FCC Measurement / Technical Report on

SPECTERA SEK
SEK UHF

FCC ID: DMOSEKUHF
IC: 2099A-SEKUHF

Test Report Reference: MDE_SENNH_2402_FCC_02

Test Laboratory:
7layers GmbH
Borsigstrasse 11
40880 Ratingen
Germany

Deutsche
Akkreditierungsstelle
D-PL-12140-01-00

Table of Contents

1 APPLIED STANDARDS AND TEST SUMMARY

1.1 APPLIED STANDARDS

Applicable FCC Rules

Prepared in accordance with the requirements of FCC Rules and Regulations as listed in 47 CFR Ch.1 Parts 2 and 15 (10-1-23 Edition). 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

§ 15.207 Conducted limits

§ 15.236 Operation of wireless microphones in the bands 54-72 MHz, 76-88 MHz, 174-216 MHz, 470-608 MHz and 614-698 MHz.

Applicable ISED Standards

RSS-Gen, Issue 5 + Amendment 1 (March 2021) + Amendment 2 (February 2021)

RSS-210, Issue 11

Note:

- ANSI C63.10–2020 is applied.
- EN 300 422-1, V2.2.1 is applied

1.2 FCC-IC CORRELATION TABLE

Correlation of measurement requirements for
Operation of wireless microphones in the bands 54-72 MHz, 76-88 MHz, 174-216 MHz, 470-608 MHz and 614-698 MHz
from
FCC and ISED Canada

WMAS Systems

Measurement	FCC reference	ISED reference
Conducted Emissions (AC Power Line)	§15.207	RSS-GEN, Issue 5: 8.8
Output Power	§15.236 (d)(1),(ii),(iii)	RSS-210, Issue 11: Annex G, G.2
Occupied Bandwidth	§15.236 (d)(2)	RSS-210, Issue 11: Annex G, G.3
Transmitter Frequency Stability	-	RSS-210, Issue 11: Annex G, G.4
Transmitter Unwanted Emissions	15.236 (g), (3), (4)	RSS-210, Issue 11: Annex G, G.5
Modulation	-	RSS-210, Issue 11: Annex G, G.6

2 MEASUREMENT SUMMARY

47 CFR CHAPTER I FCC PART 15.207 (a)
RSS-GEN, Issue 5 Chapter 8.8

Conducted AC measurement
The measurement was performed according to ANSI C63.10, chapter 6.2

OP-Mode	**Setup**	**Date**	**Final Result FCC**	**IC**
Measurement method, Radio Technology				
conducted, WMAS 6 MHz	-	-	N/A	N/A

47 CFR CHAPTER I FCC PART 15.236 §15.236 (d)(1),(ii),(iii)
RSS-210, Issue 11 Annex G, G.2

Output Power
The measurement was performed according to ANSI C63.10, chapter 6.5

OP-Mode	**Setup**	**Date**	**Final Result FCC**	**IC**
Measurement method, Operating Frequency, Radio Technology				
radiated, Lowest, WMAS 6 MHz	S01_AC01	2024-08-08	Passed	Passed
radiated, Mid, WMAS 6 MHz	S01_AC01	2024-08-08	Passed	Passed
radiated, Highest, WMAS 6 MHz	S01_AC01	2024-08-08	Passed	Passed
radiated, Mid (Duplex Gap), WMAS 6 MHz	S01_AC01	2024-08-12	Passed	Passed

47 CFR CHAPTER I FCC PART 15.236
RSS-210, Issue 11 Annex G, G.4

Transmitter Frequency Stability
The measurement was performed according to RSS-GEN Issue 5, chapter 6.11

OP-Mode	**Setup**	**Date**	**Final Result FCC**	**IC**
Measurement method, Operating Frequency, Radio Technology				
conducted, Mid, WMAS 6 MHz	S01_AA01	2024-08-08 2024-09-17	-	Passed
conducted, Mid (Duplex Gap), WMAS 6 MHz	S01_AA01	2024-08-12 2024-09-17	-	Passed

47 CFR CHAPTER I FCC PART 15.236 §15.236 (d)(2)
RSS-210, Issue 11 Annex G, G.3

Occupied Bandwidth
The measurement was performed according to ANSI C63.10, chapter 6.9.3

OP-Mode	**Setup**	**Date**	**Final Result**	**Result**
Measurement Method, Operating Frequency, Radio Technology				
Conducted, Lowest, WMAS 6 MHz	S02_AA01	2024-08-08	Passed	Passed
Conducted, Mid, WMAS 6 MHz	S02_AA01	2024-08-08	Passed	Passed
Conducted, Highest, WMAS 6 MHz	S02_AA01	2024-08-08	Passed	Passed
Conducted, Mid (Duplex Gap), WMAS 6 MHz	S02_AA01	2024-08-12	Passed	Passed

47 CFR CHAPTER I FCC PART 15.236 §15.236 (g)(4)
RSS-210, Issue 11 Annex G, G.5

Transmitter unwanted emissions in the spurious domain
The measurement was performed according to ANSI C63.10, chapter 6.4/6.5/6.6.5 **Final Result**

OP-Mode Measurement method, temperature, Operating Frequency, Radio Technology	Setup	Date	FCC	IC
radiated, Normal, Lowest, WMAS 6 MHz	S01_AC01	2024-08-01 2024-08-13 2024-08-29	Passed	Passed
radiated, Normal, Mid, WMAS 6 MHz	S01_AC01	2024-08-01 2024-08-13 2024-08-29	Passed	Passed
radiated, Normal, Highest, WMAS 6 MHz	S01_AC01	2024-08-01 2024-08-13 2024-08-29	Passed	Passed
radiated, Normal, Mid (Duplex Gap), WMAS 6 MHz	S01_AC01	2024-08-01 2024-08-13 2024-08-29	Passed	Passed

47 CFR CHAPTER I FCC PART 15.236 §15.236 (g)(3)
RSS-210, Issue 11 Annex G, G.5

Transmitter unwanted emissions in the OOB domain
The measurement was performed according to EN 300 422-1, clause 5.4.4 **Final Result**

OP-Mode Measurement method, temperature, Operating Frequency, Radio Technology	Setup	Date	FCC	IC
conducted, Normal, Lowest, WMAS 6 MHz	S02_AA01	2024-08-08	Passed	Passed
conducted, Normal, Mid, WMAS 6 MHz	S02_AA01	2024-08-08	Passed	Passed
conducted, Normal, Highest, WMAS 6 MHz	S02_AA01	2024-08-08	Passed	Passed
Conducted, Mid (Duplex Gap), WMAS 6 MHz	S02_AA01	2024-08-12	Passed	Passed

3 REVISION HISTORY

Report version control			
Version	**Release date**	**Change Description**	**Version validity**
initial	2024-09-20	--	valid
--	--	--	--

COMMENT: -

(responsible for accreditation scope)
Dipl.-Ing. Robert Machulec

(responsible for testing and report)
Dipl.-Ing. Marco Kullik

7 layers GmbH, Borsigstr. 11
40880 Ratingen, Germany
Phone +49 (0)2102 749 0

4 ADMINISTRATIVE DATA

4.1 TESTING LABORATORY

Company Name:	7layers GmbH
Address:	Borsigstr. 11 40880 Ratingen Germany
Laboratory accreditation no:	DAkkS D-PL-12140-01-00
FCC Designation Number:	DE0015
FCC Test Firm Registration:	929146
ISED CAB Identifier	DE0007; ISED#: 3699A
Responsible for accreditation scope:	Dipl.-Ing. Robert Machulec
Report Template Version:	2024-07-04

4.2 PROJECT DATA

Responsible for testing and report:	Dipl.-Ing. Marco Kullik
Date of Report:	2024-09-20
Testing Period:	2024-08-01 to 2024-09-17

4.3 APPLICANT DATA

Company Name: Address:	Sennheiser electronic SE & Co. KG Am Labor 1 D-30900 Wedemark Germany
Contact Person:	Mr. Ouajdi Ochi

4.4 MANUFACTURER DATA

Company Name:	please see Applicant Data
Address:	
Contact Person:	

5 TEST OBJECT DATA

5.1 GENERAL DESCRIPTION OF RADIO DEVICE

Kind of Device product description	Bodypack MIC/EM Transceiver part of SPECTERA WMAS system.
Product name	SPECTERA SEK
Modell	SPECTERA SEK UHF
Declared EUT data by the supplier	
Power Supply Type	DC Battery (Li-Ion Battery), Model: BA 70
Normal Voltage	3.8 V / DC
Normal Temperature	20°C
Low Temperature	-10.0 °C (according to RSS-GEN tested at -30°C)
High Temperature	+50.0 °C (according to RSS-GEN tested at +50°C)
Antenna type / gain	Integral, Lower Band Edge: -2.7 dBi (-4.8 dBd) Higher Band Edge: -0.3 dbi (-2.4 dBd)
Tuning Range	473 – 605 MHz 660 MHz
Declared Channel Bandwidth	6.0 MHz
Declared Maximum Transmission Output Power [E.I.R.P]	473 – 605 MHz: 100 mW / 20.0 dBm [E.I.R.P] 660 MHz: 20 mW / 13 dBm [E.I.R.P.]
Channel Separation [MHz]	Typically 12.0 MHz, minimum 6.0 MHz
Transmission Type	Continuous
Operating Modes, used Modulations and Data Rates for testing	Live Ultra Low Latency, OFDM
Frequency of Channels	Lowest: 473.0 MHz Mid: 539.0 MHz Highest: 605.0 MHz Mid Duplex Gap: 660.0 MHz
Min. Number of Audio Channels	1
Max. Number of Audio Channels	64
EUT provides unmodulated Test Mode	Yes
Interfaces	• Enclosure • Antenna port • Earphone port

5.2 TESTED RADIO DEVICES

Sample Name	Sample Code	Description
EUT aa01	DE1511003aa01	Conducted Sample
Sample Parameter	**Value**	
HW Version	FMO2	
SW Version	v0.20.1+48-g3aba512d	
Serial No.	1174000243	
Comment	-	

Sample Name	Sample Code	Description
EUT ac01	DE1511003ac01	Radiated Sample
Sample Parameter	**Value**	
HW Version	FMO2	
SW Version	v0.20.1+48-g3aba512d	
Serial No.	1174000248	
Comment	-	

5.3 TESTED ANCILLARY EQUIPMENT

Device	Details (Manufacturer, Type Model, OUT Code)	Reason for using
-	-	-

5.4 GENERAL DESCRIPTION OF AUXILIARY EQUIPMENT

Device	Details (Manufacturer, Type Model, HW, SW, S/N)	Description
AUX01	Sennheiser, 19- Inch Rack, Art. No.: 509162, 594190 Rev. 04, Nightly.20240103.1, 1393000079	SPECTERA Base Station
AUX02	Sennheiser, SPECTERA DAD UHF, FMO2, v0.20.1+48-g3aba512d, 1493000050	SPECTERA DAD

5.5 USED SETUPS

Setup	Combination of EUTs, auxiliary and ancillary equipment	Description
S01_AA01	EUT aa01	Conducted Setup, TX-Testmode, TX-CW Testmode
S02_AA01	EUT aa01, AUX01, AUX02	Conducted Setup, TX 1 kHz tone
S01_AC01	EUT ac01	Radiated Setup, TX-Testmode

5.6 OPERATING MODES / TEST CHANNELS

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

WMAS	**Band: 470 – 608 MHz**		
Test Channels:	**lowest**	**mid**	**highest**
Frequency [MHz]	473	539	605

WMAS	**Band: 657 – 663 MHz**		
Test Channels:	**lowest**	**mid**	**highest**
Frequency [MHz]	-	660	-

5.7 PRODUCT LABELLING

5.7.1 FCC ID LABEL

Please refer to the documentation of the applicant.

5.7.2 LOCATION OF THE LABEL ON THE EUT

Please refer to the documentation of the applicant.

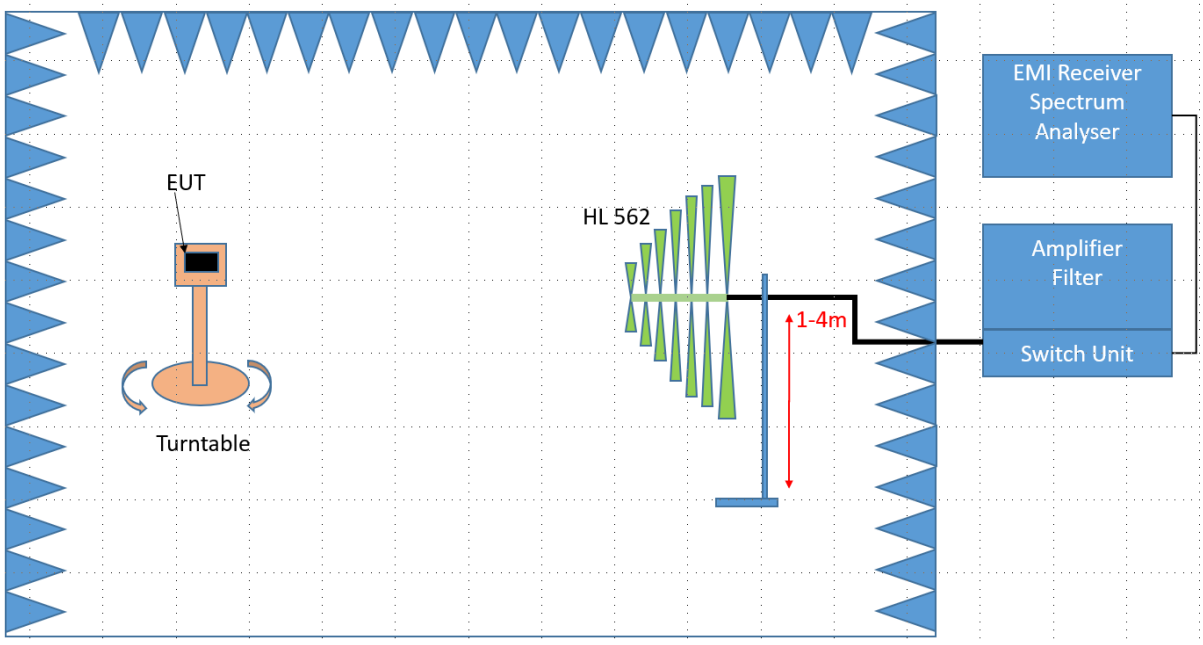
6 TEST RESULTS

6.1 OUTPUT POWER §15.236 (d)(1),(ii),(iii)

Test case performed according: ANSI C63.10, chapter 6.5

The measurement procedure is implemented into the EMI test software EMC32 from R&S. Exploratory tests are performed at 3 orthogonal axes (> 1GHz) / 2°orthogonal (< 1 GHz) 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.

Test Setup:
The test was performed with the following setups:
Radiated < 1 GHz:



Test Setup; E.I.R.P. / E.R.P. (SAC), 30 MHz- 1GHz

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: Average
- Frequency range: TX-frequency +/- 20 MHz
- IF–Bandwidth: 10 MHz
- Measuring time / Frequency step: 100 ms
- Turntable angle range: –180° to 90°
- Turntable step size: 90°
- Height variation range: 1 – 4 m
- Height variation step size: 1.5 m
- Polarisation: Horizontal + Vertical

Intention of this step is, to determine the radiated TX-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 360°. 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 between 1 – 4 meter. 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: 10 MHz
- Measuring time: 100 ms
- Turntable angle range: 360 °
- Height variation range:1 – 4 m
- Antenna Polarisation: max. value determined in step 1

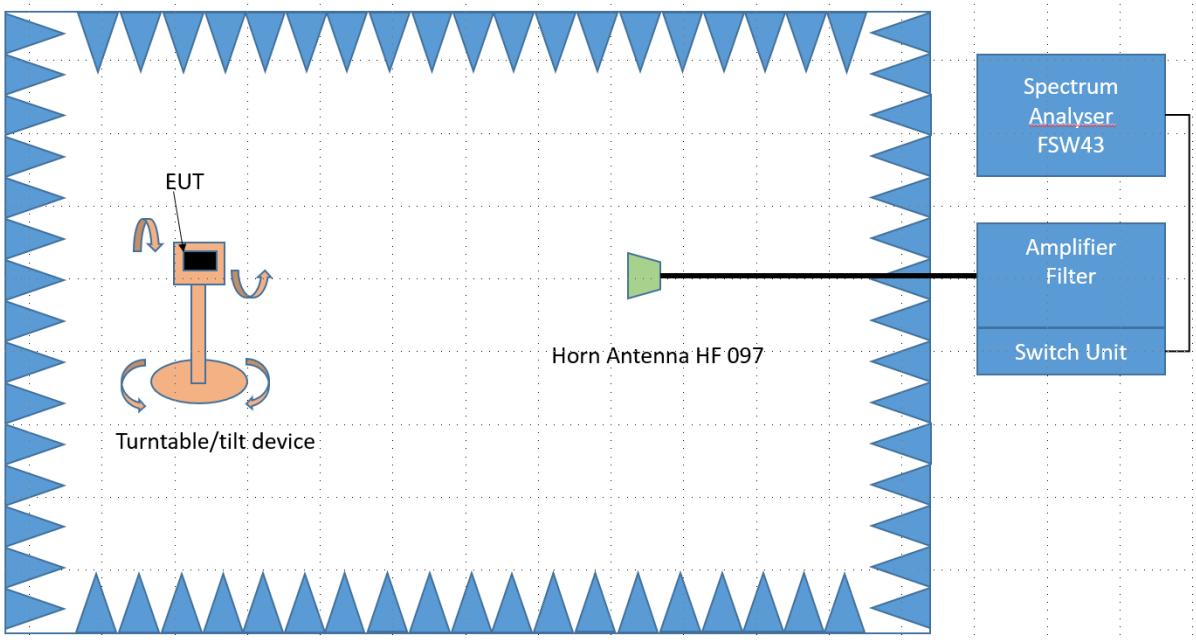
Step 3: Final measurement with QP detector
With the settings determined in step 2, the final measurement will be performed:
EMI receiver settings for step 3:
- Detector: Average
- Measured frequencies: in step 1 determined frequencies
- IF – Bandwidth: 10 MHz
- Measuring time: 1 s

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.

The calculation from the measured electrical field strength value [dBµV/m] to the E.I.R.P output value was done with the measured far field loss of the SAC at these particular frequencies.

Radiated > 1 Ghz:

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 (1.5 m) of the receiving antenna only.



Test Setup; E.I.R.P. / E.R.P. (FAC), 1 – 18 GHz

Step 1:
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 °.
Spectrum analyser settings:
- Detector: Peak, Average
- RBW = 1 MHz
- VBW = 3 MHz

Step 2:
The turn table azimuth will slowly vary by ± 22.5°.
The elevation angle will slowly vary by ± 45°
Spectrum analyser settings:
- Detector: Peak

Step 3:
Spectrum analyser settings for step 3:
- Detector: Peak / CISPR Average
- Measured frequencies: in step 1 determined frequencies
- RBW = 1 MHz
- VBW = 3 MHz
- Measuring time: 1 s

6.1.1 LIMITS: § 15.236 (D)(1),(II),(III), RSS-210 ANNEX G, G.2

Frequency Bands	Output Power (FCC) (E.I.R.P.)	Output Power (ISED) (E.I.R.P.)
470 – 608 MHz	OBW ≤ 1MHz: 50 mW [17 dBm] OBW > 1MHz: 100 mW [20 dBm]	≤ 250 mW [24 dBm]
657 -663 MHz	≤ 20 mW [13 dBm]	≤ 20 mW [13 dBm]

6.1.2 TEST CASE DETAILS:

Ambient temperature: 29 °C
Air Pressure: 1009 hPa
Humidity: 51 %

Band: 470 MHz - 608 MHz

Measurement Method	EUT Position	Frequency	Voltage	Nominal Operating Frequency [MHz]	Output Power e.i.r.p. [dBm]	Limit e.i.r.p. [dBm]	Margin to Limit [dB]
Radiated	Vertical	Low	Normal	473.000	12.6	20.0	7.4
Radiated	Horizontal	Low	Normal	473.000	13.2	20.0	6.8
Radiated	Vertical	Mid	Normal	539.000	19.3	20.0	0.7
Radiated	Horizontal	Mid	Normal	539.000	9.1	20.0	10.9
Radiated	Vertical	High	Normal	605.000	16.8	20.0	3.2
Radiated	Horizontal	High	Normal	605.000	17.3	20.0	2.7

Band (Duplex Gap): 657 MHz - 663 MHz

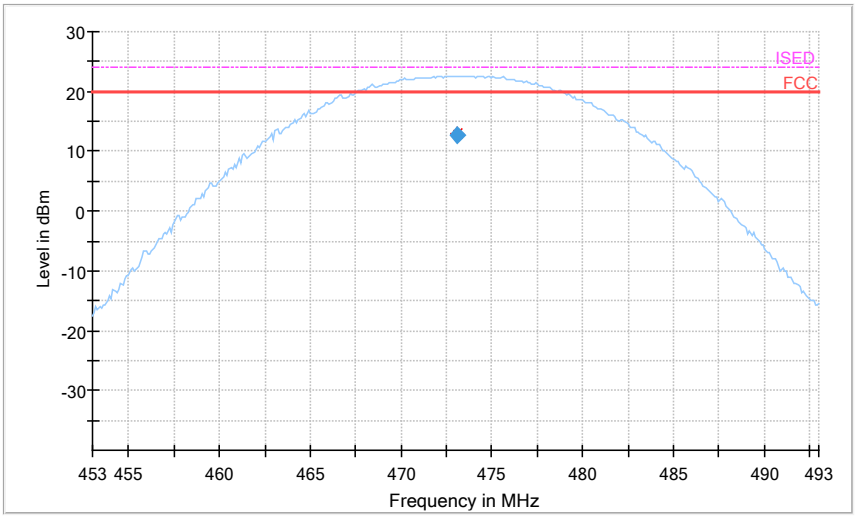
Measurement Method	EUT Position	Frequency	Voltage	Nominal Operating Frequency [MHz]	Output Power e.i.r.p. [dBm]	Limit e.i.r.p. [dBm]	Margin to Limit [dB]
Radiated	Vertical	Mid	Normal	660.000	9.5	13.0	3.5
Radiated	Horizontal	Mid	Normal	660.000	8.3	13.0	4.7

Comments:

- The measurement was performed radiated.
- TX Test Mode of the EUT used.

6.1.3 MEASUREMENT PLOTS:

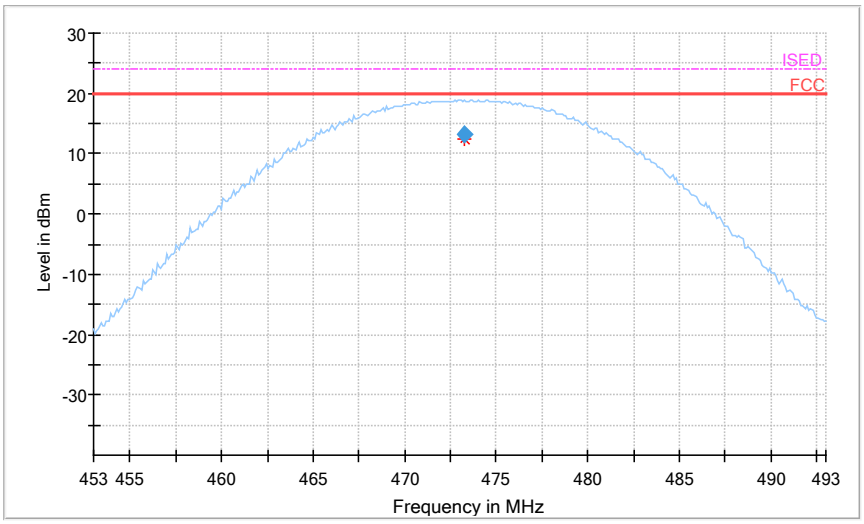
Measurement method = radiated, EUT = vertical, Operating Frequency = Low,
Radio Technology = WMAS
(S01_AD01)



Final Result

Frequency (MHz)	Average (dBm)	Limit (dBm)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
473.056250	12.62	20.00	7.03	1000.0	10000.00	107.0	V	-19.0	-81.6

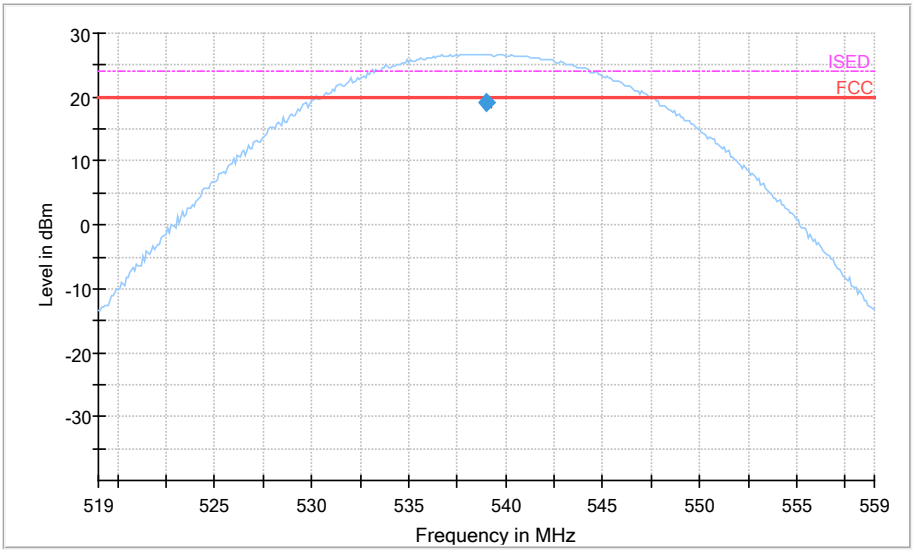
Measurement method = radiated, EUT = horizontal, Operating Frequency = Low,
Radio Technology = WMAS
(S01_AD01)



Final Result

Frequency (MHz)	Average (dBm)	Limit (dBm)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
473.268750	13.22	20.00	6.78	1000.0	10000.00	191.0	H	248.0	-81.8

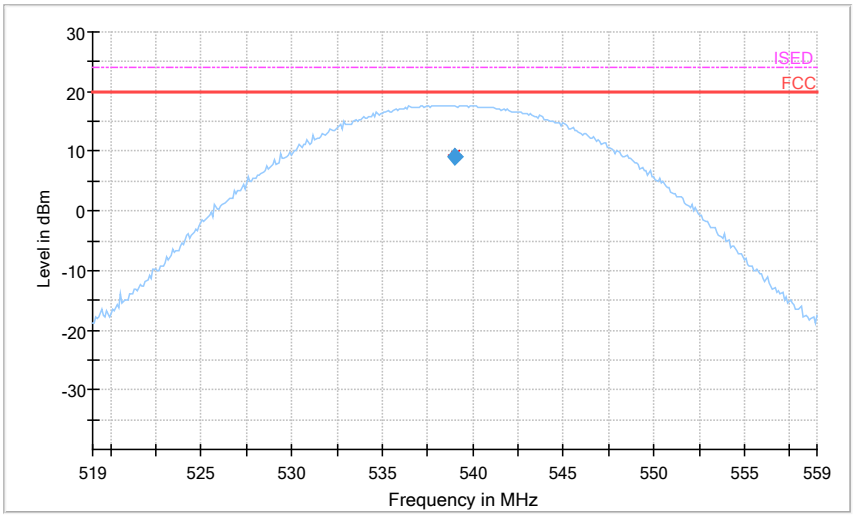
Measurement method = radiated, EUT = vertical, Operating Frequency = Mid,
Radio Technology = WMAS
(S01_AD01)



Final Result

Frequency (MHz)	Average (dBm)	Limit (dBm)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
539.037500	19.28	20.00	0.72	1000.0	10000.00	100.0	V	-12.0	-78.7

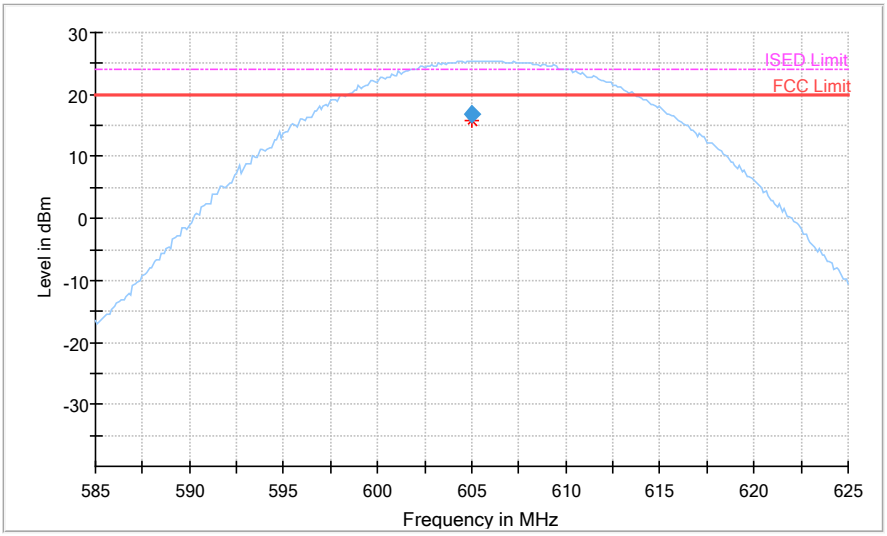
Measurement method = radiated, EUT = horizontal, Operating Frequency = Mid,
Radio Technology = WMAS
(S01_AA01)



Final Result

Frequency (MHz)	Average (dBm)	Limit (dBm)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
539.037500	9.14	20.00	10.86	1000.0	10000.00	359.0	H	251.0	-74.6

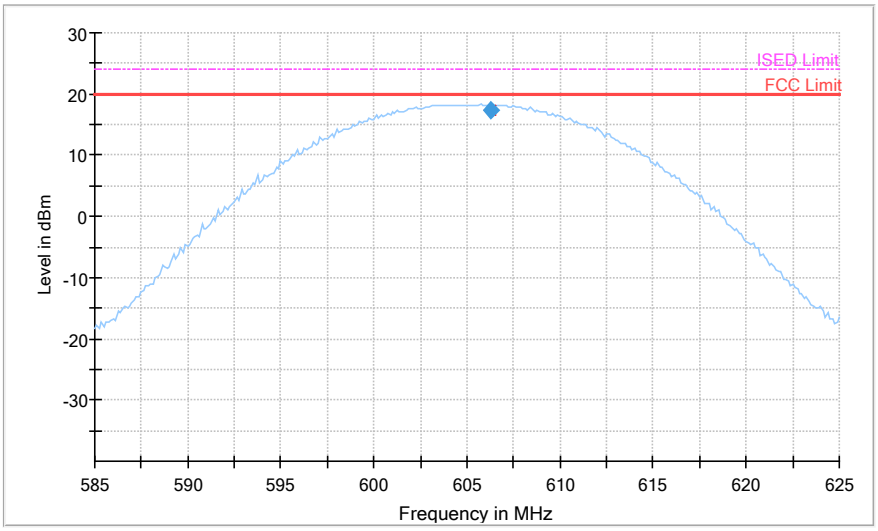
Measurement method = radiated, EUT = vertical, Operating Frequency = High,
Radio Technology = WMAS
(S01_AD01)



Final Result

Frequency (MHz)	Average (dBm)	Limit (dBm)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
605.000000	16.76	20.00	3.24	1000.0	10000.00	100.0	V	-154.0	-75.3

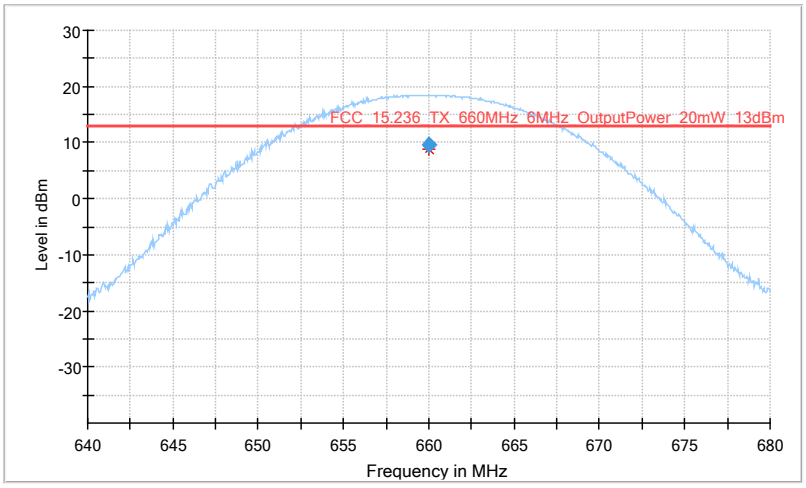
Measurement method = radiated, EUT = horizontal, Operating Frequency = High,
Radio Technology = WMAS
(S01_AA01)



Final Result

Frequency (MHz)	Average (dBm)	Limit (dBm)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
606.250000	17.26	20.00	2.74	1000.0	10000.00	143.0	H	-90.0	-75.9

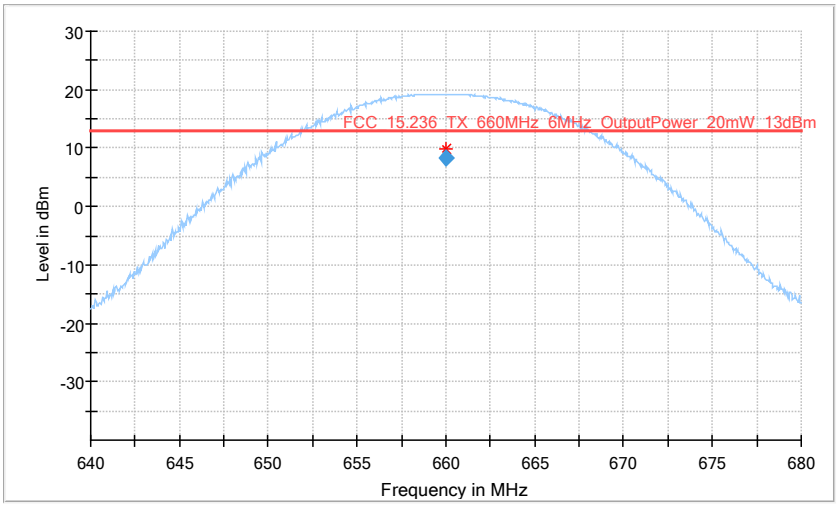
Measurement method = radiated, EUT = vertical, Operating Frequency = Mid (Duplex Gap), Radio Technology = WMAS
(S01_AA01)



Final Result

Frequency (MHz)	Average (dBm)	Limit (dBm)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
660.000000	9.51	13.00	3.49	1000.0	10000.000	161.0	V	-8.0	-74.0

Measurement method = radiated, EUT = horizontal, Operating Frequency = Mid (Duplex Gap), Radio Technology = WMAS
(S01_AA01)



Final Result

Frequency (MHz)	Average (dBm)	Limit (dBm)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
660.000000	8.33	13.00	4.67	1000.0	10000.00	160.0	V	-21.0	-74.9

TEST EQUIPMENT USED:

- Radiated Emissions SAC < 1GHz

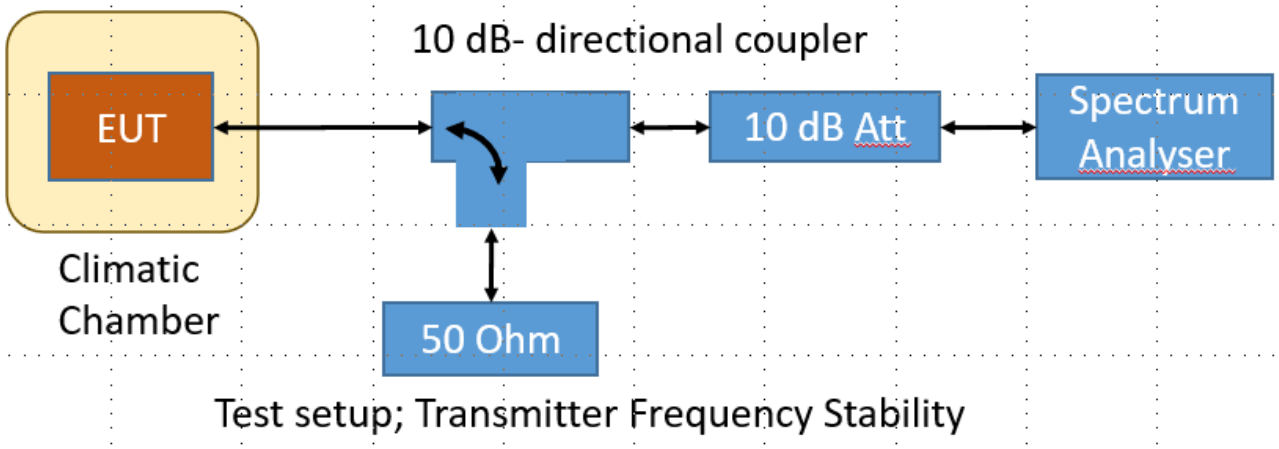
6.2 TRANSMITTER FREQUENCY STABILITY

RSS-210, Annex G, G.4

Test case performed according: RSS-GEN, Chapter 6.11

Definition:
The Declared Centre Frequency (fc) is the centre of the Operating Channel. Transmitter Frequency Stability is a measurement of the transmitter frequency error determined by the positive or negative difference between the declared centre frequency and the actual centre frequency of the device.

Test Setup:
The test was performed with the following setup:



Test setup; Transmitter Frequency Stability

6.2.1 LIMITS: LIMITS: § 15.236 (F)(2) RSS-210, ANNEX G, G.4

§ 15.236

The frequency stability for WMAS shall be sufficient to ensure that the authorized bandwidth stays within the TV channel (6 MHz)

RSS-210

The frequency stability for WMAS shall be sufficient to ensure that the authorized bandwidth stays within the TV channel (6 MHz) when tested to the temperature and supply voltage variations specified in RSS-Gen.

6.2.2 TEST CASE DETAILS:

Ambient temperature: 26 °C
Air Pressure: 1014 hPa
Humidity: 62 %

Band; 470 MHz - 608 MHz						
Frequency	**Temperature [°C]**	**Voltage**	**Nominal Operating Frequency [MHz]**	**Stays in Channel**	**Measured Operating Frequency [MHz]**	**Delta f [kHz]**
Mid	20	Normal	539.000	YES	538.9995359	-0.46
Mid	20	Low	539.000	YES	538.9995641	-0.44
Mid	20	High	539.000	YES	538.9995722	-0.43
Mid	-30	Normal	539.000	YES	538.9997822	-0.22
Mid	50	Normal	539.000	YES	538.9996491	-0.35

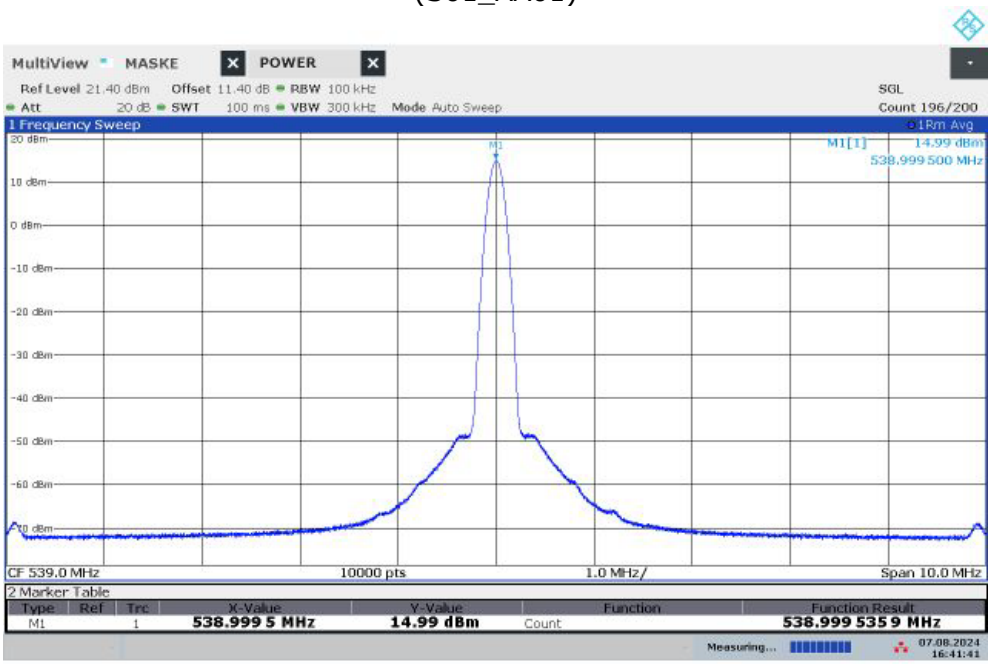
Band; 657 MHz - 663 MHz						
Frequency	**Temperature [°C]**	**Voltage**	**Nominal Operating Frequency [MHz]**	**Stays in Channel**	**Measured Operating Frequency [MHz]**	**Delta f [kHz]**
Mid	20	Normal	660.000	YES	659.9994979	0.50
Mid	20	Low	660.000	YES	659.9994835	0.52
Mid	20	High	660.000	YES	659.9994925	0.51
Mid	-30	Normal	660.000	YES	659.9997429	0.26
Mid	50	Normal	660.000	YES	659.9995652	0.43

Comments:

- The measurement was performed conducted.
- TX-CW Test Mode of the EUT used.
- Low voltage = 3.23 V (according to RSS-GEN)
- High voltage = 4.37 V (according to RSS-GEN)
- The verdict "Stays in Channel" is given, because the measured frequency deviation is much smaller than the difference of the 99% OBW lower and upper frequency to the channel border frequencies.

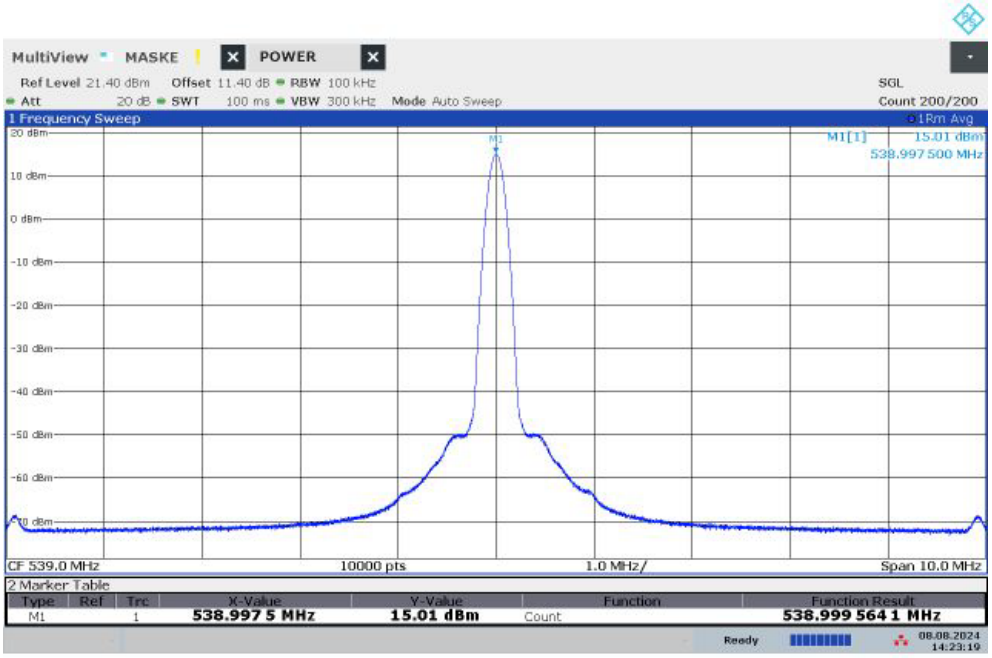
6.2.3 MEASUREMENT PLOTS:

Temperature = Normal, Voltage = Normal, Operating Frequency = Mid, (S01_AA01)



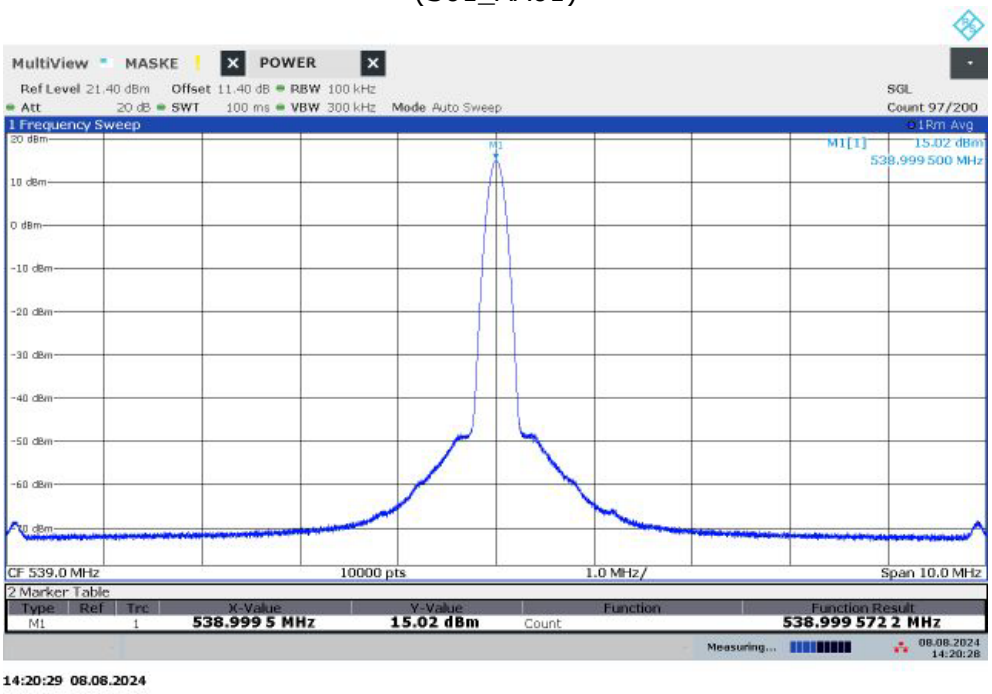
16:41:41 07.08.2024

Temperature = Normal, Voltage = Low, Operating Frequency = Mid (S01_AA01)

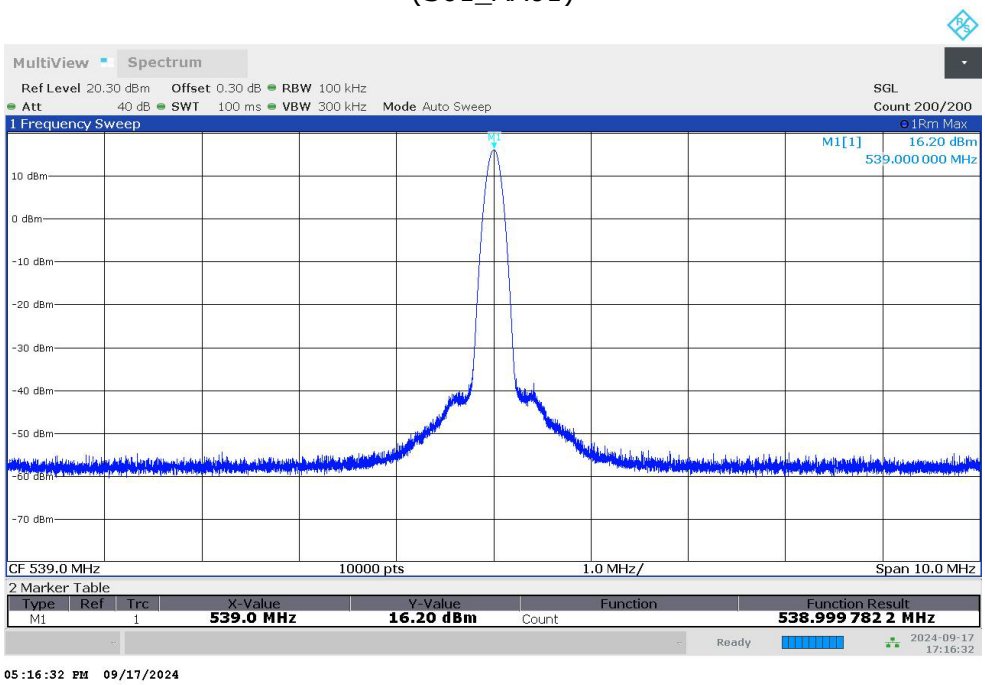


14:23:19 08.08.2024

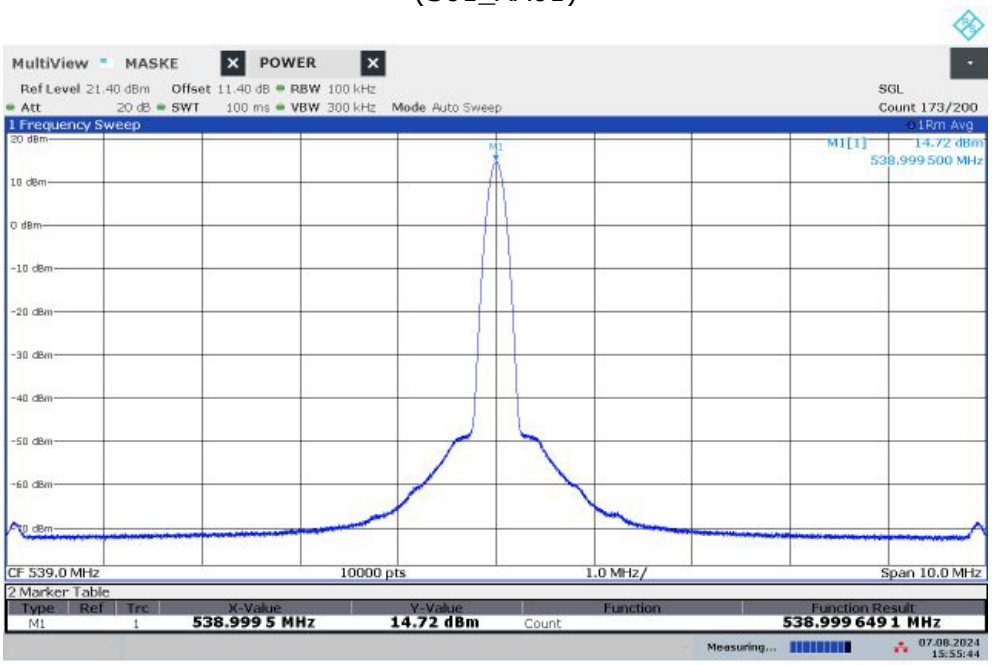
Temperature = Normal, Voltage = High, Operating Frequency = Mid (S01_AA01)



Temperature = Low, Voltage = Normal, Operating Frequency = Mid (S01_AA01)

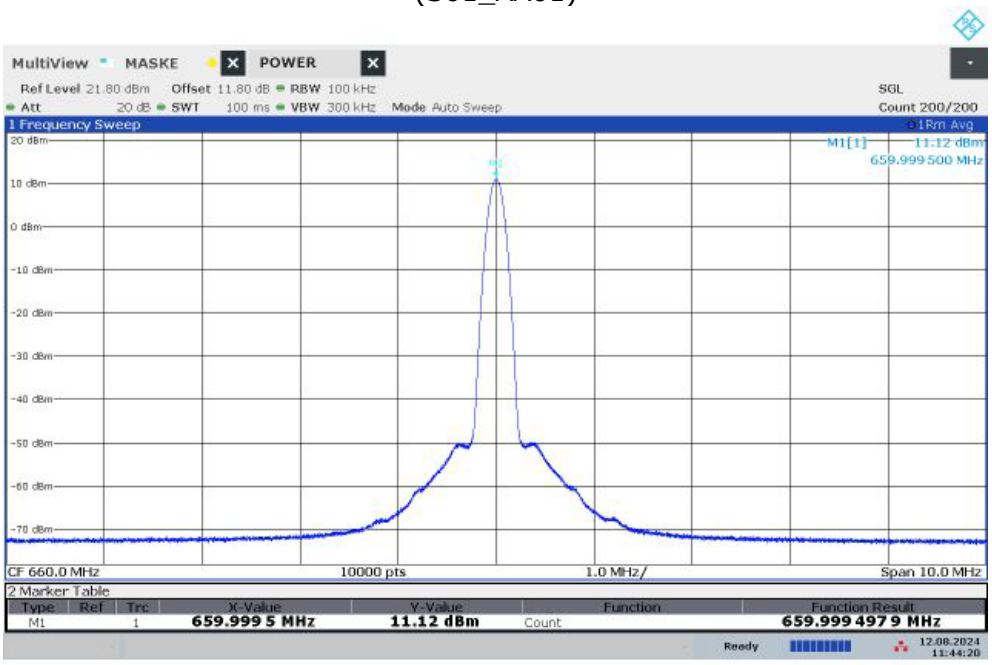


Temperature = High, Voltage = Normal, Operating Frequency = Mid (S01_AA01)



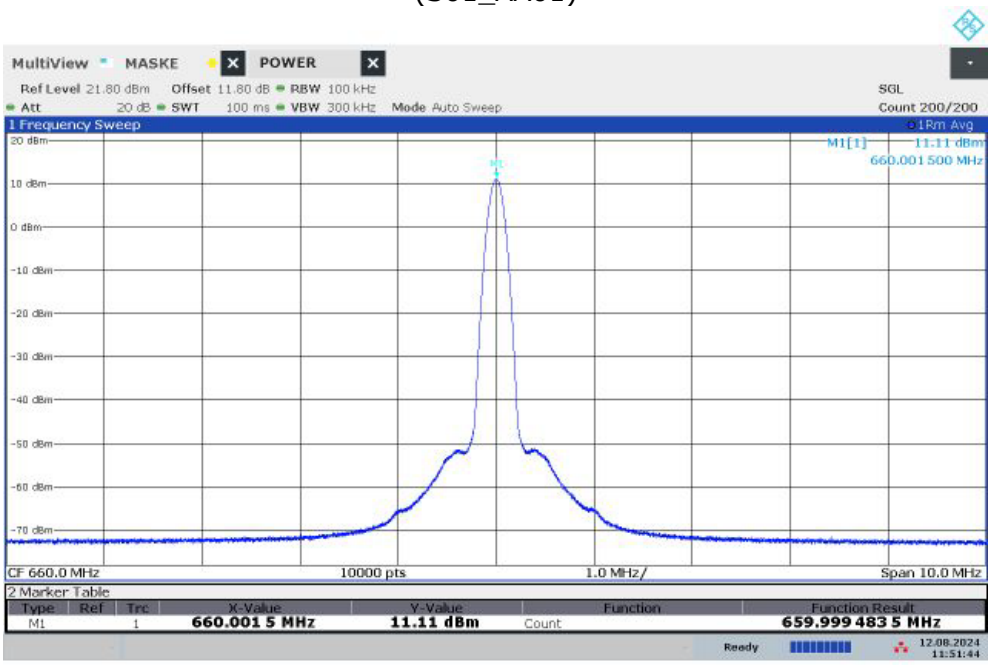
15:55:44 07.08.2024

Temperature = Normal, Voltage = Normal, Operating Frequency = Mid (Duplex Gap), (S01_AA01)



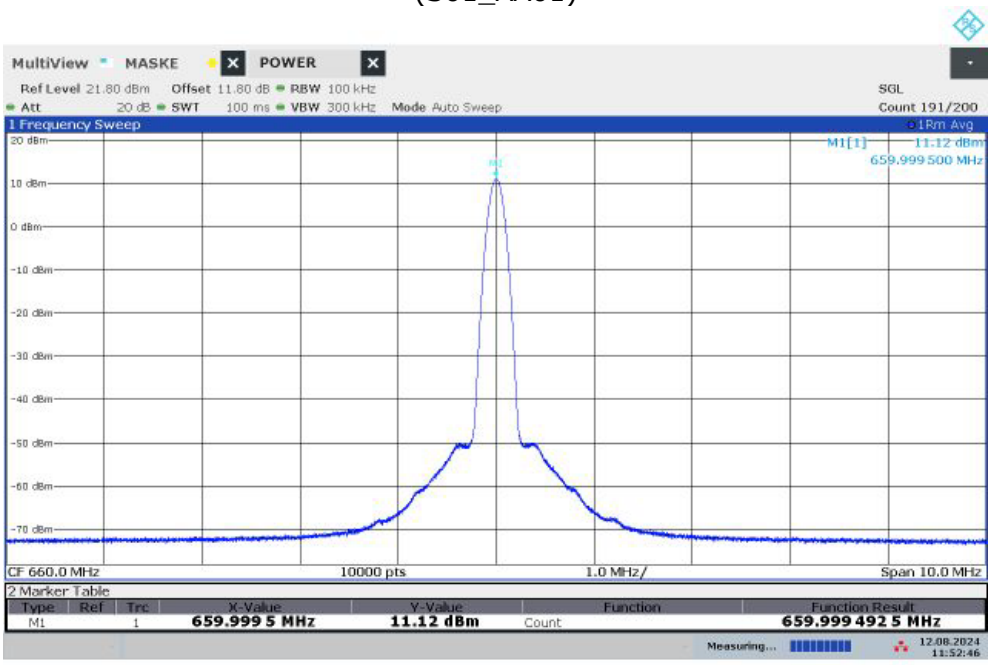
11:44:21 12.08.2024

Temperature = Normal, Voltage = Low, Operating Frequency = Mid (Duplex Gap) (S01_AA01)



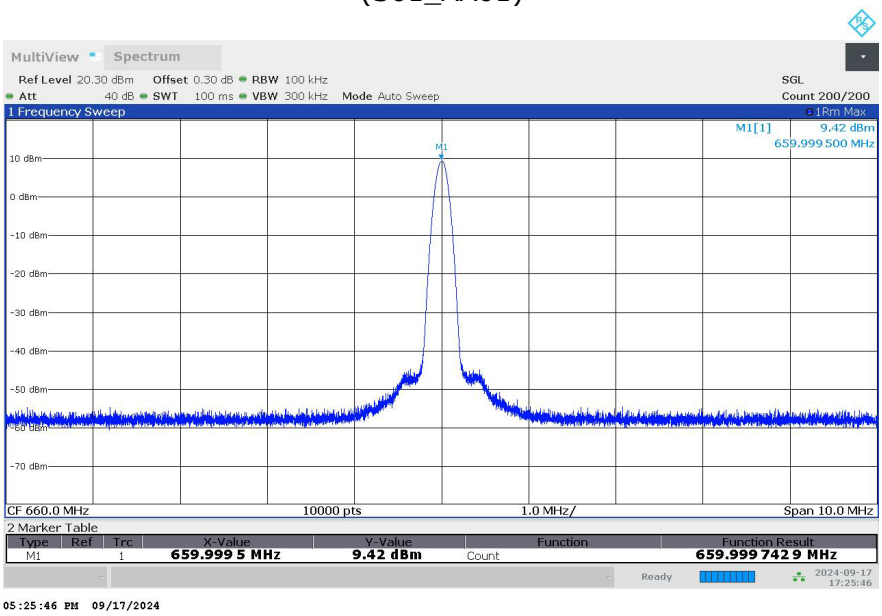
11:51:45 12.08.2024

Temperature = Normal, Voltage = High, Operating Frequency = Mid (Duplex Gap) (S01_AA01)

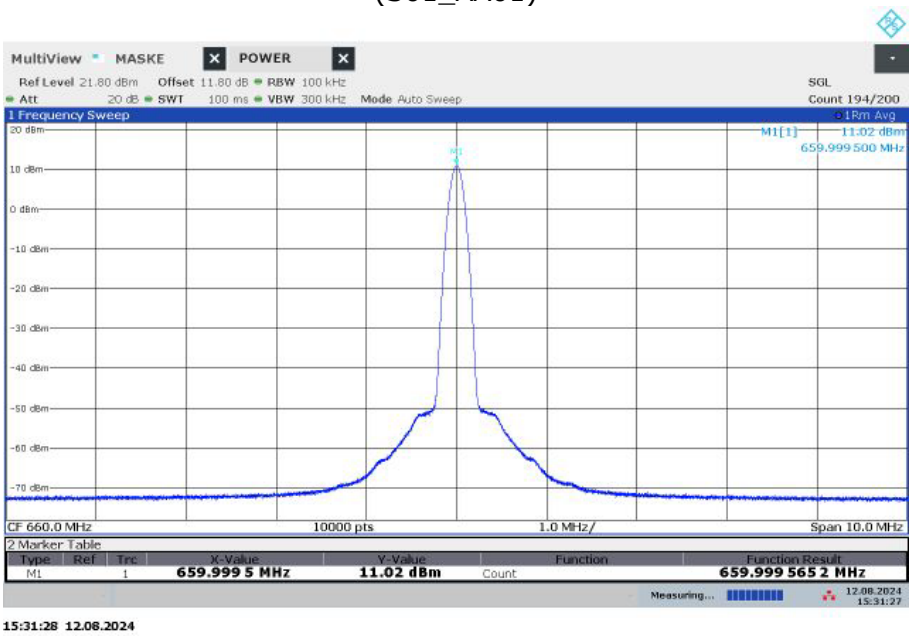


11:52:47 12.08.2024

Temperature = Low, Voltage = Normal, Operating Frequency = Mid (Duplex Gap) (S01_AA01)



Temperature = High, Voltage = Normal, Operating Frequency = Mid (Duplex Gap) (S01_AA01)



TEST EQUIPMENT USED:
Radio Lab

6.3 OCCUPIED BANDWIDTH §15.236 (d)(2)

Test case performed according: ANSI C63.10, Clause 6.9.3

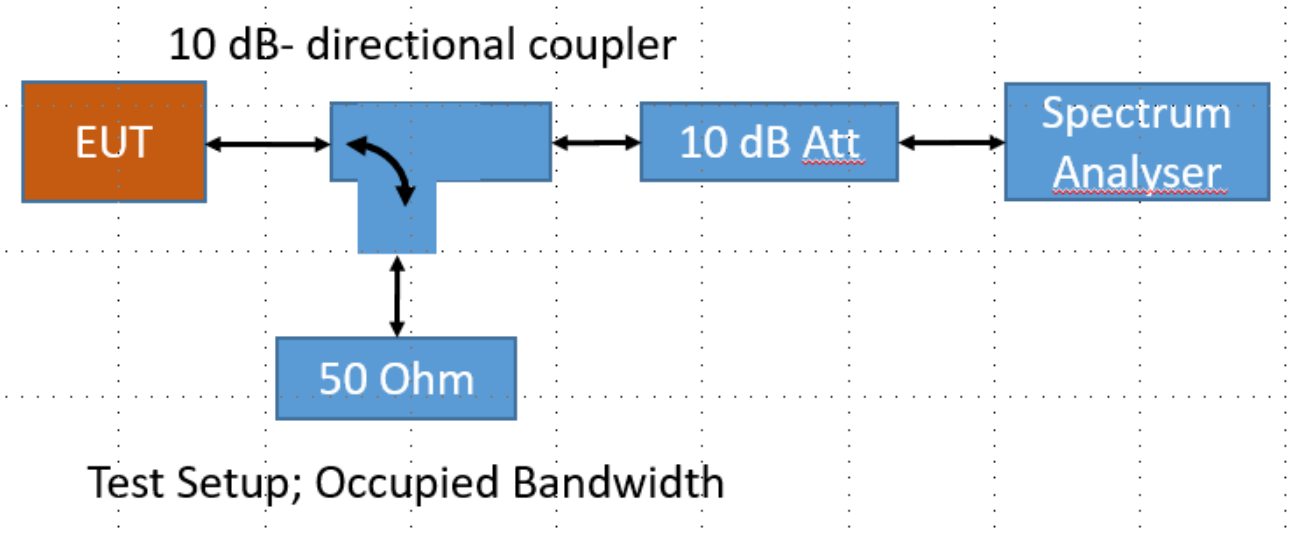
Definition:
The reference level is the level of the highest amplitude signal observed from the transmitter at either the fundamental frequency or first-order modulation products in all typical modes of operation, including the unmodulated carrier, even if atypical.
The results recorded were measured with the modulation which produce the worst-case (widest) emission bandwidth.

Analyzer settings:

- Resolution Bandwidth (RBW): approx. ≥ 1 % of the span, but not below
- Video Bandwidth (VBW): ≥ 3 times the RBW
- Span: 30 Mhz
- Trace: Maxhold
- Sweeps: allow the trace to stabilize
- Sweeptime: 1 ms
- Detector: Peak

The 99 % measurement function of the spectrum analyser function was used to determine the 99 % bandwidth.

Test Setup:
The test was performed with the following setup:



Test Setup; Occupied Bandwidth

6.3.1 LIMITS: §15.236 (D),(2)
RSS-210, ANNEX G, G.3

Occupied Bandwidth

§15.236 (d),(2)	RSS-210, Annex G, G.3
≤ 6 MHz	< 6 MHz

Audio channels

§15.236 (d),(2)	RSS-210, Annex G, G.3
≥ 3 / MHz	≥ 3 / MHz

6.3.2 TEST CASE DETAILS:

Ambient temperature: 26 °C
Air Pressure: 1014 hPa
Humidity: 62 %

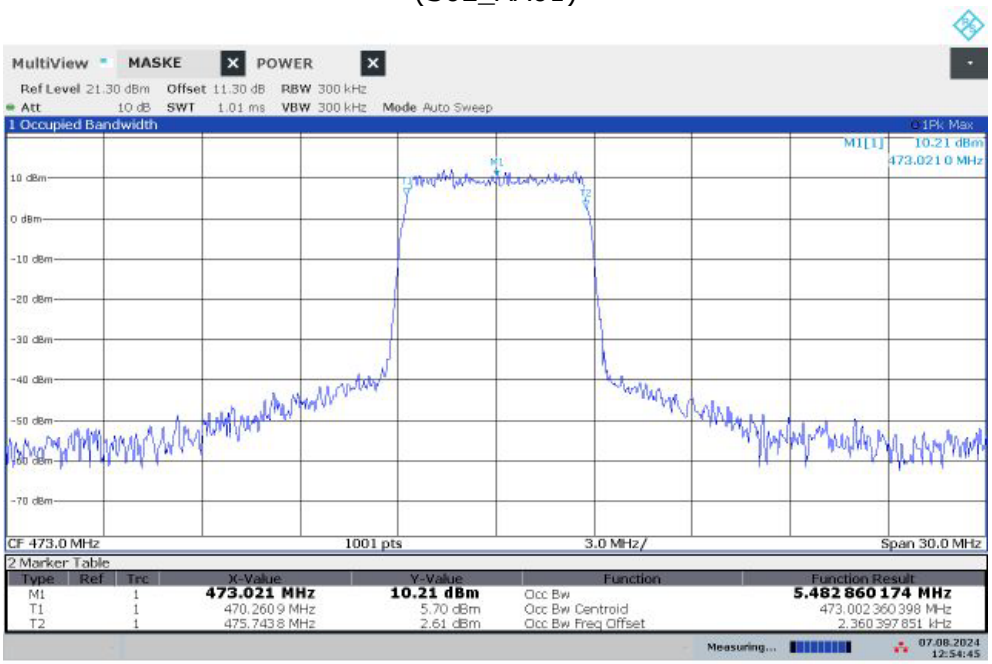
Band: 470 MHz - 608 MHz						
Frequency	**Nominal Operating Frequency [MHz]**	**Lower 99% Frequency [MHz]**	**Upper 99% Frequency [MHz]**	**OCW [kHz]**	**Limit OCB [kHz]**	**Margin to Limit [kHz]**
Low	473.000	470.2609	475.7438	5482.9000	6000.0000	517.1000
Mid	539.000	536.2346	541.7346	5500.0000	6000.0000	500.0000
High	605.000	602.2338	607.7591	5525.3000	6000.0000	474.7000

Band: 657 MHz - 663 MHz						
Frequency	**Nominal Operating Frequency [MHz]**	**Lower 99% Frequency [MHz]**	**Upper 99% Frequency [MHz]**	**OCW [kHz]**	**Limit OCB [kHz]**	**Margin to Limit [kHz]**
Mid	660.000	657.2400	662.7423	5502.3000	6000.0000	497.7000

Comments:
- The measurement was performed conducted.

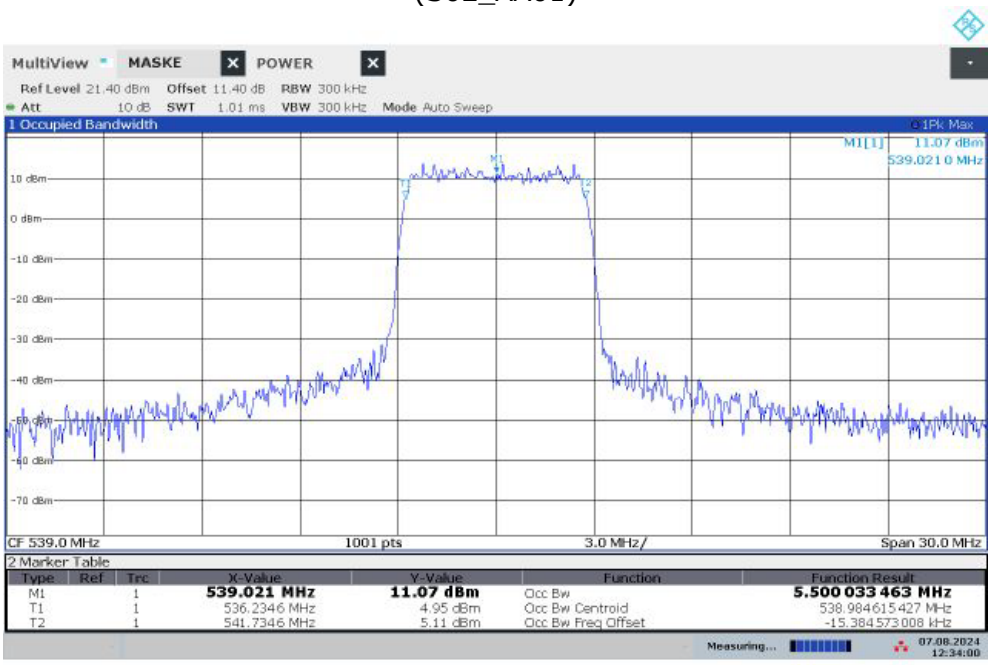
6.3.3 MEASUREMENT PLOTS:

Operating Frequency = Low, Radio Technology = WMAS (S02_AA01)



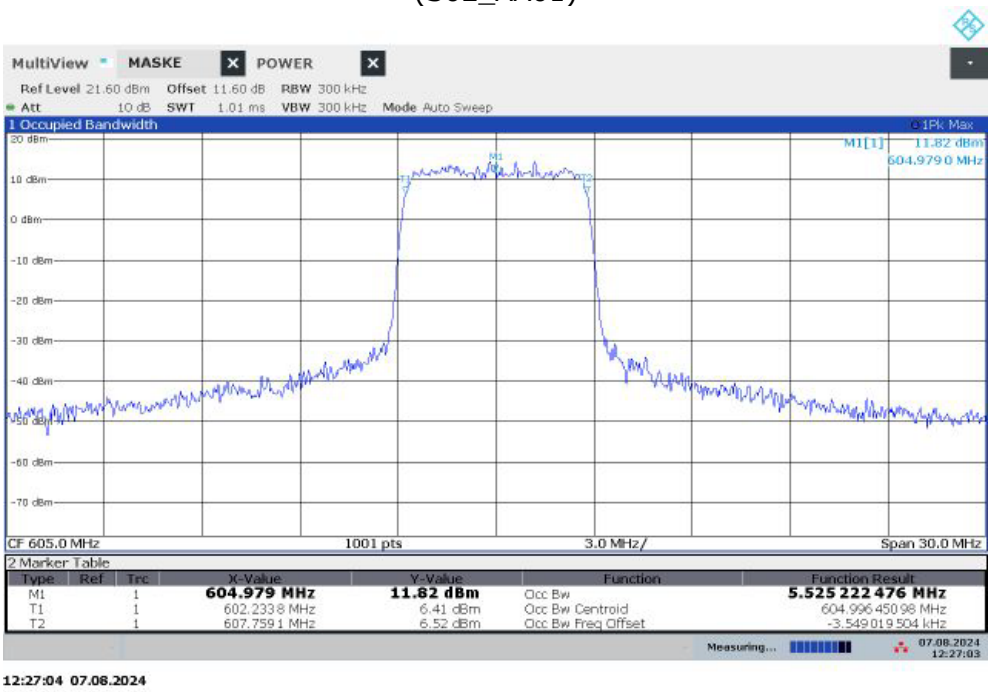
12:54:45 07.08.2024

Operating Frequency = Mid, Radio Technology = WMAS (S02_AA01)



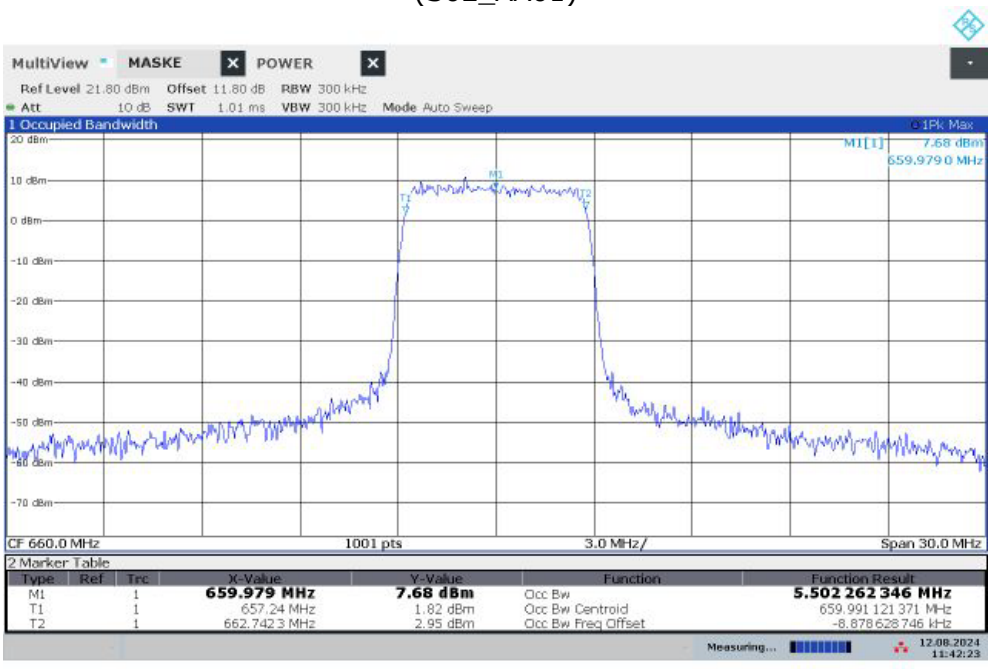
12:34:00 07.08.2024

Operating Frequency = High, Radio Technology = WMAS (S02_AA01)



12:27:04 07.08.2024

Operating Frequency = Mid (Duplex Gap), Radio Technology = WMAS (S02_AA01)



11:42:24 12.08.2024

TEST EQUIPMENT USED:

- Radio Lab

6.4 TRANSMITTER UNWANTED EMISSIONS IN THE SPURIOUS DOMAIN **§15.236 (g)(4)**

The test was performed according to:
ANSI C63.10, chapter 6.4, 6.5, 6.6.5

6.4.1 TEST DESCRIPTION

The test set-up was made in accordance with the general provisions of ANSI C63.10 in a typical installation configuration. The measurements were performed according to the following sub-chapters of ANSI C63.10:

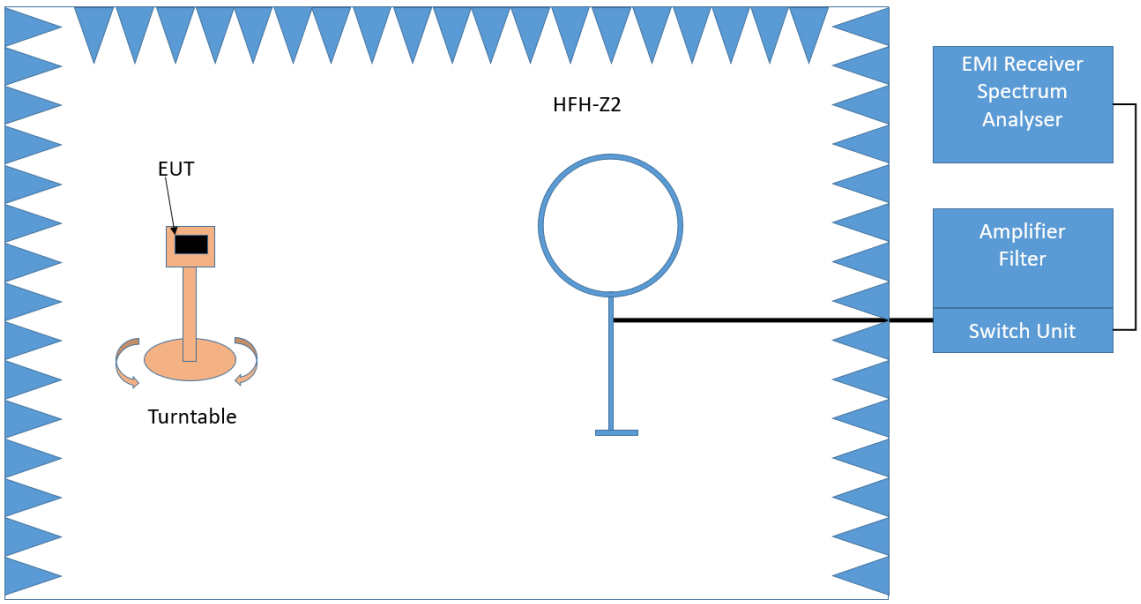
- < 30 MHz: Chapter 6.4
- 30 MHz – 1 GHz: Chapter 6.5
- > 1 GHZ: Chapter 6.6 (procedure according 6.6.5 used)

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.

Below 1 GHz:

The Equipment Under Test (EUT) was set up on a non-conductive table in the semi-anechoic chamber. The influence of the EUT support table that is used between 30–1000 MHz was evaluated.

1. Measurement up to 30 MHz



Test Setup; Spurious Emission Radiated (SAC), 9 kHz – 30 MHz

The Loop antenna HFH2-Z2 is used.

Step 1: pre measurement

- Anechoic chamber
- Antenna distance: 3 m
- Antenna height: 1 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)

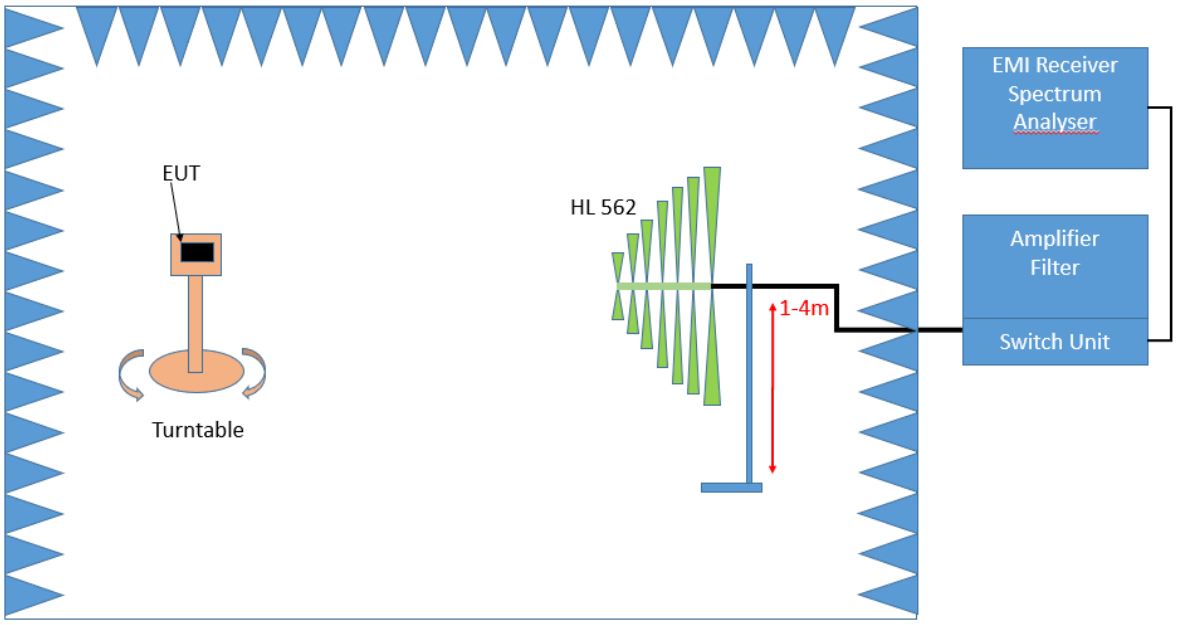
Intention of this step is, to determine the radiated EMI-profile of the EUT. Afterwards the relevant emissions for the final measurement are identified.

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.

- Detector: Quasi-Peak (9 kHz – 150 kHz, Peak / Average 150 kHz- 30 MHz)
- 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



Test Setup; Spurious Emission Radiated (SAC), 30 MHz- 1GHz

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
- Frequency range: 30 – 1000 MHz
- RBW: 100 kHz
- VBW: 300 kHz
- Sweep time: 10 s
- Turntable angle range: –180° to 90°
- Turntable step size: 90°
- Height variation range: 1 – 4 m
- Height variation step size: 1.5 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 360°. 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 between 1 – 4 meter. 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
- RBW: 100 kHz
- VBW: 300 kHz
- Sweep time: 100 ms
- Turntable angle range: 360 °
- Height variation range:1 – 4 m
- Antenna Polarisation: max. value determined in step 1

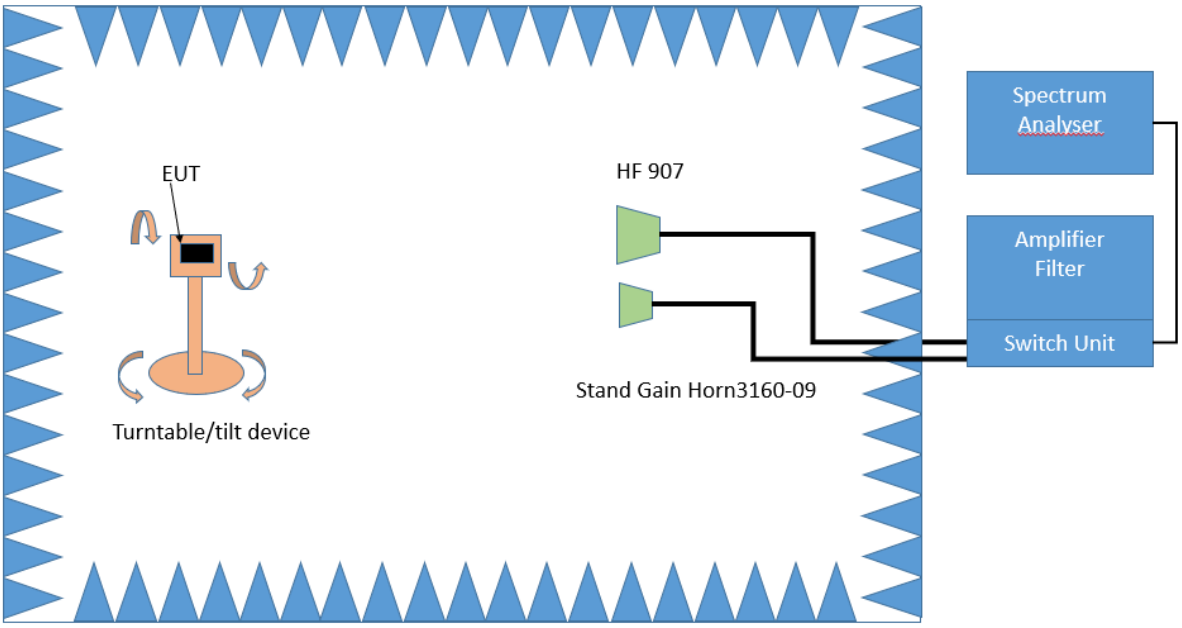
Step 3: Final measurement with RMS detector
With the settings determined in step 2, the final measurement will be performed:
EMI receiver settings for step 3:
- Detector: RMS
- Measured frequencies: in step 1 determined frequencies
- RBW: 100 kHz
- VBW = 300 kHz
- Sweep time: 1 s

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.

Above 1 GHz:

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 (1.5 m) of the receiving antenna only.

3. Measurement above 1 GHz



Test Setup; Spurious Emission Radiated (FAC), 1 GHz-26.5 GHz

Step 1:
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 °.
Spectrum analyser settings:
- Detector: RMS
- RBW = 1 MHz
- VBW = 3 MHz

Step 2:
The turn table azimuth will slowly vary by ± 22.5°.
The elevation angle will slowly vary by ± 45°
Spectrum analyser settings:
- Detector: Peak

Step 3:
Spectrum analyser settings for step 3:
- Detector: RMS / CISPR Average
- Measured frequencies: in step 1 determined frequencies
- RBW = 1 MHz
- VBW = 3 MHz
- Measuring time: 1 s

6.4.2 LIMITS: EN 300 422-1, CLAUSE 4.2.4.1.2

Frequency range	**Maximum power, e.r.p. (≤ 1 GHz) e.i.r.p. (> 1 GHz)**	**Bandwidth**
9 kHz – 150 kHz	–36 dBm	1 kHz
150 kHz – 30 MHz	–36 dBm	10 kHz
30 MHz to 1 GHz	–36 dBm	Fc + 2,5 B ≤ f ≤ fc + 4 B: 1 kHz Fc + 4 B < f ≤ fc + 10 B: 10 kHz f > fc + 10 B: 100 kHz f < fc - 10 B: 100 kHz fc - 10 B ≤ f < fc - 4 B: 10 kHz fc - 4 B ≤ f ≤ fc - 2,5 B: 1 kHz
Except:		
47 MHz to 74 MHz 87.5 MHz to 118 MHz	–54 dBm	100 kHz
174 MHz to 230 MHz 470 MHz to 862 MHz	–54 dBm	Fc + 2,5 B ≤ f ≤ fc + 4 B: 1 kHz Fc + 4 B < f ≤ fc + 10 B: 10 kHz f > fc + 10 B: 100 kHz f < fc - 10 B: 100 kHz fc - 10 B ≤ f < fc - 4 B: 10 kHz fc - 4 B ≤ f ≤ fc - 2,5 B: 1 kHz
1 GHz < f ≤ F_{upper}	–30 dBm	Fc + 2,5 B ≤ f ≤ fc + 10 B: 30 kHz Fc + 10 B < f ≤ fc + 12 B: 300 kHz f > fc + 12 B: 1 MHz f < fc - 12 B: 1 MHz fc - 12 B ≤ f < fc - 10 B: 300 kHz fc - 10 B ≤ f ≤ fc - 2,5 B: 30 kHz

Table: Frequency range for measurement of unwanted emissions (from ERC Recommendation 74-01 [2])

Applicable fundamental Frequency range	**Frequency range for measurements**	
	Lower frequency	**Upper frequency**
9 kHz – 100 MHz	9 kHZ	1 GHz
100 MHz – 300 MHz	9 kHz	10th harmonics of the operating frequency
300 MHz - 600 MHz	30 MHz	3 GHz
600 MHz – 3 GHz	30 MHz	5th harmonics of the operating frequency

6.4.3 TEST CASE DETAILS:

Ambient temperature: 26-31°C
Air Pressure: 1000 -1009 hPa
Humidity: 40 – 49 %

Band: 470 MHz - 608 MHz					
Operating Mode: TX-On, Low channel					
Measurement Method	**Frequency [MHz]**	**Spurious Level RMS [dBm]**	**RBW [kHz]**	**Limit [dBm]**	**Margin to Limit [dB]**
Radiated	946.1616	-53.8	100	-36.0	17.8

Band: 470 MHz - 608 MHz					
Operating Mode: TX-On, Mid channel					
Measurement Method	**Frequency [MHz]**	**Spurious Level RMS [dBm]**	**RBW [kHz]**	**Limit [dBm]**	**Margin to Limit [dB]**
Radiated	1616.200	-49.8	1000	-30.0	19.8

Band: 470 MHz - 608 MHz					
Operating Mode: TX-On, High channel					
Measurement Method	**Frequency [MHz]**	**Spurious Level RMS [dBm]**	**RBW [kHz]**	**Limit [dBm]**	**Margin to Limit [dB]**
Radiated	536.3480	-62.2	100	-54.0	8.2
Radiated	1814.2000	-45.0	1000	-30.0	15.0

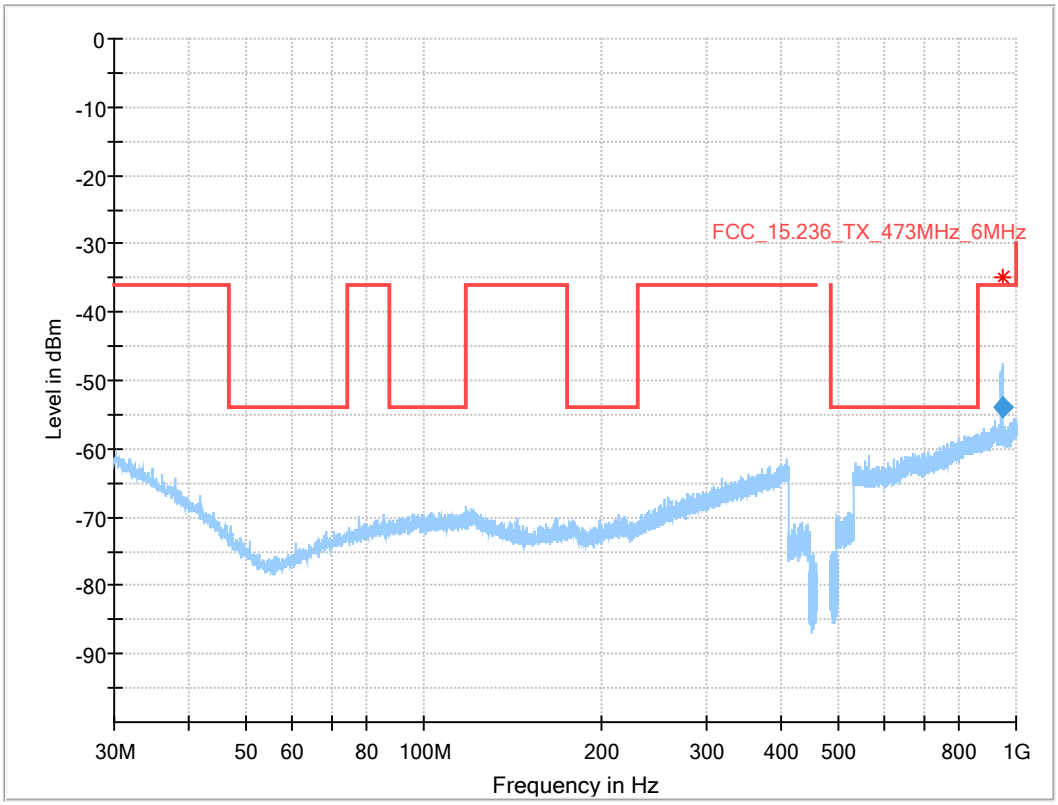
Band: 657 MHz - 663 MHz					
Operating Mode: TX-On, Mid channel					
Measurement Method	**Frequency [MHz]**	**Spurious Level RMS [dBm]**	**RBW [kHz]**	**Limit [dBm]**	**Margin to Limit [dB]**
Radiated	1978.900	-49.2	1000	-30.0	19.2

Comments:

- Tested frequency range: 30 MHz – 7 GHz.
- The measurement was performed with maximum output power.
- TX - Test mode used.

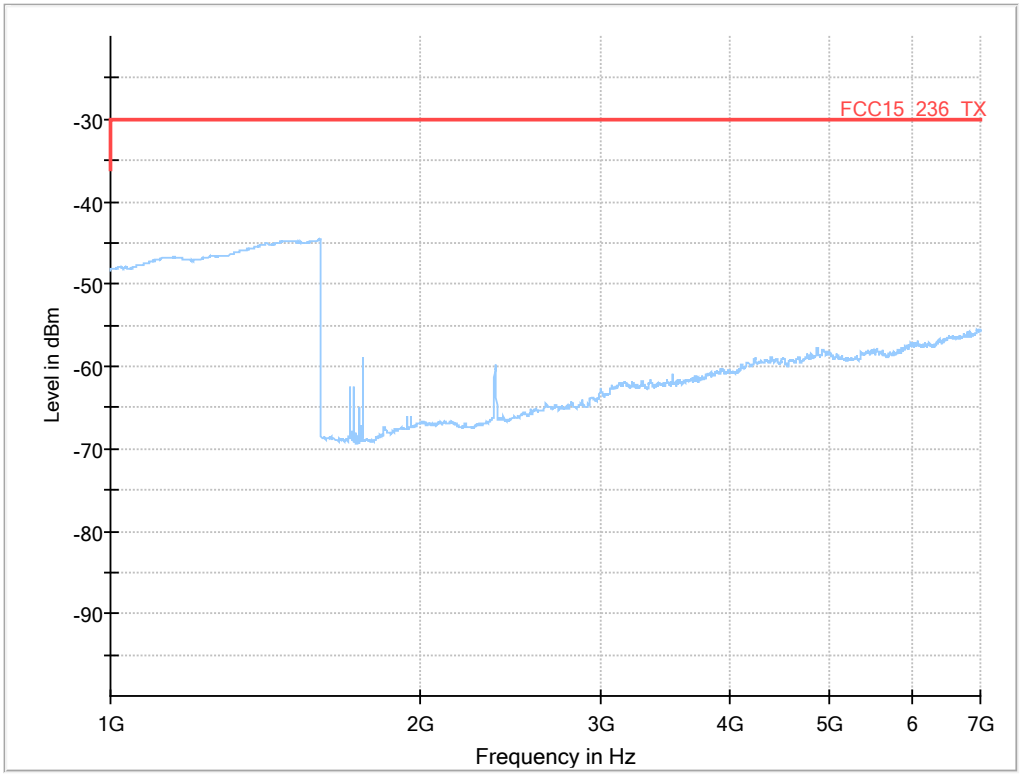
6.4.4 MEASUREMENT PLOTS:

Measurement method = radiated, Temperature = Normal, Operating Frequency = Low, Radio Technology = WMAS
(S01_AC01)



Final Result

Frequency (MHz)	RMS (dBm)	Limit (dBm)	Margin	Meas. Time (ms)	Bandwidth	Height	Pol	Azimuth	Corr. (dB)
946.161571	-53.82	-36.00	17.82	1000.0	100.000	102.0	V	127.0	-68.9



Final Result

Frequency (MHz)	RMS (dBm)	Limit (dBm	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Elevation	Corr. (dB)
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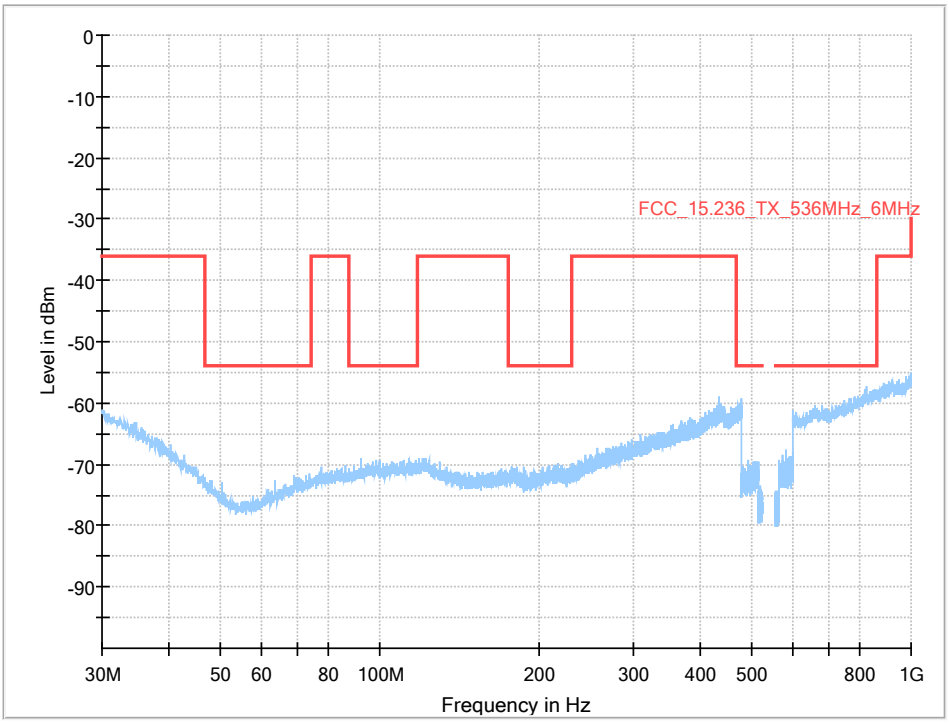
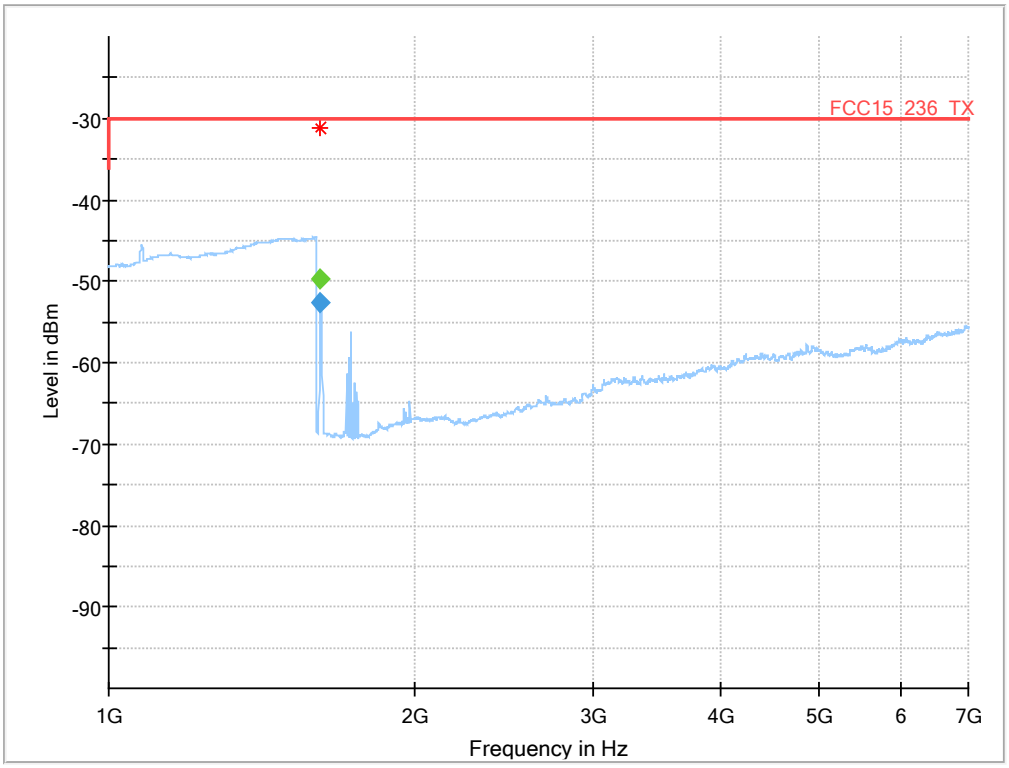
Measurement method = radiated, Temperature = Normal, Operating Frequency = Mid, Radio Technology = WMAS
(S01_AC01)



Final Result

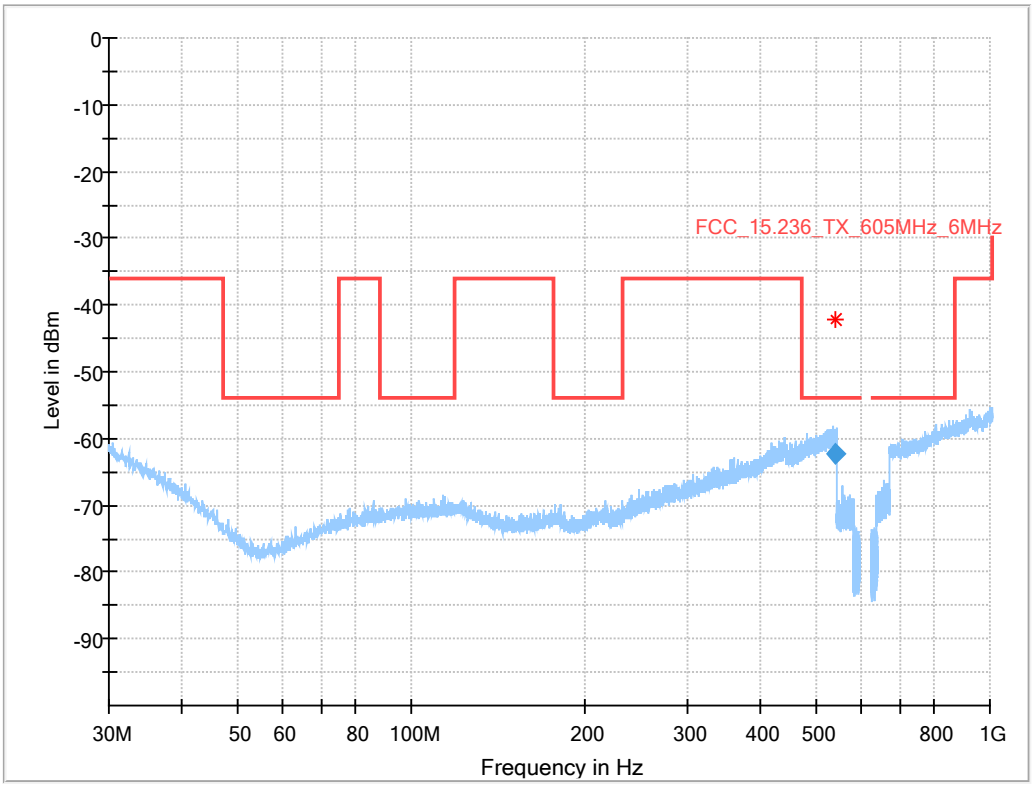
Frequency (MHz)	RMS (dBm)	Limit (dBm)	Margin	Meas. Time (ms)	Bandwidth	Height	Pol	Azimuth	Corr. (dB)
---	---	---	---	---	---	---		---	---



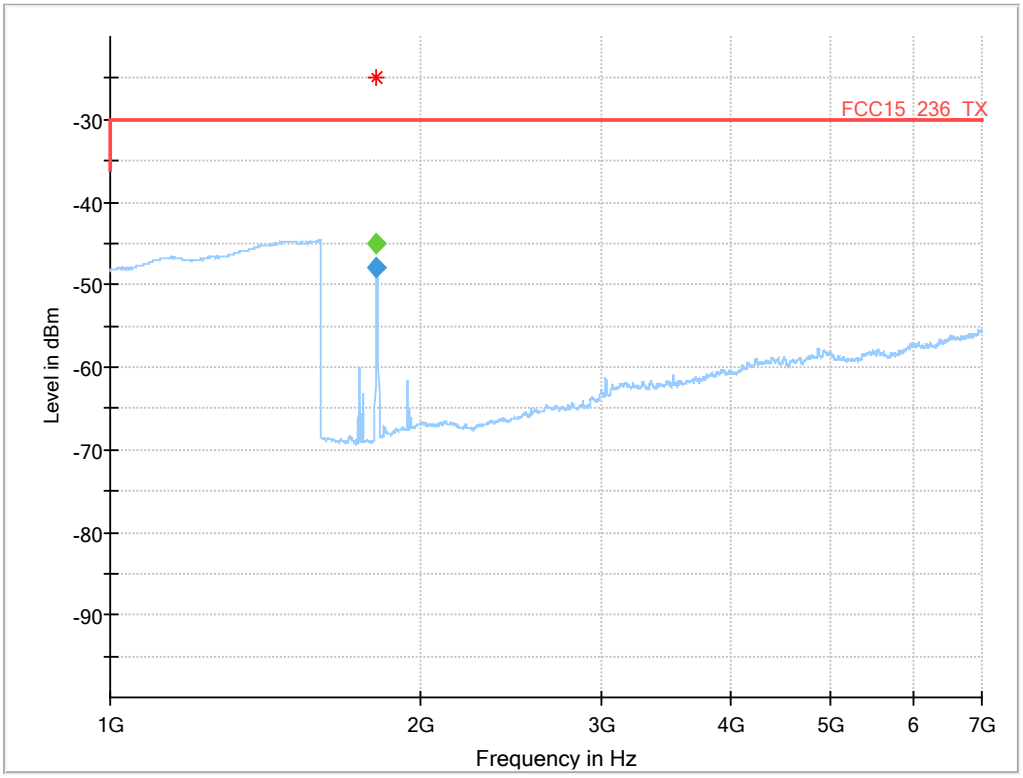
Final Result

Frequency (MHz)	CAverage (dBm)	RMS (dBm	Limit (dBm)	Margin (dB)	Meas. Time (ms)	Bandwidth	Height (cm)	Pol	Azimuth	Elevation (deg)	Corr. (dB)
1616.200	-52.7	---	-30.00	22.72	1000.0	1000.000	150.0	H	-18.0	-13.0	-100.5
1616.200	---	-49.8	-30.00	19.84	1000.0	1000.000	150.0	H	-18.0	-13.0	-100.5

Measurement method = radiated, Temperature = Normal, Operating Frequency = high, Radio Technology = WMAS
(S01_AC01)



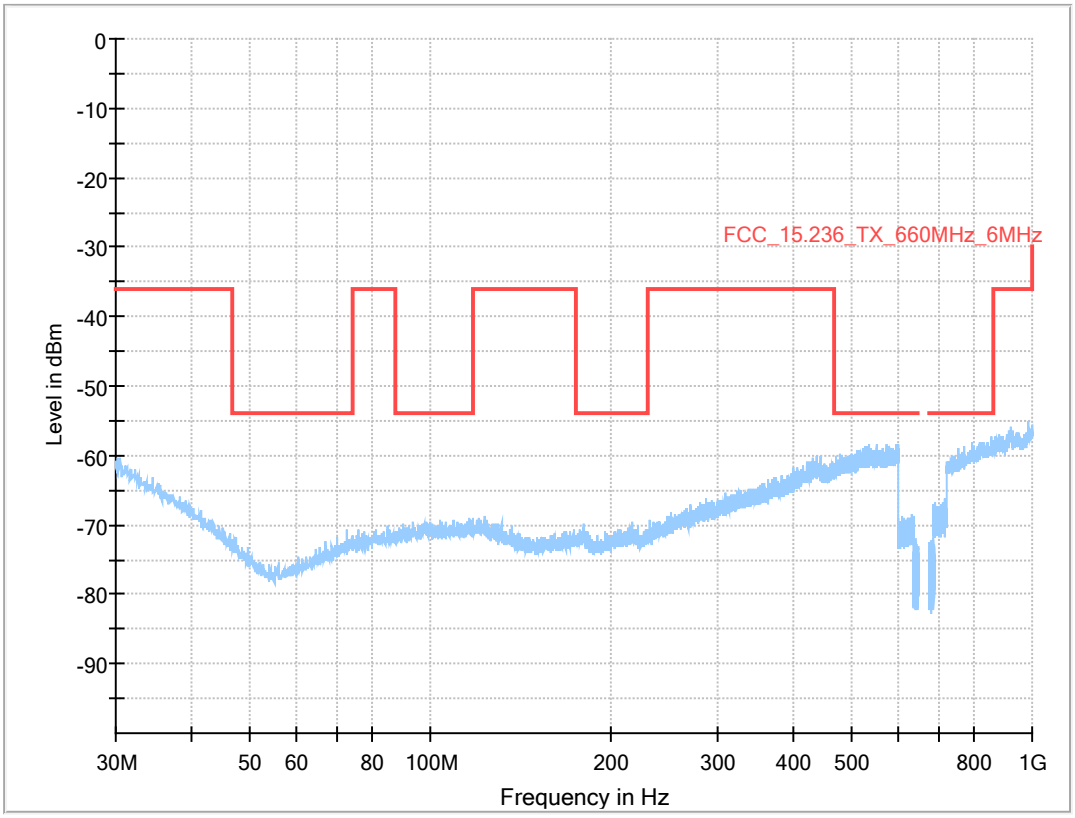
Frequency (MHz)	RMS (dBm)	Limit (dBm)	Margin (dB)	Meas. Time	Bandwidth (kHz)	Height (cm)	Pol	Azimuth	Corr. (dB)
536.348000	-62.16	-54.00	8.16	1000.0	100.000	143.0	V	-101.0	-76.2



Final Result

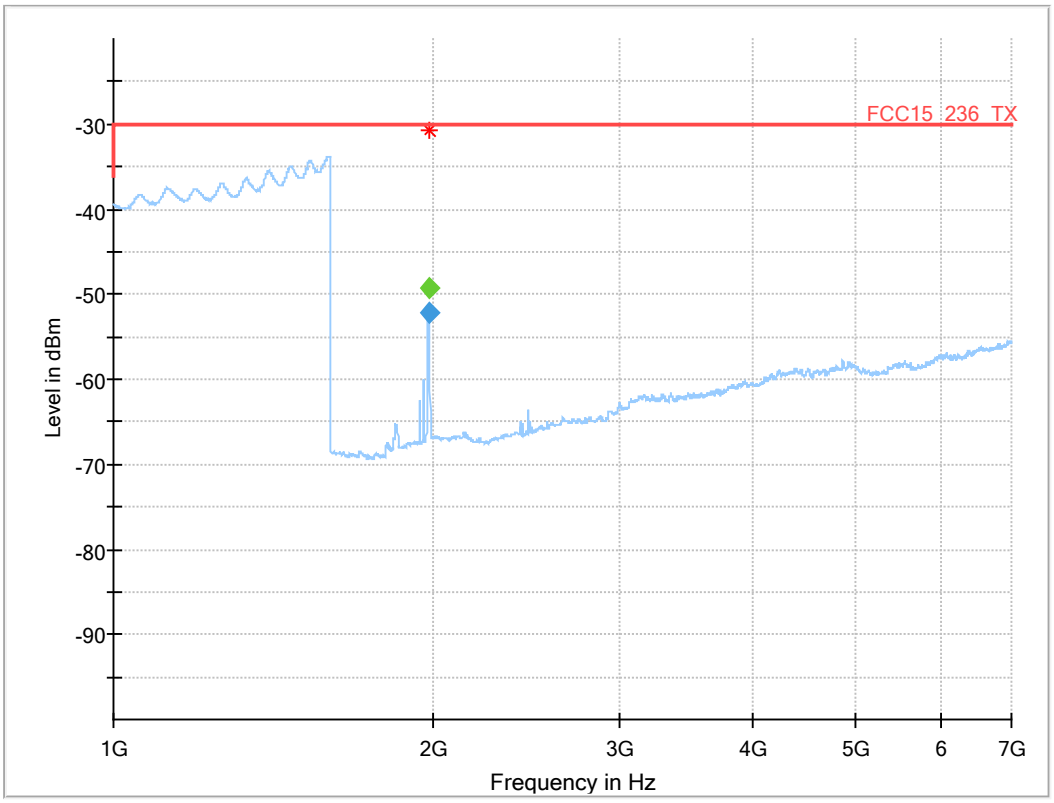
Frequency (MHz)	CAverage (dBm)	RMS (dBm	Limit (dBm)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB)
1814.200	-48.0	---	-30.00	18.02	1000.0	1000.000	150.0	H	111.0	9.0	-
1814.200	---	-45.0	-30.00	15.01	1000.0	1000.000	150.0	H	111.0	9.0	-

Measurement method = radiated, Temperature = Normal,
Operating Frequency = Mid (Duplex Gap), Radio Technology = WMAS
(S01_AC01)



Final Result

Frequency (MHz)	RMS (dBm)	Limit (dBm)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height	Pol	Azimuth (deg)	Corr. (dB)
---	---	---	---	---	---	---		---	---



Final Result

Frequency (MHz)	CAverage (dBm)	RMS (dBm	Limit (dBm)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB)
1978.900	---	-49.2	-30.00	19.16	1000.0	1000.000	150.0	H	125.0	22.0	-99.1
1978.900	-52.1	---	-30.00	22.11	1000.0	1000.000	150.0	H	125.0	22.0	-99.1

TEST EQUIPMENT USED:

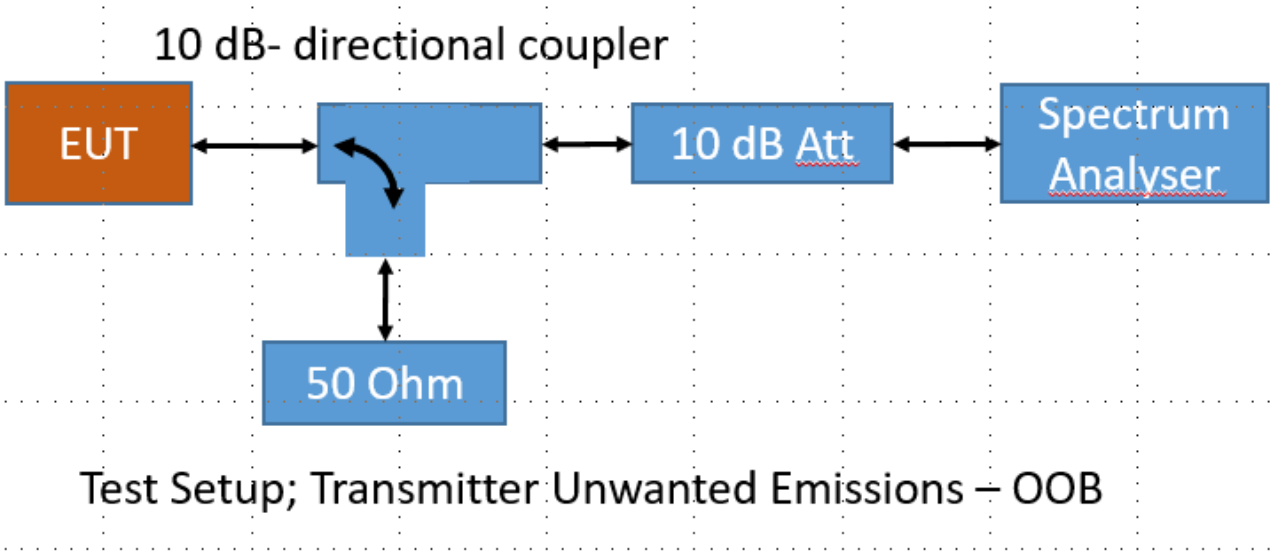
- Radiated Emissions SAC < 1 Ghz
- Radiated Emissions FAR 2.4 GHz FCC

6.5 TRANSMITTER UNWANTED EMISSIONS IN THE OUT OF BAND DOMAIN §15.236 (g)(3)

Test case performed according: EN 300 422-1, clause 5.4.3

Definition:
Transmitter unwanted emissions in the out of band domain are emissions on a frequency or frequencies immediately outside the operating channel, which results from the modulation process, but excluding spurious emissions.

Test Setup:
The test was performed with the following setup:



6.5.1 LIMITS: EN 300 422-1, CLAUSE 4.2.4.2.2

The limits in figure 3 are applicable for WMAS, where B is the Declared Channel Bandwidth.

The mean Power Density, measured with 100 kHz measurement bandwidth and PEAK detector, of the transmitter unwanted emissions shall not exceed the limits of the mask provided in figure 3.

The limits in figure 3 are relative to transmitter RF output power according to clauses 4.2.1 and 5.4.1.

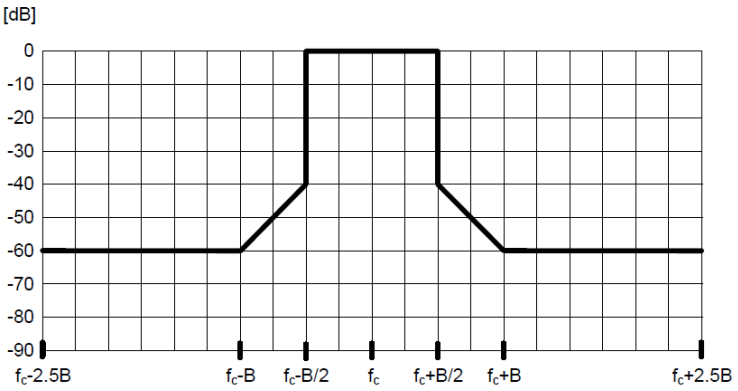


Figure 3: Transmit spectral power mask for WMAS, RBW = 100 kHz

6.5.2 TEST CASE DETAILS:

Ambient temperature: 26°C
Air Pressure: 1014 hPa
Humidity: 62%

Ban:, 470 MHz - 608 MHz		
Frequency	**Nominal Operating Frequency [MHz]**	**Within Spectrum Mask**
Low	473.000	YES
Mid	539.000	YES
High	605.000	YES

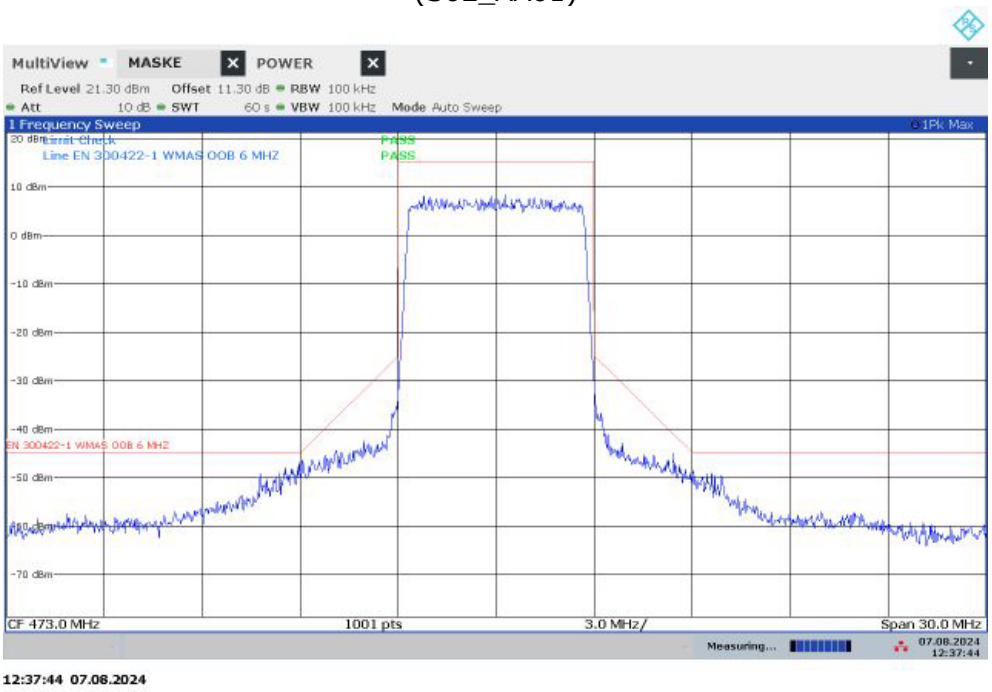
Band: 657 MHz - 663 MHz		
Frequency	**Nominal Operating Frequency [MHz]**	**Within Spectrum Mask**
Mid	660.000	YES

Comments:

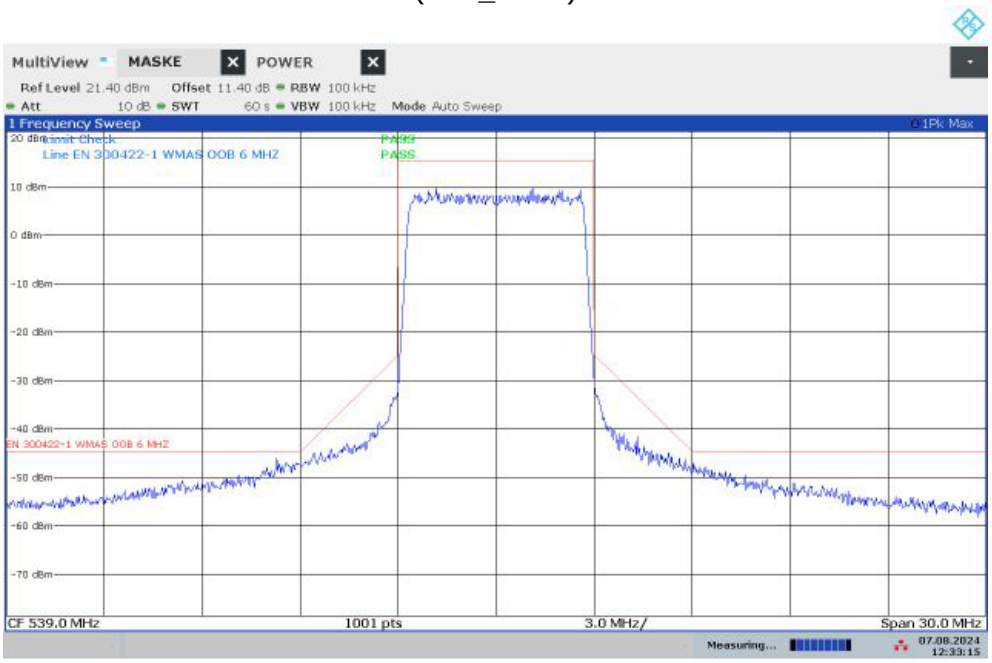
- The measurement was performed conducted.

6.5.3 MEASUREMENT PLOTS:

Measurement method = conducted, Temperature = Normal, Operating Frequency = Low, Radio Technology = WMAS
(S02_AA01)

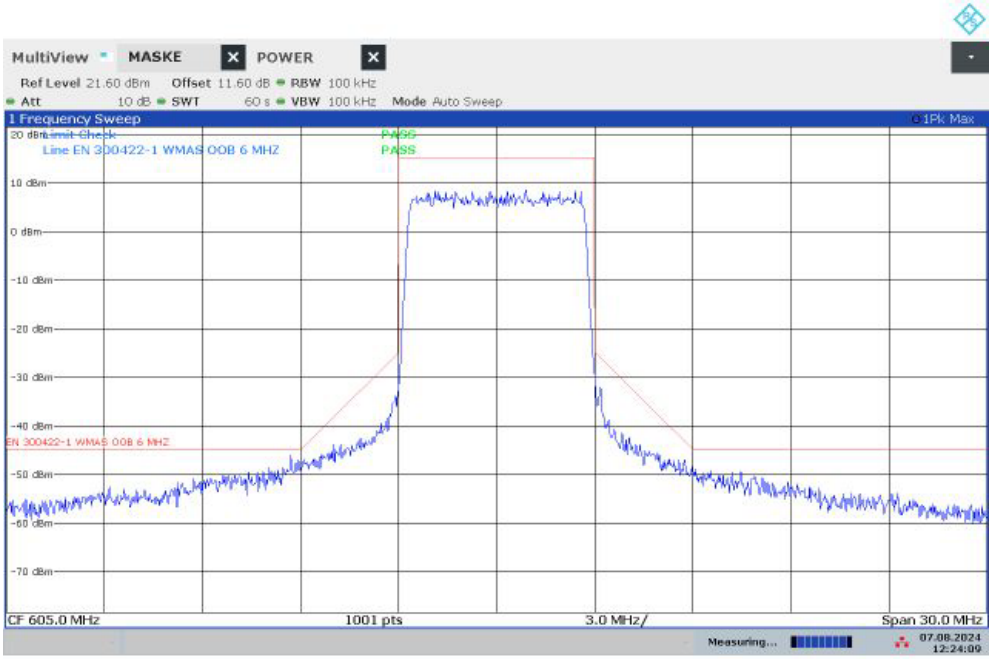


Measurement method = conducted, Temperature = Normal, Operating Frequency = Mid, Radio Technology = WMAS
(S02_AA01)



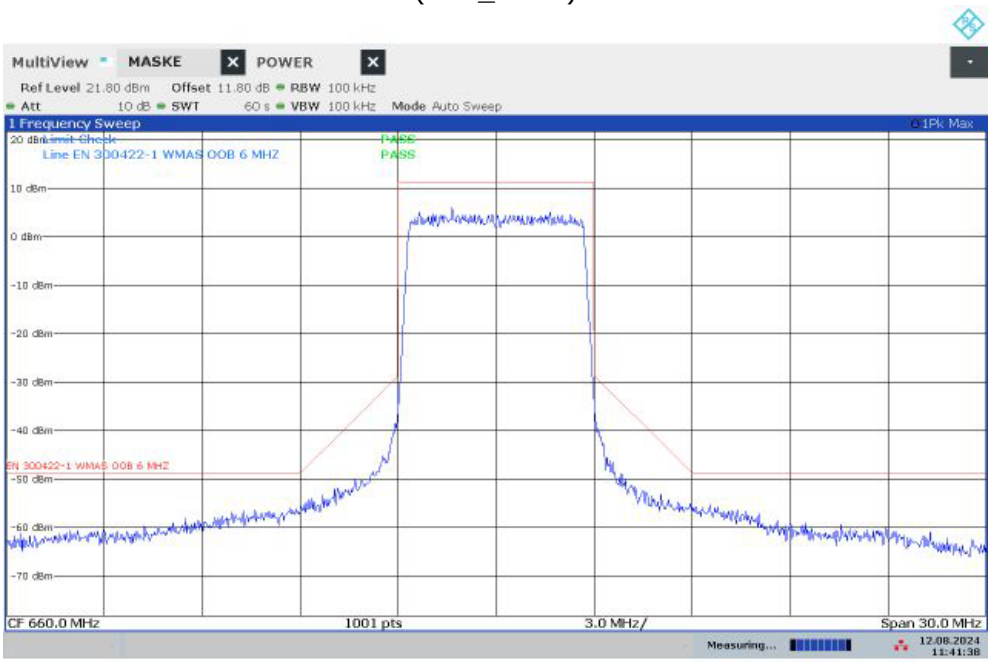
12:33:16 07.08.2024

Measurement method = conducted, Temperature = Normal, Operating Frequency = High, Radio Technology = WMAS
(S02_AA01)



12:24:10 07.08.2024

Measurement method = conducted, Temperature = Normal,
Operating Frequency = Mid (Duplex Gap), Radio Technology = WMAS (S02_AA01)



TEST EQUIPMENT USED:

- Radio Lab

7 TEST EQUIPMENT USED FOR TESTS

7.1 TEST EQUIPMENT HARDWARE

1 Radio Lab
Conducted 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	2024-07	2027-07
1.2	EX520	Digital Multimeter 12	Extech Instruments Corp	05157876	2022-06	2024-06
1.3	Temperature Chamber VT 4002	Temperature Chamber Vötsch 03	Vötsch	58566002150010	2022-05	2024-05
1.4	FSW43	Signal Analyser	Rohde & Schwarz GmbH & Co. KG	102013	2023-07	2025-07
1.5	FSW26	Signal Analyser	Rohde & Schwarz GmbH & Co. KG	104459	2023-05	2025-07
1.6	Opus10 THI	T/H Logger 03	Lufft Mess- und Regeltechnik GmbH	7482	2023-12	2025-12
1.7	SMBV100A	Vector Signal Generator 9 kHz - 6 GHz	Rohde & Schwarz	260001	2023-08	2026-08
1.8	UPL 16	Audio Analyser	Rohde & Schwarz	830695/001	2022-01	2025-01
1.9	10 dB coupler	A2023-10	Atlantic Microwave	-	-	-
1.10	10 dB coupler	A2023-10	Atlantic Microwave	-	-	-

1 Radiated Emissions FAR 2.4 GHz FCC
Radiated emission tests for 2.4 GHz ISM devices in a fully anechoic room

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
1.1	Opus10 TPR (8253.00)	T/P Logger 13	Lufft Mess- und Regeltechnik GmbH	13936	2023-12	2025-12
1.2	Innco Systems CO3000	Controller for bore sight mast FAC	innco systems GmbH	CO3000/1460/54740522/P	N/A	N/A
1.3	AMF-7D00101800-30-10P-R	Broadband Amplifier 100 MHz - 18 GHz	Miteq		N/A	N/A
1.4	Anechoic Chamber 03	FAR, 8.80m x 4.60m x 4.05m (l x w x h)	Albatross Projects	P26971-647-001-PRB	N/A	N/A
1.5	Fluke 177	Digital Multimeter 03 (Multimeter)	Fluke Europe B.V.	86670383	2023-08	2025-08
1.6	JS4-18002600-32-5P	Broadband Amplifier 18 GHz - 26 GHz	Miteq	849785	N/A	N/A
1.7	FSW43	Spectrum Analyzer	Rohde & Schwarz GmbH & Co. KG	103779	2023-04	2025-04
1.8	EP 1200/B, NA/B1	AC Source, Amplifier with integrated variable Oscillator	Spitzenberger & Spies GmbH & Co. KG	B6278	N/A	N/A

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
1.9	3160-09	Standard Gain / Pyramidal Horn Antenna 26.5 GHz	EMCO Elektronic GmbH	00083069	N/A	N/A
1.10	WHKX 7.0/18G-8SS	High Pass Filter	Wainwright Instruments GmbH	09	N/A	N/A
1.11	MA3000/0800-XP-ET-compact	Bore Sight Antenna Mast	innco systems GmbH	9210522	N/A	N/A
1.12	TT 1.5 WI	Turn Table	Maturo GmbH	-	N/A	N/A
1.13	5HC3500/18000-1.2-KK	High Pass Filter	Trilithic	200035008	N/A	N/A
1.14	Opus 20 THI (8120.00)	ThermoHygro Datalogger	Lufft Mess- und Regeltechnik GmbH	115.0318.0802.033	2023-08	2025-08
1.15	TD1.5-10kg	EUT Tilt Device (Rohacell)	Maturo GmbH	TD1.5-10kg/024/3790709	N/A	N/A
1.16	AFS42-00101800-25-S-42	Broadband Amplifier 25 MHz - 18 GHz	Miteq	2035324	N/A	N/A
1.17	HF 907	Double-ridged horn	Rohde & Schwarz	102444	2021-09	2024-09

2 Radiated Emissions SAC H-Field
Radiated emission tests in the H-Field in a semi anechoic room

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
2.1	N5000/NP	Filter for EUT, 2 Lines, 250 V, 16 A	ETS-LINDGREN	241515	N/A	N/A
2.2	Opus10 TPR (8253.00)	T/P Logger 13	Lufft Mess- und Regeltechnik GmbH	13936	2023-12	2025-12
2.3	ESW44	EMI Receiver / Spectrum Analyzer	Rohde & Schwarz GmbH & Co. KG	101603	2024-03	2026-03
2.4	Anechoic Chamber 01	SAC/FAR, 10.58 m x 6.38 m x 6.00 m	Frankonia Germany EMC Solution GmbH	none	N/A	N/A
2.5	Fluke 177	Digital Multimeter 03 (Multimeter)	Fluke Europe B.V.	86670383	2023-08	2025-08
2.6	Opus10 THI (8152.00)	T/H Logger 10	Lufft Mess- und Regeltechnik GmbH	12488	2023-12	2025-12
2.7	EP 1200/B, NA/B1	AC Source, Amplifier with integrated variable Oscillator	Spitzenberger & Spies GmbH & Co. KG	B6278	N/A	N/A
2.8	DS 420S	Turn Table 2 m diameter	HD GmbH	420/573/99	N/A	N/A
2.9	HFH2-Z2	Loop Antenna + 3 Axis Tripod	Rohde & Schwarz GmbH & Co. KG	829324/006		
2.10	CS-RUB6	Rubidium Frequency Standard	Rohde & Schwarz GmbH & Co. KG	100321	2023-10	2024-10

3 Radiated Emissions SAC up to 1 GHz
Radiated emission tests up to 1 GHz in a semi anechoic room

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
3.1	N5000/NP	Filter for EUT, 2 Lines, 250 V, 16 A	ETS-LINDGREN	241515	N/A	N/A
3.2	Opus10 TPR (8253.00)	T/P Logger 13	Lufft Mess- und Regeltechnik GmbH	13936	2023-12	2025-12
3.3	ESW44	EMI Receiver / Spectrum Analyzer	Rohde & Schwarz GmbH & Co. KG	101603	2024-03	2026-03
3.4	Anechoic Chamber 01	SAC/FAR, 10.58 m x 6.38 m x 6.00 m	Frankonia Germany EMC Solution GmbH	none	N/A	N/A
3.5	HL 562 ULTRALOG	Biconical-log-per antenna (30 MHz - 3 GHz) with HL 562E biconicals	Rohde & Schwarz GmbH & Co. KG	830547/003	2021-09	2024-09
3.6	Fluke 177	Digital Multimeter 03 (Multimeter)	Fluke Europe B.V.	86670383	2023-08	2025-08
3.7	Opus10 THI (8152.00)	T/H Logger 10	Lufft Mess- und Regeltechnik GmbH	12488	2023-12	2025-12
3.8	EP 1200/B, NA/B1	AC Source, Amplifier with integrated variable Oscillator	Spitzenberger & Spies GmbH & Co. KG	B6278	N/A	N/A
3.9	DS 420S	Turn Table 2 m diameter	HD GmbH	420/573/99	N/A	N/A
3.10	CS-RUB6	Rubidium Frequency Standard	Rohde & Schwarz GmbH & Co. KG	100321	2023-10	2024-10
3.11	AM 4.0	Antenna Mast 4 m	Maturo GmbH	AM4.0/180/1192 0513	N/A	N/A

The calibration interval is the time interval between “Last Calibration” and “Calibration Due”

7.2 TEST EQUIPMENT SOFTWARE

Semi-Anechoic Chamber:	
Software	Version
EMC32 Measurement Software	10.60.10
INNCO Mast Controller	1.02.62
INNCO Mast Height	34.10
INNCO Mast Elevation	36.11
MATURO Controller	1.24
MATURO Mast	12.19
MATURO Turn-Table	30.10
Fully-Anechoic Chamber:	
Software	Version
EMC32 Measurement Software	10.60.10
MATURO Controller	1.30
MATURO Turn-Unit	11.10
MATURO Mast	12.10
MATURO Turntable	12.11
INNCO Controller	1.03.02
INNCO Mast Height	34.10
INNCO Mast Elevation	36.11
TS 8997	
WMS32 Measurement Software	11.60.00 (till 2024-03-19), 11.70.00 + Hotfix 01
Conducted AC Emissions:	
Software	Version
EMC32 Measurement Software	10.60.20

8 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.

8.1 LISN R&S ESH3-Z5 (150 KHZ – 30 MHZ)

Frequency		Corr.	LISN insertion loss ESH3-Z5	cable loss (incl. 10 dB atten-uator)
MHz		dB	dB	dB
0.15		10.1	0.1	10.0
5		10.3	0.1	10.2
7		10.5	0.2	10.3
10		10.5	0.2	10.3
12		10.7	0.3	10.4
14		10.7	0.3	10.4
16		10.8	0.4	10.4
18		10.9	0.4	10.5
20		10.9	0.4	10.5
22		11.1	0.5	10.6
24		11.1	0.5	10.6
26		11.2	0.5	10.7
28		11.2	0.5	10.7
30		11.3	0.5	10.8

Sample calculation

U_{LISN} (dB µV) = U (dB µV) + Corr. (dB)
U = Receiver reading
LISN Insertion loss = Voltage Division Factor of LISN
Corr. = sum of single correction factors of used LISN, cables, switch units (if used)
Linear interpolation will be used for frequencies in between the values in the table.

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

Frequency	AF HFH-Z2)	Corr.	cable loss 1 (inside chamber)	cable loss 2 (outside chamber)	cable loss 3 (switch unit)	cable loss 4 (to receiver)	distance corr. (-40 dB/ decade)	d_{Limit} (meas. distance (limit)	d_{used} (meas. distance (used)
MHz	dB (1/m)	dB	dB	dB	dB	dB	dB	m	m
0.009	20.50	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.01	20.45	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.015	20.37	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.02	20.36	-79.6	0.1	0.1	0.1	0.1	-80	300	3
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
22	19.61	-39.3	0.3	0.1	0.2	0.1	-40	30	3
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
28	19.46	-39.2	0.3	0.1	0.3	0.1	-40	30	3
30	19.73	-39.1	0.4	0.1	0.3	0.1	-40	30	3

Sample calculation

E (dB µV/m) = U (dB µV) + 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

8.3 ANTENNA R&S HL562 (30 MHZ – 1 GHZ)

(d_{Limit} = 3 m)

Frequency	AF R&S HL562	Corr.	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)
MHz	dB (1/m)	dB	dB	dB	dB	dB	dB	m	m
30	18.6	0.6	0.29	0.04	0.23	0.02	0.0	3	3
50	6.0	0.9	0.39	0.09	0.32	0.08	0.0	3	3
100	9.7	1.2	0.56	0.14	0.47	0.08	0.0	3	3
150	7.9	1.6	0.73	0.20	0.59	0.12	0.0	3	3
200	7.6	1.9	0.84	0.21	0.70	0.11	0.0	3	3
250	9.5	2.1	0.98	0.24	0.80	0.13	0.0	3	3
300	11.0	2.3	1.04	0.26	0.89	0.15	0.0	3	3
350	12.4	2.6	1.18	0.31	0.96	0.13	0.0	3	3
400	13.6	2.9	1.28	0.35	1.03	0.19	0.0	3	3
450	14.7	3.1	1.39	0.38	1.11	0.22	0.0	3	3
500	15.6	3.2	1.44	0.39	1.20	0.19	0.0	3	3
550	16.3	3.5	1.55	0.46	1.24	0.23	0.0	3	3
600	17.2	3.5	1.59	0.43	1.29	0.23	0.0	3	3
650	18.1	3.6	1.67	0.34	1.35	0.22	0.0	3	3
700	18.5	3.6	1.67	0.42	1.41	0.15	0.0	3	3
750	19.1	4.1	1.87	0.54	1.46	0.25	0.0	3	3
800	19.6	4.1	1.90	0.46	1.51	0.25	0.0	3	3
850	20.1	4.4	1.99	0.60	1.56	0.27	0.0	3	3
900	20.8	4.7	2.14	0.60	1.63	0.29	0.0	3	3
950	21.1	4.8	2.22	0.60	1.66	0.33	0.0	3	3
1000	21.6	4.9	2.23	0.61	1.71	0.30	0.0	3	3

(d_{Limit} = 10 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 µV/m) = U (dB µV) + 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.

8.4 ANTENNA R&S HF907 (1 GHZ – 18 GHZ)

Frequency	AF R&S HF907	Corr.	cable loss 1 (relay + cable inside chamber)	cable loss 2 (outside chamber)	cable loss 3 (switch unit, atten-uator & pre-amp)	cable loss 4 (to 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		

Frequency	AF R&S HF907	Corr.	cable loss 1 (relay inside chamber)	cable loss 2 (inside chamber)	cable loss 3 (outside chamber)	cable loss 4 (switch unit, atten-uator & pre-amp)	cable loss 5 (to receiver)	used for FCC 15.247
MHz	dB (1/m)	dB	dB	dB	dB	dB	dB	
3000	31.0	-23.4	0.47	1.87	0.53	-27.58	1.33	
4000	33.1	-23.3	0.56	2.41	0.67	-28.23	1.31	
5000	34.4	-21.7	0.61	2.78	0.86	-27.35	1.40	
6000	34.7	-21.2	0.58	2.74	0.90	-26.89	1.47	
7000	35.6	-19.8	0.66	2.82	0.86	-25.58	1.46	

Frequency	AF R&S HF907	Corr.	cable loss 1 (relay inside chamber)	cable loss 2 (High Pass)	cable loss 3 (pre-amp)	cable loss 4 (inside chamber)	cable loss 5 (outside chamber)	cable loss 6 (to 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	0.91	0.53	-63.03	3.91	1.40	1.77
15000	40.9	-54.1	0.98	0.54	-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

Sample calculation

E (dB µV/m) = U (dB µV) + 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.

8.5 ANTENNA EMCO 3160-09 (18 GHZ – 26.5 GHZ)

Frequency	AF EMCO 3160-09	Corr.	cable loss 1 (inside chamber)	cable loss 2 (pre-amp)	cable loss 3 (inside chamber)	cable loss 4 (switch unit)	cable loss 5 (to receiver)
MHz	dB (1/m)	dB	dB	dB	dB	dB	dB
18000	40.2	-23.5	0.72	-35.85	6.20	2.81	2.65
18500	40.2	-23.2	0.69	-35.71	6.46	2.76	2.59
19000	40.2	-22.0	0.76	-35.44	6.69	3.15	2.79
19500	40.3	-21.3	0.74	-35.07	7.04	3.11	2.91
20000	40.3	-20.3	0.72	-34.49	7.30	3.07	3.05
20500	40.3	-19.9	0.78	-34.46	7.48	3.12	3.15
21000	40.3	-19.1	0.87	-34.07	7.61	3.20	3.33
21500	40.3	-19.1	0.90	-33.96	7.47	3.28	3.19
22000	40.3	-18.7	0.89	-33.57	7.34	3.35	3.28
22500	40.4	-19.0	0.87	-33.66	7.06	3.75	2.94
23000	40.4	-19.5	0.88	-33.75	6.92	3.77	2.70
23500	40.4	-19.3	0.90	-33.35	6.99	3.52	2.66
24000	40.4	-19.8	0.88	-33.99	6.88	3.88	2.58
24500	40.4	-19.5	0.91	-33.89	7.01	3.93	2.51
25000	40.4	-19.3	0.88	-33.00	6.72	3.96	2.14
25500	40.5	-20.4	0.89	-34.07	6.90	3.66	2.22
26000	40.5	-21.3	0.86	-35.11	7.02	3.69	2.28
26500	40.5	-21.1	0.90	-35.20	7.15	3.91	2.36

Sample calculation

E (dB µV/m) = U (dB µV) + 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.
Table shows an extract of values.

8.6 ANTENNA EMCO 3160-10 (26.5 GHZ – 40 GHZ)

Frequency	AF EMCO 3160-10	Corr.	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)
GHz	dB (1/m)	dB	dB	dB	dB	dB	dB	m	m
26.5	43.4	-11.2	4.4				-9.5	3	1.0
27.0	43.4	-11.2	4.4				-9.5	3	1.0
28.0	43.4	-11.1	4.5				-9.5	3	1.0
29.0	43.5	-11.0	4.6				-9.5	3	1.0
30.0	43.5	-10.9	4.7				-9.5	3	1.0
31.0	43.5	-10.8	4.7				-9.5	3	1.0
32.0	43.5	-10.7	4.8				-9.5	3	1.0
33.0	43.6	-10.7	4.9				-9.5	3	1.0
34.0	43.6	-10.6	5.0				-9.5	3	1.0
35.0	43.6	-10.5	5.1				-9.5	3	1.0
36.0	43.6	-10.4	5.1				-9.5	3	1.0
37.0	43.7	-10.3	5.2				-9.5	3	1.0
38.0	43.7	-10.2	5.3				-9.5	3	1.0
39.0	43.7	-10.2	5.4				-9.5	3	1.0
40.0	43.8	-10.1	5.5				-9.5	3	1.0

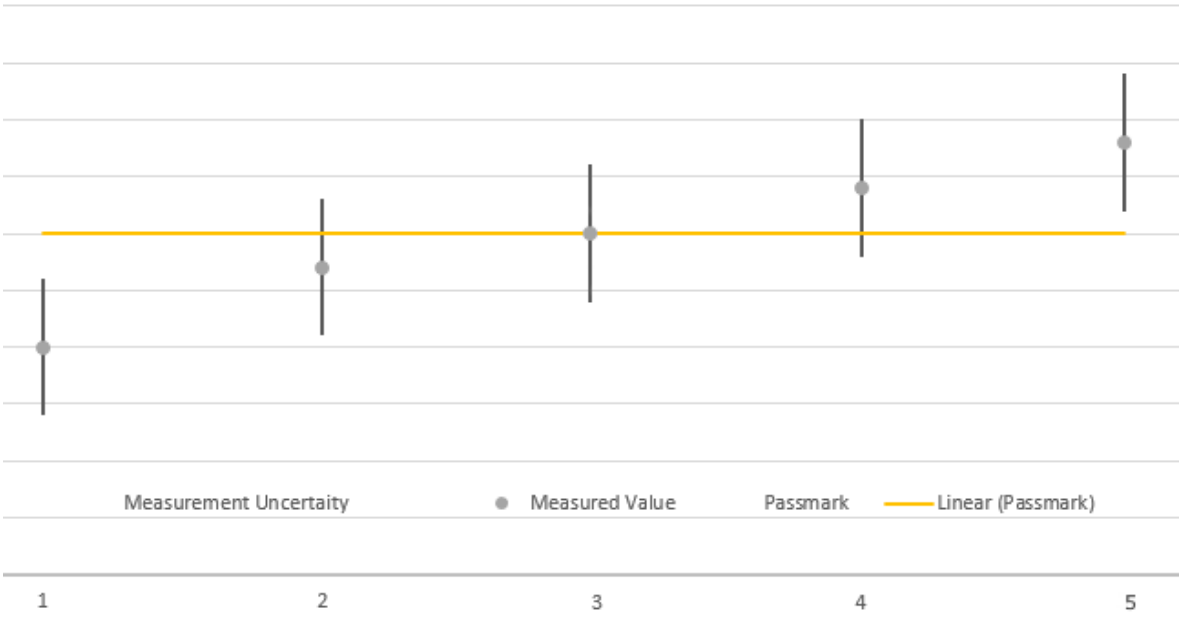
Sample calculation

E (dB µV/m) = U (dB µV) + 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.
distance correction = -20 * 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.

9 MEASUREMENT UNCERTAINTIES

Parameter	Uncertainty
Occupied channel Bandwidth	± 5%
RF Output Power, conducted	± 1.5 dB
Power Spectral Density, conducted	± 3.0 dB
Unwanted Emissions, conducted	± 3.0 dB
Unwanted emissions, radiated	± 4.5 dB
RF Output power, radiated	± 2.8 dB
Temperature	± 0.3 °C
Humidity	± 3%
DC and low frequency voltages	± 1.5% + 2 digits
Time	± 5%
Duty Cycle	± 5%

The measurement uncertainties for all parameters are calculated with an expansion factor (coverage factor) k = 1.96. This means, that the true value is in the corresponding interval with a probability of 95 %.



The verdicts in this test report are given according the above diagram:

Case	Measured Value	Uncertainty Range	Verdict
1	below pass mark	below pass mark	Passed
2	below pass mark	within pass mark	Passed
3	on pass mark	within pass mark	Passed
4	above pass mark	within pass mark	Failed
5	above pass mark	above pass mark	Failed

That means, the laboratory applies, as decision rule (see ISO/IEC 17025:2017), the so-called shared risk principle.

10 PHOTO REPORT

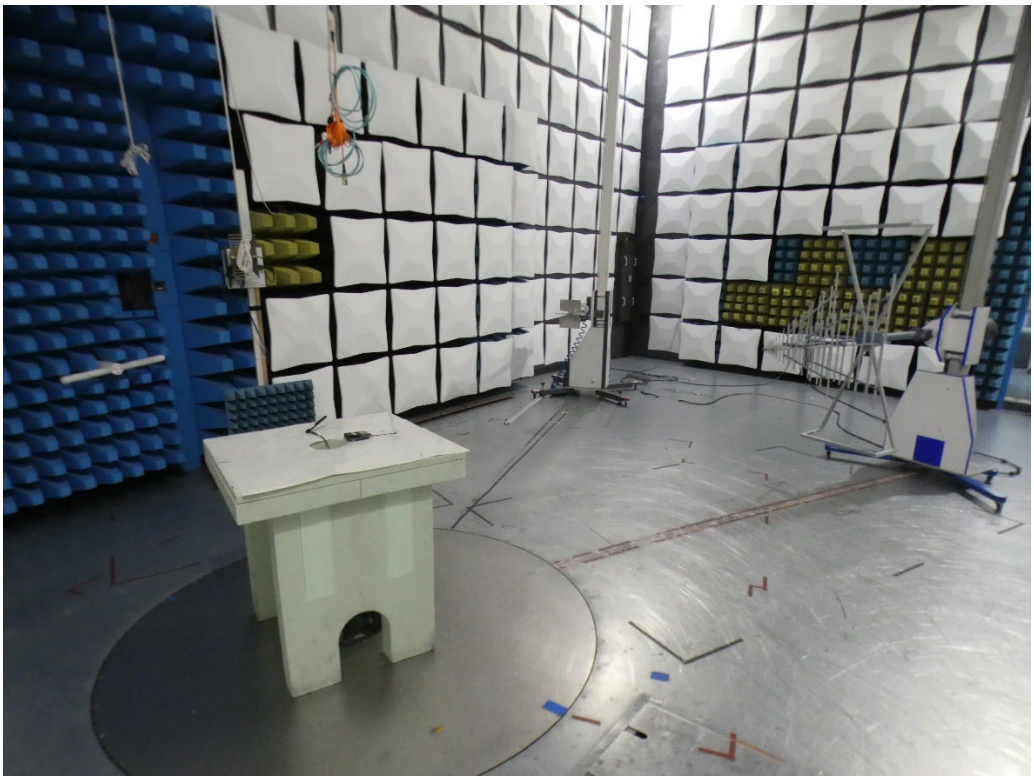


Photo 1: Setup Spurious Emissions Radiated (SAC), < 1 GHz, EUT horizontal

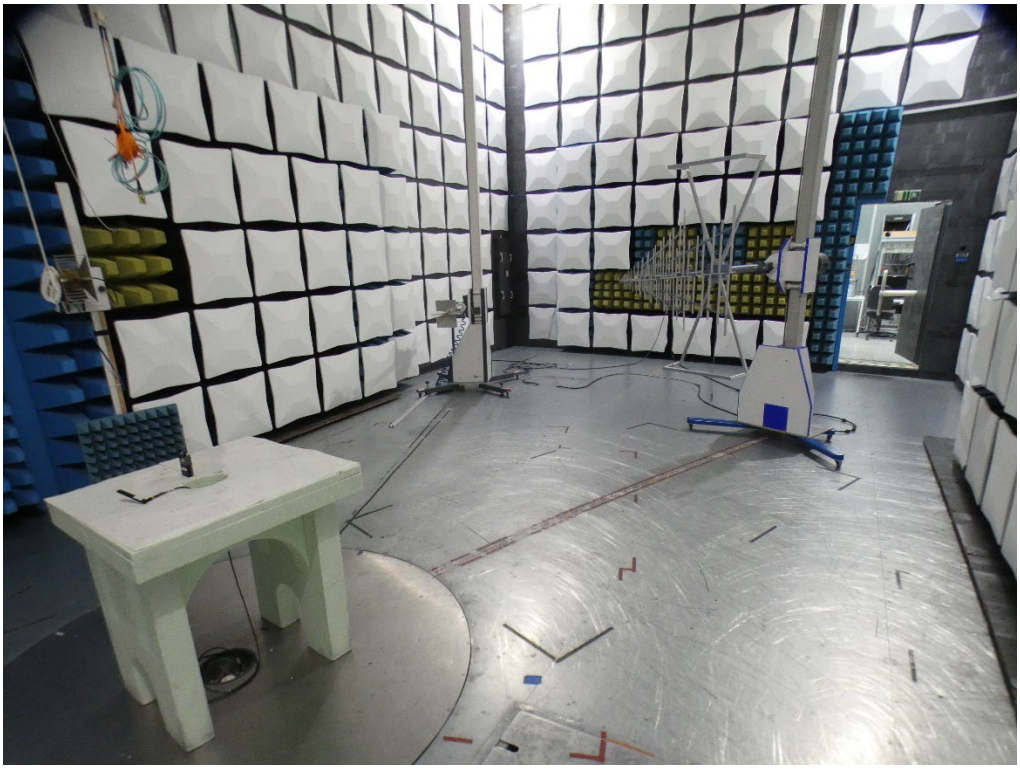


Photo 2: Setup Spurious Emissions Radiated (SAC), < 1 GHz, EUT vertical

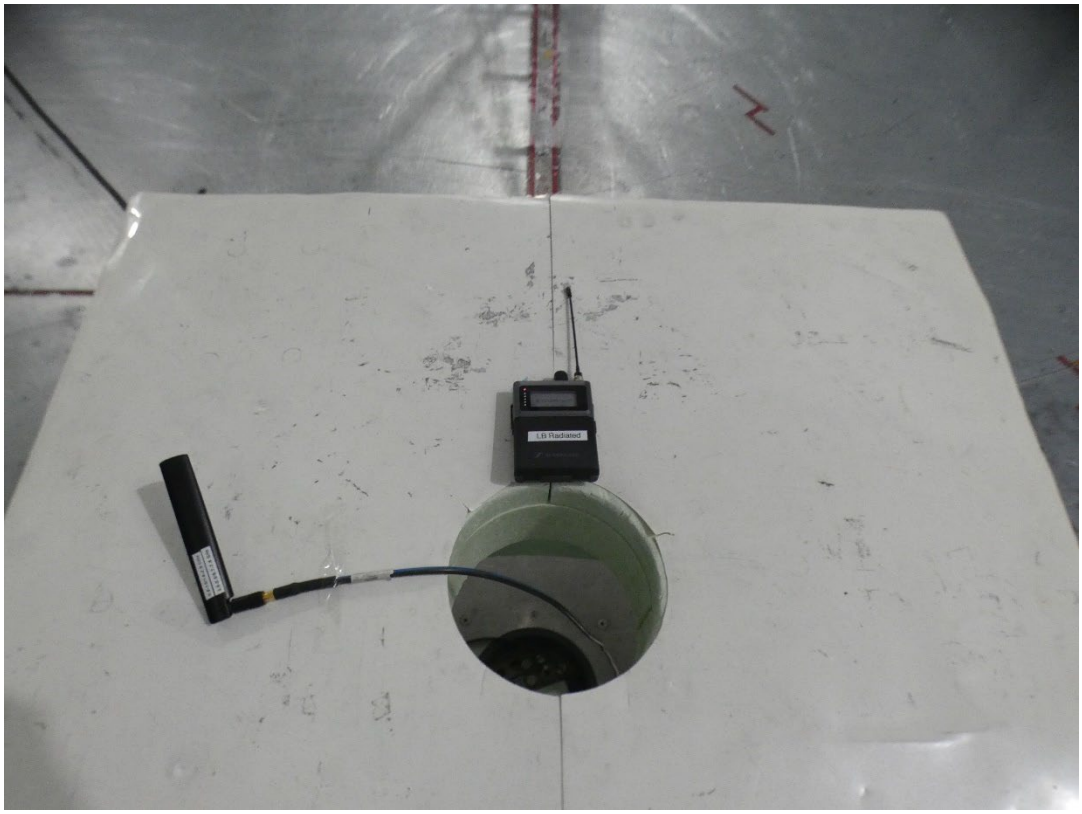


Photo 3: Setup Spurious Emissions Radiated (SAC), < 1 GHz, detail view

Photo 3: Setup Spurious Emissions Radiated (FAC), > 1GHz

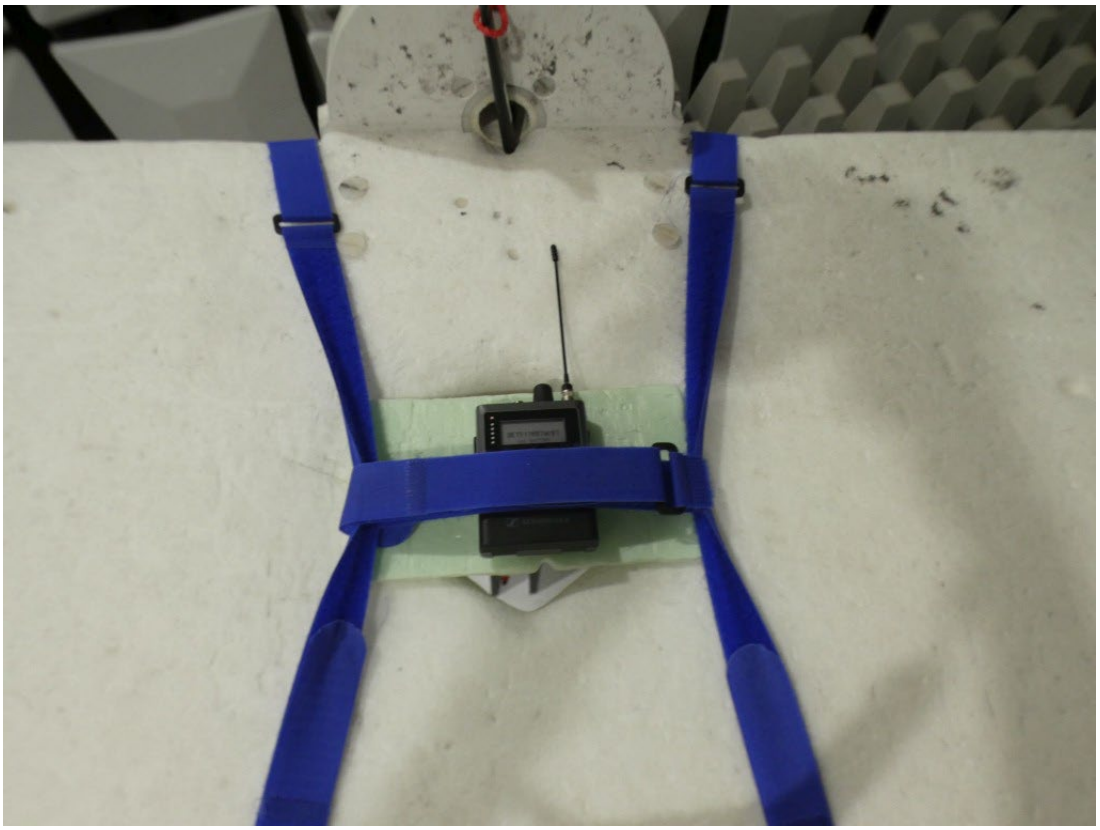


Photo 4: Setup Spurious Emissions Radiated (FAC), > 1GHz, detail view

**********END OF TEST REPORT**********