

전자파 내성 시험 (EMS)의 변화

김근호 매니저 / 로데슈바르츠 코리아
Application Engineer

ROHDE & SCHWARZ

Make ideas real

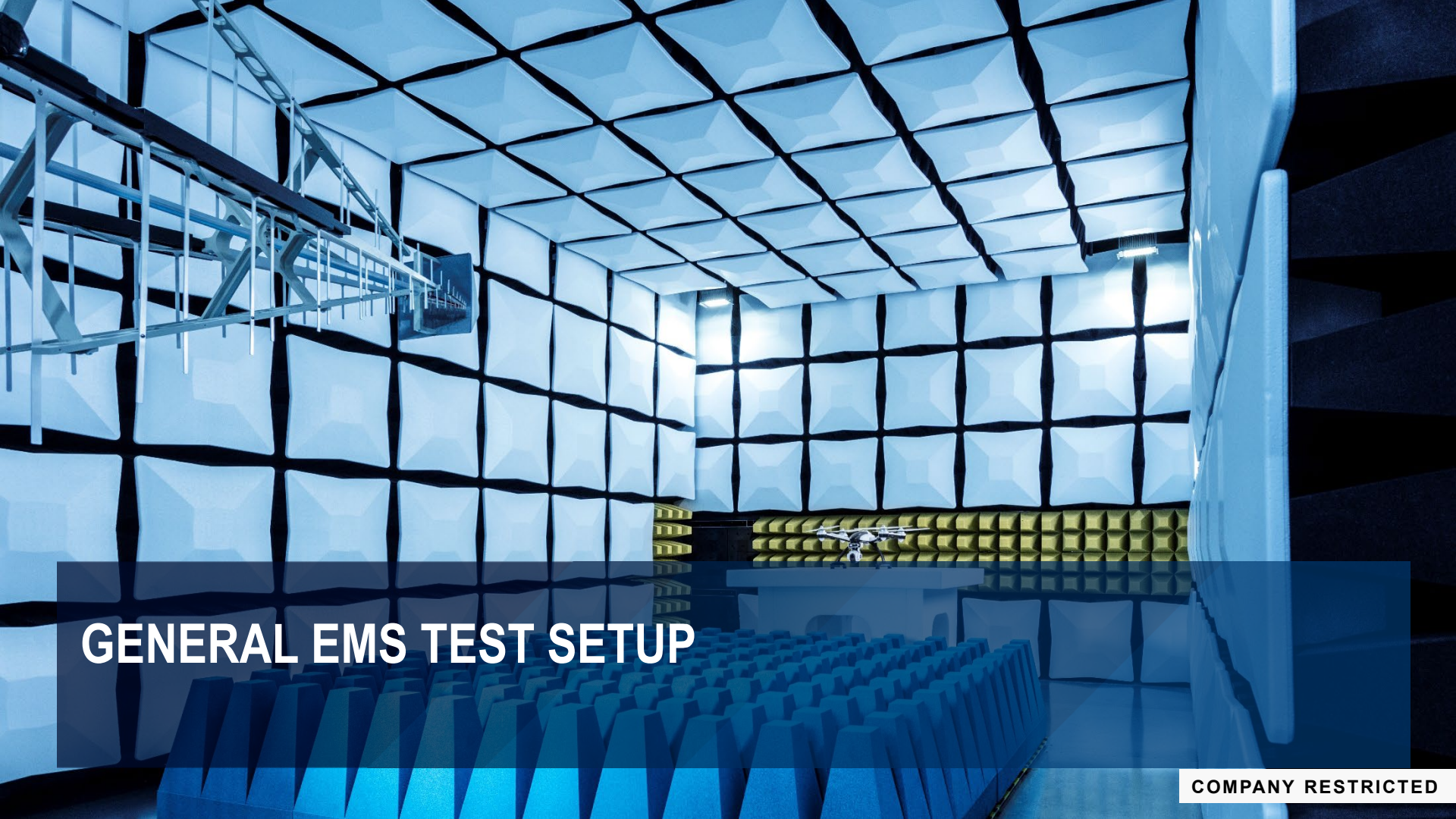


COMPANY RESTRICTED

CONTENTS

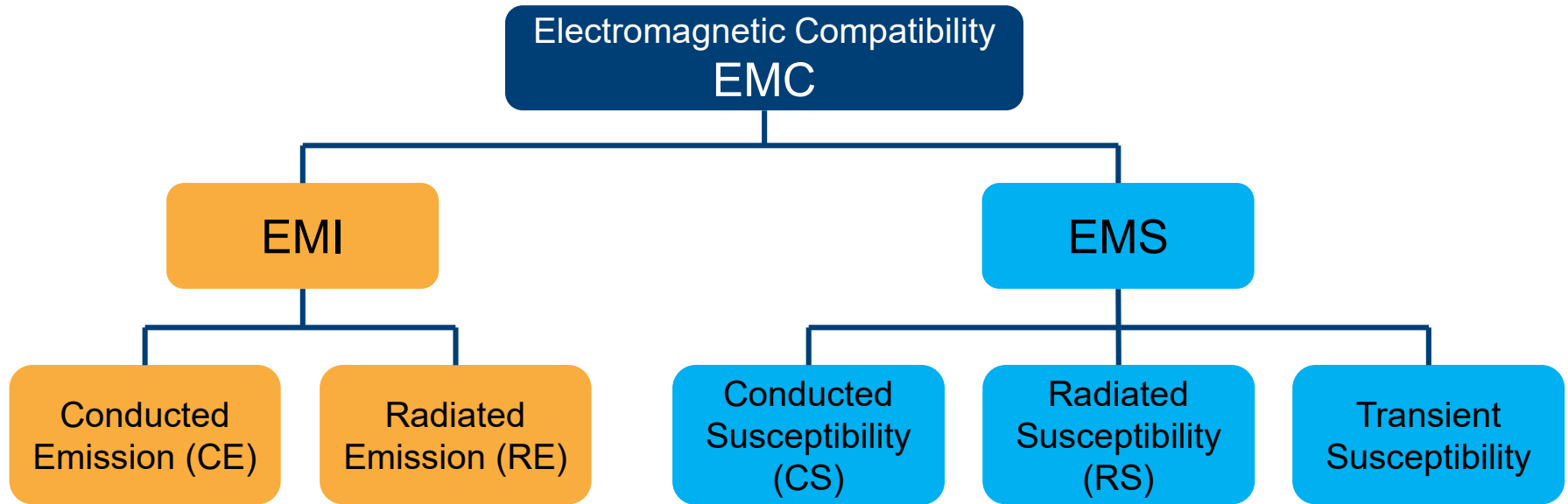
- ▶ General EMS Test Setup
- ▶ Radiated field in close proximity
- ▶ Electromagnetic Environment Test (EME)





GENERAL EMS TEST SETUP

What is the EMC?



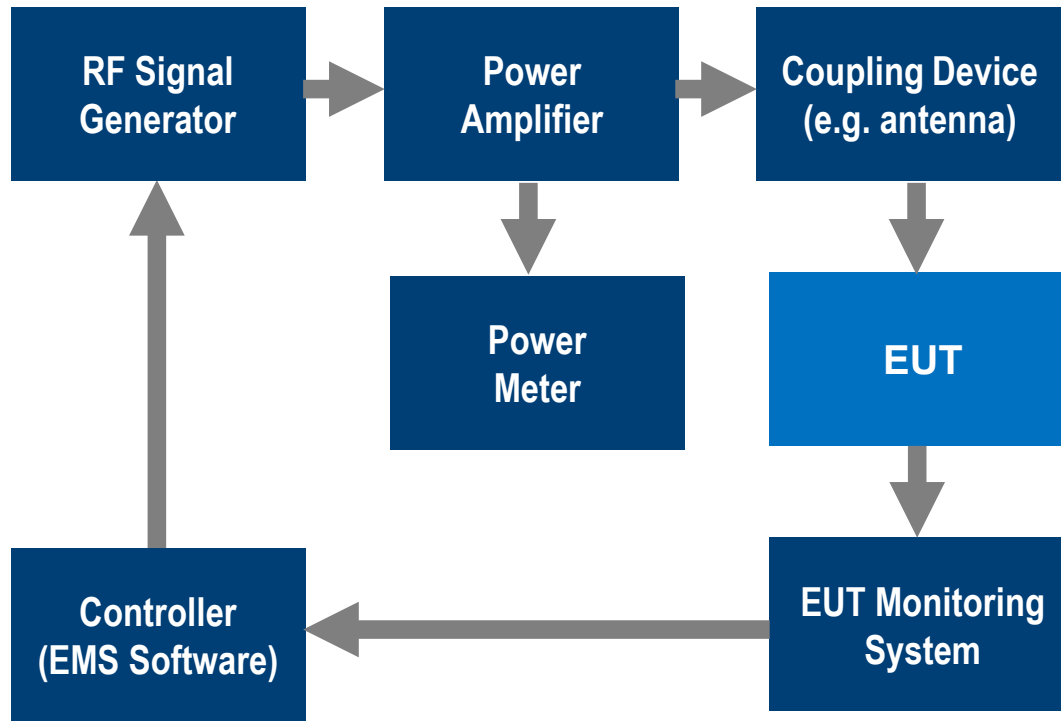
▶ EMI : 기기가 전자파를 외부로 방출하여 복사(Radiation)와 전도(Conduction)의 형태로 다른 기기나 제어회로에 방해를 주는 것

▶ EMS : 각종 전자파 방해로부터 기기나 부품의 성능 저하가 발생되지 않도록 견딜 수 있는 정도를 검증하는 것

EMC Standards Overview (Commercial)

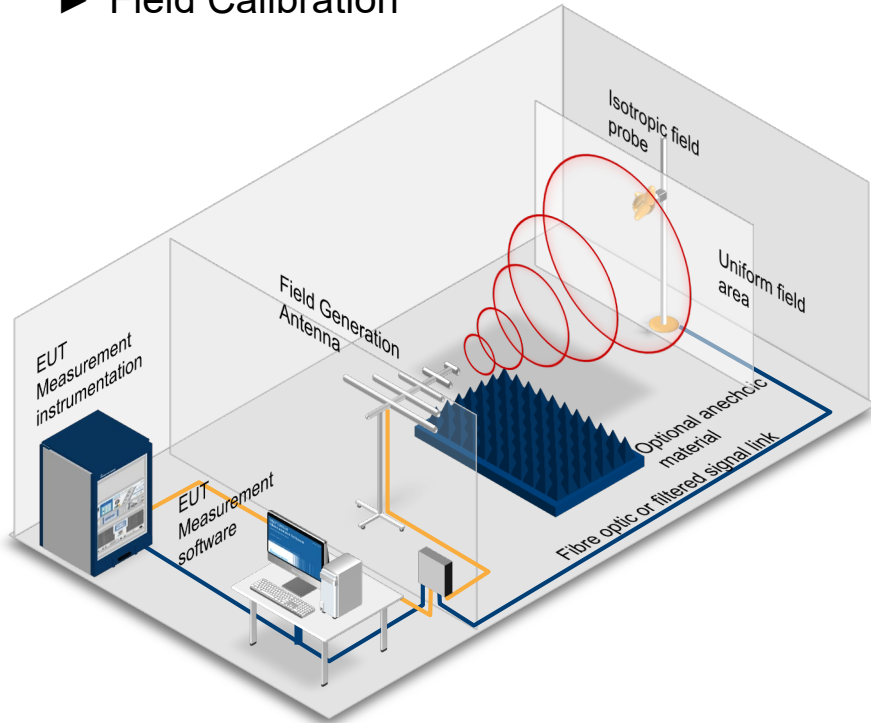
EMC								
EMI				EMS				
RF		Power Frequency	Transient	RF		Magnetic Field	Power Quality	
Conducted		Radiated	Harmonics/ Flicker	ESD EFT Surge	Conducted	Radiated	Pulsed Damped Oscillatory	Voltage Dips/ Interruption/ Variation
Voltage	Power	CISPR 11 CISPR 14-1 CISPR 15 CISPR 32 IEC 61000-4-20 IEC 61000-4-21	IEC 61000-3-2 IEC 61000-3-3	IEC 61000-4-2 IEC 61000-4-4 IEC 61000-4-5/-12 ITU FCC	IEC 61000-4-6	IEC 61000-4-3 IEC 61000-4-20 IEC 61000-4-21	IEC 61000-4-9 IEC 61000-4-10	IEC 61000-4-11
CISPR 11 CISPR 14-1 CISPR 15 CISPR 32	CISPR 11							

EMS Test System Configuration

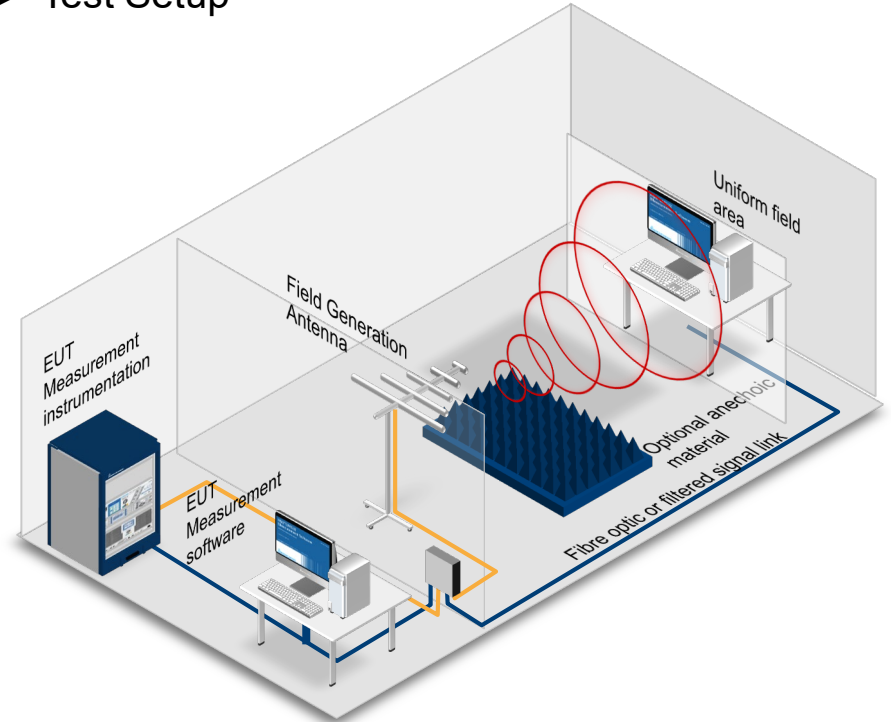


RS Test System Configuration Commercial

► Field Calibration



► Test Setup



RS Test System Configuration

▶ Example : System Rack



▶ Example : Chamber



RS Test Condition

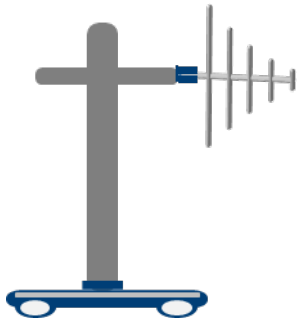
▶ Commercial

- Standard : IEC 61000-4-3
- Test Distance : 3m (min. 1m)
- Test Level : 1 V/m, 3 V/m, 10 V/m, etc
- Test Step : Max 1%
- Modulation : AM, PM
- Test Point : Field Uniform (1.5m X 1.5m)

▶ Automotive

- Standard : ISO 11452-2
- Test Distance : 1m
- Test Level : 25 V/m, 50 V/m, 75 V/m, 100 V/m, etc
- Test Step : Linear or Log
- Modulation : CW, AM, PM
- Test Point : Harness, DUT (One point)

RS Test Signals Generation





RADIATED FIELD IN CLOSE PROXIMITY

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Mobile Service Protection

- ▶ Mobile service signals have a high output power
 - GSM : Max. 2W (+33dBm)
- ▶ Mobile device can be used to close to DUT for battery change or data sharing. These mobile signals can effect to operation of DUT.



Radiated field in close proximity

CISPR 35 Spot Test

Table Clause	Environmental phenomenon	Test specification		Units	Basic standard	Remarks	Performance criteria
1.1	Power frequency Magnetic field	Frequency Field strength	50 or 60 1	Hz A/m	IEC 61000-4-8	See a	A
1.2	Continuous RF electromagnetic field disturbances, swept test	Frequency range Field strength	80 to 1000 3	MHz V/m	IEC 61000-4-3 or IEC 61000-4-20 or IEC 61000-4-21	For modulation details see 4.2.2.1	A
1.3	Continuous RF electromagnetic field disturbances, spot test	Frequency ($\pm 1\%$)	1800, 2600, 3500, 5000	MHz	IEC 61000-4-3 or IEC 61000-4-20 or IEC 61000-4-21	For modulation details see 4.2.2.1	A
		Field strength	3	V/m			
1.4	ESD	Contact discharge Air discharge	4 8	kV	IEC 61000-4-2		B

Radiated field in close proximity

IEC 60601-1-2 Edition 4.0 Spot Test

Test frequency (MHz)	Band (MHz)	Service	Modulation	Maximum power (W)	Distance (m)	Immunity test level (V/m)
385	380 – 390	TETRA 400	Pulse modulation 18 Hz	1.8	0.3	27
450	430 – 470	GMRS 460, FRS 460	FM ± 5 kHz deviation 1 kHz sine	2	0.3	28
710	704 – 787	LTE Band 13, 17	Pulse modulation 217 Hz	0.2	0.3	9
745						
780						
810	800 – 960	GSM 800/900, TETRA 800, iDEN 820, CDMA 850, LTE Band 5	Pulse modulation 18 Hz	2	0.3	28
870						
930						

Radiated field in close proximity

IEC 60601-1-2 Edition 4.0 Spot Test

Test frequency (MHz)	Band (MHz)	Service	Modulation	Maximum power (W)	Distance (m)	Immunity test level (V/m)
1720	1700 – 1990	GSM 1800; CDMA 1900; GSM 1900; DECT; LTE Band 1, 3, 4, 24; UMTS	Pulse modulation 217 Hz	2	0.3	28
1845						
1970						
2450	2400 – 2570	Bluetooth, WLAN, 802.11 b/g/n, RFID 2450, LTE Band 7	Pulse modulation 217 Hz	2	0.3	28
5240	5100 – 5800	WLAN 802.11 a/n	Pulse modulation 217 Hz	0.2	0.3	9
5500						
5785						

Minimum separation distance

- ▶ Minimum separation distances for higher immunity test levels shall be calculated using the following equation :

$$E = \frac{6}{d} \sqrt{P}$$

- P = Maximum power in W
 - d = Minimum separation distance in m
 - E = Immunity test level in V/m
- ▶ Reference standard is IEC 61000-4-3.
 - The test method documented in this part of IEC 61000 describes a consistent method to assess the immunity of an equipment or system against RF electromagnetic fields from **RF sources not in close proximity to the EUT**.
 - Test distance is **typically 3m**.
 - ▶ **Immunity testing against RF sources in close proximity to the EUT is defined in IEC 61000-4-39.**

Radiated field in close proximity

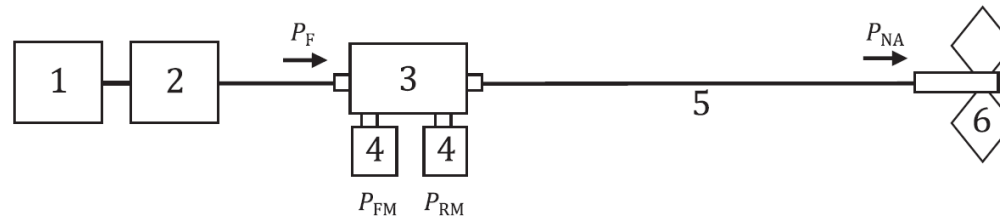
ISO 11452-9

- ▶ This document specifies test methods and procedures for testing electromagnetic immunity of electronic components for passenger cars and commercial vehicles to [portable transmitters in close proximity](#).
- ▶ Standard require test level to [net power](#).
 - Insertion loss and VSWR characteristic on system component are very important.

Radiated field in close proximity

ISO 11452-9

▶ Typical hardware configuration :

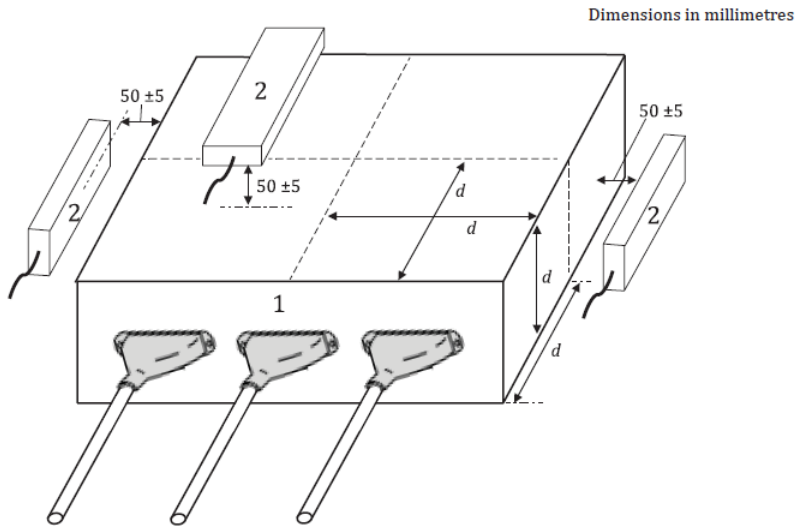


- 1 RF signal generator
- 2 RF amplifier
- 3 Dual directional coupler
- 4 Power sensor or measurement receiver
- 5 Low loss coaxial cable
- 6 Transmit antenna

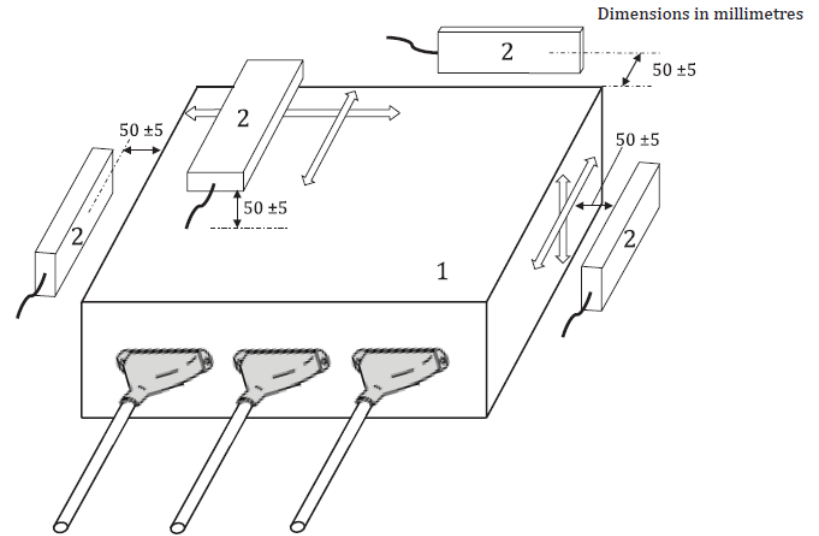
Source : ISO 11452-9:2021

Radiated field in close proximity ISO 11452-9 DUT Test

▶ Test method 1



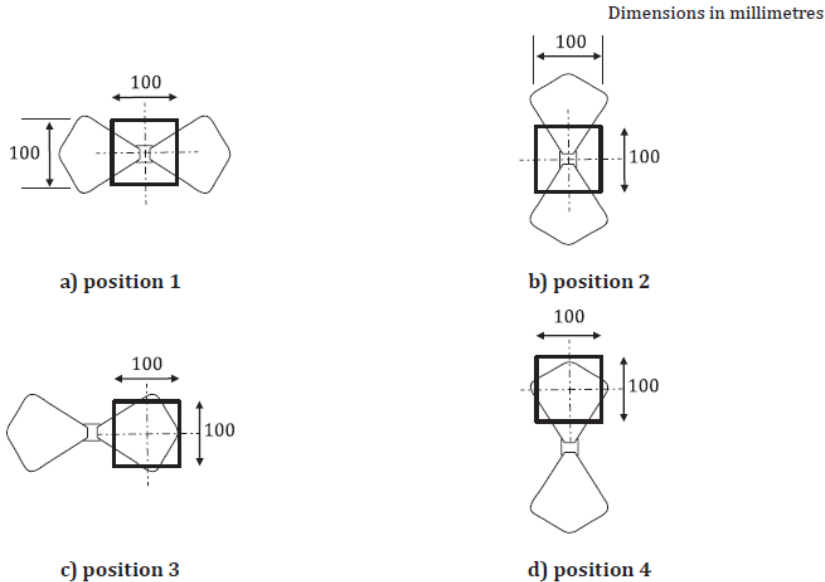
▶ Test method 2 (Sweep)



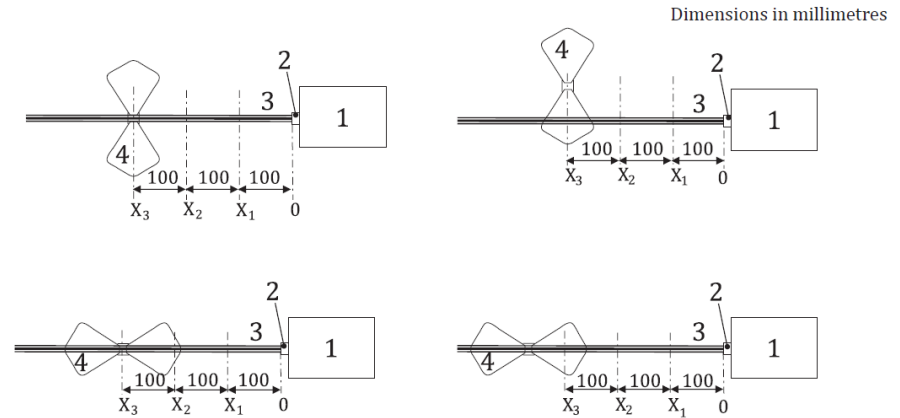
Source : ISO 11452-9:2021

Radiated field in close proximity ISO 11452-9 DUT Test

► Test reference point of antenna



► Test on harness



Source : ISO 11452-9:2021

Radiated field in close proximity

ISO 11452-9 Typical characteristics for portable transmitters

Transmitter designation	Frequency [MHz]	Power [W]	Typical transmitter modulation	Test modulation
10 m	26 to 30	10 (RMS)	Telegraphy, AM, SSB FM	AM 1 kHz, 80%
2 m	144 to 148	10 (RMS)	Telegraphy, AM, SSB FM	CW
1.25 m	220 to 225	10 (RMS)	Telegraphy, AM, SSB FM	CW
70 cm	420 to 450	10 (RMS)	Telegraphy, AM, SSB FM	CW
LAND MOBILE	146 to 174 216 to 223	10 (Peak)	FM, FSK	CW
TETRA/TETRAPOL	380 to 390 410 to 420 / 450 to 460 806 to 825 / 870 to 876	10 (Peak)	$\pi/4$ DQPSK	PM 18 Hz 50% duty cycle
CDMA 800 (cellular)	815 to 849	0.25 (Peak)	QPSK	PM 1600 Hz 50% duty cycle

Radiated field in close proximity

ISO 11452-9 Typical characteristics for portable transmitters

Transmitter designation	Frequency [MHz]	Power [W]	Typical transmitter modulation	Test modulation
GSM 850 (mobile) GSM 900 (mobile)	824 to 849 876 to 915	2 (Peak)	GMSK	PM 217 Hz 50% duty cycle
GSM 1800/1900 (mobile phone)	1710 to 1785 1850 to 1910	1 (Peak)	GMSK	PM 217 Hz 50% duty cycle
CDMA 1900 (PCS)	1850 to 1910	0.25 (Peak)	QPSK	PM 1600 Hz 50% duty cycle
UMTS (mobile phone WCDMA & TD/CDMA)	824 to 849 880 to 915 1850 to 1980 1885 to 2025 1920 to 1980	0.25 (Peak)	HPSK QAM	PM 1600 Hz 50% duty cycle

Radiated field in close proximity

ISO 11452-9 Typical characteristics for portable transmitters

Transmitter designation	Frequency [MHz]	Power [W]	Typical transmitter modulation	Test modulation
Bluetooth, WLAN (data) WIFI	2400 to 2500	0.1 (Peak)	QPSK	PM 1600 Hz 50 % duty cycle Or broadband noise of 20MHz by AWG
LTE (mobile phone OFDMA & SC-FDMA)	452 to 458 698 to 803 / 807 to 862 / 880 to 915 / 1427 to 1463 1625 to 1661 / 1710 to 1785 1850 to 2025 / 2300 to 2400 2496 to 2690 3400 to 3800	0.25 (Peak)	OFDM – PSK	PM 1000 Hz 10 % duty cycle Or broadband noise of 20MHz by AWG
IEEE 802.11a (5G WIFI)	5150 to 5350 5725 to 5850	0.5 (Peak)	OFDM – PSK	PM 1600 Hz 50 % duty cycle Or broadband noise of 20MHz by AWG

Radiated field in close proximity

Particular considerations for IEC 61000-4-39

- ▶ This part of IEC 61000 is an international standard which gives immunity requirements and test procedures related to radiated disturbances **caused by radio-frequency fields from devices used in close proximity.**
- ▶ Immunity testing according to existing standards, such as IEC 61000-4-3, 61000-4-20, 61000-4-21 and 61000-4-22, **may not be suitable** to assess compatibility with the complex electric and magnetic fields generated by RF emitters located in close proximity (for example, within a few centimeters) of the surface of electronic equipment. **The power levels required for the higher disturbance intensities associated with such very small separation distances may make application of some of the existing test standards quite challenging or cost prohibitive.**

Radiated field in close proximity

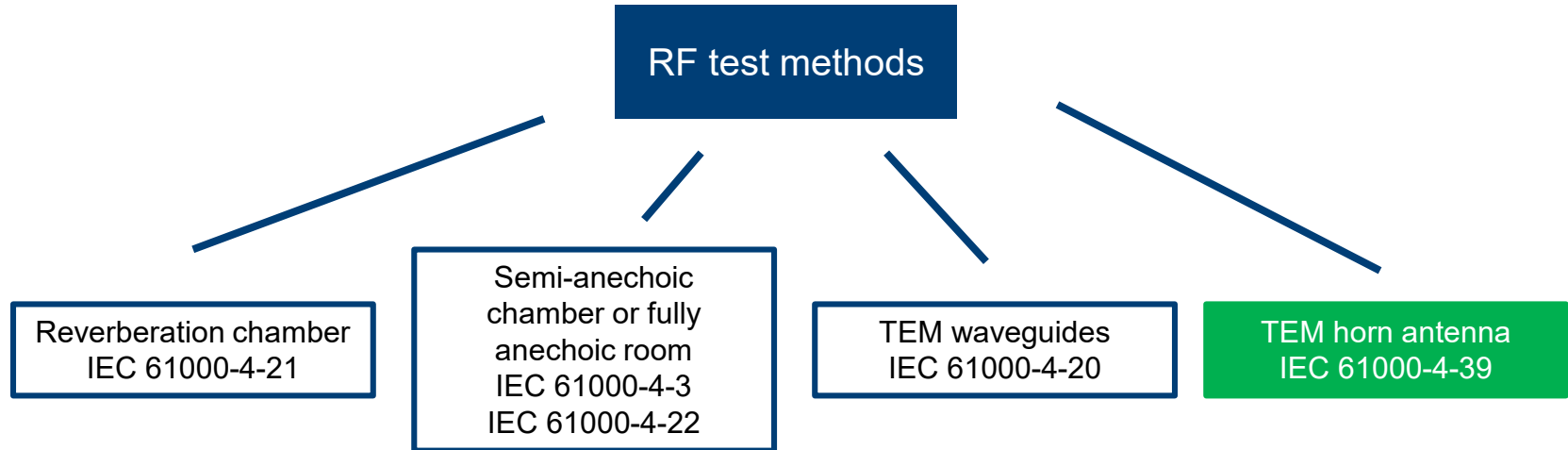
Particular considerations for IEC 61000-4-39

- ▶ This part of IEC 61000 does not replace general immunity requirements of electrical and electronic equipment to radiated electromagnetic energy as given in IEC 61000-4-3 and other part of IEC 61000.
- ▶ “close proximity” generally refers to a separation distance between the source and victim equipment of less than or equal to 200mm for frequencies greater than 26MHz and 500mm for frequencies lower than 26MHz.

Radiated field in close proximity

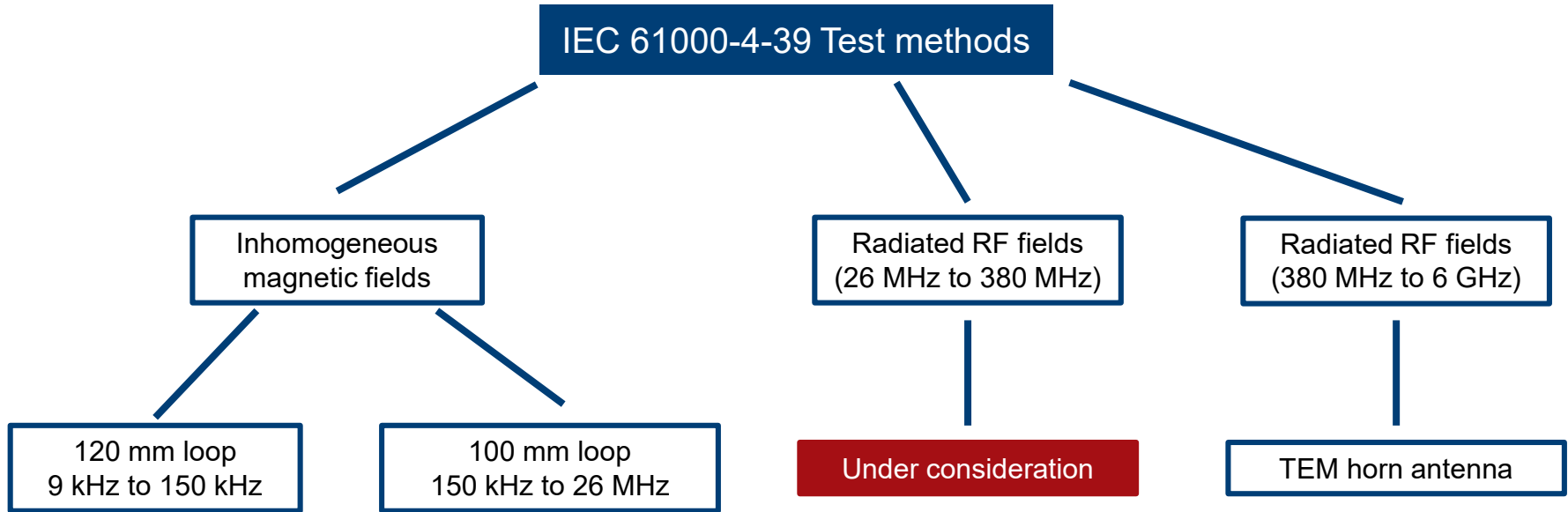
IEC 61000-4-39

- ▶ Immunity of EUTs to disturbances from RF transmitters can be tested using several different methods.



Radiated field in close proximity

IEC 61000-4-39

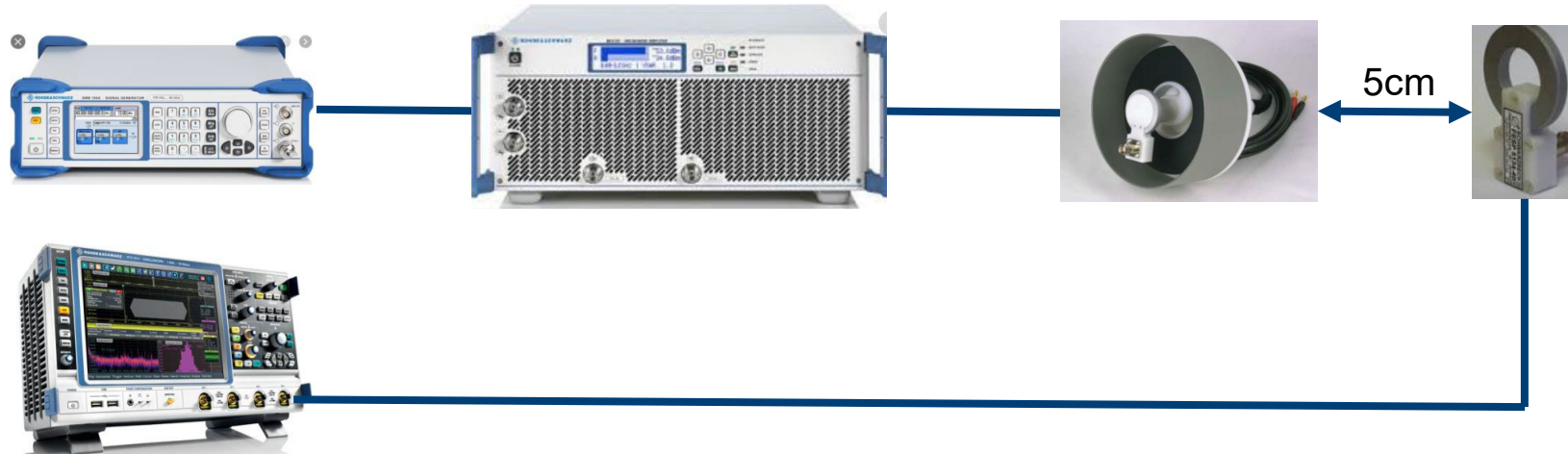


- ▶ Magnetic fields test method are very similar to ISO 11452-8 and RS101 test

Radiated field in close proximity

IEC 61000-4-39 – Magnetic field immunity

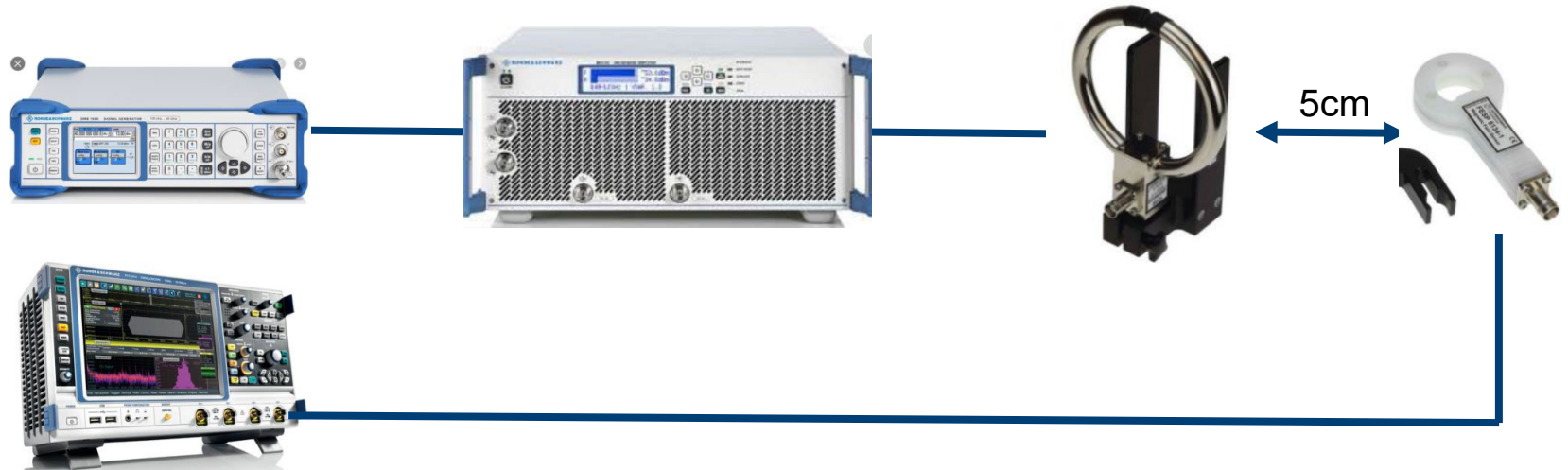
- ▶ Hardware Configuration for 9 – 150kHz



Radiated field in close proximity

IEC 61000-4-39 – Magnetic field immunity

- ▶ Hardware Configuration for 150k – 26MHz

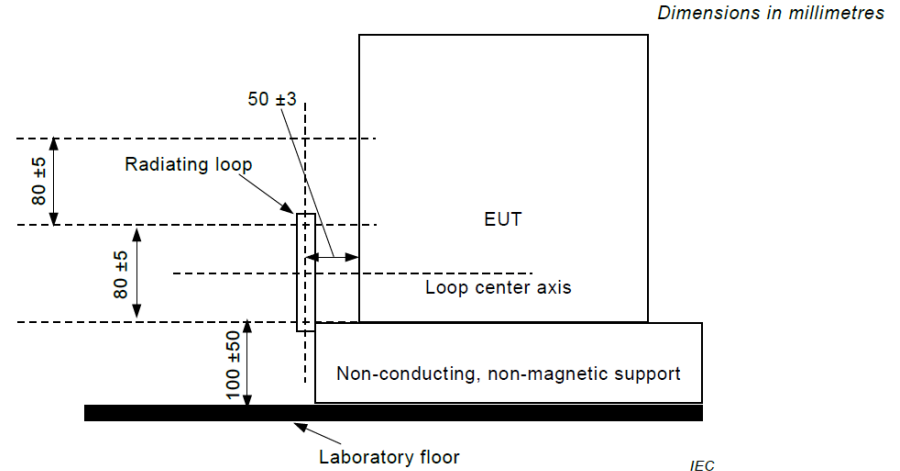
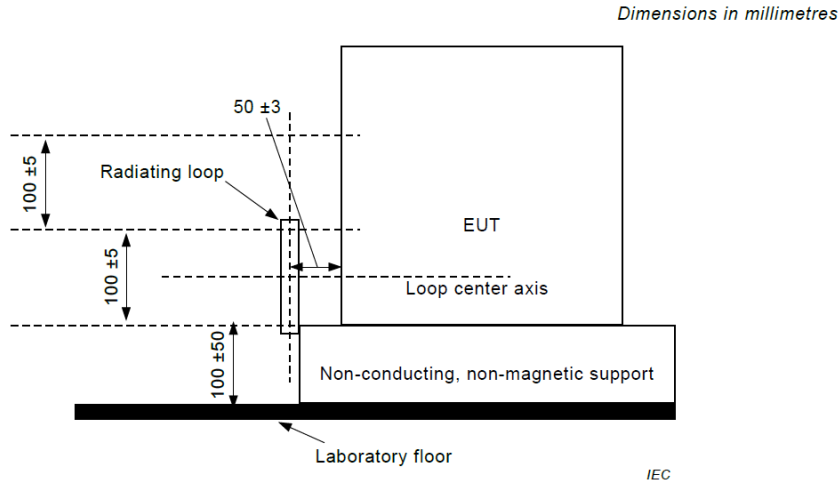


Radiated field in close proximity

IEC 61000-4-39 – Magnetic field immunity

▶ DUT Test : 9 – 150kHz

▶ DUT Test : 150k – 26MHz



Source : IEC 61000-4-39 :2017

Radiated field in close proximity

IEC 61000-4-39 – Magnetic field immunity

▶ Maximum frequency steps size

Frequency band kHz	Linear steps kHz
9 to 150	10
150 to 1000	100
1000 to 26000	1000

▶ Test Level

Level	Test field strength A/m
1	0.1
2	0.3
3	1
4	3
X	Special

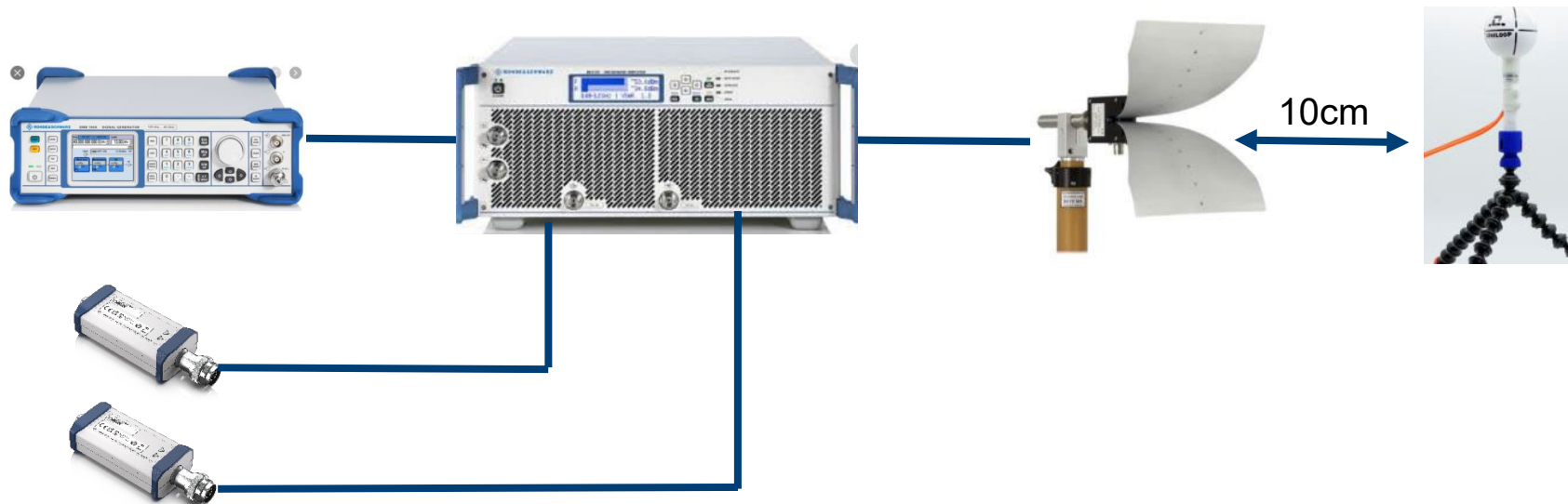
▶ Annex B is intended to provide guidance on the selection of test levels

Source : IEC 61000-4-39 :2017

Radiated field in close proximity

IEC 61000-4-39 – RF field immunity

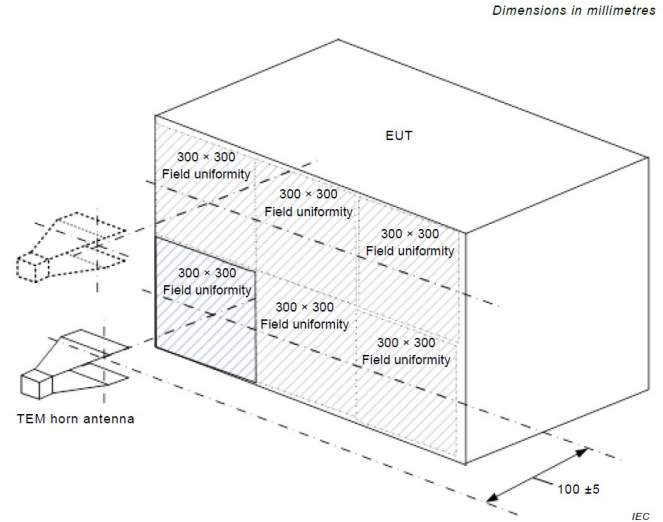
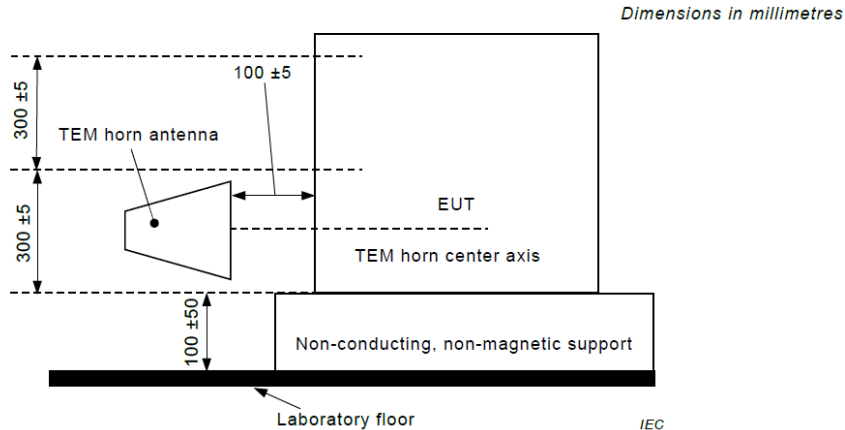
- ▶ Hardware Configuration for 380M – 6GHz



Radiated field in close proximity

IEC 61000-4-39 – RF field immunity

► DUT Test : 380M – 6GHz

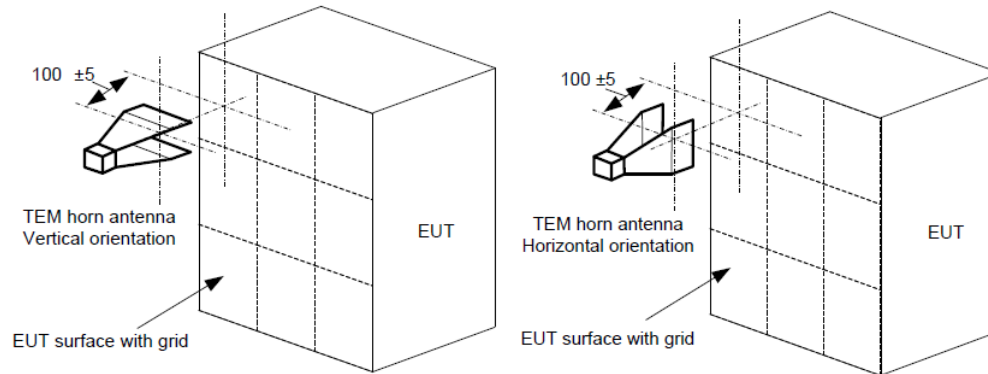


Source : IEC 61000-4-39 :2017

Radiated field in close proximity

IEC 61000-4-39 – RF field immunity

- ▶ The antenna is moved according to the **window size of the uniform area** covered by the TEM horn antenna used.
 - **Annex A for details on determining the size of the uniform area** covered by the TEM horn antenna.
- ▶ Each window shall be illuminated using the TEM horn antenna in **horizontal and vertical orientation**.



Source : IEC 61000-4-39 :2017

Radiated field in close proximity

IEC 61000-4-39 – RF field immunity

- ▶ Maximum frequency step size is 1%
- ▶ Test Level

Level	Test field strength V/m
1	10
2	30
3	100
4	300
X	Special

- ▶ Annex B is intended to provide guidance on the selection of test levels

Source : IEC 61000-4-39 :2017

Radiated field in close proximity

IEC 60601-1-2 Edition 4.0 Amendment 1

- ▶ Test is base on the IEC 61000-4-39
- ▶ Testing only H Field and spot frequency (RFID/NFC, WPT, etc)
- ▶ Test Signal :

Test frequency	Modulation	Immunity test level (A/m)
30 kHz	CW	8
134.2 kHz	Pulse modulation 2.1 kHz	65
13.56 MHz	Pulse modulation 50 kHz	7.5

Radiated field in close proximity

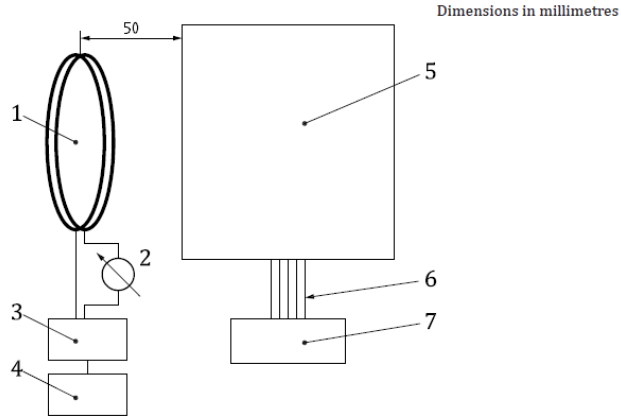
ISO 11452-8

- ▶ This test method is based on the MIL-STD-461 RS101 Test
- ▶ There are two test methods
 - Radiating loop
 - Helmholtz coil

RADIATED FIELD IN CLOSE PROXIMITY

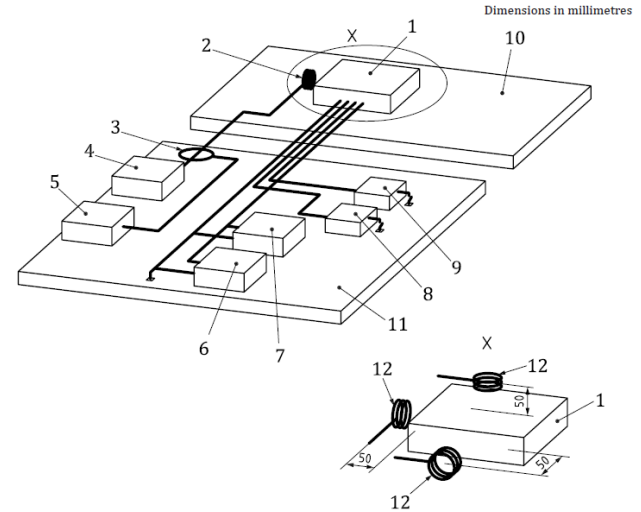
ISO 11452-8

▶ Hardware Configuration



- 1 radiating loop
- 2 current monitor
- 3 LF amplifier (if required)
- 4 LF generator / d.c power supply
- 5 DUT

▶ Test setup



Source : ISO 11452-8 :2015

Radiated field in close proximity

ISO 11452-8

Frequency band Hz	Test level I A/m	Test level II A/m	Test level III A/m	Test level IV A/m	Test level V A/m
0 (d.c)	90	300	900	3000	Specific value agreed between the users of this part of ISO 11452
15 to 1000	30	100	300	1000	
1000 to 10000	$30/(f/1000)^2$	$100/(f/1000)^2$	$300/(f/1000)^2$	$1000/(f/1000)^2$	
10000 to 150000	0.3	1	3	10	

Frequency band kHz	Linear steps kHz	Logarithmic steps %
0 (d.c)	-	-
0.015 to 0.1	0.01	10
0.1 to 1	0.1	10
1 to 10	1	10
10 to 150	10	10



ELECTROMAGNETIC ENVIRONMENT TEST (EME)

COMPANY RESTRICTED

Broadband radiated immunity test

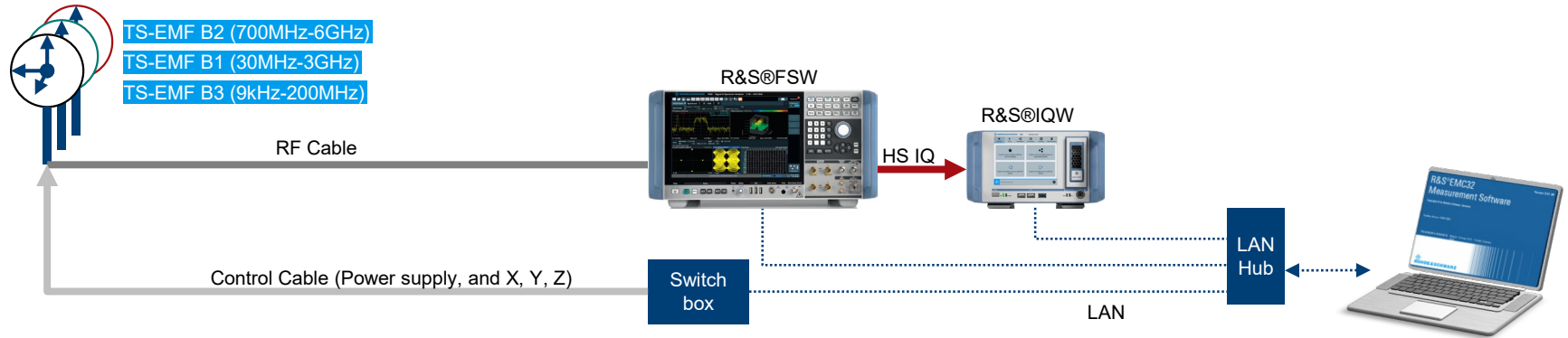
- ▶ Real mobile services use wide band digital modulation.
- ▶ ISO 11452-9 ED 2.0
 - Broadband noise of 20MHz by AWG (alternative)
- ▶ Mercedes-Benz MBN 10284-2
 - CW alternative OFDM (BW= 1.4, 10, 20, 160MHz)
- ▶ Test method is in development
 - IEC 61000-4-41
- ▶ New instrument will be required.
 - Vector signal generator
 - Spectrum analyzer

Electromagnetic Environment Test (EME)

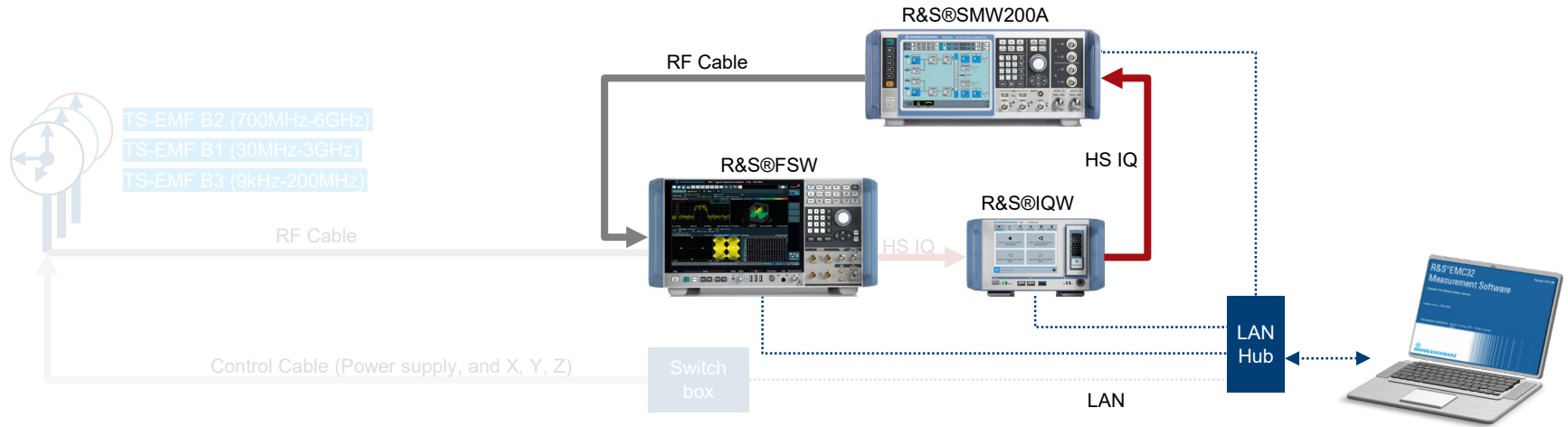
▶ Background

- Electromagnetic Environment (EME) testing is now included in the latest version of CSAE150 - 2020 “[Requirements and Test Methods of Road Vehicle’s Adaptability to Complex Electromagnetic Environment](#)”. CSAE committee approved the proposal submitted by CATARC on 30th June 2020, and was officially published in Aug 2020. Test requirements involve generation of complex EME signals below 30 MHz (shortwave EME), and from 30MHz up to 1GHz (FM transmitter / walkie-talkie signals and GSM Base station transmissions).
- The research of EME testing aims to avoid or mitigate road accidents due to EME influences when driving. This is to be achieved by collecting and building up the critical Field2Lab EME database for testing of new cars, as well as developing a waveform library in order to generate a real EME in EMC chamber. The performance of the vehicle under test (VUT) due to EME interference test signals shall be evaluated.

Electromagnetic Environment Test (EME)

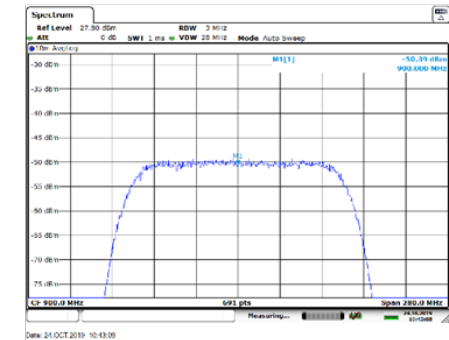


Electromagnetic Environment Test (EME)

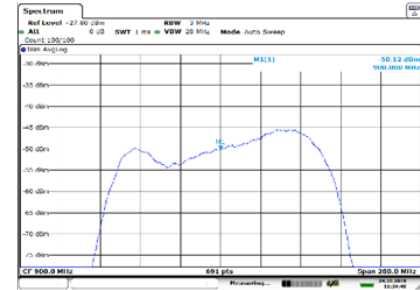
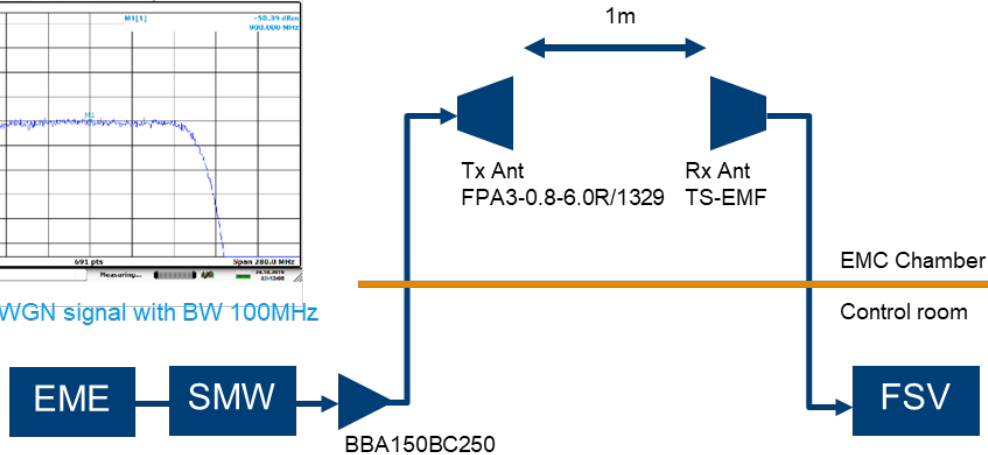


Electromagnetic Environment Test (EME)

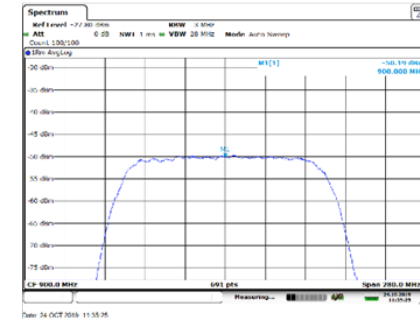
Carried out EME system calibration and EME signals adjustment with SMW-K544



Reference AWGN signal with BW 100MHz

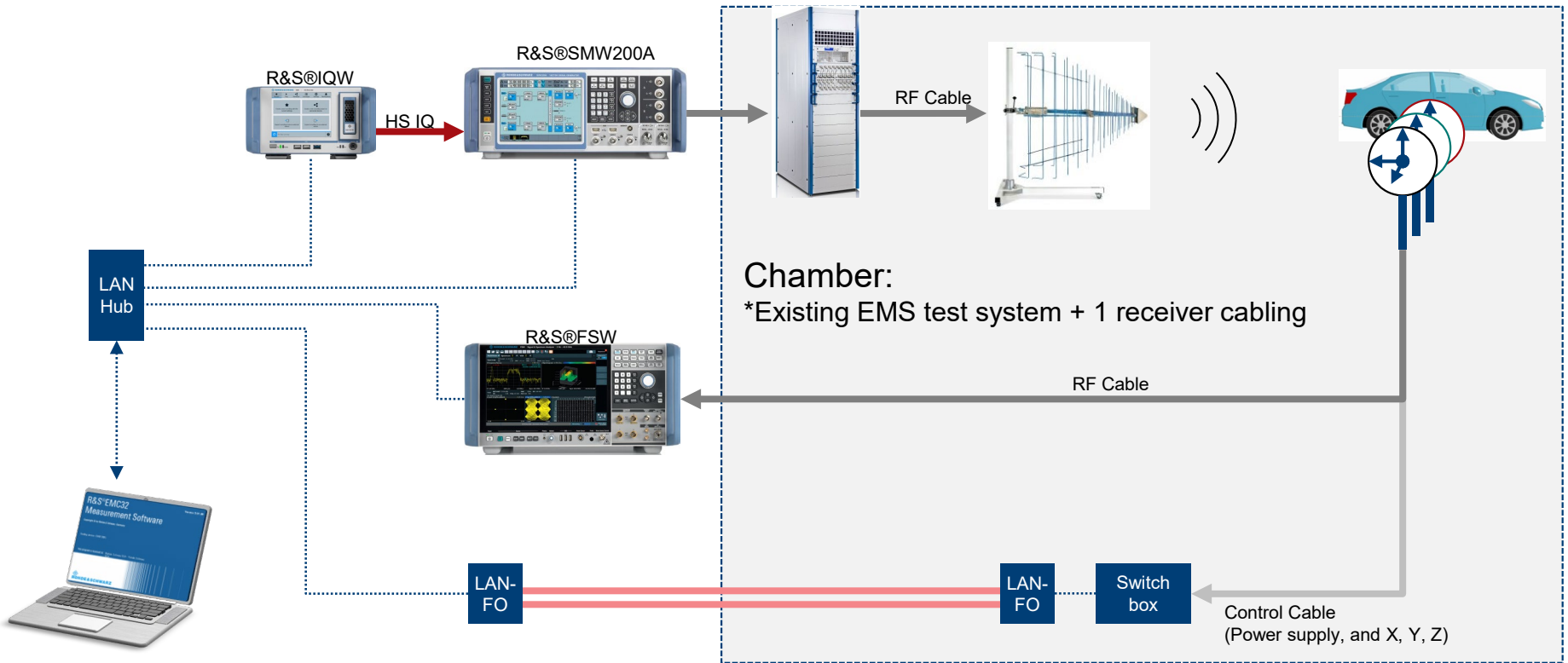


Without frequency response correction



With K544 frequency response correction

Electromagnetic Environment Test (EME)



Next Step

- ▶ New radio service and extend test frequency up to 7.125GHz
 - IEEE 802.11 ax (Wi-Fi 6E) : 5.925 GHz ~ 7.125GHz (Max BW : 1,200 MHz)
 - 5G NR FR1 : 410 MHz ~ 7.125 GHz

Next Step

► Reverbration Chamber

- High efficiency :
 - Lower cost than SAC (Semi anechoic chamber)
 - Lower power than ALSE test method
- Field Uniformity : 3D Working volume
- Reality

