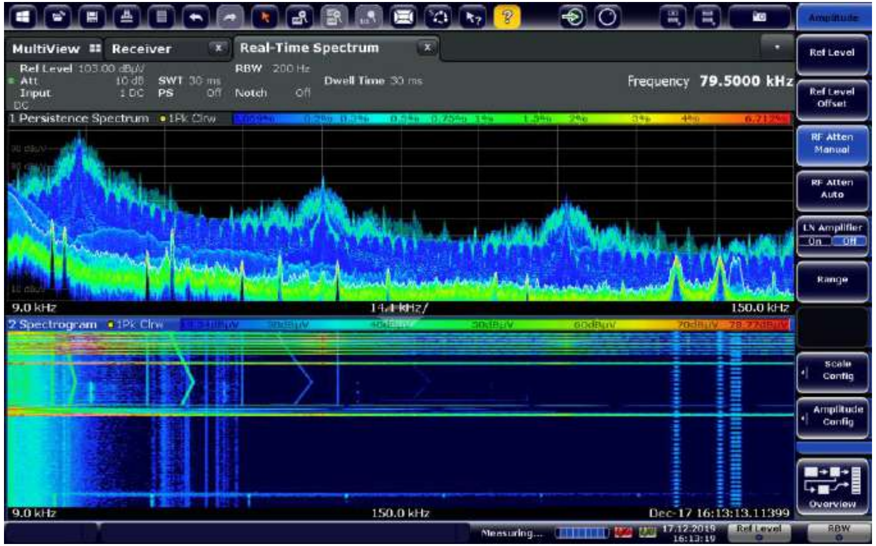
REAL-TIME SPECTRUM

- Data acquisition and processing **in parallel** with **80 MHz bandwidth**
- Measurement without blind time
  - Fully gapless
  - Resolves even shortest pulses

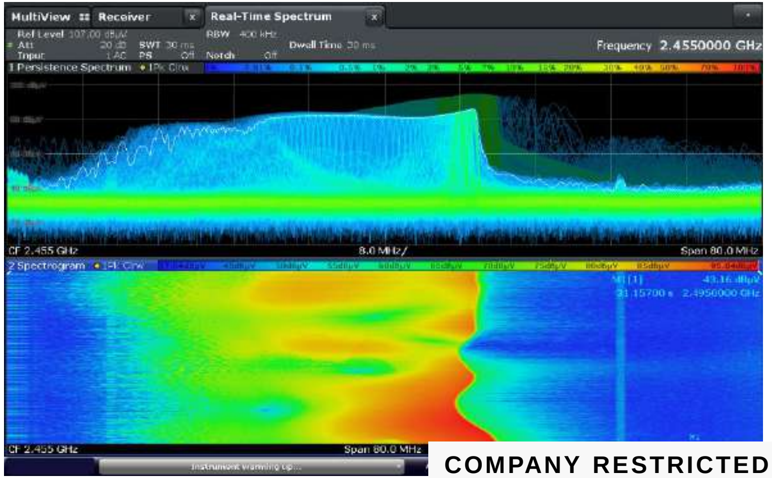




REAL-TIME SPECTRUM



- ▶ **Detect complex signals at first**
- ▶ **Persistence mode**
  - – Shows probability of amplitude appearence with colors. Signals with different behavior in time become visible even if hidden behind broadband interferers
- ▶ **Spectrum mode**
  - – Displays behavior of traces in time for easy identification of drifting or pulsed signals



RS SOLUTION_TAS-EME SYSTEM

Thanks for your attention