T E S T R E P O R T
No.: 18-1-0244501T06a

According to:
47 CFR Part 95
RSS-Gen Issue 5
RSS-251 Issue 2

for

Veoneer US, Inc.

77V12CRN
77 GHz CRN Radar Sensor

FCC ID: WU877V12CRN
IC: 8436B-77V12CRN

Laboratory Accreditation
ilac-MRA DAkkS Deutsche Akkreditierungsstelle D-PL-12047-01-01 D-PL-12047-01-03 D-PL-12047-01-04
accredited according to DIN EN ISO/IEC 17025

CETECOM GmbH
Laboratory Radio Communications & Electromagnetic Compatibility
Im Teelbruch 116 • 45219 Essen • Germany
Registered in Essen, Germany, Reg. No.: HRB Essen 8984
Tel.: + 49 (0) 20 54 / 95 19-954 • Fax: + 49 (0) 20 54 / 95 19-964
E-mail: info@cetecom.com • Internet: www.cetecom.com

Table of contents

Table of annex

The listed attachments are an integral part of this report.

Separate document annex 4: Internal photographs of EUT **to be supplied by the customer.**

1. Summary of test results

The test results apply exclusively to the test samples as presented in this report. The CETECOM GmbH does not assume responsibility for any conclusions and generalizations taken in conjunction with other specimens or samples of the type of the item presented to tests. Also we refer on special conditions which the applicant should fulfill according §2.927 to §2.948, special focus regarding modification of the equipment and availability of sample equipment for market surveillance tests.

1.1. Tests measurement overview according of US CFR Title 47, Subpart 95:

Test cases	References & Limits		Test conditions (temperature and voltage)	EUT set-up	EUT opera-ting mode	Result
	Standard	Test Limit				
Max. peak power EIRP/ peak EIRP spectral density. Max. power EIRP/ average EIRP	FCC §95.3367 (a) (b)	50 dBm (Average) 55 dBm (Peak)	Nominal and extreme	1-4	1	passed
	RSS-251 (Section 8 and 9)	50 dBm (Average) 55 dBm (Peak)				
Modulation characteristics	FCC §2.1047 (d)	-	Nominal	1-4	1	passed
	RSS-251 (Section 6b)	-				
Occupied bandwidth	FCC §95.3379 (b)	76 GHz - 81 GHz	Nominal and extreme	1-4	1	passed
	RSS-251 (Section 7)	76 GHz - 81 GHz				
Field strength of emissions (band edge)	FCC §95.3379 (a)(2)(i)	600 pW/cm^2 ~ -1.7 dBm	Nominal	1,4	1	passed
	RSS-251 (Section 10)	lower BE: 0 dBm upper BE: -30 dBm				
Field strength of emissions (radiated spurious)	FCC §95.3379 (a)	9 kHz – 40 GHz: see section 5.5. in the report 40 GHz – 200 GHz: 600 pW/cm^2 ~ -1.7 dBm 200 GHz – 231 GHz: 1000 pW/cm^2 ~ 0.5 dBm	Nominal	1, 4-6	1,2	passed
	RSS-251 (Section 10)	9 kHz – 40 GHz: see section 5.5. and 5.6. in the report 40 GHz – 162 GHz*: -30 dBm Here 73.5 GHz – 76 GHz: 0 dBm				
Frequency stability	FCC §95.3379 (b)	-	Nominal and extreme	1-4	1	passed
	RSS-251 (Section 11)	RSS-251 (Subsection 11.2)				

1.2. Attestation:

I declare that all measurements were performed by me or under my supervision and that all measurements have been performed and are correct to my best knowledge and belief to FCC and Industry Canada standards. All requirements as shown in above table are met in accordance with enumerated standards.

.....

Dipl.-Ing. Niels Jeß
Responsible for test section

.....

M.Sc. G. Huang
Responsible for test report

2. Administrative Data

2.1. Identification of the testing laboratory

Company name:	CETECOM GmbH
Address:	Im Teelbruch 116 45219 Essen - Kettwig Germany
Responsible for testing laboratory:	Volker Wittmann
Deputy:	Dipl.-Ing. Niels Jeß

2.2. Test location

2.2.1. Test laboratory "CTC"

Company name:	see chapter 2.1. Identification of the testing laboratory

2.3. Organizational items

Responsible for test report and project leader:	M.Sc. G. Huang
Receipt of EUT:	2019-05-10
Date(s) of test:	2019-05-10 to 2019-05-19
Date of report:	2019-06-24
Version of template: 13.02	

2.4. Applicant's details

Applicant's name:	Veoneer US, Inc.
Address:	26360 American Drive Southfield, MI 48034 USA
Contact person:	Mr. Stefan Gipser

2.5. Manufacturer's details

Manufacturer's name:	please see Applicant's details
Address:	please see Applicant's details

3. Equipment under test (EUT)

3.1. TECHNICAL DATA OF MAIN EUT DECLARED BY APPLICANT*

Main function	Automotive radar		
Transmit frequency	76 GHz to 77 GHz		
Number of modes	2		
Antenna polarization	vertical		
Type of modulation	FMCW		
Bandwidth	< 1000 MHz		
Antenna Type	☒ Integrated ☐ External, no RF- connector ☐ External, separate RF-connector		
Power supply	☒ DC power supply: 8 – 19 V		
Temperature	-40 °C to +85°C		
Interfaces	CAN/CAN-FD		
EUT sample type	☐ Production	☒ Pre-Production	☐ Engineering
FCC label attached	☐ yes	☒ no	
UPN Number	77V12CRN		
Company Number	8436B		
Product Marketing Name (PMN)	Veoneer 77V12CRN		
Hardware Version Identification Number (HVIN)	77V12CRN		
Firmware Version Identification Number (FVIN)	n/a		
Host Marketing Name (HMN)	n/a		

*: customer information

3.2. EUT: Type, S/N etc. and short descriptions used in this test report**

Short descrip-tion*)	EUT	Type	S/N serial number	HW hardware status **	SW software status**	Waveform parameters****
EUT A*** S09	77V12CRN (thin radome)	77 GHz CRN Radar Sensor	80213	CRN_2.35_1.0	R255_31_12D28_1	CRN1
EUT B S16	77V12CRN (thick radome)	77 GHz CRN Radar Sensor	80562	CRN_2.5_1.0	R255_31_10D28_1	CRN3
EUT C*** S17	77V12CRN (thick radome)	77 GHz CRN Radar Sensor	80619	CRN_2.5_1.0	R255_31_12D28_1	CRN1
EUT D S10	77V12CRN (thick radome)	77 GHz CRN Radar Sensor	80468	CRN_2.5_1.0	R255_31_15D28_1	CRN2

*) EUT short description is used to simplify the identification of the EUT in this test report.
**: customer information
***: The difference between EUT A and EUT B, C, D is only the thickness of the radome (customer information). That is why EUT A has a different hardware version than the rest.
****: See Section 5.2. for more details.

3.3. Auxiliary Equipment (AE): Type, S/N etc. and short descriptions

AE short description *)	Auxiliary Equipment	Type	S/N serial number	HW hardware status	SW software status
AE 1 S02	Cable harness	-	-	-	-
AE 2 S04	CAN-USB converter	Vector VN1610	-	-	-
AE 3 S05	Laptop with test software	hp EliteBook 840	-	-	Win7 with DanView V.3.27.0.2**

*) AE short description is used to simplify the identification of the auxiliary equipment in this test report.
**) Test software DanView V.3.27.0.2 (SW) can be found on CETECOM server under the address: \\cetecom.de\essen\CETECOMPMT\Archive\2018\18-1-02445\3_Documentation\03_SW. The SW can be installed at any computer.

3.4. EUT set-ups

EUT set-up no.*)	Combination of EUT and AE	Remarks
set. 1	EUT A + AE 1 + AE 2	Radiated RF-setup without Laptop
set. 2	EUT B + AE 1 + AE 2	Radiated RF-setup without Laptop
set. 3	EUT C + AE 1 + AE 2	Radiated RF-setup without Laptop
set. 4	EUT D + AE 1 + AE 2	Radiated RF-setup without Laptop
set. 5	EUT A + AE 1 + AE 2 + AE 3	Radiated RF-setup with Laptop
set. 6	EUT D + AE 1 + AE 2 + AE 3	Radiated RF-setup with Laptop

*) EUT set-up no. is used to simplify the identification of the EUT set-up in this test report.

3.5. EUT operating modes

EUT operating mode no.*)	Description of operating modes	Additional information		
op. 1	Continuously transmitting and receiving	FMCW modulation		
op. 2	Continuously transmitting and receiving	CW	Low	76.038 GHz
			Center	76.5 GHz
			High	76.955 GHz

*) EUT operating mode no. is used to simplify the test report.

4. Description of test system set-up's

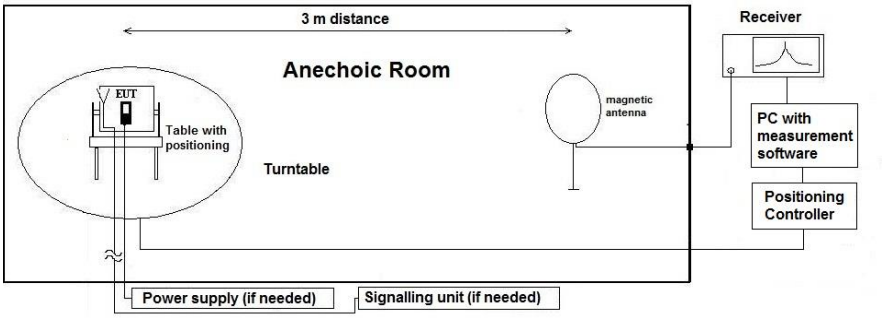
4.1. Test system set-up for radiated magnetic field measurements below 30 MHz

Specification: ANSI C63.4-2014 §5.3, §8.2.1, §8.3.1.1+§8.3.2.1 , ANSI C63.10-2013 chapter 6.4 (§6.4.4.2)

General Description: Evaluating the radiated field emissions are done first by an exploratory emission measurement and a final measurement for most critical frequencies determined.

The loop antenna was placed at 1 m height above ground plane and 3 m measurement distance from set-up for investigations. Because of reduced measurement distance, correction data were applied, as stated in chapter "General Limit - Radiated field strength emissions below 30 MHz". The tests are performed in the semi anechoic room recognized by the regulatory commission.

Schematic:



Testing method:

Exploratory, preliminary measurement
The EUT and it's associated accessories are placed on a non-conductive position manipulator (tipping device) of 0.8 m height which is placed on the turntable. By rotating the turntable (step 90°, range 0°to 360°) and the EUT itself either on 3-orthogonal axis (portable equipment) or 2-orthogonal axis (defined operational position of EUT), the emission spectrum was recorded. The loop antenna was moved at least to 2-perpendicular axes (antenna vector in direction of EUT and parallel to EUT) in order to maximize the emissions. The results are documented in a diagram. Critical frequencies (low margin to limit) are saved within a data reduction table for further investigations. If various operating modes are supported, further investigations are made to find the worst-case. Also the interconnection cables and equipment position were varied in order to maximize the emissions.

Final measurement on critical frequencies
Based on the exploratory measurements, the most critical frequencies are re-measured by maintaining the EUT's worst-case operation mode, cable position, etc.

First a frequency zoom around the critical frequency is done to locate the frequency more precisely. After this step, for all identified critical frequencies, the maximum peak was determined.

Following parameters were varied: the turntable angle continuously in the range 0 to 360 degree, the EUT itself either over 3-orthogonal axis (not defined usage position) or 2-orthogonal axis (defined usage position).

On the determined worst-case position, a final measurement with necessary bandwidth and detector according standard has been carried out.

Formula:

$E_C = E_R + AF + C_L + D_F - G_A$

$M = L_T - E_C$

AF =Antenna factor
C_L = Cable loss
D_F= Distance correction factor
E_C = Electrical field – corrected value
E_R = Receiver reading
G_A= Gain of pre-amplifier (if used)
L_T = Limit
M = Margin

All units are dB-units, positive margin means value is below limit.

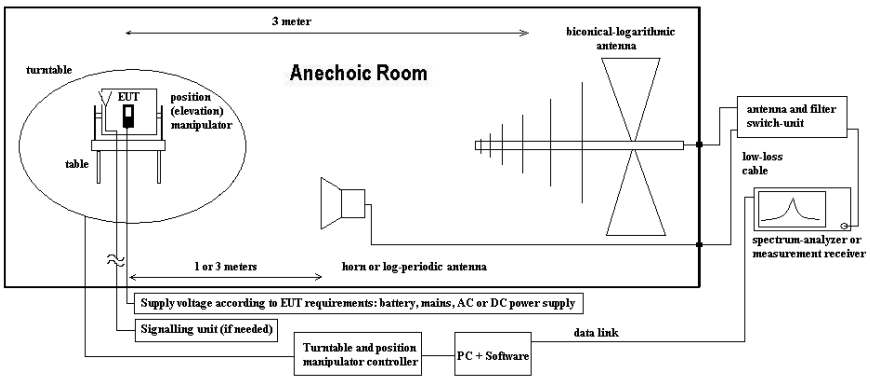
Distance correction: Reference for applied correction (extrapolating) factors due to reduced measurement distance:
ANSI C63.10:2013, §6.4.4.2 - Equations (2) + (3) + (4)

4.2. Test system set-up for radiated electric field measurement 30 MHz to 960MHz

Specification: ANSI C63.4-2014 chapter 8.2.3, ANSI C63.10-2013 chapter 6.5

General Description: Evaluating the field emissions have to be done first by an exploratory emissions measurement and a final measurement for most critical frequencies. The tests are performed in a NSA-compliant semi anechoic room (SAR) recognized by the regulatory commissions.

Schematic:



Testing method:

Exploratory, preliminary measurements
The EUT and its associated accessories are placed on a non-conductive position manipulator (tipping device) of 0.8 m height which is placed on the turntable. By rotating the turntable (range 0° to 360°, step 90°) and the EUT itself either on 3-orthogonal axis (portable equipment) or 2-orthogonal axis (defined operational position of EUT) the emission spectrum and it's characteristics was recorded with an EMI-receiver, broadband antenna and software.

Measurement antenna: horizontal and vertical, heights: 1,0 m and 1,82 m as worst-case determined by an exploratory emission measurements. The results are documented in a diagram. Critical frequencies (low margin to limit) are saved within a table for further investigations. If various operating modes are supported, further investigations are made to find the worst-case of them. Also the interconnection cables and equipment position were varied in order to maximize the emissions.

Final measurement on critical frequencies
Based on the exploratory measurements, the most critical frequencies are re-measured by maintaining the EUT's worst-case operation mode, cable position, etc. either on 10m OATS or 3m semi-anechoic room.

First a frequency zoom around the critical frequency is done to locate the frequency more precisely. After this step, for all identified critical frequencies, the maximum peak was determined.

Following parameters were varied: the turntable angle continuously in the range 0 to 360 degree, the EUT itself either over 3-orthogonal axis (not defined usage position) or 2-orthogonal axis (defined usage position). The measurement antenna height between 1 m and 4 m.

On the determined worst-case position, a final measurement with necessary bandwidth and detector according standard has been carried out.

Formula:

$$E_C = E_R + AF + C_L + D_F - G_A \quad (1)$$

$$M = L_T - E_C \quad (2)$$

AF = Antenna factor
C_L = Cable loss
D_F = Distance correction factor (if used)
E_C = Electrical field – corrected value
E_R = Receiver reading
G_A = Gain of pre-amplifier (if used)
L_T = Limit
M = Margin

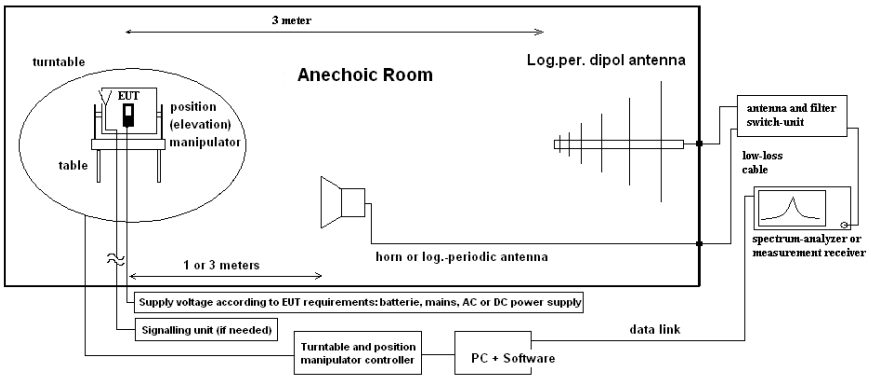
All units are dB-units, positive margin means value is below limit.

4.3. Test system set-up for radiated electric field measurement above 960MHz

Specification: ANSI C63.10-2013, chapter 10.3

General Description: The tests are performed in a CISPR 16-1-4:2010 compliant fully anechoic room (FAR) recognized by the regulatory commission. The measurement distance was set to 1 m or 3 m. Horn antennas are used for frequency range 1 GHz to 40 GHz. The EUT is aligned within 3 dB beam width of the measurement antenna with three orthogonal axis measurements on the EUT.

Schematic:



Testing method:

Exploratory, preliminary measurements
The EUT and its associated accessories are placed on a non-conductive position manipulator (tipping device) of 1.55 m height which is placed on the turntable. By rotating the turntable continuously (range 0° to 360°) and the EUT itself either on 3-orthogonal axis (portable equipment) or 2-orthogonal axis (defined operational position of EUT) the emission spectrum and it's characteristics was recorded with an EMI-receiver, broadband antenna and software.
The measurements are performed in horizontal and vertical polarization of the measurement antennas. The results are documented in a diagram. Also the interconnection cables and equipment position were varied in order to maximize the emissions.

Formula:

$E_C = E_R + AF + C_L + D_F - G_A$ (1)

$M = L_T - E_C$ (2)

E_C = Electrical field – corrected value
E_R = Receiver reading
M = Margin
L_T = Limit
AF = Antenna factor
C_L = Cable loss
D_F = Distance correction factor (if used)
G_A = Gain of pre-amplifier (if used)

All units are dB-units, positive margin means value is below limit.

5. Measurements

5.1. The maximum peak power EIRP / peak EIRP spectral density. The maximum power EIRP/ average EIRP.

5.1.1. Test location and equipment

Ambient Climatic conditions			Temperature: nominal and extreme		Rel. humidity: (45±15)%		
test site	☐ 443 FAR Spuri	☐ 348 EMI cond.	☐ 443 EMI FAR	☐ 347 Radio.lab.	☐ 337 OATS	☒ 412 FAR 2/ OTA1	
equipment	☒ 331 HC 4055	☐	☐	☐	☐	☐	
spectr. Analys.	☒ 714 FSW67	☐ 264 FSEK	☐ 264 FSEK	☐ 584 FSU		☐	
antenna meas < 18GHz	☐ 574 BTA-L	☐ 289 CBL 6141	☐ 439 HL 562	☐ 549 HL 025		☐	
antenna meas 18-40GHz	☐ 302 BBHA9170	☐ 13254-01 / Q-Band SAR-2309-22-S2					
antenna meas f > 40GHz	☐ 748 FH-PP 4060						
antenna meas f > 50GHz	☐ 792 FH-PP 075		☒ 794 FH-PP 110		☐ 795 SGH-26-WR		
antenna meas f > 90GHz	☐ 793 FH-PP 140		☐ 750 FH-PP 220				
antenna meas f > 220GHz	☐ 791 FH-PP3-25						
antenna subst	☐ 071 HUF-Z2	☐ 020 EMCO3115	☐ 063 LP 3146	☐ 303 BBHA9170	☐ 1144 SGH-26-WR	☐	
power meter	☐ 009 NRV	☐ 010 URV5-Z2	☐ 011 URV5-Z2	☐ 100 984 NRT-T110	☐	☐	
Other:	☐ Adapter Q-Band to 1.85mm						
Signalgener.	☐ 008 SMG	☐ 140 SMHU	☐ 263 SMP04	☐	☐	☐	
mixer	☐ 713 FS-Z75	☒ 712 FS-Z110	☐ 711 FS-Z140	☐ 715 FS-Z220	☐ 716 FS-Z325		
power meter	☐ 262 NRV-S	☐ 266 NRV-Z31	☐ 265 NRV-Z33	☐ 261 NRV-Z55	☐ 356 NRV-Z1	☐ 261 NRP-T110	
multimeter	☐ 341 Fluke 112	☐	☐	☐	☐	☐	
DC power	☐ 086 LNG50-10	☒ 087 EA3013	☐ 354 NGPE 40	☐ 349 car battery	☐ 350 Car battery	☐	
line voltage	☐ 230 V 50 Hz via public mains		☐060 120 V 60 Hz via PAS 5000				

5.1.2. Reference

FCC/RSS	See section 1.1.
ANSI	C63.10-2013

5.1.3. Limits

See section 1.1. in the report.

5.1.4. Test environment

Temperature	Nominal: 22±3 °C Extreme, min.: -40 °C Extreme, max.: +85 °C
Rel. humidity	(40±20)%
Power supply	Nominal: 12 V Extreme, min.: 8 V Extreme, max.: 19 V

5.1.5. Spectrum-Analyzer settings:

Span	> 1 GHz
Resolution Bandwidth (RBW)	1 MHz
Video Bandwidth (VBW)	Minimum 3 times the resolution bandwidth
Sweep time	120 s
Detector	Peak detector with max peak search. RMS with channel power measurement.
Sweep mode	Singale sweep, MAX-HOLD

5.1.6. Measurement method:

All the measurements are done according to standards and rules listed in subsection 5.1.2. The measured power is EIRP*.

The EUT is ON and set to default mode: FMCW modulation. At first the EUT is tested under nominal condition. Then it is tested under extreme conditions (extreme temperatures and voltages) with the help of a climate cabinet and a variable power supply.
For the maximum peak power EIRP / peak EIRP spectral density test function Signal-ID is activated to exclude ghost signals (product of the mixer).
*EIRP: Equivalent Isotropic Radiated Power

5.1.7. Results

Power measurement				Verdict
Setup / Op. Mode / measuring distance	Nominal condition			
	Peak detector, max peak search (marker power) [dBm]	Peak detector, max peak search (marker frequency) [GHz]	RMS detector, channel power measurement [dBm]*	
Set. 1 / Op. 1 / 1 m	25,9	76,5845	20,61	**Pass**
Set. 2 / Op. 1 / 1 m	22,85	76,5825	18,13	**Pass**
Set. 3 / Op. 1 / 1 m	23,5	76,5325	17,31	**Pass**
Set. 4 / Op. 1 / 1 m	24,69	76,5835	21,22	**Pass****
Extreme conditions				
Set. 1 / Op. 1 / 2.5 m TminVnom	24,73	76,5875	20,41	**Pass**
Set. 1 / Op. 1 / 2.5 m TmaxVnom	24,68	76,5325	18,84	**Pass**
Set. 1 / Op. 1 / 2.5 m TnomVmin	26,15	76,5835	21,15	**Pass**
Set. 1 / Op. 1 / 2.5 m TnomVmax	26,07	76,5835	20,52	**Pass**
Set. 2 / Op. 1 / 2.5 m TminVnom	22,56	76,5815	17,78	**Pass**
Set. 2 / Op. 1 / 2.5 m TmaxVnom	23,47	76,5775	17,67	**Pass**
Set. 2 / Op. 1 / 2.5 m TnomVmin	23,7	76,4995	18,58	**Pass**
Set. 2 / Op. 1 / 2.5 m TnomVmax	22,91	76,5325	17,78	**Pass**
Set. 3 / Op. 1 / 2.5 m TminVnom	22,45	76,5845	19,17	**Pass**
Set. 3 / Op. 1 / 2.5 m TmaxVnom	21,21	76,4915	16,67	**Pass**
Set. 3 / Op. 1 / 2.5 m TnomVmin	23,87	76,5315	17,71	**Pass**
Set. 3 / Op. 1 / 2.5 m TnomVmax	23,41	76,4915	17,21	**Pass**
Set. 4 / Op. 1 / 2.5 m TminVnom	23,97	76,5015	21,57	**Pass**
Set. 4 / Op. 1 / 2.5 m TmaxVnom	23,3	76,5245	18,52	**Pass**
Set. 4 / Op. 1 / 2.5 m TnomVmin	24,61	76,5795	21,25	**Pass**
Set. 4 / Op. 1 / 2.5 m TnomVmax	24,48	76,5245	21,06	**Pass**

Remark: For graphical results, pls. see annex 1 to this test report.
* for this measurement a channel 76 GHz to 77 GHz was used (see plots in annex 1 to test report).
** EUT D in the set-up 4 has the same hardware version as the EUT B and EUT C. EUT D shows the highest value of the power measurement among EUT B/C/D. Therefore, the radiated unwanted emissions test (Field strength of emissions (radiated spurious)) is conducted with EUT D, representing EUT B and EUT C (EUTs with thick radome) and EUT A (EUT with thin radome).

5.2. Modulation characteristics

5.2.1. Test location and equipment

See 5.1.1.

5.2.2. Reference

Standard	FCC §2.1047 (d) RSS-251 (Section 6b)

5.2.3. Description:

FCC §2.1047 (d): *Other types of equipment. A curve or equivalent data which shows that the equipment will meet the modulation requirements of the rules under which the equipment is to be licensed.*
RSS-251 (Section 6b): *Non-pulsed radar (e.g. frequency modulated continuous wave (FMCW)): modulation type (i.e. sawtooth, sinusoid, triangle, or square wave) and sweep characteristics (sweep bandwidth, sweep rate, sweep time).*

5.2.4. Test environment

Temperature	Nominal: 22±3 °C
Rel. humidity	(40±20)%
Power supply	Nominal: 12 V

5.2.5. Spectrum-Analyzer settings:

Span	> 1 GHz
Resolution Bandwidth (RBW)	1 MHz
Video Bandwidth (VBW)	Minimum 3 times the resolution bandwidth
Sweep time	120 s
Detector	Peak detector
Sweep mode	Single sweep, MAX-HOLD

5.2.6. Measurement method:

Start and stop frequency was measured for all operating modes and all frequency bands with nominal conditions. Wave form and sweep characteristics were supplied by applicant.

5.2.7. Results

For graphical results for start and stop frequency pls. see annex 1 to this test report.
The applicant supplied following information about wave form and sweep characteristics:
Waveform:
All the radar sensors in the family utilize FMCW modulation. Small variations of the transmitted waveform are used to achieve different radiation patterns. The patterns are selected by adjusting which of the 3 different transmitters are turned ON at a given time and by relative phase setting between the transmitters.
The total number of chirps is set to 32, they are arranged on 2 or 3 sections depending on the variant. The pulse repetition rate is 5ms.

***Generic Specifications (for all waveforms)**:*
Waveform: *Fast chirp FMCW*
Modulation type: *sawtooth*
Cycle time: *40/50 ms*

***Waveform Parameters CRN1**:*
This variant of the sensor is intended for corner radar applications. The waveform (SW) incorporates elevation and the Tx3 antenna. The hardware (HW) for CRN1, CRN2 & CRN3 are identical.
Sequence 1: Number of chirps = 8 (Tx1+Tx2)
Sequence 2: Number of chirps = 16 (Tx1-Tx2)
Sequence 3: Number of chirps = 8 (toggling Tx2/Tx3)

Antennas Used	*Tx1, Tx2, Tx3*
Range	*105 m*
FOV	*+/-70 degrees*
Center Frequency	*76.5 GHz*
Bandwidth	*925 MHz*
Tx_on/off	*67 µs / 23 µs*
Duty Cycle	*43%*

***Waveform Parameters CRN2**:*
This variant of the sensor is intended for corner radar applications. The waveform (SW) does not incorporate elevation or the Tx3 antenna. The hardware (HW) for CRN1, CRN2 & CRN3 are identical.
Sequence 1: Number of chirps = 16 (Tx1+Tx2)
Sequence 2: Number of chirps = 16 (Tx1-Tx2)

Antennas used	*Tx1, Tx2*
Range	*105m*
FOV	*+/-70 degrees*
Center frequency	*76.5GHz*
Bandwidth	*925 MHz*
Tx_on/off	*67us/23us*
Duty Cycle	*43%*

***Waveform Parameters CRN3**:*
This variant of the sensor is intended for a corner blind spot application. The waveform (SW) does not incorporate elevation and utilizes one antenna. The hardware (HW) for CRN1, CRN2 & CRN3 are identical.
Sequence 1: Number of chirps = 8 (Tx2)
Sequence 2: Number of chirps = 16 (Tx2)

Antennas Used	*TX2*
Range	*85m*
FOV	*+/-70 degrees*
Center Frequency	*76.5GHz*
Bandwidth	*925 MHz*
TX_on/off	*67us/23us*
Duty Cycle	*29%*

5.3. Occupied bandwidth

5.3.1. Test location and equipment

See section 5.1.1.

5.3.2. Reference

Standard	See section 1.1. in the report.

5.3.3. Limits

See section 1.1. in the report.

5.3.4. Test environment

Temperature	Nominal: 22±3 °C Extreme, min.: -40 °C Extreme, max.: +85 °C
Rel. humidity	(40±20)%
Power supply	Nominal: 12 V Extreme, min.: 8 V Extreme, max.: 19 V

5.3.5. Spectrum-Analyzer settings:

Span	> 1 GHz
Resolution Bandwidth (RBW)	FCC: 1 MHz IC: RSS-Gen Issue 5 March 2019 Amendment 1 Section 6.7.: "*The resolution bandwidth (RBW) shall be in the range of 1% to 5% of the actual occupied / x dB bandwidth and the video bandwidth (VBW) shall not be smaller than three times the RBW value.*" Actual occupied bandwidth (99% emission bandwidth) of all EUTs is 916 MHz to 933 MHz. 1 % of 916 MHz – 933 MHz is 9,16 MHz – 9,33 MHz. So RBW = 10 MHz was chosen.
Video Bandwidth (VBW)	Minimum 3 times the resolution bandwidth
Sweep time	120 s
Detector	Peak detector
Sweep mode	Single sweep, MAX-HOLD

5.3.6. Measurement method:

Occupied bandwidth was measured for operating mode 1 under nominal and extreme conditions. Occupied bandwidth (99 %) function is activated in spectrum analyzer for this measurement.

5.3.7. Results

Nominal condition				Verdict
Setup / Op. Mode	Low edge [GHz]	High edge [GHz]	Occ. bandwidth [MHz]	
Set. 1 / Op. 1 / RBW = 1 MHz	76,03866	76,95537	916,703	**Pass**
Set. 2 / Op. 1 / RBW = 1 MHz	76,03816	76,95498	916,828	**Pass**
Set. 3 / Op. 1 / RBW = 1 MHz	76,0377	76,95591	918,213	**Pass**
Set. 4 / Op. 1 / RBW = 1 MHz	76,03708	76,956	918,921	**Pass***
Set. 1 / Op. 1 / RBW = 10 MHz (for ISED only)	76,03181	76,96504	933,231	**Pass**
Set. 2 / Op. 1 / RBW = 10 MHz (for ISED only)	76,03083	76,96331	932,48	**Pass**
Set. 3 / Op. 1 / RBW = 10 MHz (for ISED only)	76,03033	76,96238	932,058	**Pass**
Set. 4 / Op. 1 / RBW = 10 MHz (for ISED only)	76,03115	76,9632	932,053	**Pass**
Extreme conditions				
Set. 1 / Op. 1 TnomVmin / RBW = 1 MHz	76,03846	76,95548	917,019	**Pass**
Set. 1 / Op. 1 TnomVmax / RBW = 1 MHz	76,03883	76,95529	916,454	**Pass**

Set. 1 / Op. 1 TmaxVnom / RBW = 1 MHz	76,03821	76,95633	918,119	**Pass**
Set. 1 / Op. 1 TminVnom / RBW = 1 MHz	76,04114	76,95947	918,326	**Pass**
Set. 2 / Op. 1 TnomVmin / RBW = 1 MHz	76,03837	76,95581	917,441	**Pass**
Set. 2 / Op. 1 TnomVmax / RBW = 1 MHz	76,03802	76,95463	916,611	**Pass**
Set. 2 / Op. 1 TmaxVnom / RBW = 1 MHz	76,03834	76,95466	916,316	**Pass**
Set. 2 / Op. 1 TminVnom / RBW = 1 MHz	76,03991	76,95753	917,626	**Pass**
Set. 3 / Op. 1 TnomVmin / RBW = 1 MHz	76,0383	76,95636	918,055	**Pass**
Set. 3 / Op. 1 TnomVmax / RBW = 1 MHz	76,03744	76,9554	917,957	**Pass**
Set. 3 / Op. 1 TmaxVnom / RBW = 1 MHz	76,03647	76,95429	917,820	**Pass**
Set. 3 / Op. 1 TminVnom / RBW = 1 MHz	76,03935	76,95819	918,840	**Pass**
Set. 4 / Op. 1 TnomVmin / RBW = 1 MHz	76,03804	76,95653	918,493	**Pass**
Set. 4 / Op. 1 TnomVmax / RBW = 1 MHz	76,03726	76,95578	918,517	**Pass**
Set. 4 / Op. 1 TmaxVnom / RBW = 1 MHz	76,03798	76,9543	916,312	**Pass**
Set. 4 / Op. 1 TminVnom / RBW = 1 MHz	76,03921	76,95858	919,370	**Pass**

Remark: For graphical results pls. see annex 1 to this test report.
* EUT D in the set-up 4 has the same hardware version as the EUT B and EUT C. EUT D shows the highest value of the OBW among EUT B/C/D. Therefore, the radiated unwanted emissions test (Field strength of emissions (radiated spurious)) is conducted with EUT D, representing EUT B and EUT C (EUTs with thick radome) and EUT A (EUT with thin radome).

5.4. Field strength of emissions (band edge)

5.4.1. Test location and equipment

See section 5.2.1.

5.4.2. Reference

Standard	See section 1.1. in the report.

5.4.3. Limits:

See section 1.1. in the report.

5.4.4. Test environment

Temperature	Nominal: 22±3 °C
Rel. humidity	(40±20)%
Power supply	Nominal: 12 V

5.4.5. Spectrum-Analyzer settings:

Span	> 1 GHz
Resolution Bandwidth (RBW)	1 MHz
Video Bandwidth (VBW)	Minimum 3 times the resolution bandwidth
Sweep time	66 s
Detector	RMS detector
Sweep mode	Single sweep, MAX-HOLD

5.4.6. Measurement method:

Low band edge was measured for mode 1. For high band edge see “Field strength of emission (radiated spurious)” in the corresponding frequency range.
The measurement was done with set-up 1 (EUT A with the thin radome) and set-up 4 (EUT D with thick radome). Set-up 4 was chosen due to the fact, the this set-up shows the highest values of max. peak power EIRP / peak EIRP spectral density, respectively max. power EIRP/ average EIRP and OBW among the EUTs with the thick radome.

5.4.7. Verdict

Pass. For graphical results pls. see annex 1 to this test report.

5.5. Radiated field strength emissions, below 30 MHz

5.5.1. Test location and equipment

test location	☒ CETECOM Essen (Chapter. 2.2.1)		☐ Please see Chapter. 2.2.2		☐ Please see Chapter. 2.2.3	
test site	☒ 441 EMI SAR	☐ 487 SAR NSA	☐ 347 Radio.lab.		☐	☐
receiver	☒ 377 ESCS30	☐ 001 ESS	☐	☐	☐	☐
spectr. analys.	☐ 584 FSU	☐ 120 FSEM	☐ 264 FSEK	☐	☐	☐
antenna	☐ 574 BTA-L	☐ 133 EMCO3115	☐ 302 BBHA9170	☐ 289 CBL 6141	☐ 030 HFH-Z2	☒ 021 EMCO6502
signalling	☐ 757 CMW500	☐ 371 CBT32	☐ 547 CMU	☐ 594 CMW500		
otherwise	☐ 400 FTC40x15E	☐ 401 FTC40x15E	☐ 110 USB LWL	☐ 482 Filter Matrix	☐ 378 RadiSense	
DC power	☒ 456 EA 3013A	☐ 457 EA 3013A	☐ 459 EA 2032-50	☐ 268 EA- 3050	☐ 494 AG6632A	☐ 498 NGPE 40
line voltage	☐ 230 V 50 Hz via public mains		☐ 060 120 V 60 Hz via PAS 5000			

5.5.2. Requirements

FCC/RSS	See section 1.1.			
ANSI	C63.10-2013			
Frequency [MHz]	Field strength limit [µV/m]	[dBµV/m]	Distance [m]	Remarks
0.009 – 0.490	2400/f (kHz)	67.6 – 20Log(f) (kHz)	300	Correction factor used due to measurement distance of 3 m
0.490 – 1.705	24000/f (kHz)	87.6 – 20Log(f) (kHz)	30	Correction factor used due to measurement distance of 3 m
1.705 – 30	30	29.5	30	Correction factor used due to measurement distance of 3 m

5.5.3. Test condition and test set-up

EUT-grounding		☒ none	☐ with power supply	☐ additional connection
Equipment set up		☒ table top		☐ floor standing
Climatic conditions		Temperature: (22±3°C)		Rel. humidity: (40±20)%
EMI-Receiver or Analyzer Settings	Scan data	☒ 9 – 150 kHz RBW/VBW = 200 Hz Scan step = 80 Hz ☒ 150 kHz – 30 MHz RBW/VBW = 9 kHz Scan step = 4 kHz ☐ other:		
	Scan-Mode Detector Mode: Sweep-Time	☒ 6 dB EMI-Receiver Mode ☐ 3dB Spectrum analyser Mode Peak (pre-measurement) and Quasi-PK/Average (final if applicable) Repetitive-Scan, max-hold Coupled – calibrated display if continuous signal otherwise adapted to EUT's individual transmission duty-cycle		
General measurement procedures		Please see chapter "Test system set-up radiated magnetic field measurements below 30 MHz"		

5.5.4. Measurement method:

Measurement is done for mode 2. The mode 2 was chosen according to CFR 47 Part 15.31(c).
The measurement was done with set-up 1 (EUT A with the thin radome) and set-up 4 (EUT D with thick radome). Set-up 4 was chosen due to the fact, the this set-up shows the highest values of max. peak power EIRP / peak EIRP spectral density, respectively max. power EIRP/ average EIRP and OBW among the EUTs with the thick radome. EUT A und EUT D were tested together simultaneously (no spurious emissions were detected).

5.5.5. Measurement results:

The results are presented below in summary form only. For more information please consult the diagrams included in annex 1.
Table of measurement radiated spurious results **(EUT A+D)**:

Diag. No.	Setup No.	Op. Mode	Max. Signal Level [dBuV/m]	Frequency [MHz]	Limit [dBuV/m]
5.1	5-6	2	-13,656	8,306	**
5.2	5-6	2	-11,318	19,49	**

** See subsection 5.5.2.

Measurement distance:

Frequency range:	Distance [m]:
9 kHz – 30 MHz	3

5.5.6. Verdict

Pass. No emissions above the limit line. Pls. see annex 1 to this test report.

5.5.7. Correction factors due to reduced meas. distance (f< 30 MHz)

The used correction factors when the measurement distance is reduced compared to regulatory measurement distance, are calculated according Extrapolation formulas valid for EUT's with maximum dimension of 0.625xLambda. Formula 2+3+4 as presented in ANSI C63.10, Chapter 6.4.4 are used for the calculations of proper extrapolation factors.

Frequency -Range	f [kHz/MHz]	Lambda [m]	Far-Field Point [m]	Distance Limit accord. 15.209 [m]	1st Condition (dmeas< $D_{near-field}$)	2'te Condition (Limit distance bigger $d_{near-field}$)	Distance Correction accord. Formula
kHz	9,00E+03	33333,33	5305,17	300	fullfilled	not fullfilled	-80,00
	1,00E+04	30000,00	4774,65		fullfilled	not fullfilled	-80,00
	2,00E+04	15000,00	2387,33		fullfilled	not fullfilled	-80,00
	3,00E+04	10000,00	1591,55		fullfilled	not fullfilled	-80,00
	4,00E+04	7500,00	1193,66		fullfilled	not fullfilled	-80,00
	5,00E+04	6000,00	954,93		fullfilled	not fullfilled	-80,00
	6,00E+04	5000,00	795,78		fullfilled	not fullfilled	-80,00
	7,00E+04	4285,71	682,09		fullfilled	not fullfilled	-80,00
	8,00E+04	3750,00	596,83		fullfilled	not fullfilled	-80,00
	9,00E+04	3333,33	530,52		fullfilled	not fullfilled	-80,00
	1,00E+05	3000,00	477,47		fullfilled	not fullfilled	-80,00
	1,25E+05	2400,00	381,97		fullfilled	not fullfilled	-80,00
	2,00E+05	1500,00	238,73		fullfilled	fullfilled	-78,02
	3,00E+05	1000,00	159,16		fullfilled	fullfilled	-74,49
	4,00E+05	750,00	119,37		fullfilled	fullfilled	-72,00
	4,90E+05	612,24	97,44		fullfilled	fullfilled	-70,23
	5,00E+05	600,00	95,49	30	fullfilled	not fullfilled	-40,00
	6,00E+05	500,00	79,58		fullfilled	not fullfilled	-40,00
	7,00E+05	428,57	68,21		fullfilled	not fullfilled	-40,00
	8,00E+05	375,00	59,68		fullfilled	not fullfilled	-40,00
	9,00E+05	333,33	53,05		fullfilled	not fullfilled	-40,00
MHz	1,00	300,00	47,75		fullfilled	not fullfilled	-40,00
	1,59	188,50	30,00		fullfilled	not fullfilled	-40,00
	2,00	150,00	23,87		fullfilled	fullfilled	-38,02
	3,00	100,00	15,92		fullfilled	fullfilled	-34,49
	4,00	75,00	11,94		fullfilled	fullfilled	-32,00
	5,00	60,00	9,55		fullfilled	fullfilled	-30,06
	6,00	50,00	7,96		fullfilled	fullfilled	-28,47
	7,00	42,86	6,82		fullfilled	fullfilled	-27,13
	8,00	37,50	5,97		fullfilled	fullfilled	-25,97
	9,00	33,33	5,31		fullfilled	fullfilled	-24,95
	10,00	30,00	4,77		fullfilled	fullfilled	-24,04
	10,60	28,30	4,50		fullfilled	fullfilled	-23,53
	11,00	27,27	4,34		fullfilled	fullfilled	-23,21
	12,00	25,00	3,98		fullfilled	fullfilled	-22,45
	13,56	22,12	3,52		fullfilled	fullfilled	-21,39
	15,00	20,00	3,18		fullfilled	fullfilled	-20,51
	15,92	18,85	3,00		fullfilled	fullfilled	-20,00
	17,00	17,65	2,81		not fullfilled	fullfilled	-20,00
	18,00	16,67	2,65		not fullfilled	fullfilled	-20,00
	20,00	15,00	2,39		not fullfilled	fullfilled	-20,00
	21,00	14,29	2,27		not fullfilled	fullfilled	-20,00
	23,00	13,04	2,08		not fullfilled	fullfilled	-20,00
	25,00	12,00	1,91		not fullfilled	fullfilled	-20,00
	27,00	11,11	1,77		not fullfilled	fullfilled	-20,00
	29,00	10,34	1,65		not fullfilled	fullfilled	-20,00
	30,00	10,00	1,59		not fullfilled	fullfilled	-20,00

5.6. Radiated field strength emissions, 30 MHz – 960 MHz

5.6.1. Test location and equipment

test location	☒ CETECOM Essen (Chapter. 2.2.1)		☐ Please see Chapter. 2.2.2		☐ Please see Chapter. 2.2.3	
test site	☒ 441 EMI SAR	☒ 487 SAR NSA				
receiver	☐ 377 ESCS30	☐ 001 ESS	☐ 489 ESU 40	☒ 620 ESU 26		
spectr. analys.	☐ 584 FSU	☐ 120 FSEM	☐ 264 FSEK			
antenna	☒ 574 BTA-L	☐ 133 EMCO3115	☐ 302 BBHA9170	☐ 289 CBL 6141	☐ 030 HFH-Z2	☐ 477 GPS
signalling	☐ 392 MT8820A	☐ 371 CBT32	☐ 547 CMU	☐ 594 CMW		
otherwise	☐ 400 FTC40x15E	☐ 401 FTC40x15E	☐ 110 USB LWL	☒ 482 Filter Matrix		
DC power	☐ 456 EA 3013A	☒ 457 EA 3013A	☐ 459 EA 2032-50	☐ 268 EA- 3050	☐ 494 AG6632A	☐ 498 NGPE
line voltage	☐ 230 V 50 Hz via public mains		☐ 060 120 V 60 Hz via PAS 5000			

5.6.2. Requirements/Limits

FCC/RSS		See section 1.1.	
ANSI		☐ C63.4-2014 ☒ C63.10-2013	
Limit	Frequency [MHz]	Radiated emissions limits, 3 meters	
		QUASI Peak [µV/m]	QUASI-Peak [dBµV/m]
	30 - 88	100	40.0
	88 - 216	150	43.5
	216 - 960	200	46.0
	above 960	500	54.0

5.6.3. Restricted bands of operation (FCC §15.205/ RSS-Gen, Issue 4 Chapter 8.9, Table 4)

MHz	MHz	MHz	GHz
0.090-0.110	16.42-16.423	399.9-410	4.5-5.15
0.495-0.505	16.69475-16.69525	608-614	5.35-5.46
2.1735-2.1905	16.80425-16.80475	960-1240	7.25-7.75
4.125-4.128	25.5-25.67	1300-1427	8.025-8.5
4.20725-4.20775	37.5-38.25	1645.5-1646.5	9.3-9.5
6.215-6.218	73-74.6	1660-1710	10.6-12.7
6.26775-6.26825	74.8-75.2	1718.8-1722.2	13.25-13.4
6.31175-6.31225	108-121.94	2200-2300	14.47-14.5
8.291-8.294	123-138	2310-2390	15.35-16.2
8.362-8.366	149.9-150.05	2483.5-2500	17.7-21.4
8.37625-8.38675	156.52475-156.52525	2690-2900	22.01-23.12
8.41425-8.41475	156.7-156.9	3260-3267	23.6-24.0
12.29-12.293	162.0125-167.17	3332-3339	31.2-31.8
12.51975-12.52025	167.72-173.2	3345.8-3358	36.43-36.5
12.57675-12.57725	240-285	3600-4400	--
13.36-13.41	322-335.4	--	--
Remark: only spurious emissions are allowed within these frequency bands not exceeding the limits per §15.209			

5.6.4. Test condition and measurement test set-up

EUT-grounding		☒ none	☐ with power supply	☐ additional connection
Equipment set up		☒ table top 0.8m height		☐ floor standing
Climatic conditions		Temperature: (22±3°C)		Rel. humidity: (40±20)%
EMI-Receiver (Analyzer) Settings	Scan frequency range:	☒ 30 – 1000 MHz ☐ other:		
	Scan-Mode	☒ 6 dB EMI-Receiver Mode ☐ 3 dB spectrum analyser mode		
	Detector	Peak / Quasi-peak		
	RBW/VBW	100 kHz/300 kHz		
	Mode:	Repetitive-Scan, max-hold		
	Scan step	80 kHz		
	Sweep-Time	Coupled – calibrated display if continuous tx-signal otherwise adapted to EUT's individual duty-cycle		
General measurement procedures		Please see chapter "Test system set-up for electric field measurement in the range 30 MHz to 1 GHz"		

5.6.5. Measurement method:

Measurement is done for mode 2. The mode 2 was chosen according to CFR 47 Part 15.31(c).
The measurement was done with set-up 1 (EUT A with the thin radome) and set-up 4 (EUT D with thick radome).
Set-up 4 was chosen due to the fact, the this set-up shows the highest values of max. peak power EIRP / peak EIRP

spectral density, respectively max. power EIRP/ average EIRP and OBW among the EUTs with the thick radome. EUT A und EUT D were tested together simultaneously (no spurious emissions were detected).

Measurement distance:

Frequency range:	Distance [m]:
30 MHz – 1 GHz	3

5.6.6. Measurement results:

Table of measurement radiated spurious results **(EUT A+D)**:

Diag. No.	Setup No.	Op. Mode	Max. Signal Level [dBuV/m]	Frequency [MHz]	Limit [dBuV/m]
5.3	5-6	2	31,38	848,22	**
5.4	5-6	2	31,99	899,972	**

** See subsection 5.5.2.

5.6.7. Verdict

Pass. No emissions above the limit line. Pls. see annex 1 to this test report.

5.7. Radiated field strength emissions, 960 MHz – 40 GHz

5.7.1. Test location and equipment

Ref.-No.	Equipment	Type	Serial-No.
Frequency range 960 MHz – 7000 MHz			
Measurement in FAC 1 with the distance between the EUT and the antenna 3 m			
Frequency range 7000 MHz – 18000 MHz			
Measurement in FAC 1 with the distance between the EUT and the antenna 1 m			

Ambient Climatic conditions	Temperature: (22±2)°C			Rel. humidity: (45±15)%		
test site	☐ 441 EMI SAR	☐ 348 EMI cond.	☒ 443 EMI FAR	☐ 347 Radio.lab.	☐ 337 OATS	☐
test receiver	☐ 377 ESCS 30	☐	☐	☐	☐	☐
spectr. analys.	☒ 584 FSU	☐ 120 FSEM	☐ 264 FSEK	☒ 747 FSU	☐ 377 GPS	☐
sig. generator	☐ 689 SMU	☐	☐	☐	☐	☐
antenna meas	☐ 574 BTA-L	☒ 549 HL025	☒ 439 HL 562	☐ 133 EMCO3115	☐ 302 BBHA9170	☐
antenna meas	☐ 123 HUF-Z2	☐ 132 HUF-Z3	☐ 030 HFH-Z2	☐	☐	☐
antenna subst	☐ 071 HUF-Z2	☐ 020 EMCO3115	☐ 063 LP 3146	☐ 303 BBHA9170	☐	☐
power meter	☐ 009 NRV	☐ 010 URV5-Z2	☐ 011 URV5-Z2	☐	☐	☐
power meter	☐ 262 NRV-S	☐ 266 NRV-Z31	☐ 265 NRV-Z33	☐ 261 NRV-Z55	☐ 356 NRV-Z1	☐
multimeter	☐ 341 Fluke 112	☐	☐	☐	☐	☐
DCpower	☐ 086 LNG50-10	☒ 087 EA3013	☐ 354 NGPE 40	☐ 349 car battery	☐ 350 Car battery	☐
line voltage	☒ 12.0 V DC		☐ 060 120 V 60 Hz via PAS 5000			

Frequency range 18000 MHz – 40000 MHz			
Measurement in FAC 2 with the distance between the EUT and the antenna 1 m			
714	Spectrum Analyzer	R&S FSW67	104023
302	Antenna	BBHA9170	155
688	RF Amplifier	Miteq JS-18004000-40-8P	1750117

5.7.2. Requirements/Limits

FCC/RSS	See section 1.1.
ANSI	☐ C63.4-2014 ☒ C63.10-2013
Limits, EIRP in dBm	Field strength limit [dBµV/m] for 3 m is 54 dBµV/m. EIRP limit is -41.23 dBm. EIRP limit was calculated according to the equation (38) in ANSI C63.10-2013: EIRP[dBm] = E[dBµV/m]+ 20log(d [m])−104.77 $EIRP_{limit}$ = [54 + 20log(3)−104.77] dBm = [54 + 9.54−104.77] dBm = -41.23 dBm

5.7.3. Test condition and measurement test set-up

EUT-grounding		☒ none ☐ with power supply	☐ additional connection
Equipment set up		☒ table top 1.5m height	☐ floor standing
Climatic conditions		Temperature: (22±3°C)	Rel. humidity: (40±20)%
Spectrum-Analyzer settings	Scan frequency range:	☒ 1 – 18 GHz ☒ 18 – 25 GHz ☒ 18 – 40 GHz ☐ other:	
	Scan-Mode	☐ 6 dB EMI-Receiver Mode ☒ 3 dB Spectrum analyser Mode	
	Detector	RMS	
	RBW/VBW	1 MHz / 3 MHz	
	Mode:	Repetitive-Scan, max-hold	
	Sweep-Time	≤ 1 s over each measurement bin	
General measurement procedures		Please see chapter “Test system set-up for radiated electric field measurements above 1 GHz”	

5.7.4. Measurement method:

Measurement is done for mode 2. The mode 2 was chosen according to CFR 47 Part 15.31(c).
The measurement was done with set-up 1 (EUT A with the thin radome) and set-up 4 (EUT D with thick radome). Set-up 4 was chosen due to the fact, the this set-up shows the highest values of max. peak power EIRP / peak EIRP spectral density, respectively max. power EIRP/ average EIRP and OBW among the EUTs with the thick radome. EUT A und EUT D were tested together simultaneously (no spurious emissions were detected).

Measurement distance:

Frequency range:	Distance [m]:
1 GHz – 7 GHz	3
7 GHz – 18 GHz	1
18 GHz – 40 GHz	1

5.7.5. Measurement results:

The results are presented below in summary form only. For more information please consult the diagrams included in annex 1.

Table of measurement radiated spurious results **(EUT A)**:

Diag. No.	Setup No.	Op. Mode	Max. Signal Level [dBm]	Frequency [GHz]	Limit [dBm]
5.5	5	2	-80	*	-41.23
5.6	5	2	-47,5	*	-41.23
5.7	5	2	-47	14,3997	-41.23
5.8	5	2	-56,27	28,7995	-41.23
5.9	5	2	-57,54	28,7999	-41.23

* Noise level

Table of measurement radiated spurious results **(EUT D)**:

Diag. No.	Setup No.	Op. Mode	Max. Signal Level [dBm]	Frequency [GHz]	Limit [dBm]
5.5	6	2	-80	*	-41.23
5.6	6	2	-47,5	*	-41.23
5.7	6	2	-47	14,3997	-41.23
5.88	6	2	-53,48	28,7991	-41.23
5.89	6	2	-59,12	28,7998	-41.23

* Noise level

5.7.6. Verdict

Pass. No emissions above the limit line. Pls. see annex 1 to this test report.

5.8. Radiated field strength emissions, above 40 GHz

5.8.1. Test location and equipment (for reference numbers please see chapter 'List of test equipment')

Ambient Climatic conditions			Temperature: (22±2)°C		Rel. humidity: (45±15)%		
test site	☐ 443 FAR Spuri	☐ 348 EMI cond.	☐ 443 EMI FAR	☐ 347 Radio.lab.	☐ 337 OATS	☒ 412 OTA1	
equipment	☐ 331 HC 4055	☐	☐	☐	☐	☐	
spectr. Analys.	☒ 714 FSW67	☐ 264 FSEK	☐ 264 FSEK	☐ 584 FSU		☐	
antenna meas f > 40GHz	☒ 748 FH-PP 4060						
antenna meas f > 50GHz	☒ 792 FH-PP 075		☒ 794 FH-PP 110		☐ 795 SGH-26-WR		
antenna meas f > 90GHz	☒ 793 FH-PP 140		☒ 750 FH-PP 220				
antenna meas f > 220GHz	☒ 791 FH-PP3-25						
antenna subst	☐ 071 HUF-Z2	☐ 020 EMCO3115	☐ 063 LP 3146	☐ 303 BBHA9170	☐ 1144 SGH-26-WR	☐	
Other:	☒ Adapter Q-Band to 1.85mm		☒ RF cable PFA61-B1B1-1M0 TESTeLINK C03411				
Signalgener.	☐ 008 SMG	☐ 140 SMHU	☐ 263 SMP04	☐	☐	☐	
mixer	☒ 713 FS-Z75	☒ 712 FS-Z110	☒ 711 FS-Z140	☒ 715 FS-Z220	☒ 716 FS-Z325		
multimeter	☐ 341 Fluke 112	☐	☐	☐	☐	☐	
DC power	☐ 086 LNG50-10	☐ 087 EA3013	☒ 354 NGPE 40	☐ 349 car battery	☐ 350 car battery	☐	
line voltage	☐ 230 V 50 Hz via public mains		☐060 120 V 60 Hz via PAS 5000				

5.8.2. Reference

Standard	See section 1.1. in the report.

5.8.3. Limits:

Limits, EIRP in dBm	FCC §95.3379 (a)	9 kHz – 40 GHz: see section 5.5. in the report 40 GHz – 200 GHz: 600 pW/cm^2 ~ -1.7 dBm 200 GHz – 231 GHz: 1000 pW/cm^2 ~ 0.5 dBm
	RSS-251 (Section 10)	9 kHz – 40 GHz: see section 5.5. and 5.6. in the report 40 GHz – 162 GHz*: -30 dBm Here 73.5 GHz – 76 GHz: 0 dBm
Limit conversion (pW/cm^2 to dBm):		P[dBm]=10*log(4*pi*d^2*P[W/m^2]) d- distance of the limit defined in W/m^2. Here: 3 m. --- 600 pW/cm^2: P[dBW]=10*log(4*pi*(3m)^2*6*10^{-6}W/m^2) 600 pW/cm^2: P[dBW]= -31.7 dBW P[dBm] = P[dBW] + 30 600 pW/cm^2: P[dBm]= -31.7 dBW + 30 600 pW/cm^2: P[dBm]= -1.7 dBm --- 1000 pW/cm^2: P[dBW]=10*log(4*pi*(3m)^2*1*10^{-5}W/m^2) 1000 pW/cm^2: P[dBW]= -29.5 dBW P[dBm] = P[dBW] + 30 1000 pW/cm^2: P[dBm]= -29.5 dBW + 30 1000 pW/cm^2: P[dBm]= +0.5 dBm

5.8.4. Test environment

Temperature	Nominal: 22±3 °C
Rel. humidity	(40±20)%
Power supply	Nominal: 12 V

5.8.5. Spectrum-Analyzer settings*:

Resolution Bandwidth (RBW)	1 MHz
Video Bandwidth (VBW)	Minimum 3 times the resolution bandwidth
Sweep time	≤ 1 s
Detector	RMS detector.
Sweep mode	Single sweep, MAX-HOLD

* See also settings on the screenshots from the spectrum analyzer in Annex 1

5.8.6. Measurement method:

The measurements are done for operating mode 1 and 2. The measurement begins with the operating mode 2. The measuring sweeps are repeated with Maxhold function activated. Thus the measuring diagrams in annex 1 covers emissions of the EUT in all 3D directions and all 3 CW signals. The alignment where the EUT transmits the maximum power is also determined.

The measurements are made with the mixer. There is a ref level line in all measurements. This line is not to be mistaken for limit line.

There are many image signals and mixer products to see on the measurement graphs. Signal ID function is used for the most measurement above 55 GHz for the purpose to distinguish these image signals and mixer products from the real signals. Here is the description of Signal ID function from user manual for R&S FSW Signal and Spectrum Analyzer (1173.9411.02 ─ 31):

two sweeps are performed alternately. Trace 1 shows the trace measured on the upper side band (USB) of the LO (the test sweep), trace 2 shows the trace measured on the lower side band (LSB), i.e. the reference sweep.

*The reference sweep is performed using an LO setting shifted downwards by 2*IF/<Harmonic order>. Input signals in the desired sideband that are converted using the specified harmonic are displayed in both traces at the same position on the frequency axis. Image signals and mixer products caused by other harmonics are displayed at different positions in both traces. The user identifies the signals visually by comparing the two traces.*

Since the LO frequency is displaced downwards in the reference sweep, the conversion loss of the mixer may differ from the test sweep. Therefore the signal level should only be measured in the test sweep (trace 1).

According to the description of the Signal ID function above the following measurement procedure was developed: the measurement was done with Signal ID function ON, when there are any emissions on the measurement graph or with Signal ID function OFF, when there are no emissions at all. On the measurement graph with Signal ID function ON there are two traces at first, LSB and USB. These traces can cover each other. For this reason two more graphs are made and included in the test report for each measurement. One graph with only USB trace and one graph with only LSB trace. These two already saved graphs are opened and compared on the wide enough screen. The scaling of the both graphs is the same. So the graphs can be easily compared by the switching between them (at first one graph is showed on the screen and then the second one). Each area of both traces is compared manually in this way. When there is an emission at the same frequency at LSB as well as at USB trace then it is a real signal. Such signal will be flagged with a marker and later remeasured. **No image signals and mixer products are flagged with the marker.** There are too many image signals and mixer products. When all they will be flagged with the marker then it looks not clearly.

For this reason one more measurement will be done with the operating mode 1 with extended sweep time (ST). ST = average time * number of sweep points. Average time is larger than the EUT cycle time. The measurement will be done in the position with the highest power determined in the first part of the measurement. Image signals and mixer products are easily distinguished on the plots for such a measurement. This measurement is not really demanded. Aber it acts as a good instrument to ensure and clarify the measurements results from the first part of the measurement.

The measurement was done with set-up 1 (EUT A with the thin radome) and set-up 4 (EUT D with thick radome). Set-up 4 was chosen due to the fact, that this set-up shows the highest values of max. peak power EIRP / peak EIRP spectral density, respectively max. power EIRP/ average EIRP and OBW among the EUTs with the thick radome.

Traces on all diagrams up to 200 GHz include all losses inclusive antenna gain and free-space path loss. The SW of the spectrum analyzer doesn't permit to include antenna gain and free-space path loss in the trace for frequency range above 200 GHz. The real noise level for the measurements above 200 GHz is calculated in the table below:

200 GHz – 220 GHz					
Column identification	A	B	C	D	-
Frequency [GHz]	Antenna gain [dBi]	Free-space path loss [dB] for 1 m	Noise level read by spectrum analyzer [dBm]	A + B + C Calculate noise level, [dBm]	Limit [dBm]/ Verdict
200	-23.75	78.52	-76,82	-23,32	0.5/ ok
210	-24.15	78.95	-76,74	-23,2	0.5/ ok
220	-24.5	79.35	-78,53	-24,98	0.5/ ok
220 GHz – 243 GHz					

Frequency [GHz]	Antenna gain [dBi]	Free-space path loss [dB] for 0.5 m	Noise level read by spectrum analyzer [dBm]	A + B + C Calculate noise level, [dBm]	Limit [dBm]/ Verdict
220	-19.8	73.33	-67,66	-14,16	0.5/ ok
225.5	-20	73.54	-70,08	-16,54	0.5/ ok
243	-20.2	73.75	-72,22	-18,67	0.5/ ok

Calculation of the boundary near/far field:
The aperture dimensions of the antenna shall be small enough so that the measurement distance in m is equal to or greater than the Rayleigh (**far-field**) distance (i.e., $R_m = 2D^2 / \lambda$), where D is the largest dimension of the antenna aperture in m and λ is the free-space wavelength in m at the frequency of measurement.

Antenna range, [GHz]	D, [m]	Highest frequency in the measurement, [GHz]	Lowest wavelength λ in the measurement, [m]	Boundary for near/far field, [m]
40-55	0.0384	55	0.005450772	0.54
55-75	0.03072	73.5	0.004078809	0.46
55-75	0.03072	74.5	0.00402406	0.50
55-75	0.03072	75	0.003997233	0.54
75-110	0.020757	76	0.003944638	0.22
75-110	0.020757	78.5	0.003819012	0.25
75-110	0.020757	79.5	0.003770974	0.27
75-110	0.020757	81	0.003701141	0.30
75-110	0.020757	90	0.003331027	0.37
75-110	0.020757	98	0.003059107	0.43
75-110	0.020757	110	0.002725386	0.53
90-140	0.016696	122	0.002457315	0.23
90-140	0.016696	138	0.002172409	0.29
90-140	0.016696	140	0.002141375	0.33
140-220	0.010666	154	0.001946704	0.12
140-220	0.010666	162	0.001850571	0.15
140-220	0.010666	170	0.001763485	0.18
140-220	0.010666	200	0.001498962	0.25
140-220	0.010666	220	0.001362693	0.32
220-325	0.007046	243	0.001297803	0.08

Measurement distance:

Measurement frequency range:	Measurement distance, [m]	Boundary for near/far field, [m]
40 GHz – 55 GHz	1	0.54
55 GHz – 73.5 GHz	1	0.46
73.5 GHz – 74.5 GHz	1	0.50
74.5 GHz – 75 GHz	1	0.54
75 GHz – 76 GHz	1	0.22
77 GHz – 78.5 GHz	1	0.25
78.5 GHz – 79.5 GHz	1	0.27
79.5 GHz – 81 GHz	1	0.30
81 GHz – 90 GHz	1	0.37
90 GHz – 98 GHz	1	0.43
98 GHz – 110 GHz	0.55	0.53
110 GHz – 140 GHz	0.5	0.33
110 GHz – 122 GHz	0.5	0.23
122 GHz – 138 GHz	0.3	0.29
138 GHz – 140 GHz	0.5	0.33
140 GHz – 154 GHz	0.25	0.12
154 GHz – 162 GHz	0.25	0.15
162 GHz – 170 GHz	1	0.18

170 GHz – 200 GHz	1	0.25
200 GHz – 220 GHz	1	0.32
220 GHz – 243 GHz	0.5	0.08

5.8.7. Measurement results:

The results are presented below in summary form only. For more information please consult the diagrams included in annex 1.

According **FCC §95.3379 (a)**

Table of measurement radiated spurious results **(EUT A)**:

Diag. No.	Setup No.	Op. Mode	Max. Signal Level [dBm]	Limit [dBm]
5.10 - 5.12	5	2	-40 *	-1.7
5.13	5	1	-47 *	-1.7
5.14 – 5.22	5	2	-47 *	-1.7
5.23 – 5.25	5	1	-43 *	-1.7
5.26 – 5.34	5	2	-41 *	-1.7
5.35 – 5.36	5	1	-32 *	-1.7
5.37 – 5.40	5	1	-38 *	-1.7
5.41 – 5.49	5	2	-38 *	-1.7
5.50	5	1	-40 *	-1.7
5.51 – 5.59	5	2	-34 *	-1.7
5.60 – 5.62	5	1	-36 *	-1.7
5.63 – 5.65	5	2	-33 *	-1.7
5.66 – 5.67	5	1	-35 *	-1.7
5.68 – 5.70	5	2	-22 *	-1.7
5.71 – 5.72	5	1	-22.5 *	-1.7
5.73 – 5.75	5	2	**	0.5
5.76	5	1	**	0.5
5.77 – 5.79	5	2	**	0.5
5.80	5	1	**	0.5

* Noise level

** For noise level above 200 GHz see calculation in the subsection 5.8.6.

Table of measurement radiated spurious results **(EUT D)**:

Diag. No.	Setup No.	Op. Mode	Max. Signal Level [dBm]	Limit [dBm]
5.90 - 5.92	6	2	-40 *	-1.7
5.93	6	1	-47 *	-1.7
5.94 – 5.102	6	2	-47 *	-1.7
5.103 – 5.105	6	1	-43 *	-1.7
5.106 – 5.114	6	2	-41 *	-1.7
5.115 – 5.116	6	1	-32 *	-1.7
5.117 – 5.120	6	1	-38 *	-1.7
5.121 – 5.129	6	2	-38 *	-1.7
5.130	6	1	-40 *	-1.7
5.131 – 5.139	6	2	-34 *	-1.7
5.140 – 5.142	6	1	-36 *	-1.7
5.143 – 5.145	6	2	-33 *	-1.7
5.146 – 5.147	6	1	-35 *	-1.7
5.148 – 5.150	6	2	-22 *	-1.7
5.151 – 5.152	6	1	-22.5 *	-1.7
5.153 – 5.155	6	2	**	0.5
5.156	6	1	**	0.5
5.157 – 5.159	6	2	**	0.5

5.160	6	1	**	0.5

* Noise level
** For noise level above 200 GHz see calculation in the subsection 5.8.6.

According **RSS-251 (Section 10)**
Table of measurement radiated spurious results **(EUT A)**:

Diag. No.	Setup No.	Op. Mode	Max. Signal Level [dBm]	Limit [dBm]
5.10 - 5.12	5	2	-40 *	-30
5.13	5	1	-47 *	-30
5.14 – 5.22	5	2	-47 *	-30
5.23	5	1	-43 *	-30
5.24 – 5.25	5	1	-43 *	0
5.26 – 5.34	5	2	-41 *	-30
5.35	5	1	-31.5 *	0
5.36	5	1	-32 *	-30
5.37 – 5.40	5	1	-38 *	-30
5.41 – 5.49	5	2	-38 *	-30
5.50	5	1	-40 *	-30
5.51 – 5.59	5	2	-34 *	-30
5.60 – 5.62	5	1	-36 *	-30
5.63 – 5.65	5	2	-33 *	-30
5.66 – 5.67	5	1	-35 *	-30

* Noise level

Table of measurement radiated spurious results **(EUT D)**:

Diag. No.	Setup No.	Op. Mode	Max. Signal Level [dBm]	Limit [dBm]
5.90 - 5.92	6	2	-40 *	-30
5.93	6	1	-47 *	-30
5.94 – 5.102	6	2	-47 *	-30
5.103	6	1	-43 *	-30
5.104 – 5.105	6	1	-43 *	0
5.106 – 5.114	6	2	-41 *	-30
5.115	6	1	-32 *	0
5.116	6	1	-32 *	-30
5.117 – 5.120	6	1	-38 *	-30
5.121 – 5.129	6	2	-38 *	-30
5.130	6	1	-40 *	-30
5.131 – 5.139	6	2	-34 *	-30
5.140 – 5.142	6	1	-36 *	-30
5.143 – 5.145	6	2	-33 *	-30
5.146 – 5.147	6	1	-35 *	-30

* Noise level

5.8.8. Verdict
Pass. No real emissions above the limit line. Pls. see annex 1 to this test report.

5.9. Frequency stability

5.9.1. Test location and equipment

See section 5.1.1.

5.9.2. Reference

Standard	See section 1.1. in the report.

5.9.3. Limits

RSS-251 Section 11.2	The radar device's occupied bandwidth (i.e. 99% emission bandwidth) shall be maintained within the 76-81 GHz frequency band while subjected to all conditions of operation specified in RSS-Gen.

5.9.4. Test environment

Temperature	Nominal: 22±3 °C Extreme, min.: -40 °C Extreme, max.: +85 °C For other temperatures see table in subpart 5.9.6.
Rel. humidity	(40±20)%
Power supply	Nominal: 12 V Extreme, min.: 8 V Extreme, max.: 19 V

5.9.5. Spectrum-Analyzer settings:

Span	> 1 GHz
Resolution Bandwidth (RBW)	1 MHz
Video Bandwidth (VBW)	Minimum 3 times the resolution bandwidth
Sweep time	Auto
Detector	Peak detector
Sweep mode	Single sweep, MAX-HOLD

5.9.6. Measurement method:

Frequency stability was measured for operating mode 1 under nominal and extreme conditions. One marker was set on the low and high edge of the signal in each measurement. The frequency of the markers was compared for all measurements.

The measurement was done for following conditions:

Conditions No	Temperature [ºC]	Voltage [V]
1	Nominal*	Nominal*
2	Nominal*	V_{min}*
3	Nominal*	V_{max}*
4	T_{min}*	Nominal*
5	-20	Nominal*
6	-10	Nominal*
7	0	Nominal*
8	10	Nominal*
9	20	Nominal*
10	30	Nominal*
11	40	Nominal*
12	50	Nominal*
13	T_{max}*	Nominal*

* See subpart 5.9.4.

5.9.7. Results

Nominal conditions, **EUT A**		
Setup / Op. Mode	Low edge [GHz]	High edge [GHz]

Set. 1 / Op. 1 TnomVnom	76,0381	76,9577
Extreme conditions		
Set. 1 / Op. 1 TmaxVnom	76,0381	76,9567
Set. 1 / Op. 1 T50ºCVnom	76,0401	76,9577
Set. 1 / Op. 1 T40ºCVnom	76,0377	76,9589
Set. 1 / Op. 1 T30ºCVnom	76,0381	76,9589
Set. 1 / Op. 1 TnomVmin	76,0381	76,9577
Set. 1 / Op. 1 TnomVmax	76,0381	76,9567
Set. 1 / Op. 1 T10ºCVnom	76,0385	76,9586
Set. 1 / Op. 1 T0ºCVnom	76,0381	76,9595
Set. 1 / Op. 1 T-10ºCVnom	76,0392	76,958
Set. 1 / Op. 1 T-20ºCVnom	76,0387	76,9592
Set. 1 / Op. 1 TminVnom	76,0391	76,9597

Nominal conditions, **EUT B**		
Setup / Op. Mode	Low edge [GHz]	High edge [GHz]
Set. 2 / Op. 1 TnomVnom	76,0371	76,9567
Extreme conditions		
Set. 2 / Op. 1 TmaxVnom	76,0361	76,9557
Set. 2 / Op. 1 T50ºCVnom	76,0371	76,9567
Set. 2 / Op. 1 T40ºCVnom	76,0377	76,9579
Set. 2 / Op. 1 T30ºCVnom	76,0381	76,9579
Set. 2 / Op. 1 TnomVmin	76,0381	76,9587
Set. 2 / Op. 1 TnomVmax	76,0371	76,9567
Set. 2 / Op. 1 T10ºCVnom	76,0378	76,9583
Set. 2 / Op. 1 T0ºCVnom	76,0379	76,9599
Set. 2 / Op. 1 T-10ºCVnom	76,0387	76,9594
Set. 2 / Op. 1 T-20ºCVnom	76,0388	76,9603
Set. 2 / Op. 1 TminVnom	76,0385	76,9591

Nominal conditions, **EUT C**		
Setup / Op. Mode	Low edge [GHz]	High edge [GHz]
Set. 3 / Op. 1 TnomVnom	76,0361	76,9567
Extreme conditions		
Set. 3 / Op. 1 TmaxVnom	76,0361	76,9567
Set. 3 / Op. 1 T50ºCVnom	76,0371	76,9567
Set. 3 / Op. 1 T40ºCVnom	76,0387	76,9579
Set. 3 / Op. 1 T30ºCVnom	76,0381	76,9579
Set. 3 / Op. 1 TnomVmin	76,0391	76,9584
Set. 3 / Op. 1 TnomVmax	76,0361	76,9567
Set. 3 / Op. 1 T10ºCVnom	76,0378	76,9593
Set. 3 / Op. 1 T0ºCVnom	76,0399	76,9599
Set. 3 / Op. 1 T-10ºCVnom	76,0407	76,9594
Set. 3 / Op. 1 T-20ºCVnom	76,0388	76,9603
Set. 3 / Op. 1 TminVnom	76,0377	76,9603

Nominal conditions, **EUT D**

Setup / Op. Mode	Low edge [GHz]	High edge [GHz]
Set. 4 / Op. 1 TnomVnom	76,0371	76,9577
Extreme conditions		
Set. 4 / Op. 1 TmaxVnom	76,0371	76,9567
Set. 4 / Op. 1 T50ºCVnom	76,0371	76,9567
Set. 4 / Op. 1 T40ºCVnom	76,0377	76,9579
Set. 4 / Op. 1 T30ºCVnom	76,0381	76,9589
Set. 4 / Op. 1 TnomVmin	76,0371	76,9567
Set. 4 / Op. 1 TnomVmax	76,0371	76,9567
Set. 4 / Op. 1 T10ºCVnom	76,0398	76,9593
Set. 4 / Op. 1 T0ºCVnom	76,0389	76,9599
Set. 4 / Op. 1 T-10ºCVnom	76,0387	76,9604
Set. 4 / Op. 1 T-20ºCVnom	76,0388	76,9603
Set. 4 / Op. 1 TminVnom	76,0395	76,9599

Remark: For graphical results for conditions No 1, 2, 3, 4, 13 (see subpart 5.9.6.) pls. see annex 1 to this test report.

5.9.8. Verdict

Pass

5.10. Measurement uncertainties

The reported uncertainties are calculated based on the standard uncertainty multiplied with the appropriate coverage factor **k**, such that a confidence level of approximately 95% is achieved.
For uncertainty determination, each component used in the concrete measurement set-up was taken in account and it's contribution to the overall uncertainty according it's statistical distribution calculated.

Following table shows expectable uncertainties for each measurement type performed.

RF-Measurement	Reference	Frequency range	Calculated uncertainty based on a confidence level of 95%						Remarks
Conducted emissions (U_{CISPR})	CISPR 16-2-1	9 kHz - 150 kHz 150 kHz - 30 MHz	4.0 dB 3.6 dB						-
Radiated emissions Enclosure	CISPR 16-2-3	30 MHz - 1 GHz 1 GHz - 18 GHz	4.2 dB 5.1 dB						E-Field
Disturbance power	CISPR 16-2-2	30 MHz - 300 MHz	-						-
Power Output radiated	-	30 MHz - 4 GHz	3.17 dB						Substitution method
		24 GHz	3.24 dB						
		76-77GHz	3.32 dB						
Power Output conducted	-	Set-up No.	Cel-C1	Cel-C2	BT1	W1	W2	--	
		9 kHz - 12.75 GHz	N/A	0.60	0.7	0.25	N/A	--	-
		12.75 - 26.5GHz	N/A	0.82	--	N/A	N/A	--	
Conducted emissions on RF-port	-	9 kHz - 2.8 GHz	0.70	N/A	0.70	N/A	0.69	--	N/A - not applicable
		2.8 GHz - 12.75GHz	1.48	N/A	1.51	N/A	1.43	--	
		12.75 GHz - 18GHz	1.81	N/A	1.83	N/A	1.77	--	
		18 GHz - 26.5GHz	1.83	N/A	1.85	N/A	1.79	--	
Power density	-	1 – 2.8GHz	1.40 dB						--
Radiated emissions Enclosure	-	150 kHz - 30 MHz	5.0 dB						Magnetic field
		30 MHz - 1 GHz	4.2 dB						E-field
		1 GHz - 18 GHz	3.17 dB						Substitution Method
		18-33 GHz	3.60 dB						
		33-50 GHz	3.99 dB						
		40-60 GHz	3.95 dB						
		50-75 GHz	3.24 dB						External Mixer
		75-90 GHz	3.32 dB						
		90-140 GHz	4.94 dB						
		140-225 GHz	5.42 dB						

Table: measurement uncertainties, valid for conducted/radiated measurements

6. Abbreviations used in this report

The abbreviations	
ANSI	American National Standards Institute
AV , AVG, CAV	Average detector
EIRP	Equivalent isotropically radiated power, determined within a separate measurement
EGPRS	Enhanced General Packet Radio Service
EUT	Equipment Under Test
FCC	Federal Communications Commission, USA
IC	Industry Canada
n.a.	not applicable
Op-Mode	Operating mode of the equipment
PK	Peak
RBW	resolution bandwidth
RF	Radio frequency
RSS	Radio Standards Specification, Dokuments from Industry Canada
Rx	Receiver
TCH	Traffic channel
Tx	Transmitter
QP	Quasi peak detector
VBW	Video bandwidth
ERP	Effective radiated power

7. Accreditation details of CETECOM's laboratories and test sites

Ref.-No.	Accreditation Certificate	Valid for laboratory area or test site	Accreditation Body
-	D-PL-12047-01-01	All laboratories and test sites of CETECOM GmbH, Essen	DAkkS, Deutsche Akkreditierungsstelle GmbH
337 487 558 348 348	(MRA US-EU 0003)	Radiated Measurements 30 MHz to 1 GHz, 3 m / 10 m (OATS) Radiated Measurements 30 MHz to 1 GHz, 3 m (SAR) Radiated Measurements above 1 GHz, 3 m (FAR) Mains Ports Conducted Interference Measurements Telecommunication Ports Conducted Interference Measurem.	FCC, Federal Communications Commission Laboratory Division, USA
337 487 550 558	-- 3462D-2 3462D-2 3462D-3	Radiated Measurements 30 MHz to 1 GHz, 3 m / 10 m (OATS) Radiated Measurements 30 MHz to 1 GHz, 3 m (SAR) Radiated Measurements 1 GHz to 6 GHz, 3 m (SAR) Radiated Measurements above 1 GHz, 3 m (FAR)	ISED, Industry Canada Certification and Engineering Bureau
487 550 348 348	R- 4452 G- 20013 C- 20009 T- 20006	Radiated Measurements 30 MHz to 1 GHz, 3 m (SAR) Radiated Measurements 1 GHz to 6 GHz, 3 m (SAR) Mains Ports Conducted Interference Measurements Telecommunication Ports Conducted Interference Measurem.	VCCI, Voluntary Control Council for Interference by Information Technology Equipment, Japan
OATS = Open Area Test Site, SAR = Semi Anechoic Room, FAR = Fully Anechoic Room			

8. Instruments and Ancillary

8.1. Used equipment "CTC"

The "Ref.-No" in the left column of the following tables allows the clear identification of the laboratory equipment.

8.1.1. Test software and firmware of equipment

Ref.-No.	Equipment	Type	Serial-No.	Version of Firmware or Software during the test
001	EMI Test Receiver	ESS	825132/017	Firm.= 1.21 , OTP=2.0, GRA=2.0
012	Signal Generator (EMS-cond.)	SMY 01	839069/027	Firm.= V 2.02
013	Power Meter (EMS cond.)	NRVD	839111/003	Firm.= V 1.51
017	Digital Radiocommunication Tester	CMD 60 M	844365/014	Firmware = V 3.52 .22.01.99, DECT = D2.87 13.01.99
053	Audio Analyzer	UPA3	860612/022	Firm. V 4.3
119	RT Harmonics Analyzer dig. Flickermeter	B10	G60547	Firm.= V 3.1DHG
140	Signal Generator	SMHU	831314/006	Firm.= 3.21
261	Thermal Power Sensor	NRV-Z55	825083/0008	EPROM-Datum 02.12.04, SE EE 1 B
262	Power Meter	NRV-S	825770/0010	Firm.= 2.6
263	Signal Generator	SMP 04	826190/0007	Firm.=3.21
295	Racal Digital Radio Test Set	6103	1572	UNIT Firmware= 4.04, SW-Main=4.04, SW-BBP=1.04, SW-DSP=1.02, Hardboot=1.02, Softboot=2.02
298	Univ. Radio Communication Tester	CMU 200	832221/091	R&S Test Firmware =3.53 /3.54 (current Testsoftw. f. all band used
323	Digital Radiocommunication Tester	CMD 55	825878/0034	Firm.= 3.52 .22.01.99
335	CTC-EMS-Conducted	System EMS Conducted	-	EMC 32 V 8.52
340	Digital Radiocommunication Tester	CMD 55	849709/037	Firm.= 3.52 .22.01.99
355	Power Meter	URV 5	891310/027	Firm.= 1.31
365	10V Insertion Unit 50 Ohm	URV5-Z2	100880	Eprom Data = 31.03.08
366	Ultra Compact Simulator	UCS 500 M4	V0531100594	Firm. UCS 500=001925/3.06a02, rc=ISMIEC 4.10
371	Bluetooth Tester	CBT32	100153	CBT V5,30+ SW-Option K55, K57
377	EMI Test Receiver	ESCS 30	100160	Firm.= 2.30, OTP= 02.01, GRA= 02.36
378	Broadband RF Field Monitor	RadiSense III	03D00013SNO-08	Firm.= V.03D13
389	Digital Multimeter	Keithley 2000	0583926	Firm. = A13 (Mainboard) A02 (Display)
392	Radio Communication Tester	MT8820A	6K00000788	Firm.= 4.50 #005, IPL=4.01#001,OS=4.02#001, GSM=4.41#013, W-CDMA= 4.54#004, scenario= 4.52#002
436	Univ. Radio Communication Tester	CMU 200	103083	R&S Test Firmware Base=5.14, Mess-Software= GSM:5.14 WCDMA:5.14 (current Testsoftw. F. all band
441	CTC-SAR-EMI Cable Loss	System EMI field (SAR)	-	EMC 32 Version 8.52
442	CTC-SAR-EMS	System EMS field (SAR)	-	EMC 32 Version 8.40
443	CTC-FAR-EMI-RSE	System CTC-FAR-EMI-RSE	-	Spuri 7.2.5 or EMC 32 Ver. 9.15.00
444	CTC-FAR-EMS field	System-EMS-Field (FAR)	-	EMC 32 Version 9.15.00
460	Univ. Radio Communication Tester	CMU 200	108901	R&S Test Firmware Base=5.14, GSM=5.14 WCDMA=5.14 (current Testsoftw.,f. all band to be used,
489	EMI Test Receiver	ESU40	1000-30	Firmware=4.43 SP3, Bios=V5.1-16-3, Spec. =01.00
491	ESD Simulator dito	ESD dito	dito307022	V 2.30
524	Voltage Drop Simulator	VDS 200	0196-16	Software Nr: 000037 Version V4.20a01
526	Burst Generator	EFT 200 A	0496-06	Software Nr. 000034 Version V2.32
527	Micro Pulse Generator	MPG 200 B	0496-05	Software-Nr. 000030 Version V2.43
528	Load Dump Simulator	LD 200B	0496-06	Software-Nr. 000031 Version V2.35a01
546	Univ. Radio Communication Tester	CMU 200	106436	R&S Test Firmware Base=5.14, GSM=5.14 WCDMA=5.14 (current Testsoftw.,f. all band to be used
547	Univ. Radio Communication Tester	CMU 200	835390/014	R&S Test Firmware Base=V5.1403 (current Testsoftw., f. all band used, GSM = 5.14 WCDMA: = 5.14
584	Spectrum Analyzer	FSU 8	100248	2.82_SP3
597	Univ. Radio Communication Tester	CMU 200	100347	R&S Test Firmware Base=5.01, GSM=5.02 WCDMA= not installed, Mainboard= µP1=V.850
598	Spectrum Analyzer	FSEM 30	831259/013	Firmware Bios 3.40 , Analyzer 3.40 Sp 2
607	Signal Generator	SMR 20	832033/011	V1.25
620	EMI Test Receiver	ESU 26	100362	4.43_SP3
642	Wideband Radio Communication Tester	CMW 500	126089	Setup V03.26, Test programm component V03.02.20
670	Univ. Radio Communication Tester	CMU 200	106833	µP1 =V8.50, Firmware = V.20
689	Vector Signal Generator	SMU200	100970	02.20.360.142
692	Bluetooth Tester	CBT 32	100236	CBT V 5.40, FW: V.2.41 (FPGA Digital, V. 3.09 FPGA RF)

8.1.2. Single instruments and test systems

Ref.-No.	Equipment	Type	Serial-No.	Manufacturer	Interval of calibration	Remark	Cal due
016	Line Impedance Simulating Network	Op. 24-D	B6366	Spitzenberger+Spies	36 M	-	30.05.2019
021	Loop Antenna (H-Field)	6502	9206-2770	EMCO	36 M	-	30.06.2021
057	relay-switch-unit (EMS system)	RSU	494440/002	Rohde & Schwarz	pre-m	1a	
060	power amplifier (DC-2kHz)	PAS 5000	B6363	Spitzenberger+Spies	-	3	
086	DC - power supply, 0 -10 A	LNG 50-10	-	Heinzinger Electronic	pre-m	2	
087	DC - power supply, 0 -5 A	EA-3013 S	-	Elektro Automatik	pre-m	2	
091	USB-LWL-Converter	OLS-1	007/2006	Ing. Büro Scheiba	-	4	
099	passive voltage probe	ESH2-Z3	299.7810.52	Rohde & Schwarz	36 M	-	30.05.2021
100	passive voltage probe	Probe TK 9416	without	Schwarzbeck	36 M	-	30.05.2021
110	USB-LWL-Converter	OLS-1	-	Ing. Büro Scheiba	-	4	
119	RT Harmonics Analyzer dig. Flickermeter	B10	G60547	BOCONSULT	36 M	-	30.05.2019
133	horn antenna 18 GHz (Meas 1)	3115	9012-3629	EMCO	36 M	1c	10.03.2020
134	horn antenna 18 GHz (Subst 2)	3115	9005-3414	EMCO	36 M	-	10.03.2020
248	attenuator	SMA 6dB 2W	-	Radiall	pre-m	2	
249	attenuator	SMA 10dB 10W	-	Radiall	pre-m	2	
252	attenuator	N 6dB 12W	-	Radiall	pre-m	2	
256	attenuator	SMA 3dB 2W	-	Radiall	pre-m	2	
257	hybrid	4031C	04491	Narda	pre-m	2	
260	hybrid coupler	4032C	11342	Narda	pre-m	2	
261	Thermal Power Sensor	NRV-Z55	825083/0008	Rohde & Schwarz	24 M	-	30.05.2020
262	Power Meter	NRV-S	825770/0010	Rohde & Schwarz	24 M	-	30.05.2019
263	Signal Generator	SMP 04	826190/0007	Rohde & Schwarz	36 M	-	30.05.2019
265	peak power sensor	NRV-Z33, Model 04	840414/009	Rohde & Schwarz	24 M	-	30.05.2020
266	Peak Power Sensor	NRV-Z31, Model 04	843383/016	Rohde & Schwarz	24 M	-	30.05.2020
267	notch filter GSM 850	WRCA 800/960-6EEK	9	Wainwright GmbH	pre-m	2	
270	termination	1418 N	BB6935	Weinschel	pre-m	2	
271	termination	1418 N	BE6384	Weinschel	pre-m	2	
272	attenuator (20 dB) 50 W	Model 47	BF6239	Weinschel	pre-m	2	
273	attenuator (10 dB) 100 W	Model 48	BF9229	Weinschel	pre-m	2	
274	attenuator (10 dB) 50 W	Model 47 (10 dB) 50 W	BG0321	Weinschel	pre-m	2	
275	DC-Block	Model 7003 (N)	C5129	Weinschel	pre-m	2	
276	DC-Block	Model 7006 (SMA)	C7061	Weinschel	pre-m	2	
279	power divider	1515 (SMA)	LH855	Weinschel	pre-m	2	
298	Univ. Radio Communication Tester	CMU 200	832221/091	Rohde & Schwarz	pre-m	3	
301	attenuator (20 dB) 50W, 18GHz	47-20-33	AW0272	Lucas Weinschel	pre-m	2	
302	horn antenna 40 GHz (Meas 1)	BBHA9170	155	Schwarzbeck	36 M	-	14.03.2020
303	horn antenna 40 GHz (Subst 1)	BBHA9170	156	Schwarzbeck	36 M	-	20.03.2020
331	Climatic Test Chamber -40/+180 Grad	HC 4055	43146	Heraeus Vötsch	24 M	-	30.10.2020
341	Digital Multimeter	Fluke 112	81650455	Fluke	24 M	-	30.05.2020
347	laboratory site	radio lab.	-	-	-	5	
348	laboratory site	EMI conducted	-	-	-	5	
354	DC - Power Supply 40A	NGPE 40/40	448	Rohde & Schwarz	pre-m	2	
357	power sensor	NRV-Z1	861761/002	Rohde & Schwarz	24 M	-	24.05.2019
371	Bluetooth Tester	CBT32	100153	R&S	36 M	-	30.05.2019
377	EMI Test Receiver	ESCS 30	100160	Rohde & Schwarz	12 M	-	30.05.2019
389	Digital Multimeter	Keithley 2000	0583926	Keithley	pre-m	-	
431	Model 7405	Near-Field Probe Set	9305-2457	EMCO	-	4	
454	Oscilloscope	HM 205-3	9210 P 29661	Hameg	-	4	
456	DC-Power supply 0-5 A	EA 3013 S	207810	Elektro Automatik	pre-m	2	
459	DC -Power supply 0-5 A , 0-32 V	EA-PS 2032-50	910722	Elektro Automatik	pre-m	2	
460	Univ. Radio Communication Tester	CMU 200	108901	Rohde & Schwarz	12 M	-	30.05.2019
463	Universal source	HP3245A	2831A03472	Agilent	-	4	
466	Digital Multimeter	Fluke 112	89210157	Fluke USA	24 M	-	30.05.2020
467	Digital Multimeter	Fluke 112	89680306	Fluke USA	36 M	-	30.05.2019
468	Digital Multimeter	Fluke 112	90090455	Fluke USA	36 M	-	30.04.2021
477	ReRadiating GPS-System	AS-47	-	Automotive Cons. Fink	-	3	
482	filter matrix	Filter matrix SAR 1	-	CETECOM (Brl)	-	1d	
502	band reject filter	WRCG 1709/1786-1699/1796-	SN 9	Wainwright	pre-m	2	
503	band reject filter	WRCG 824/849-814/859-	SN 5	Wainwright	pre-m	2	
517	relais switch matrix	HF Relais Box Keithley	SE 04	Keithley	pre-m	2	
529	6 dB Broadband resistive power divider	Model 1515	LH 855	Weinschel	pre-m	2	
530	10 dB Broadband resistive power divider	R 416110000	LOT 9828	-	pre-m	2	
549	Log.Per-Antenna	HL025	1000060	Rohde & Schwarz	36/12 M	-	31.07.2021
558	System CTC FAR S-VSWR	System CTC FAR S-VSWR	-	CTC	24 M	-	08.08.2019
584	Spectrum Analyzer	FSU 8	100248	Rohde & Schwarz	pre-m	-	
594	Wideband Radio Communication Tester	CMW 500	101757	Rohde & Schwarz	12 M	-	30.05.2019

Ref.-No.	Equipment	Type	Serial-No.	Manufacturer	Interval of calibration	Remark	Cal due
597	Univ. Radio Communication Tester	CMU 200	100347	Rohde & Schwarz	pre-m	-	
602	peak power sensor	NRV-Z32 (Reserve)	835080	Rohde & Schwarz	24 M	-	
611	DC power supply	E3632A	KR 75305854	Agilent	pre-m	2	
612	DC power supply	E3632A	MY 40001321	Agilent	pre-m	2	
613	Attenuator	R416120000 20dB 10W	Lot. 9828	Radiall	pre-m	2	
616	Digitalmultimeter	Fluke 177	88900339	Fluke	24 M	-	30.05.2020
617	Power Splitter/Combiner	ZFSC-2-2-S+	S F987001108	Mini Circuits	-	2	
618	Power Splitter/Combiner	50PD-634	600994	JFW Industries USA	-	2	
619	Power Splitter/Combiner	50PD-634	600995	JFW Industries, USA	-	3	
620	EMI Test Receiver	ESU 26	100362	Rohde-Schwarz	12 M	-	30.05.2019
621	Step Attenuator 0-139 dB	RSP	100017	Rohde & Schwarz	pre-m	2	
625	Generic Test Load USB	Generic Test Load USB	-	CETECOM	-	2	
634	Spectrum Analyzer	FSM (HF-Unit)	826188/010	Rohde & Schwarz	pre-m	2	
637	High Speed HDMI with Ethernet 1m	HDMI cable with Ethernet 1m	-	KogiLink	-	2	
638	HDMI Kabel with Ethernet 1,5 m flach	HDMI cable with Ethernet	-	Reichelt	-	2	
640	HDMI cable 2m rund	HDMI cable 2m rund	-	Reichelt	-	2	
641	HDMI cable with Ethernet	Certified HDMI cable with	-	PureLink	-	2	
642	Wideband Radio Communication Tester	CMW 500	126089	Rohde&Schwarz	24 M	-	24.05.2019
644	Amplifierer	ZX60-2534M+	SN865701299	Mini-Circuits	-	-	
670	Univ. Radio Communication Tester	CMU 200	106833	Rohde & Schwarz	24 M	-	30.05.2020
671	DC-power supply 0-5 A	EA-3013S	-	Elektro Automatik	pre-m	2	
678	Power Meter	NRP	101638	Rohde&Schwarz	pre-m	-	
683	Spectrum Analyzer	FSU 26	200571	Rohde & Schwarz	12 M	-	30.05.2019
687	Signal Generator	SMF 100A	102073	Rohde&Schwarz	12 M	-	30.05.2019
688	Pre Amp	JS-18004000-40-8P	1750117	Miteq	pre-m	-	
691	OSP120 Base Unit	OSP120	106833	Rohde & Schwarz	12 M	-	30.05.2019
692	Bluetooth Tester	CBT 32	100236	Rohde & Schwarz	36 M	-	29.05.2020
697	Power Splitter	ZN4PD-642W-S+	165001445	Mini-Circuits	-	2	
703	INNCO Antennen Mast	MA 4010-KT080-XPET-ZSS3	MA4170-KT100-XPET-	INNCO	pre-m	-	
704	INNCON Controller	CO 3000-4port	CO3000/933/3841051 6/L	INNCO Systems GmBh	pre-m	-	
714	Signal Analyzer 67GHz	FSW67	104023	Rohde & Schwarz	24 M	-	28.02.2020
747	Spectrum Analyzer	FSU 26	200152	Rohde & Schwarz	12 M	-	30.05.2019
748	Pickett-Potter Horn Antenna	FH-PP 4060	010001	Radiometer Physiscs	-	-	
749	Pickett-potter Horn Antenna	FH-PP 60-90	010003	Radiometer Physics	-	-	
750	Pickett-Potter Horn Antenna	FH-PP 140-220	010011	Radiometer Physics	-	-	
751	Digital Optical System	optoCAN-FD Transceiver	17-010416	mk-messtechnik GmbH	-	-	
752	Digital Optical System	optoCAN-FD Transceiver	17-010083	mk-messtechnik GmbH	-	-	
753	Digital Optical System	optoCAN-FD Transceiver	17-010084	mk-messtechnik GmbH	-	-	
754	Digital Optical System	optoCAN-FD Transceiver	17-010415	mk-messtechnik GmbH	-	-	
755	Digital Optical System	optoLAN-100-MAX	17-010795	mk-messtechnik GmbH	-	-	
701	WIDEBAND RADIO COMMUNICATION	CMW500	158150	Rohde&Schwarz	12 M	-	20.07.2019
758	Signal Generator	SMU 200A	100754	Rohde & Schwarz	24 M	-	11.10.2019
781	Power Supply	PS 2042-10 B	2815450369	Elektro-Automatik GmbH	-	-	
782	Power Supply	PS 2042-10 B	2815450348	lektro-Automatik GmbH &Co.KG	-	-	
783	Spectrum Analyzer	FSU 26	100414	Rohde & Schwarz	12 M	-	30.05.2019
784	Power Supply	NGSM 32/10	00196	Rohde & Schwarz	12 M	-	
785	RSP	RF Step Attenuator	860712/012	Rohde & Schwarz	12 M	-	
786	SAR Probe	ES3DV3	3340	Speag	36 M	-	14.02.2021
787	OSP	OSP B157WX	101264	Rohde & Schwarz	12 M	-	30.05.2019
791	Pickett-Potter Horn Antenna	FH-PP-325	10024	Radiometer Physics	36 M	-	
792	Pickett-Potter Horn Antenna	FH-PP 075	10006	Radiometer Physics	36 M	-	
793	Pickett-Potter Horn Antenna	FH-PP 140	10008	Radiometer Physics	36 M	-	
794	Pickett-Potter Horn Antenna	FH-PP 110	10014	Radiometer Physics	36 M	-	
795	SGH Antenna	SGH-26-WR10	1144	Anteral S.L.	36 M		

8.1.3. Legend

Note / remarks		Calibrated during system calibration:
	1a	System CTC-SAR-EMS (Ref.-No. 442)
	1b	System-CTC-EMS-Conducted (Ref.-No. 335)
	1c	System CTC-FAR-EMI-RSE (Ref.-No . 443)
	1d	System CTC-SAR-EMI (Ref.-No . 441)
	1e	System CTC-OATS (EMI radiated) (Ref.-No. 337)
	1 f	System CTC-CTIA-OTA (Ref.-No . 420)
	1 g	System CTC-FAR-EMS (Ref.-No . 444)
	2	Calibration or equipment check immediately before measurement
	3	Regulatory maintained equipment for functional check or support purpose
	4	Ancillary equipment without calibration e.g. mechanical equipment or monitoring equipment
	5	Test System

Interval of calibration	12 M	12 month
	24 M	24 month
	36 M	36 month
	24/12 M	Calibration every 24 months, between this every 12 months internal validation
	36/12 M	Calibration every 36 months, between this every 12 months internal validation
	Pre-m	Check before starting the measurement
	-	Without calibration

9. Versions of test reports (change history)

Version	Applied changes	Date of release
--	Initial release	2019-06-24

The End of the Report