

FCC Measurement/Technical Report on

Tire Pressure Monitor Sensor TIS-09DH

FCC ID: KR5TIS-09DH IC: 7812D-TIS09DH

Report Reference: MDE_CONTI_1826_FCCa

Test Laboratory: 7layers GmbH Borsigstrasse 11 40880 Ratingen Germany



Note:

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Table of Contents

1 Ap	plied Standards and Test Summary	3
1.1 1.2 1.3	Applied Standards FCC-IC Correlation table Measurement Summary /Signatures	3 4 5
2 Ad	ministrative Data	6
2.1 2.2 2.3 2.4	Testing Laboratory Project Data Applicant Data Manufacturer Data	6 6 6
3 Te	st object Data	7
3.1 3.2 3.3 3.4	General EUT Description EUT Main components Operating Modes Product labelling	7 8 9 9
4 Te	st Results	10
4.1 4.2 4.3 4.4	Duty cycle measurement (based on dwell time measurement) Spurious radiated emissions Maximum radiated field strength at fundamental frequency Occupied bandwidth	10 15 25 27
5 Te	st Equipment	30
6 An	tenna Factors, Cable Loss and Sample Calculations	32
6.1 6.2 6.3	Antenna R&S HFH2-Z2 (9 kHz – 30 MHz) Antenna R&S HL562 (30 MHz – 1 GHz) Antenna R&S HF907 (1 GHz – 18 GHz)	32 33 34
7 Ph	oto Report	35
8 Se	tup Drawings	35



1 APPLIED STANDARDS AND TEST SUMMARY

1.1 APPLIED STANDARDS

Type of Authorization

Certification for an Intentional Radiator (Periodic operation in the band above 70 MHz)

Applicable FCC Rules

Edition of FCC Rules: October 1, 2017

Prepared in accordance with the requirements of FCC Rules and Regulations as listed in 47 CFR Ch.1 Parts 2 and 15. The following subparts are applicable to the results in this test report.

- Part 2, Subpart J Equipment Authorization Procedures, Certification
- Part 15, Subpart C Intentional Radiators
- § 15.201 Equipment authorization requirement
- § 15.207 Conducted limits
- § 15.209 Radiated emission limits; general requirements
- § 15.231 Periodic operation in the band 40.66-40.70 MHz, above 70 MHz

Note: § 15.207 is not applicable because the EUT is battery powered.

Summary Test Results:

The EUT complied with all performed tests as listed in chapter 1.3 Measurement Summary / Signatures.



1.2 FCC-IC CORRELATION TABLE

Correlation of measurement requirements for Momentarily (incl. Periodically) Operated Devices and Remote Control from FCC and IC

Radio equipment

Measurement	FCC reference	IC reference
Conducted emissions on AC Mains	§ 15.207	RSS-Gen Issue 5: 8.8
Transmitter spurious radiated emissions	§ 15.231 (b) / (e)	RSS Gen Issue 5: 6.10/6.13/8.9/8.10; RSS-210 Issue 9: A1.1.2, A1.1.5
Duty cycle measurement (based on dwell time measurement)	§ 15.231 (a)	RSS-210 Issue 9: A1.1.1, A1.1.5
Maximum radiated field strength at fundamental frequency	§ 15.231 (b) / (e)	RSS-210 Issue 9: A1.1.2, A1.1.5; RSS Gen Issue 9: 6.12
Occupied bandwidth	§ 15.231 (c)	RSS-210 Issue 9: A1.1.3
Frequency Stability	§ 15.231 (d)	RSS-210 Issue 9: A1.1.4
Antenna requirement	§ 15.203 / 15.204	RSS-Gen Issue 9: 8.3
Receiver spurious emissions	-	RSS-210 Issue 9: 2.3 RSS Gen Issue 5: 5/7 *)

*) Receivers are exempted from certification besides if operating in stand-alone mode in the frequency range 30–960 MHz or if these are scanner receivers.



1.3 MEASUREMENT SUMMARY /SIGNATURES

	sions (AC power line	§ 15.207 () () () () () () () () () () () () ()	2013
OP-Mode	Setup	Port	Final Result
	•	AC Port (power line)	N/A
FCC Part 15, S	ubpart C	§ 15.231	
		dwell time measurement)	
		cording to ANSI C63.10	2013
OP-Mode	Setup	Port	Final Result
op-mode 2	Setup_02	Enclosure	passed
FCC Part 15, S	ubpart C	§ 15.231	
Spurious Radiate	ed Emissions		
The measureme	nt was performed ac	cording to ANSI C63.10	2013
OP-Mode	Setup	Port	Final Result
op-mode 1	Setup_01	Enclosure	passed
FCC Part 15, S	ubpart C	§ 15.231	
Maximum radiat	ed field strength at I	fundamental frequency	
The measureme	nt was performed ac	cording to ANSI C63.10	2013
OP-Mode	Setup	Port	Final Result
op-mode 1	Setup_01	Enclosure	passed
FCC Part 15, S	ubpart C	§ 15.231	
Occupied Bandw			
		cording to ANSI C63.10	2013
OP-Mode	Setup	Port	Final Result
op-mode 1	Setup_02	Enclosure	passed

N/A not applicable (the EUT is powered by internal CR2032 lithium battery)

He iv

(responsible for accreditation scope) Dipl.-Ing. Wolfgang Richter

(responsible for testing and report) Dipl.-Ing. Dobrin Dobrinov





2 ADMINISTRATIVE DATA

2.1 TESTING LABORATORY

Company Name:

7layers GmbH

Address:

Borsigstr. 11 40880 Ratingen Germany

This facility has been fully described in a report submitted to the ISED and accepted under the registration number: Site# 3699A-1.

The test facility is also accredited by the following accreditation organisation:

Laboratory accreditation no:	DAkkS D-PL-12140-01-00		
FCC Designation Number:	DE0015		
FCC Test Firm Registration:	929146		
Responsible for accreditation scope:	DiplIng. Wolfgang Richter		
Report Template Version:	2017-07-14		
2.2 PROJECT DATA			
Responsible for testing and report:	DiplIng. Dobrin Dobrinov		
Date of Report:	2018-08-13		
Testing Period:	2018-08-05 to 2018-08-13		
2.3 APPLICANT DATA			
Company Name:	Continental Automotive GmbH		
Address:	Siemensstraße 12 93055 Regensburg Germany		
Contact Person:	Mr. René Spanel		
2.4 MANUFACTURER DATA			
Company Name:	Continental Automotive		
Address:	1 Avenue Paul Ourliac 31100 Toulouse France		
Contact Person:			



3 TEST OBJECT DATA

3.1 GENERAL EUT DESCRIPTION

Kind of Device product description	SRD Transmitter, operating in 433 MHz frequency band	
Product name	Tire Pressure Monitor Sensor	
Туре	TIS-09DH	
Declared EUT data by	the supplier	
Voltage Type	DC lithium battery, CR2032 Type	
Normal Voltage	3.0 V	
Low Voltage	2.21 V	
High Voltage	3.2 V	
Normal Temperature	23 °C	
Low Temperature	-40 °C	
High Temperature	+120 °C	
Specific product description for the EUT	The EUT is part of a vehicle tire pressure monitoring system. It is mounted inside each tire, integrated in the valve stem. The EUT consists of pressure, temperature and acceleration sensor, RF transmitter and LF receiver.	
The EUT provides the following ports:	Enclosure	
Special software used for testing	Controlling software installed in a LF trigger tool	
Type of operation	Automatically activated transmitter, FCC15c.231 e)	

The main components of the EUT are listed and described in Chapter 3.2.



3.2 EUT MAIN COMPONENTS

Sample Name	Sample Code	Description	
EUT A	DE1024012ab01	radiated sample	
Sample Parameter		Value	
Serial No.	1		
HW Version	01		
SW Version	01		
Comment	Used for radiated measurements, continuously sending non- modulated carrier for Output Power measurement (CW) and continuously modulated (CM - FSK and ASK modulated carrier) for Spurious emissions, and Occupied BW measurements.		

Sample Name	Sample Code	Description
EUT B	DE1024012ac01	radiated sample
Sample Parameter	Valu	Ie
Serial No.	3	
HW Version	01	
SW Version	01	
Comment	Used for a Duty Cycle measurement, sending a pulse train every 16 s.	

General description of ancillary equipment

Device	Details (Manufacturer, Type Model, OUT Code)	Reason for using
ANC 1:	Continental, Trigger tool, DE1024ANC	controlling the EUT
Activation tool for TPMS		modes of operation

General description of auxiliary equipment

Device	Details (Manufacturer, HW, SW, S/N)	Description



EUT SETUPS

This chapter describes the combination of EUTs and ancillary equipment used for testing.

Setup No.	Combination of EUTs	Description
Setup_01	EUT A + ANC 1	Setup for radiated measurements: Output power, Occupied BW and Spurious emissions bellow 30 MHz, 30 MHz to 1 GHz and 1 to 6 GHz
Setup_02	EUT B + ANC 1	Setup for Duty Cycle measurements

3.3 OPERATING MODES

This chapter describes the operating modes of the EUTs used for testing.

Op. Mode	Description of Operating Modes	Remarks
op-mode 1	Continuous transmission	Transmitter sends continuously CW, ASK or FSK modulated signal
op-mode 2	Single burst	Transmitter sends a burst of 4 pulses every 16 s

3.4 PRODUCT LABELLING

3.4.1 FCC ID label KR5TIS-09DH

3.4.2 IC Label 7812D-TIS09DH

3.4.3 LOCATION OF THE LABEL ON THE EUT Please refer to the documentation of the applicant.



4 TEST RESULTS

4.1 DUTY CYCLE MEASUREMENT (BASED ON DWELL TIME MEASUREMENT)

Standard FCC Part 15 Subpart C

The test was performed according to: ANSI C63.10

4.1.1 TEST DESCRIPTION

The Equipment Under Test (EUT) was setup in a shielded room to perform the dwell time measurements. For analyzer settings please see measurement plots.

4.1.2 TEST REQUIREMENTS / LIMITS

Depending on the function of the EUT different paragraphs of FCC §15.231 apply:

Either

(a)(1): A manually operated transmitter shall employ a switch that will automatically deactivate the transmitter within not more than 5 seconds of being released.

Or

(a)(2) A transmitter activated automatically shall cease transmission within 5 seconds after activation.

And

(a)(3) Periodic transmissions at regular predetermined intervals are not permitted. However, polling or supervision transmissions, including data, to determine system integrity of transmitters used in security or safety applications are allowed if the total duration of transmissions does not exceed more than two seconds per hour for each transmitter. There is no limit on the number of individual transmissions, provided the total transmission time does not exceed two seconds per hour.

Otherwise

(e) Intentional radiators may operate at a periodic rate exceeding that specified in paragraph (a) of this section and may be employed for any type of operation [...]. In addition, [...] the duration of each transmission shall not be greater than one second and the silent period between transmissions shall be at least 30 times the duration of the transmission but in no case less than 10 seconds.

This test is also performed to determine the pulse train of the transmitter and calculate the correction factor for pulse modulated transmitters according to FCC §15.35. This factor is used as a correction factor for the field strength measurements, both for Spurious radiated emissions and Maximum radiated field strength at fundamental frequency.



4.1.3 TEST PROTOCOL

Temperature:	23 °C
Air Pressure:	1009 hPa
Humidity:	38 %

Op. Mode	Setup	Port
op-mode 2	Setup_02	Enclosure

a) Determine the total duration of a transmission within 100 ms:

Duty cycle = ((L1*N1) + (L2*N2) + ... + (Ln*Nn)) / 100 ms or T, whichever is less Correction factor = 20 * LOG (Duty cycle) [dB]

Step 1	Holdover time	Less than 5s
Step 2	Cycle to determine the on/off ratio within a cycle (period T)	100 ms
Step 3	Sweep of a data word to determine the on time within a data word (L1-LN)	L1 = 21.035 ms

Calculation of Duty Cycle / Correction Factor: If T > 100 ms => T = 100 ms; L1 = 21.035 ms; N1 = 1; In 100 ms T_{on} = 21.035 ms Duty cycle = 21.035 / 100 = 0.21035

CORRECTION FACTOR = 20 * LOG (0.21035) = -13.54 dB

b) Determine the period of periodic re-transmission, if any, or cease (deactivation) time:

The period of retransmission is ${\bf 16}~{\bf s}$ measured during the tests and declared by the manufacturer.

Deactivation after $T_c = 0.402 \ s$, Limit: $\leq 5 \ s$

c) Determine the total duration of periodic transmissions within 1 hour, if any:

Duration t_d of all pulses/bursts during T_R ("on-time"):

$t_d = 17.82 s.$

d) If the result of c) exceeds 2 seconds/hour then paragraph (e) applies:

Determine the duration of each transmission (one complete pulse train) and silent time: Duration t_{PT} , Limit: ≤ 1 s (Remark: t_{PT} is identical to t_d if T ≤ 100 ms).

The duration of each transmission shall not be greater than one second and the silent period between transmissions shall be at least 30 times the duration of the transmission but in no case less than 10 seconds.

 $t_{PT} = 19.87 \text{ ms} + 19.9 \text{ ms} + 19.57 \text{ ms} + 20.29 \text{ ms} = 0.0796 \text{ s} (\le 1 \text{ s})$

Silent time between transmissions $t_s = 15.58 \text{ s}$, Limit: $\leq \text{Maximum}$ (>10 s and >30* t_{PT}).

4.1.4 TEST RESULT: DUTY CYCLE / CORRECTION FACTOR

FCC Part 15, Subpart C	Op. Mode	Result
	op-mode 2	passed

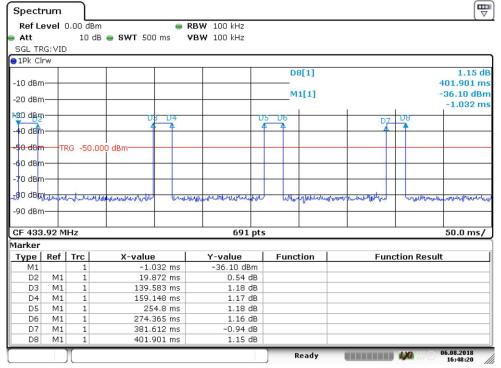


4.1.5 MEASUREMENT PLOTS DUTY CYCLE



Date: 6.AUG.2018 17:07:53

The periodic transmission after the transmitter is activated by the LF Trigger tool test software.



Date: 6.AUG.2018 16:48:20

Each burst consists of 4 pulses with \sim 20 ms length.



Spectru	ım)											
Ref Lev	el -14.	DO dBr	n		RBV	V 100 kH	z						(
🖷 Att		10 di	3 👄 SWT 3	100 ms	VBV	V 100 kH	z						
SGL TRG	: VID												
⊖1Pk Clrw	r												
								M	1[1]			25	36.50 dBm
-20 dBm—													-307 µs
								D	2[1]				0.08 dB
4130 dBm−			10								ı	r.	20.017 ms
L		-MML-4	4										
-40 dBm—													
-50 dBm—													
6 0 I 0													
-60 dBm—	TDC	64.000	dBro										
70 40	IKO -	04.000	ивш										
-70 dBm—													
00 40									52				
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-90 ubiii—													
-100 dBm-													
-100 üBIII													
-110 dBm·													
Segurgalere exectioned													
CF 433.9	2 MHz					691	pts						10.0 ms/
Marker													
	tef Tro		X-value			-value		Func	tion		Fur	iction Result	
M1		1)7.2 μs		-36.50 dE							
D2	M1	1	20.0	017 ms		0.08	a8						
								F	teady	1			06.08.2018 16:43:59

Date: 6.AUG.2018 16:44:00

The pulse in the first 100 ms



Spectrum			Spectrum					
	100 kHz		Ref Level 0.00 dBm		W 100 kHz			
Att 10 dB SWT 22 ms VBW GGL TRG:VID	100 kHz		Att 10 dB SGL TRG:VID	SWT 22 ms VB	₩ 100 kHz			
1Pk Clrw			1Pk Clrw					
	M1[1]	-37.09 dBm				D4[1]		50.05 di
20 dBm-	D2[1]	-17.4 μs 0.64 dB	-10 dBm			M1[1]		21.0351 m -86.53 dBn
30. dBm	02[1]	20.0174 ms	-20 dBm-			MILI		138.1330 m
THE REPORT OF THE PARTY OF THE	and the second s	Mulumun 22	-30 dBm					D4
40 dBm			-400gBm		un nu nu nu	and the second second	contraction	www.com.
0 dBm			-50 dBm TRG -50.000) dBm				
			-60 dBm					
0 dBm			-70 dBm					
0 dBm			1-80 dBm					
			-90 dBm-					Unite
0 dBm		Mah	-yo dom					
0 dBm		- VA	CF 433.92 MHz		691	ots		2.2 ms/
			Marker	Yushie	V unlug	- Function	From	tion Decult
00 dBm			Type Ref Trc M1 1	X-value 138.133 ms	Y-value -86.53 dBn	Function	Fun	ction Result
LO dBm			D2 M1 1	0.0 s	0.00 de	3		
433.92 MHz	691 pts	2.2 ms/	D3 M1 1 D4 M1 1	988.4 μs 21.0351 ms	43.57 de 50.05 de			
rker			D5 M1 1	22.0 ms	-5.98 dB	3		
	-value Function Fu -37.09 dBm	unction Result	D6 M1 1 D7 M1 1	22.0 ms 22.0 ms	-5.98 de			
D2 M1 1 20.0174 ms	0.64 dB		D8 M1 1	22.0 ms	-5.98 dt			
			Date: 6.AUG.2018 16:51:14 Second pul Spectrum					
rst pulse pectrum Ref Level 0.00 dBm			Second pul	Se • RBV	₩ 100 kHz ₩ 100 kHz			(The second seco
Ref Level 0.00 dBm RBW 11 Att 10 dB SWT 25 ms VBW 11 GL TRG:VID 10 dB SWT 25 ms VBW 11		 ▽	Second pul Spectrum Ref Level 0.00 dBm Att 10 dB SGL TRG:VID	Se • RBV	W 100 kHz W 100 kHz			[₩ V
Ref Level 0.00 dBm RBW 11 Att 10 dB SWT 25 ms VBW 11 GL TRG:VID VBW 11 10 11	.00 kHz		Second pul	Se • RBV		00[1]		
Ref Level 0.00 dBm RBW 11 tt 10 dB SWT 25 ms VBW 11 gL TRG:VID Pk Cirw Intervention Intervention	00 kHz	(₩) 0.67 dB 20.0362 ms	Second pul Spectrum Ref Level 0.00 dBm Att 10 dB SGL TRG:VID PIPK Cirw	Se • RBV		D2[1]		0.66 di
Ref Level 0.00 dBm RBW 11 tt 10 dB SWT 25 ms VBW 11 gL TRG:VID Pk Cirw Intervention Intervention	.00 kHz	0.67 dB 20.0362 ms -37.19 dBm	Second pul Spectrum Ref Level 0.00 dBm Att 10 dB SGL TRG:VID	Se • RBV		D2[1] M1[1]		0.66 di 20.0362 m -37.14 dBr
Sectrum	00 kHz	0.67 dB 20.0362 ms	Second pul Spectrum Ref Level 0.00 dBm Att 10 dB SGL TRG:VID PIPK Cirw	Se • RBV				0.66 di 20.0362 m -37.14 dBr
vectrum	00 kHz	0.67 dB 20.0362 ms -37.19 dBm	Second pul Spectrum Ref Level 0.00 dbm Att 10 db SoL TRG: VID ● IPk Chw -10 dbm -20 dbm	Se • RBV				0.66 d 20.0362 m -37.14 dBr
vectrum	00 kHz D2[1] M1[1]	0.67 dB 20.0362 ms -37.19 dBm 254.2752 ms	Second pull Spectrum Ref Level 0.00 dBm # Att 10 dB SQL TR0://r0 # DPL Chw -10 dBm -20 dBm -30 dBm	Se swr 25 ms vb/	W 100 kHz	M1[1]		0.66 d 20.0362 m -37.14 dBr 381.6812 m
vectrum	00 kHz	0.67 dB 20.0362 ms -37.19 dBm 254.2752 ms	Second pull Spectrum Ref Level 0.00 dBm # Att 10 dB SQL TR0://r0 # DPL Chw -10 dBm -20 dBm -30 dBm	Se • RBV	W 100 kHz	M1[1]	9400-11-120-01	0.66 d 20.0362 m -37.14 dBr 381.6812 m
ectrum RBW 11 of Level 0.00 dbm • RBW 11 LT 100, UD • RBW 12 March 10 • RBW 13 March 10 • RBW 14 March 10 • RBW 15 March 10 • RBW 14 March 10 • RBW 15 March 10 • RBW 14 March 10 • RBW 15 March 10 • RBW 14 March 10 • RBW 15 March 10 •	00 kHz D2[1] M1[1]	0.67 dB 20.0362 ms -37.19 dBm 254.2752 ms	Second pul Spectrum Ref Level 0.00 dBm # Att 10 dB SGL TPG:/JD # 10 dBm -10 dBm -20 dBm -30 dBm #1	SC SWT 25 ms VBV	W 100 kHz	M1[1]	MANANAL LENGAL	0.66 di 20.0362 m -37.14 dBr 381.6812 m
vectrum	00 kHz D2[1] M1[1]	0.67 dB 20.0362 ms -37.19 dBm 254.2752 ms	Second pul Spectrum Ref Level 0.00 dBm W Att 10 dB SQL TPG://D 0 BP/ CPw -10 dBm -20 dBm -40 dBm -80 dBm -80 dBm -80 dBm -80 dBm	SC SWT 25 ms VBV	W 100 kHz	M1[1]	N000-1-1-2-0-2-0-2	0.66 di 20.0362 m -37.14 dBr 381.6812 m
vectrum	00 kHz D2[1] M1[1]	0.67 dB 20.0362 ms -37.19 dBm 254.2752 ms	Second pul Spectrum Ref Level 0.00 dBm # Att 10 dB SGL TPG:/JD # 10 dBm -10 dBm -20 dBm -30 dBm #1	SC SWT 25 ms VBV	W 100 kHz	M1[1]	MUMMULTERCOL	0.66 di 20.0362 m -37.14 dBr 381.6812 m
Dectrum • RBW 10 Lef Level 0.00 dBm • RBW 11 Lttt 10 dB • SWT 25 ms JL TR6;VID 0 0 dBm JdBm • D • D • D • D • D • D • D • D • D • D • D • D • D • D • D • D • D • D • D • D • D • D • D • D • D • D • D • D • D • D • D • D • D • D<	00 kHz D2[1] M1[1]	0.67 dB 20.0362 ms -37.19 dBm 254.2752 ms	Second pull Spectrum Ref Level 0.00 dBm W Att 10 dB SLT PEC/VW -10 dBm -20 dBm -40 dBm -56-dBm -60 dBm	SC SWT 25 ms VBV	W 100 kHz	M1[1]	100000	0.66 di 20.0362 m -37.14 dBr 381.6812 m
Dectrum	00 kHz D2[1] M1[1]	0.67 dB 20.0362 ms -37.19 dBm 254.2752 ms	Second pull Spectrum Ref Level 0.00 dBm # Att 10 dB SQL TR0:V0 0 dBm -20 dBm -30 dBm -80 dBm -58 dBm -70 dBm	SC SWT 25 ms VBV	W 100 kHz	M1[1]	100 M0-1-100-00	0.66 di 20.0362 m -37.14 dBn 381.6912 m
bectrum 0.00 dBm • RBW 11 tef Level 0.00 dBm • RBW 11 ± 10 dB • SWT 25 ms vBw 11 ttt 10 dB • SWT 25 ms vBw 11 vBw 12 ttt 10 dB • SWT 25 ms vBw 12 vBw 12 dbm vB vBw vBw 12 dBm vBw vBw dBm vBw vB vBw vBm vBw vBm vBm <td>00 kHz D2[1] M1[1]</td> <td>0.67 dB 20.0362 ms -37.19 dbm 254.2752 ms</td> <td>Second pull Spectrum Ref Level 0.00 dBm # Att 10 dB SQL TR0://D BPk Chw -10 dBm -20 dBm -30 dBm -40 dBm -50 dBm -60 dBm -70 dBm -80 dBm</td> <td>SC SWT 25 ms VBV</td> <td>W 100 kHz</td> <td>M1[1]</td> <td>NUM (CL-DIGUE</td> <td>0.66 d -07.14 dbr 381.6812 m 409.1,4000, 02</td>	00 kHz D2[1] M1[1]	0.67 dB 20.0362 ms -37.19 dbm 254.2752 ms	Second pull Spectrum Ref Level 0.00 dBm # Att 10 dB SQL TR0://D BPk Chw -10 dBm -20 dBm -30 dBm -40 dBm -50 dBm -60 dBm -70 dBm -80 dBm	SC SWT 25 ms VBV	W 100 kHz	M1[1]	NUM (CL-DIGUE	0.66 d -07.14 dbr 381.6812 m 409.1,4000, 02
Dectrum	00 kHz D2[1] M1[1]	0.67 dB 20.0362 ms -37.19 dBm 254.2752 ms	Second pull Spectrum Ref Level 0.00 dBm # Att 10 dB SQL TR0://D BPk Chw -10 dBm -20 dBm -30 dBm -40 dBm -50 dBm -60 dBm -70 dBm -80 dBm	SC SWT 25 ms VBV	W 100 kHz	M1[1]		0.66 di 20.0362 m -37.14 dBn 381.6912 m
Dectrum	00 kHz D2[1] M1[1]	0.67 dB 20.0362 ms -37.19 dbm 254.2752 ms	Second pull Spectrum Ref Level 0.00 dBm # Att 10 dB SQL TR0:V0 0 dBm -20 dBm -30 dBm -80 dBm -58 dBm -70 dBm	SC SWT 25 ms VBV	W 100 kHz	M1[1]		0.66 dl 20.382 m -37.14 dbn 381.6812 m 400-1,400-1,22
Dectrum 0.00 dBm • RBW 11 Verf Level 0.00 dBm • RBW 11 10 dB • SWT 25 ms VBW 11 LL TRG: VID 0 dBm 10 dB • SWT 25 ms VBW 11 DL TRG: VID 0 dBm 0 10 0 VBW 11 D dBm 0 10	00 kHz D2[1] M1[1]	0.67 dB 20.0362 ms -37.19 dbm 254.2752 ms	Second pull Spectrum Ref Level 0.00 dBm # Att 10 dB SQL TR0://D BPk Chw -10 dBm -20 dBm -30 dBm -40 dBm -50 dBm -60 dBm -70 dBm -80 dBm	SC SWT 25 ms VBV	W 100 kHz	M1[1]	NUX (CL-DIGUE	0.66 dl 20.382 m -37.14 dbn 381.6812 m 400-1,400-1,22
pectrum art Level 0.00 dBm e RBW 11 Ref Level 0.00 dBm e RBW 12 wBW 12 Att 10 dB e SWT 25 ms vBW 12 GL T66(VID bww vBw 12 Ø dBm 0 dBm 0	00 kH2	0.67 dB 20.0362 ms -37.19 dbm 254.2752 ms 	Second pull Spectrum Ref Level 0.00 dBm • Att 10 dB • DBR Chw • 10 dBm • 10 dBm • 20 dBm • 40 dBm • 50 dBm • 60 dBm • 61 dBm • 62 dBm • 63 dBm • 64 dBm • 67 dBm • 70 dBm • 70 dBm • 70 dBm	Se SWT 25 ms VB1 WWWWLRLL CAMPUNATION WWWWLRLL CAMPUNATION WWWWWLRLL CAMPUNATION WWWWWLRL CAMPUNATION WWWWWLRLL CAMPUNATION WWWWWLRL CAMPUNATION WWWWWLRL CAMPUNATION WWWWWLRC CAMPUNATION WWWWN WLRC CAMPUNATION WWWWWLRC CAMPUNATION WWWWN WLRC CAMPUNATION WWW WLRC CAMPUNATION WHAT ON TON WWW WLRC CAMPUNATION WHAT ON TON WHAT ON TON W	691 p	M1[1]		20.66 di -03.14 din 381.6812 m 940-0-0040 02
pectrum Ref Level 0.00 dBm • RBW 11 Ref Level 0.00 dBm • RBW 12 • RBW 11 GL T66;VID • VBW 10 Ød Bm • OdBm • OdBm Ød Bm •	00 kH2	0.67 dB 20.0362 ms -37.19 dbm 254.2752 ms 	Second pull Spectrum Ref Level 0.00 dBm # Att 10 dB 50L TR0:/D0 91% Chw -10 dBm -20 dBm -30 dBm -40 dBm -58 dBm -70 dBm -80 dBm -70 dBm -70 dBm -70 dBm -70 dBm -70 dBm -80 dBm -90 dBm -70 dBm -70 dBm -70 dBm -80 dBm -70 dBm -80 dBm -80 dBm -80 dBm -80 dBm -90 dBm -90 dBm	SC SWT 25 m3 PB1	W 100 kHz	MI[1]		0.66 dl 20.0362 m -37.14 dbn 381.6812 m
pectrum Ref Level 0.00 dBm • RBW 11 Ref Level 0.00 dBm • RBW 12 • RBW 11 GL T66;VID • VBW 10 Ød Bm • OdBm • OdBm Ød Bm •	00 kH2	0.67 dB 20.0362 ms -37.19 dbm 254.2752 ms 	Second pull Spectrum Ref Level 0.00 dBm • Att 10 dB • DBR Chw • 10 dBm • 10 dBm • 20 dBm • 40 dBm • 50 dBm • 60 dBm • 61 dBm • 62 dBm • 63 dBm • 64 dBm • 67 dBm • 70 dBm • 70 dBm • 70 dBm	Se SWT 25 ms VB1 WWWWLRLL CAMPUNATION WWWWLRLL CAMPUNATION WWWWWLRLL CAMPUNATION WWWWWLRL CAMPUNATION WWWWWLRLL CAMPUNATION WWWWWLRL CAMPUNATION WWWWWLRC CAMPUNATION WWWWN WLRC CAMPUNATION WHANNATION WWWWN WLRC CAMPUNATION WWWWN WLRC CAMPUNATION WWWWN WLRC CAMPUNATION WWWWN WLRC CAMPUNATION WHANNATION WWWWN WLRC CAMPUNATION WHANNATION WWWWN WLRC CAMPUNATION WHANNATION WWWWN WLRC CAMPUNATION WHANTION WWWWN WLRC CAMPUNATION WHAN	691 p	M1[1]		0.66 d -03.14 dtr 381.6812 m -02.5 ms/
Dectrum Image: Constraint of the set	00 kH2	0.67 dB 20.0362 ms -37.19 dbm 254.2752 ms 	Second pull Spectrum Ref Level 0.00 dBm • Att 10 dB • DR Chw • DBR Chw • 10 dBm • -20 dBm • -30 dBm • -70 dBm	SC SWT 25 ms VB1 WWWWLNLLL LWWWWWW dBm 381.6812 ms	W 100 kHz	M1[1]		0.66 dl -0.14 dl -0.1
Dectrum Ref Level 0.00 dBm RBW 11 Kef Level 0.00 dBm WBW 125 ms VBW 11 DL TR6_VID WBW VBW 125 ms VBW 125 ms D dBm D Bm D D D dBm D D Bm D D dBm D DBm D D D dBm D DBm D D D dBm D D D D D D dBm D D D D D D D dBm D	00 kH2	0.67 dB 20.0362 ms -37.19 dbm 254.2752 ms 	Second pull Spectrum Ref Level 0.00 dBm # Att 10 dB 50L TR0:/V -10 dBm -20 dBm -30 dBm -30 dBm -30 dBm -30 dBm -80 dBm -90 dBm -80 dBm -90 dBm <td>SC SWT 25 ms VB1 WWWWLNLLL LWWWWWW dBm 381.6812 ms</td> <td>W 100 kHz</td> <td>M1[1]</td> <td>Fun</td> <td>0.66 d 20.0352 m -37.14 dbn 381.6912 m </td>	SC SWT 25 ms VB1 WWWWLNLLL LWWWWWW dBm 381.6812 ms	W 100 kHz	M1[1]	Fun	0.66 d 20.0352 m -37.14 dbn 381.6912 m
Dectrum 0.00 dBm • RBW 11 tef Level 0.00 dBm • RBW 11 • RBW 11 1.0 dB • SWT 25 ms VBW 11 recurrences 1.1 TBG: // VBW // VBW recurrences 0 dBm // VBW // VBW 0 dBm // VBW // VBW 0 dBm // VBW 0 dBm // VBW // VBW 0 dBm	00 kH2	0.67 dB 20.0362 ms -37.19 dbm 254.2752 ms 	Second pull Spectrum Ref Level 0.00 dBm • Att 10 dB • DR Chw • DBR Chw • 10 dBm • -20 dBm • -30 dBm • -70 dBm	SC SWT 25 ms VB1 WWWWLNLLL LWWWWWW dBm 381.6812 ms	W 100 kHz	M1[1]	Fun	0.66 dl -0.14 dl -0.1

The pulses of one burst



4.2 SPURIOUS RADIATED EMISSIONS

Standard FCC Part 15 Subpart C

The test was performed according to: ANSI C63.10–2013

4.2.1 TEST DESCRIPTION

The test set-up was made in accordance to the general provisions of ANSI C63.10 in a typical installation configuration. The Equipment Under Test (EUT) was set up on a non-conductive table $1.0 \times 2.0 \text{ m}^2$ in the semi-anechoic chamber. The influence of the EUT support table that is used between 30-1000 MHz was evaluated.

The measurement procedure is implemented into the EMI test software EMC32 from R&S. Exploratory tests are performed at 3 orthogonal axes to determine the worst-case orientation of a body-worn or handheld EUT. The final test on all kind of EUTs is also performed at 3 axes. A pre-check is performed while the EUT is powered from a DC power source.

1. Measurement up to 30 MHz

The Loop antenna HFH2-Z2 is used.

Step 1: pre-measurement

- Anechoic chamber
- Antenna distance: 3 m
- Detector: Peak-Maxhold
- Frequency range: 0.009 0.15 MHz and 0.15 30 MHz
- Frequency steps: 0.05 kHz and 2.25 kHz
- IF–Bandwidth: 0.2 kHz and 9 kHz
- Measuring time / Frequency step: 100 ms (FFT-based)

Intention of this step is, to determine the radiated EMI-profile of the EUT. Afterwards the relevant emissions for the final measurement are identified.

Step 2: final measurement

For the relevant emissions determined in step 1, an additional measurement with the following settings will be performed. Intention of this step is to find the maximum emission level.

- Open area test side
- Antenna distance: according to the Standard
- Detector: Quasi-Peak
- Frequency range: 0.009 30 MHz
- Frequency steps: measurement at frequencies detected in step 1
- IF-Bandwidth: 0.2 10 kHz
- Measuring time / Frequency step: 1 s

2. Measurement above 30 MHz and up to 1 GHz

Step 1: Preliminary scan

This is a preliminary test to identify the highest amplitudes relative to the limit. Settings for step 1:

- Antenna distance: 3 m
- Detector: Peak-Maxhold / Quasipeak (FFT-based)
- Frequency range: 30 1000 MHz



- Frequency steps: 30 kHz
- IF-Bandwidth: 120 kHz
- Measuring time / Frequency step: 100 ms
- Turntable angle range: -180° to 90°
- Turntable step size: 90°
- Height variation range: 1 3 m
- Height variation step size: 2 m
- Polarisation: Horizontal + Vertical

Intention of this step is, to determine the radiated EMI-profile of the EUT. Afterwards the relevant emissions for the final measurement are identified.

Step 2: Adjustment measurement

In this step the accuracy of the turntable azimuth and antenna height will be improved. This is necessary to find out the maximum value of every frequency.

For each frequency, which was determined the turntable azimuth and antenna height will be adjusted. The turntable azimuth will slowly vary by \pm 45° around this value. During this action, the value of emission is continuously measured. The turntable azimuth at the highest emission will be recorded and adjusted. In this position, the antenna height will also slowly vary by \pm 100 cm around the antenna height determined. During this action, the value of emission is also continuously measured. The antenna height of the highest emission will also be recorded and adjusted.

- Detector: Peak Maxhold
- Measured frequencies: in step 1 determined frequencies
- IF Bandwidth: 120 kHz
- Measuring time: 100 ms
- Turntable angle range: ± 45 ° around the determined value
- Height variation range: ± 100 cm around the determined value
- Antenna Polarisation: max. value determined in step 1

Step 3: Final measurement with QP detector

With the settings determined in step 3, the final measurement will be performed: EMI receiver settings for step 4:

- Detector: Quasi-Peak (< 1 GHz)
- Measured frequencies: in step 1 determined frequencies
- IF Bandwidth: 120 kHz
- Measuring time: 1 s

After the measurement a plot will be generated which contains a diagram with the results of the preliminary scan and a chart with the frequencies and values of the results of the final measurement.

3. Measurement above 1 GHz

The following modifications apply to the measurement procedure for the frequency range above 1 GHz:

Step 1:

The Equipment Under Test (EUT) was set up on a non-conductive support (tilt device) at 1.5 m height in the fully-anechoic chamber.

All steps were performed with one height of the receiving antenna only.

The EUT is turned during the preliminary measurement across the elevation axis, with a step size of 90 °.

The turn table step size (azimuth angle) for the preliminary measurement is 45 °. **Step 2:**

Due to the fact, that in this frequency range the test is performed in a fully anechoic room, the height scan of the receiving antenna instep 2 is omitted. Instead of this, a maximum search with a step size $\pm 45^{\circ}$ for the elevation axis is performed. The turn table azimuth will slowly vary by $\pm 22.5^{\circ}$.



The elevation angle will slowly vary by $\pm 45^{\circ}$ EMI receiver settings (for all steps):

- Detector: Peak, Average
- IF Bandwidth = 1 MHz

Step 3:

Spectrum analyser settings for step 3:

- Detector: Peak / Average
- Measured frequencies: in step 1 determined frequencies
- IF Bandwidth: 1 MHz
- Measuring time: 1 s

4.2.2 TEST REQUIREMENTS / LIMITS

FCC Part 15, Subpart C, §15.231 (b)

... In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(c)).

FCC Part 15, Subpart C, §15.209, Radiated Emission Limits

Frequency in MHz	Limit (µV/m)	Measurement distance (m)	Calculate Limit (dBµV/m @10m)	Limit (dBµV/m) @10m
0.009 - 0.49	2400/F (kHz)	300	(48.5 – 13.8) + 59.1 dB	107.6 - 72.9
0.49 - 1.705	24000/F (kHz)	30	(33.8 – 23.0) + 19.1 dB	52.9 - 42.1
1.705 - 30	30	30	29.5 + 19.1 dB	39.5

Frequency in MHz	Limit (µV/m)	Measurement distance (m)	Limit (dBµV/m)
30 - 88	100	3	40.0
88 - 216	150	3	43.5
216 - 960	200	3	46.0
above 960	500	3	54.0

§15.35(b)

..., there is also a limit on the radio frequency emissions, as measured using instrumentation with a peak detector function, corresponding to 20 dB above the maximum permitted average limit....

Used conversion factor: Limit $(dB\mu V/m) = 20 \log (Limit (\mu V/m)/1\mu V/m)$

§15.35(b) ..., there is also a limit on the radio frequency emissions, as measured using instrumentation with a peak detector function, corresponding to 20 dB above the maximum permitted average limit ...

Used conversion factor: Limit $(dB\mu V/m) = 20 \log (Limit (\mu V/m)/1\mu V/m)$

§15.35(c):

[...] when the radiated emission limits are expressed in terms of the average value of the emission, and pulsed operation is employed, the measurement field strength shall be determined by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 seconds.

As an alternative (provided the transmitter operates for longer than 0.1 seconds) or in cases where the pulse train exceeds 0.1 seconds, the measured field strength shall be determined from the average absolute voltage during a 0.1 second interval during which the field strength is at its maximum value. The exact method of calculating the average field strength shall be submitted [...].



Fundamental frequency (MHz)	Field strength of fundamental (microvolts/meter)	Field strength of spurious emissions (microvolts/meter)
40.66-40.70	2,250	225
70-130	1,250	125
130-174	¹ 1,250 to 3,750	¹ 125 to 375
174-260	3,750	375
260-470	¹ 3,750 to 12,500	¹ 375 to 1,250
Above 470	12,500	1,250

§15.231 (b) emissions table

¹Linear interpolations.

§15.231(b)(3)

The limits on the field strength of the spurious emissions in the above table are based on the fundamental frequency of the intentional radiator.

Spurious emissions shall be attenuated to the average (or, alternatively, CISPR quasipeak) limits shown in this table or to the general limits shown in §15.209, whichever limit permits a higher field strength.

Interpretation of the test laboratory:

The last subordinate clause of \$15.231(b)(3) is overruled by \$15.205/209, therefore within the restricted bands the limits defined at \$15.205/209 and outside the restricted bands the limits defined at \$15.231(b) resp. \$15.231(e) are applied.

Fundamental frequency (MHz)	Field strength of fundamental (microvolts/meter)	Field strength of spurious emission (microvolts/meter)
40.66-40.70	1,000	100
70-130	500	50
130-174	500 to 1,500 ¹	50 to 150 ¹
174-260	1,500	150
260-470	1,500 to 5,000 ¹	150 to 500 ¹
Above 470	5,000	500

§15.231 (e) emissions table

¹Linear interpolations.



4.2.3 TEST PROTOCOL

4.2.3.1 MEASUREMENT UP TO 30 MHz

Temperature:	24 °C
Air Pressure:	1009 hPa
Humidity:	35 %

Op. Mode Setup			Port							
op-mode 1		Setup_01 Er			Enclosure					
ASK modulated										
Measuring Antenna	Spurious Emission Frequency		rected va dBµV/m		Limit [dBµV/m]	Limit [dBµV/m]	Limit [dBµV/m]	Margin to limit [dB]	Margin to limit [dB]	
Polarisation	[MHz]	QP	Peak	AV	QP	Peak	AV	QP/Peak	AV	
0°										
90°										
FSK modula	ated									
Measuring Antenna	Spurious Emission Frequency	Corrected value [dBµV/m]		Limit [dBµV/m]	Limit [dBµV/m]	Limit [dBµV/m]	Margin to limit [dB]	Margin to limit [dB]		
Polarisation	[MHz]	QP	Peak	AV	QP	Peak	AV	QP/Peak	AV	
0°										
90°										

Remark: In step 1 no spurious emissions in the range 20 below the limit were found, using a peak detector, therefore step 2 (using a QP-detector) was not performed. For this test the EUT was sending a continuously modulated signal. Please see the measurement plots.

4.2.3.2 MEASUREMENT ABOWE 30 MHZ TO 7 GHz

Temperature:	24 °C
Air Pressure:	1006 hPa
Humidity:	32 %

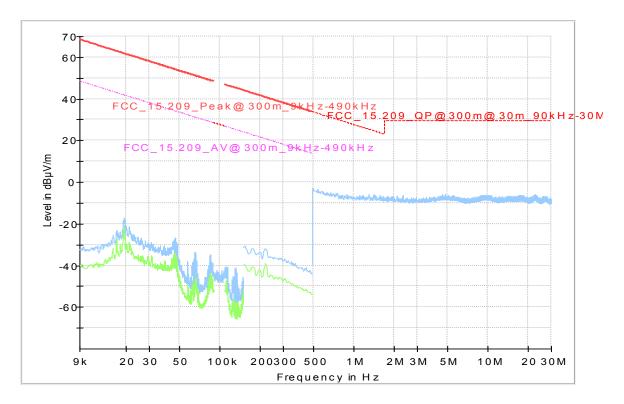
Op. Mode		Setup)		Port				
op-mode 1		Setup	Setup_01 Enclosure						
ASK modulated									
Polarisation of the antenna and	Spurious Emission Frequency		rected val dBµV/m]		Limit [dBµV/m]	Limit [dBµV/m]	Limit [dBµV/m]	Margin to limit [dB]	Margin to limit [dB]
the EUT	[MHz]	QP	Peak	AV	QP	Peak	AV	QP/Peak	AV

FSK modulated Polarisation Spurious Margin to Margin to of the Emission Corrected value Limit Limit Limit limit limit [dBµV/m] [dBµV/m] [dBµV/m] [dBµV/m] [dB] [dB] antenna and Frequency the EUT QP AV QP/Peak [MHz] Peak QP Peak AV AV horizontal 4339.200 41.2 53.98 12.77

Remarks: - No more spurious emissions in the range 15 dB below the limit were found.
 - The value in the table above is not corrected by using the Duty Cycle correction factor, calculated in clause 4.1.3.

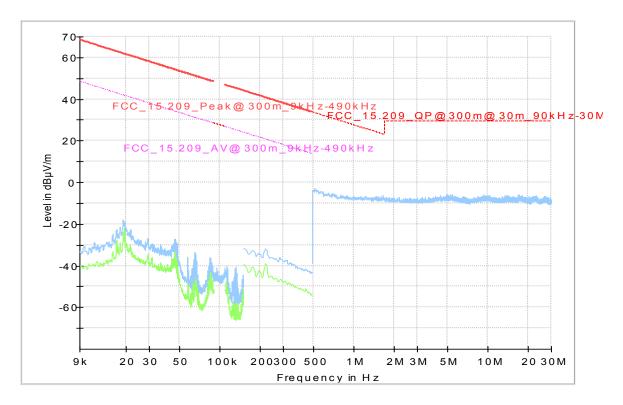


MEASUREMENT PLOTS

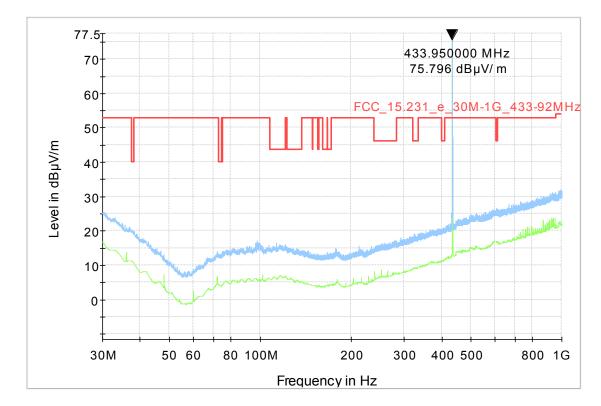


4.2.3.3 RADIATED EMISSIONS (f < 30 MHz) FSK modulated

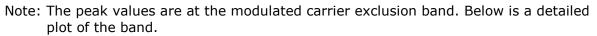
4.2.3.4 RADIATED EMISSIONS (f < 30 MHz) ASK modulated

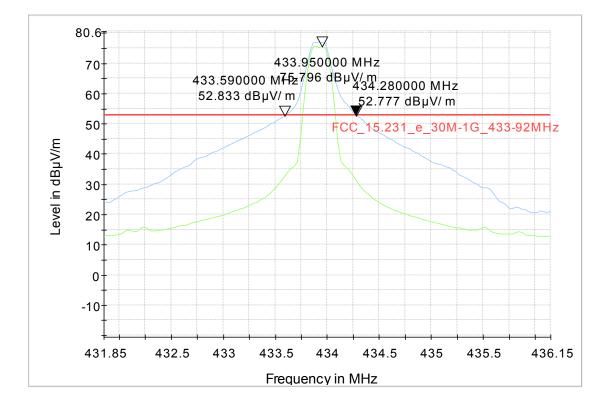




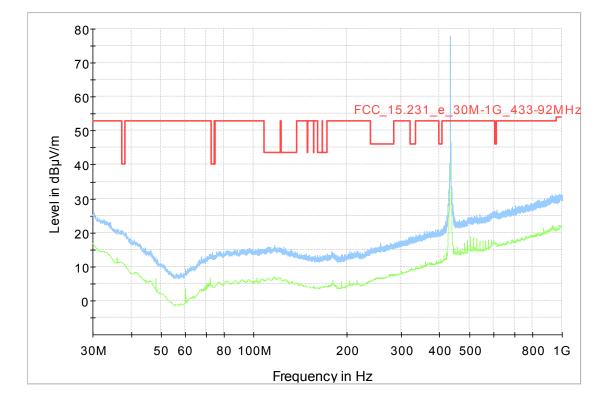


4.2.3.5 RADIATED EMISSIONS (30 MHz < f < 1 GHz) FSK modulated

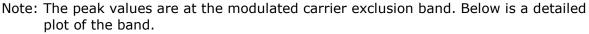


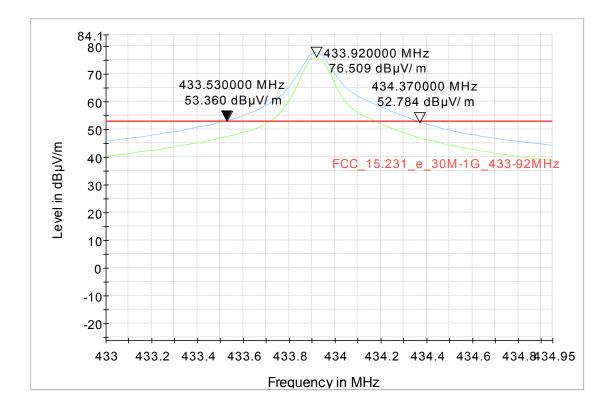




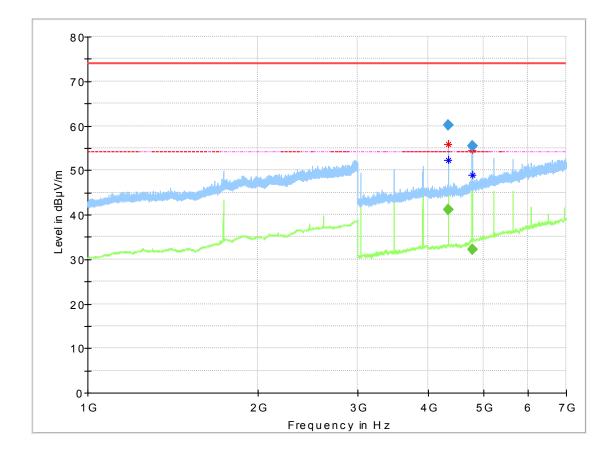


RADIATED EMISSIONS (30 MHz < f < 1 GHz) ASK modulated







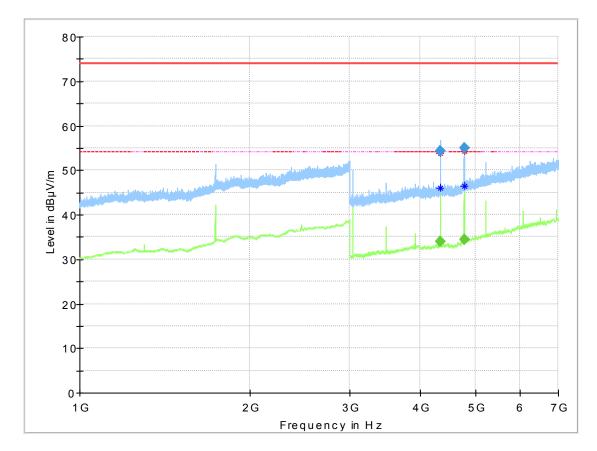


4.2.3.6 RADIATED EMISSIONS (1 GHz < f < 7 GHz) FSK modulated

Final Result

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Elevation (deg)
4339.200		41.2	53.98	12.77	1000.0	1000.000	150.0	V	-40.0	-15.0
4339.200	60.0		73.98	13.98	1000.0	1000.000	150.0	V	-38.0	-9.0
4772.800		32.2	53.98	21.75	1000.0	1000.000	150.0	Н	161.0	85.0
4772.800	55.5		73.98	18.51	1000.0	1000.000	150.0	Н	159.0	82.0





RADIATED EMISSIONS (1 GHz < f < 7 GHz) ASK modulated

Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Elevation (deg)
4339.200		33.9	53.98	20.05	1000.0	1000.000	150.0	Н	-160.0	3.0
4339.200	54.3		73.98	19.70	1000.0	1000.000	150.0	Н	-145.0	11.0
4773.200		34.5	53.98	19.48	1000.0	1000.000	150.0	Н	157.0	105.0
4773.200	55.0		73.98	19.03	1000.0	1000.000	150.0	Н	161.0	79.0



4.3 MAXIMUM RADIATED FIELD STRENGTH AT FUNDAMENTAL FREQUENCY

Standard FCC Part 15, Subpart C

The test was performed according to: ANSI C63.10-2013

4.3.1 TEST DESCRIPTION

Please refer to sub-clause 4.1.1

4.3.2 TEST LIMITS

Please refer to sub-clause 4.1.2

4.3.3 TEST PROTOCOL

Temperature:	24 °C
Air Pressure:	1009 hPa
Humidity:	38 %

Op. Mode	Setup	Port
op-mode 1	Setup_01	Enclosure

Frequency	Output power	Limit	Margin to Limit	Remarks
[MHz]	[dBµV/m]	[dBµV/m]	[dB]	
433.92	65.18	72.87	7.99	Maximum radiated field strength at fundamental frequency

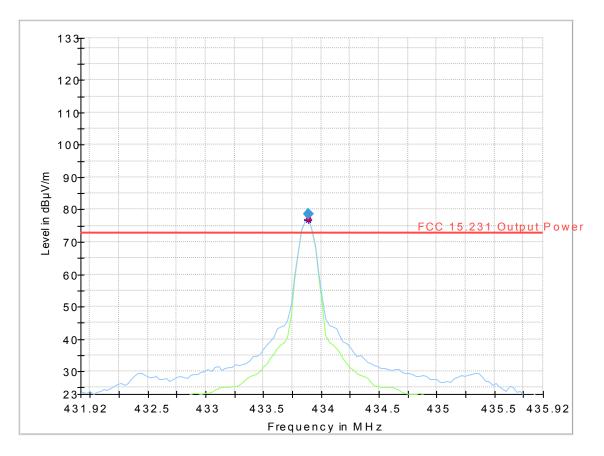
Notes: The value shown in the table above is corrected by using the Duty Cycle Correction Factor, calculated in 4.1.3 The EUT transmitted continuously non-modulated carrier.

4.3.4 TEST RESULT: Maximum radiated field strength at fundamental frequency

FCC Part 15, Subpart C	Op. Mode	Result	
	op-mode 1	passed	



4.3.5 MEASUREMENT PLOT MAXIMUM RADIATED FIELD STRENGTH AT FUNDAMENTAL FREQUENCY



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
433.890000	78.72	72.87	-5.85	1000.0	120.000	129.0	V	3.0

Note: Duty Cycle correction factor, calculated in 4.1.3 is **-13.54** dB. Hence, the maximum radiated field strength at fundamental frequency is: 78.72 - 13.54 = **65.18** dB μ V/m. The margin to the limit corrected is **7.69** dB



4.4 OCCUPIED BANDWIDTH

Standard FCC Part 15 Subpart C

The test was performed according to: ANSI C63.10-2013

4.4.1 TEST DESCRIPTION

The Equipment Under Test (EUT) was setup in a shielded room to perform the occupied bandwidth measurements.

For analyzer settings please see the measurement plots.

4.4.2 TEST LIMITS

FCC Part 15, Subpart C, §15.231(c)The maximum 20 dB bandwidth of a transmitter operating at a frequency range:70 to 900 MHz is0.25% of the centre frequencyabove 900 MHz is0.5% of the centre frequency

4.4.3 TEST PROTOCOL

Temperature:23 °CAir Pressure:1009 hPaHumidity:42 %

Op. Mode	Setup	Port
op-mode 1	Setup_02	Enclosure

Modulation	Cannel Frequency [MHz]	20 dB bandwidth [kHz]	99% bandwidth [kHz]	Limit [kHz]	Remarks
ASK	433.92	61.51	175.83	1084.8	Limit calculated as: 433.92 MHz (declared by applicant) * 0.25% = 1084.8 kHz.
FSK	433.92	105.64	117.95	1084.8	the same as above

Remark: Please see the measurement plots.

4.4.4 TEST RESULT: OCCUPIED BANDWIDTH

FCC Part 15, Subpart C	Op. Mode	Result	
	op-mode 1	passed	



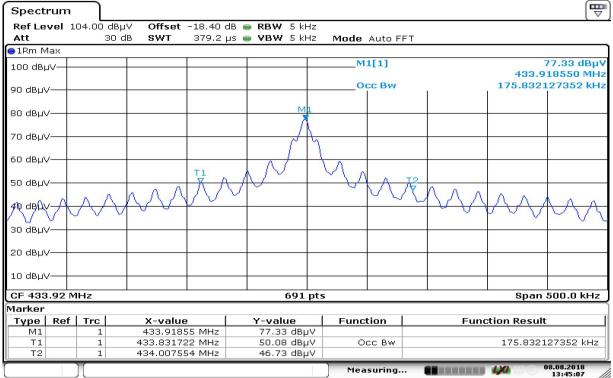
4.4.5 MEASUREMENT PLOTS OCCUPIED BANDWIDTH

20 dB occupied bandwidth between D2 and D3 = 65.51 kHz under ASK modulation

Spect	rum										E
Ref Le Att	vel 1	04.00 dB 35		-18.40 dB 379.2 µs	 RBW 5 kH VBW 50 kH 		e Auto I	FFT			
∋1Rm M	1ax										
100 dB _L						D	3[1]				-19.65 di
											30.390 kH
90 dBµ\	/		-				1B				20.00 d
					5.01	B				33.2900	000000 kH
80 dBµ\		1 77.430	deux		T M		factor				13036.
		1 //.400	dopv			M	1[1]				77.43 dBµ'
70 dBµ\	/				1	5		7	ĩ	433.9	18550 MH
co do k					D2 T1	t2 02					
60 dBµ\	/	-D2 51	7.430 dBµV			7 7					
50 dBµ\	<u> </u>			A	Λ/\sim	$\sim \sqrt{2}$	0	100			
J0 цвру			$\wedge \wedge \wedge$	AN		0	$\nabla \nabla$	$\Lambda \wedge I$			
40 dBA	A	$\Lambda \Lambda$	AAA	59			0	YV		$\Delta \Delta$	AAA
15	VΓ	,								υv	VV
30 dBµ\	/										
20 dBµ\	\leftarrow		-								
10 dBµ\	/										
CF 433	.9185	55 MHz			691 p	ts				Span	500.0 kHz
Marker											
Type	Ref	Trc	X-value	- I	Y-value	Func	tion		Functio	n Result	
M1		1	433.9185		77.43 dBµV		down				33.29 kHz
Τ1		1	433.9011	.8 MHz	56.81 dBµV		ndB				20.00 dB
Т2		1	433.9344	7 MHz	58.04 dBµ∨		factor				13036
D2	M1	1		12 kHz	-19.76 dB						
D3	M1	1	30.	39 kHz	-19.65 de	8					
		1					suring				08.08.2018

Date: 8.AUG.2018 13:47:10

99% occupied bandwidth between T1 and T2 = 175.83 kHz under ASK modulation



Date: 8.AUG.2018 13:45:07



Spectrum	Ċ					Ē
Ref Level 1 Att	.04.00 dB 35		dB 👄 RBW 5 kHz µs 👄 VBW 50 kHz		FFT	x
∋1Rm Max						
100 dBµV				M1[1]		78.77 dBµ
,						433.958350 MH
90 dBµV		-		ndB Bw		20.00 0
				M10 factor		105.640000000 kH 4107
80 dBµV			Δ.	A lactor		4107
				Λ		
70 dBµV				-/ \		
			T1	~ 12		
60 dBµV			7			
40 dBuV						
m						
30 dBuV						
20 dBµV						
10 dBµV						
CF 433.92 N	1Hz		691 pt	s		Span 500.0 kH;
Marker						
Type Ref	Trc	X-value	Y-value	Function	Fun	iction Result
M1	1	433.95835 MHz	78.77 dBµV	ndB down		105.64 kH:
Τ1	1	433.86501 MHz	58.93 dBµV	ndB		20.00 dE
T2	1	433.97065 MHz	58.94 dBµV	Q factor		4107.7
				Measuring.		08.08.2018

20 dB occupied bandwidth between T1 and T2 = 105.64 kHz under FSK modulation

Date: 8.AUG.2018 13:42:47

99% occupied bandwidth between T1 and T2 = 117.95 kHz under FSK modulation

Spectrum									[₩
Ref Level :				● RBW 5 kH			_		
Att	30	db SWT	379.2 µs	● VBW 5 kH	Z Mode	Auto FF	•]		
-						1[1]			78.67 dBµ\
100 dBµV						1[1]		433	958350 MH:
90 dBµV					0	CC BW	1		007236 kH
					M1				
80 dBµV				Λ	Ā				
70 dBµV					-+				
60 dBµV				In	~ \	72			
			J			Y			
50 dBµV							~		
40 dBµV							The		
	\sim								
30 dвµV									
20 dBuV									
10 dBµV									
CF 433.92 N	/Hz	1		691	pts		I	Span	500.0 kHz
Marker									
Type Ref		X-value		Y-value	Func	tion	Fur	nction Resu	lt
M1	1	433,9583		78.67 dBµ					
T1 T2	1	433.859219		54.78 dBµ 55.02 dBµ		cc Bw		117.945	007236 kHz
		400.97710.	T 171112	55.02 ubp					08.08.2018
	Л				Mea	suring			13:40:47

Date: 8.AUG.2018 13:40:47



5 TEST EQUIPMENT

Radiated Emissions

		erform radiated emi				
Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
1.1	NRV-Z1	Sensor Head A	Rohde & Schwarz	P26971-647001- PRB		2019-07
1.2	MFS	Rubidium Frequency Normal MFS	Datum GmbH	86670383	2018-07	2019-07
1.3	Opus10 TPR (8253.00)	ThermoAirpressure Datalogger 13 (Environ)	Lufft Mess- und Regeltechnik GmbH	egeltechnik mbH		2019-04
1.4	Anechoic Chamber	10.58 x 6.38 x 6.00 m³	Frankonia	103779	2016-05	2019-05
1.5	HL 562	Ultralog new biconicals	Rohde & Schwarz	00083069	2016-04	2019-04
1.6	5HC2700/12750- 1.5-KK	High Pass Filter	Trilithic	09		
1.7		Antenna Mast	Maturo GmbH	9942011		
1.8	Fully Anechoic 8.80m x 4.60m x Room 4.05m (l x w x h		Albatross Projects	64040001304	2018-06	2020-06
1.9	Fluke 177	Digital Multimeter 03 (Multimeter)	Fluke Europe B.V.	619368	2018-04	2020-04
1.10	JS4-18002600- 32-5P	Broadband Amplifier 18 GHz - 26 GHz	Miteq	-		
1.11	FSW 43	Spectrum Analyzer	Rohde & Schwarz	100609	2016-12	2018-12
1.12	3160-09	Standard Gain / Pyramidal Horn Antenna 26.5 GHz	EMCO Elektronic GmbH	00086675		
	WHKX 7.0/18G- 8SS	High Pass Filter	Wainwright	200035008		
1.14	4HC1600/12750- 1.5-KK	High Pass Filter	Trilithic	829324/006		
1.15	Chroma 6404	AC Power Source	Chroma ATE INC.	12482		
1.16	JS4-00102600- 42-5A	Broadband Amplifier 30 MHz - 26 GHz	Miteq	101424		
1.17	TT 1.5 WI	Turn Table	Maturo GmbH	896037		
1.18	HL 562 Ultralog	Logper. Antenna	Rohde & Schwarz	620/37	2016-04	2019-04
1.19	3160-10	Standard Gain / Pyramidal Horn Antenna 40 GHz	EMCO Elektronic GmbH	TD1.5- 10kg/024/37907 09		
1.20	5HC3500/18000- 1.2-KK		Trilithic	830482/004		
1.21	HFH2-Z2	Loop Antenna	Rohde & Schwarz	-	2018-01	2021-01
	Opus10 THI (8152.00)	ThermoHygro Datalogger 12 (Environ)	Lufft Mess- undRegeltechnik GmbH	AM4.0/180/1192 0513	2017-03	2019-03
1.23	ESR 7	EMI Receiver / Spectrum Analyzer	Rohde &	102444	2016-11	2018-11
1.24	JS4-00101800- 35-5P	Broadband Amplifier 30 MHz - 18 GHz	Miteq	P26971-647- 001- PRB		



Radiated Emissions

Lab to perform radiated emission tests

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
1.25	AS 620 P	Antenna mast	HD GmbH	86670383		
-	Tilt device Maturo (Rohacell)	Antrieb TD1.5- 10kg	Maturo GmbH	849785		
1.27	PAS 2.5 - 10 kg	Antenna Mast	Maturo GmbH	00083069		
1.28	AM 4.0	Antenna mast	Maturo GmbH	09		

Conducted Emissions Radio Test Lab

Ref.No	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
1.1	SMB100A	Signal Generator 9 kHz - 6 GHz	Rohde & Schwarz	107695	2017-07	2020-07
1.2	MFS	Rubidium Frequency Standard	Datum- Beverly	5489/001	2018-07	2019-07
1.3	FSV30	Signal Analyzer 10 Hz - 30 GHz	Rohde & Schwarz	103005	2018-04	2020-04
1.4	Fluke 177	Digital Multimeter 03 (Multimeter)	Fluke Europe B.V.	86670383	2018-04	2020-04
1.5	SMP03	Signal Generator 2 GHz - 27 GHz	Rohde & Schwarz	833680/003	2017-09	2020-09
1.6	FSIQ26	Signal Analyser	Rohde & Schwarz	840061/005	2017-05	2019-05
1.7	Chroma 6404	AC Power Source	Chroma ATE INC.	64040001304		
1.8	VT 4002	Climatic Chamber	Vötsch	58566002150010	2018-04	2020-04
1.9	WA1515	Broadband Power Divider SMA	Weinschel Associates	A855		
1.10	A8455-4	4 Way Power Divider (SMA)		-		
1.11	SMBV100A	Vector Signal Generator 9 kHz - 6 GHz	Rohde & Schwarz	259291	2018-01	2021-01



6 ANTENNA FACTORS, CABLE LOSS AND SAMPLE CALCULATIONS

This chapter contains the antenna factors with their corresponding path loss of the used measurement path for all antennas as well as the insertion loss of the LISN.

AFloss 1loss 2loss 3loss 4corr.(meas.(m distanceFrequencyHFH-Z2)Corr.Corr.chamber)chamber)unit)receiver)decade)(limit)(use)	sed eas. ance ed) n 3 3 3
AF (inside (outside (switch (to (-40 dB/ distance distance	ance ed) n 3 3 3 3
Frequency HFH-Z2 Corr. MHz dB (1/m) dB 0.009 20.50 -79.6 0.011 20.45 -79.6 0.015 20.37 -79.6 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1	ed) n 3 3 3 3
MHz dB (1/m) dB 0.009 20.50 -79.6 0.01 20.45 -79.6 0.015 20.37 -79.6 0.1 0.1 0.1 0.1 -80 300	n 3 3 3 3
0.009 20.50 -79.6 0.1 0.1 0.1 0.1 -80 300 0.01 20.45 -79.6 0.1 0.1 0.1 0.1 -80 300 0.015 20.37 -79.6 0.1 0.1 0.1 0.1 -80 300	3 3 3 3
0.01 20.45 -79.6 0.1 0.1 0.1 0.1 -80 300 0.015 20.37 -79.6 0.1 0.1 0.1 0.1 -80 300	3 3 3
0.015 20.37 -79.6 0.1 0.1 0.1 0.1 -80 300	3 3
	3
0.02 20.36 -79.6 0.1 0.1 0.1 0.1 -80 300	
	_
0.025 20.38 -79.6 0.1 0.1 0.1 0.1 -80 300	3
0.03 20.32 -79.6 0.1 0.1 0.1 0.1 -80 300	3
0.05 20.35 -79.6 0.1 0.1 0.1 0.1 -80 300	3
0.08 20.30 -79.6 0.1 0.1 0.1 0.1 -80 300	3
0.1 20.20 -79.6 0.1 0.1 0.1 0.1 -80 300	3
0.2 20.17 -79.6 0.1 0.1 0.1 0.1 -80 300	3
0.3 20.14 -79.6 0.1 0.1 0.1 0.1 -80 300	3
0.49 20.12 -79.6 0.1 0.1 0.1 0.1 -80 300	3
0.490001 20.12 -39.6 0.1 0.1 0.1 0.1 -40 30	3
0.5 20.11 -39.6 0.1 0.1 0.1 0.1 -40 30	3
0.8 20.10 -39.6 0.1 0.1 0.1 0.1 -40 30	3
1 20.09 -39.6 0.1 0.1 0.1 0.1 -40 30	3
2 20.08 -39.6 0.1 0.1 0.1 0.1 -40 30	3
3 20.06 -39.6 0.1 0.1 0.1 0.1 -40 30	3
4 20.05 -39.5 0.2 0.1 0.1 0.1 -40 30	3
5 20.05 -39.5 0.2 0.1 0.1 0.1 -40 30	3
6 20.02 -39.5 0.2 0.1 0.1 0.1 -40 30	3
8 19.95 -39.5 0.2 0.1 0.1 0.1 -40 30	3
10 19.83 -39.4 0.2 0.1 0.2 0.1 -40 30	3
12 19.71 -39.4 0.2 0.1 0.2 0.1 -40 30	3
14 19.54 -39.4 0.2 0.1 0.2 0.1 -40 30	3
16 19.53 -39.3 0.3 0.1 0.2 0.1 -40 30	3
18 19.50 -39.3 0.3 0.1 0.2 0.1 -40 30	3
20 19.57 -39.3 0.3 0.1 0.2 0.1 -40 30	3
20 1007 3010 010 011 012 011 10 50 22 19.61 -39.3 0.3 0.1 0.2 0.1 -40 30	3
22 1501 35.5 0.5 0.1 0.2 0.1 10 50 24 19.61 -39.3 0.3 0.1 0.2 0.1 -40 30	3
26 19.54 -39.3 0.3 0.1 0.2 0.1 -40 30	3
20 15.54 35.5 0.5 0.1 0.2 0.1 40 50 28 19.46 -39.2 0.3 0.1 0.3 0.1 -40 30	3
20 10.40 30.2 0.5 0.1 0.5 0.1 40 50 30 19.73 -39.1 0.4 0.1 0.3 0.1 -40 30	3

6.1 ANTENNA R&S HFH2-Z2 (9 KHZ - 30 MHZ)

Sample calculation

 $E (dB \mu V/m) = U (dB \mu V) + AF (dB 1/m) + Corr. (dB)$

U = Receiver reading

AF = Antenna factor

Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable) distance correction = $-40 * LOG (d_{Limit}/d_{used})$

Linear interpolation will be used for frequencies in between the values in the table.

Table shows an extract of values



6.2 ANTENNA R&S HL562 (30 MHZ - 1 GHZ)

(d_{Limit} = 3 m)

Frequency	AF R&S HL562	Corr.
MHz	dB (1/m)	dB
30	18.6	0.6
50	6.0	0.9
100	9.7	1.2
150	7.9	1.6
200	7.6	1.9
250	9.5	2.1
300	11.0	2.3
350	12.4	2.6
400	13.6	2.9
450	14.7	3.1
500	15.6	3.2
550	16.3	3.5
600	17.2	3.5
650	18.1	3.6
700	18.5	3.6
750	19.1	4.1
800	19.6	4.1
850	20.1	4.4
900	20.8	4.7
950	21.1	4.8
1000	21.6	4.9

cable loss 1 (inside chamber)	cable loss 2 (outside chamber)	cable loss 3 (switch unit)	cable loss 4 (to receiver)	distance corr. (-20 dB/ decade)	d _{Limit} (meas. distance (limit)	d _{used} (meas. distance (used)
dB	dB	dB	dB	dB	m	m
0.29	0.04	0.23	0.02	0.0	3	3
0.39	0.09	0.32	0.08	0.0	3	3
0.56	0.14	0.47	0.08	0.0	3	3
0.73	0.20	0.59	0.12	0.0	3	3
0.84	0.21	0.70	0.11	0.0	3	3
0.98	0.24	0.80	0.13	0.0	3	3
1.04	0.26	0.89	0.15	0.0	3	3
1.18	0.31	0.96	0.13	0.0	3	3
1.28	0.35	1.03	0.19	0.0	3	3
1.39	0.38	1.11	0.22	0.0	3	3
1.44	0.39	1.20	0.19	0.0	3	3
1.55	0.46	1.24	0.23	0.0	3	3
1.59	0.43	1.29	0.23	0.0	3	3
1.67	0.34	1.35	0.22	0.0	3	3
1.67	0.42	1.41	0.15	0.0	3	3
1.87	0.54	1.46	0.25	0.0	3	3
1.90	0.46	1.51	0.25	0.0	3	3
1.99	0.60	1.56	0.27	0.0	3	3
2.14	0.60	1.63	0.29	0.0	3	3
2.22	0.60	1.66	0.33	0.0	3	3
2.23	0.61	1.71	0.30	0.0	3	3

 $(d_{\text{Limit}} = 10 \text{ m})$

30	18.6	-9.9	0.29	0.04	0.23	0.02	-10.5	10	3
50	6.0	-9.6	0.39	0.09	0.32	0.08	-10.5	10	3
100	9.7	-9.2	0.56	0.14	0.47	0.08	-10.5	10	3
150	7.9	-8.8	0.73	0.20	0.59	0.12	-10.5	10	3
200	7.6	-8.6	0.84	0.21	0.70	0.11	-10.5	10	3
250	9.5	-8.3	0.98	0.24	0.80	0.13	-10.5	10	3
300	11.0	-8.1	1.04	0.26	0.89	0.15	-10.5	10	3
350	12.4	-7.9	1.18	0.31	0.96	0.13	-10.5	10	3
400	13.6	-7.6	1.28	0.35	1.03	0.19	-10.5	10	3
450	14.7	-7.4	1.39	0.38	1.11	0.22	-10.5	10	3
500	15.6	-7.2	1.44	0.39	1.20	0.19	-10.5	10	3
550	16.3	-7.0	1.55	0.46	1.24	0.23	-10.5	10	3
600	17.2	-6.9	1.59	0.43	1.29	0.23	-10.5	10	3
650	18.1	-6.9	1.67	0.34	1.35	0.22	-10.5	10	3
700	18.5	-6.8	1.67	0.42	1.41	0.15	-10.5	10	3
750	19.1	-6.3	1.87	0.54	1.46	0.25	-10.5	10	3
800	19.6	-6.3	1.90	0.46	1.51	0.25	-10.5	10	3
850	20.1	-6.0	1.99	0.60	1.56	0.27	-10.5	10	3
900	20.8	-5.8	2.14	0.60	1.63	0.29	-10.5	10	3
950	21.1	-5.6	2.22	0.60	1.66	0.33	-10.5	10	3
1000	21.6	-5.6	2.23	0.61	1.71	0.30	-10.5	10	3

Sample calculation

 $E (dB \mu V/m) = U (dB \mu V) + AF (dB 1/m) + Corr. (dB)$

U = Receiver reading

AF = Antenna factor

Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable) distance correction = $-20 * LOG (d_{Limit}/ d_{used})$

Linear interpolation will be used for frequencies in between the values in the table. Tables show an extract of values.



6.3 ANTENNA R&S HF907 (1 GHZ - 18 GHZ)

		•		,				
			cable		cable loss 3			
			loss 1		(switch			
			(relay +	cable	unit,			
	AF		cable	loss 2	atten-	cable		
	R&S		inside	(outside	uator &	loss 4 (to		
Frequency	HF907	Corr.	chamber)	chamber)	pre-amp)	receiver)		
MHz	dB (1/m)	dB	dB	dB	dB	dB		
1000	24.4	-19.4	0.99	0.31	-21.51	0.79		
2000	28.5	-17.4	1.44	0.44	-20.63	1.38		
3000	31.0	-16.1	1.87	0.53	-19.85	1.33		
4000	33.1	-14.7	2.41	0.67	-19.13	1.31		
5000	34.4	-13.7	2.78	0.86	-18.71	1.40		
6000	34.7	-12.7	2.74	0.90	-17.83	1.47		
7000	35.6	-11.0	2.82	0.86	-16.19	1.46		
						cable		
						loss 4		
			cable			(switch		
			loss 1	cable	cable	unit,		used
	AF		(relay	loss 2	loss 3	atten-	cable	for
Fraguanay	R&S HF907	Corr.	inside chamber)	(inside	(outside	uator &	loss 5 (to	FCC 15.247
Frequency		dB	dB	chamber) dB	chamber) dB	pre-amp)	receiver) dB	15.247
MHz 3000	dB (1/m) 31.0	-	-	-	-	dB	-	
4000	33.1	-23.4	0.47	1.87	0.53	-27.58	1.33	
5000	34.4	-23.3	0.56	2.41	0.67	-28.23	1.31	
6000	34.4	-21.7	0.61	2.78	0.86	-27.35	1.40	
7000	34.7	-21.2	0.58	2.74	0.90	-26.89	1.47	
7000	35.0	-19.8	0.66	2.82	0.86	-25.58	1.46	
			aphla					
			cable loss 1	cable	cable	cable	cable	cable
	AF		(relay	loss 2	loss 3	loss 4	loss 5	loss 6
	R&S		inside	(High	(pre-	(inside	(outside	(to
Frequency	HF907	Corr.	chamber)	Pass)	amp)	chamber)	chamber)	receiver)
MHz	dB (1/m)	dB	dB	dB	dB	dB	dB	dB
7000	35.6	-57.3	0.56	1.28	-62.72	2.66	0.94	1.46
8000	36.3	-56.3	0.69	0.71	-61.49	2.84	1.00	1.53
9000	37.1	-55.3	0.68	0.65	-60.80	3.06	1.09	1.60
10000	37.5	-56.2	0.70	0.54	-61.91	3.28	1.20	1.67
11000	37.5	-55.3	0.80	0.61	-61.40	3.43	1.27	1.70
12000	37.6	-53.7	0.84	0.42	-59.70	3.53	1.26	1.73
13000	38.2	-53.5	0.83	0.44	-59.81	3.75	1.32	1.83
14000	39.9	-56.3	0.03	0.53	-63.03	3.91	1.40	1.77
15000	40.9	-54.1	0.91	0.53	-61.05	4.02	1.44	1.83
16000	41.3	-54.1	1.23	0.49	-61.51	4.17	1.51	1.85
17000	42.8	-54.4	1.36	0.76	-62.36	4.34	1.53	2.00
18000	44.2	-54.7	1.70	0.53	-62.88	4.41	1.55	1.91
10000	77,2	JT./	1.70	0.55	02.00	1.71	1.55	1.91

Sample calculation

E (dB μ V/m) = U (dB μ V) + AF (dB 1/m) + Corr. (dB)

U = Receiver reading

AF = Antenna factor

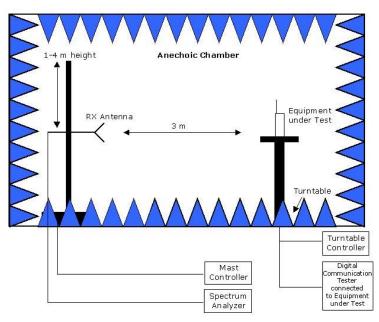
Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable) Linear interpolation will be used for frequencies in between the values in the table. Tables show an extract of values.



7 PHOTO REPORT

Photos are included in an external report.

8 SETUP DRAWINGS



<u>Remark:</u> Depending on the frequency range suitable antenna types, attenuators or preamplifiers are used.

Drawing 1: Setup in the Anechoic chamber. For measurements below 1 GHz the ground was replaced by a conducting ground plane.