FCC Measurement/Technical Report on

TBM20.H

FCC ID: RX2TBTBMF30B0
IC: 4983A-TBTBMF30B0

Test Report Reference: MDE_MARELLI_2004_FCC_02_rev01

Test Laboratory:
7layers GmbH
Borsigstrasse 11
40880 Ratingen
Germany

Deutsche Akkreditierungsstelle
D-PL-12140-01-01
D-PL-12140-01-02
D-PL-12140-01-03

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1 APPLIED STANDARDS AND TEST SUMMARY

1.1 APPLIED STANDARDS

Type of Authorization
Certification for an Intentional Radiator (Digital Device / Spread Spectrum).

Applicable FCC Rules

Prepared in accordance with the requirements of FCC Rules and Regulations as listed in 47 CFR Ch.1 Parts 2 (10-1-19 Edition) and 15 (10-1-19 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

§ 15.201 Equipment authorization requirement

§ 15.207 Conducted limits

§ 15.209 Radiated emission limits; general requirements

Part 15, Subpart E – Unlicensed National Information Infrastructure Devices

§ 15.403 Definitions

§ 15.407 General technical requirements

Note:
The tests were selected and performed with reference to the FCC Public Notice "Guidelines for Compliance Testing of Unlicensed National Information
Infrastructure (U-NII) Devices - Part 15, Subpart E, 789033 D02 General U-NII Test Procedures New Rules v02r01, 2017-12-14".

ANSI C63.10-2013 is applied.

FCC ET Docket No. 13-49, FIRST REPORT AND ORDER, April 1, 2014 ("new rules") is applied.

1.2 FCC-IC CORRELATION TABLE

Correlation of measurement requirements for UNII / LE-LAN (e.g. WLAN 5 GHz) equipment from FCC and IC

UNII equipment

Measurement	FCC reference	IC reference
Conducted emissions on AC Mains	§ 15.207	RSS-Gen Issue 5: 8.8
Occupied bandwidth	§ 15.403 (i) (26 dB) / § 15.407 (e) (6 dB)	RSS-247 Issue 2: 6.2.1.1, 6.2.2.1, 6.2.3.1 (99%) RSS-247 Issue 2: 6.2.4.1 (6 dB)
Maximum conducted output power	§ 15.407 (a) (1),(2),(3),(4)	RSS-247 Issue 2: 6.2.1.1, 6.2.2.1, 6.2.3.1, 6.2.4.1
Maximum power spectral density	§ 15.407 (a) (1),(2),(3),(5)	RSS-247 Issue 2: 6.2.1.1, 6.2.2.1, 6.2.3.1, 6.2.4.1
Transmitter undesirable emissions; General Field Strength Limits, Restricted Bands	§ 15.407 (b) § 15.209 (a)	RSS-Gen Issue 5: 6.13/8.9/8.10; RSS-247 Issue 2: 3.3/6.2 6.2.1.2, 6.2.2.2, 6.2.3.2, 6.2.4.2
Frequency stability	§ 15.407 (g)	RSS-Gen Issue 5: 6.11/8.11
Transmit Power Control (TPC) and Dynamic Frequency Selection (DFS)	§ 15.407 (h)	RSS-247 Issue 2: 6.2.2.1, 6.2.3.1, 6.3
Antenna requirement	§ 15.203 / 15.204	RSS-Gen Issue 5: 8.3
Receiver spurious emissions	–	-

1.3 MEASUREMENT SUMMARY

47 CFR CHAPTER I FCC PART 15 Subpart E §15.407 **FCC §15.31, §15.403 (i)**

26 dB Bandwidth

The measurement was performed according to ANSI C63.10 **Final Result**

OP-Mode Radio Technology, Operating Frequency, Subband	Setup	Date	FCC	IC
WLAN a, low, U-NII-3	S01_AA01	2020-11-04	Performed	N/A
WLAN ac 20 MHz, low, U-NII-3	S01_AA01	2020-11-04	Performed	N/A
WLAN ac 40 MHz, low, U-NII-3	S01_AA01	2020-11-04	Performed	N/A
WLAN n 20 MHz, low, U-NII-3	S01_AA01	2020-11-04	Performed	N/A
WLAN n 40 MHz, low, U-NII-3	S01_AA01	2020-11-04	Performed	N/A

47 CFR CHAPTER I FCC PART 15 Subpart E §15.407 **FCC §15.31, §15.407 (e)**

6 dB Bandwidth

The measurement was performed according to ANSI C63.10 **Final Result**

OP-Mode Radio Technology, Operating Frequency, Subband	Setup	Date	FCC	IC
WLAN a, low, U-NII-3	S01_AA01	2020-11-04	Passed	Passed
WLAN ac 20 MHz, low, U-NII-3	S01_AA01	2020-11-04	Passed	Passed
WLAN ac 40 MHz, low, U-NII-3	S01_AA01	2020-11-04	Passed	Passed
WLAN n 20 MHz, low, U-NII-3	S01_AA01	2020-11-04	Passed	Passed
WLAN n 40 MHz, low, U-NII-3	S01_AA01	2020-11-04	Passed	Passed

47 CFR CHAPTER I FCC PART 15 Subpart E §15.407 **FCC §15.31, IC RSS 247 Ch. 6.2.x**

99 % Bandwidth

The measurement was performed according to ANSI C63.10 **Final Result**

OP-Mode Radio Technology, Operating Frequency, Subband	Setup	Date	FCC	IC
WLAN a, low, U-NII-3	S01_AA01	2020-11-04	N/A	Performed
WLAN ac 20 MHz, low, U-NII-3	S01_AA01	2020-11-04	N/A	Performed
WLAN ac 40 MHz, low, U-NII-3	S01_AA01	2020-11-04	N/A	Performed
WLAN n 20 MHz, low, U-NII-3	S01_AA01	2020-11-04	N/A	Performed
WLAN n 40 MHz, low, U-NII-3	S01_AA01	2020-11-04	N/A	Performed

47 CFR CHAPTER I FCC PART 15 Subpart E §15.407 **FCC §15.31, §15.407 (a)(1)**

Maximum Conducted Output Power
The measurement was performed according to ANSI C63.10 **Final Result**

OP-Mode Radio Technology, Operating Frequency, Subband	Setup	Date	FCC	IC
WLAN a, low, U-NII-3	S01_AA01	2020-11-04	Passed	Passed
WLAN ac 20 MHz, low, U-NII-3	S01_AA01	2020-11-04	Passed	Passed
WLAN ac 40 MHz, low, U-NII-3	S01_AA01	2020-11-04	Passed	Passed
WLAN n 20 MHz, low, U-NII-3	S01_AA01	2020-11-04	Passed	Passed
WLAN n 40 MHz, low, U-NII-3	S01_AA01	2020-11-04	Passed	Passed

47 CFR CHAPTER I FCC PART 15 Subpart E §15.407 **FCC §15.31, §15.407 (a) (1),(5)**

Peak Power Spectral Density
The measurement was performed according to ANSI C63.10 **Final Result**

OP-Mode Radio Technology, Operating Frequency, Subband	Setup	Date	FCC	IC
WLAN a, low, U-NII-3	S01_AA01	2020-11-04	Passed	Passed
WLAN ac 20 MHz, low, U-NII-3	S01_AA01	2020-11-04	Passed	Passed
WLAN ac 40 MHz, low, U-NII-3	S01_AA01	2020-11-04	Passed	Passed
WLAN n 20 MHz, low, U-NII-3	S01_AA01	2020-11-04	Passed	Passed
WLAN n 40 MHz, low, U-NII-3	S01_AA01	2020-11-04	Passed	Passed

47 CFR CHAPTER I FCC PART 15 Subpart E §15.407 **FCC §15.407 (b), (1),(2),(3),(4); FCC §15.205, §15.209, §15.407 (b) (5),(6)**

Undesirable Emissions; General Field Strength Limits
The measurement was performed according to ANSI C63.10 **Final Result**

OP-Mode Radio Technology, Operating Frequency, Measurement range, Subband	Setup	Date	FCC	IC
WLAN a, low, 1GHz - 26GHz, U-NII-3	S01_AB01	2020-10-23	Passed	Passed
WLAN a, low, 26GHz - 40GHz, U-NII-3	S01_AB01	2020-11-06	Passed	Passed
WLAN a, low, 30MHz - 1GHz, U-NII-3	S01_AB01	2020-10-21	Passed	Passed
WLAN a, low, 9kHz – 30MHz, U-NII-3	S01_AB01	2020-10-21	Passed	Passed
WLAN n 20 MHz, low, 1GHz - 18GHz, U-NII-3	S01_AB01	2020-11-08	Passed	Passed
WLAN n 40 MHz, low, 1GHz - 26GHz, U-NII-3	S01_AB01	2020-11-08	Passed	Passed
WLAN n 40 MHz, low, 30MHz - 1GHz, U-NII-3	S01_AB01	2020-11-08	Passed	Passed
WLAN n 40 MHz, low, 9kHz – 30MHz, U-NII-3	S01_AB01	2020-11-08	Passed	Passed

47 CFR CHAPTER I FCC PART 15 Subpart E §15.407 **FCC §15.407 (b), (1),(2),(3),(4)**

Band Edge

The measurement was performed according to ANSI C63.10 **Final Result**

OP-Mode Radio Technology, Operating Frequency, Subband	**Setup**	**Date**	**FCC**	**IC**
WLAN a, low, U-NII-3	S01_AB01	2020-10-23	Passed	Passed
WLAN ac 20 MHz, low, U-NII-3	S01_AB01	2020-11-04	Passed	Passed
WLAN ac 40 MHz, low, U-NII-3	S01_AB01	2020-11-08	Passed	Passed
WLAN n 20 MHz, low, U-NII-3	S01_AB01	2020-11-08	Passed	Passed
WLAN n 40 MHz, low, U-NII-3	S01_AB01	2020-11-08	Passed	Passed

N/A: Not applicable
N/P: Not performed

2 REVISION HISTORY / SIGNATURES

Report version control			
Version	**Release date**	**Change Description**	**Version validity**
initial	2020-11-19	--	invalid
rev01	2020-12-21	Corrected limit in result table test case undesirable emissions, Corrected limit for ac 40 MHz in test case Band Edge	valid

COMMENT: -

(responsible for accreditation scope)
Dipl.-Ing. Daniel Gall

(responsible for testing and report)
B.Sc. Jens Dörwald

3 ADMINISTRATIVE DATA

3.1 TESTING LABORATORY

Company Name:	7layers GmbH
Address:	Borsigstr. 11 40880 Ratingen Germany

The test facility is accredited by the following accreditation organisation:

Laboratory accreditation no:	DAkkS D-PL-12140-01-01| -02 | -03
FCC Designation Number:	DE0015
FCC Test Firm Registration:	929146
ISED CAB Identifier	DE0007; ISED#: 3699A
Responsible for accreditation scope:	Dipl.-Ing. Daniel Gall
Report Template Version:	2020-06-15

3.2 PROJECT DATA

Responsible for testing and report:	B.Sc. Jens Dörwald
Employees who performed the tests:	documented internally at 7Layers
Date of Report:	2020-12-21
Testing Period:	2020-10-21 to 2020-11-08

3.3 APPLICANT DATA

Company Name:	Marelli Europe S.p.A.
Address:	V.le A. Borletti 61/63 20011 Corbetta (MI) Italy
Contact Person:	Gianluca Capuzzo

3.4 MANUFACTURER DATA

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

4 TEST OBJECT DATA

4.1 GENERAL EUT DESCRIPTION

Kind of Device product description	Telematic Control unit
Product name	TBM20.H
Type	TBTBMF30B0
Declared EUT data by the supplier	
Voltage Type	DC (vehicular battery)
Voltage Level	13.5 VDC
Antenna / Gain	Integral /+ 1 dBi
Tested Modulation Type	OFDM:BPSK
General product description	Telematic Control Unit
Specific product description for the EUT	The EUT supports WLAN (IEEE 802.11) modes a/n/ac 20 MHz and n/ac 40 MHz in the U-NII-3 band. Only the channels 149 for 20 MHz BW and 151 for 40 MHz BW are supported.
EUT ports (connected cables during testing):	- Cable Harness (2m connected to AUX 09) - Ethernet (1m connected to AUX 01) - LTE 1 (2m connected to AUX 39) - LTE 2 ((2m connected to AUX 34) - GPS IN (2m connected to AUX 39) - GPS OUT (2m connected to 50 Ohm Load)
Tested datarates	WLAN a 6 Mbps WLAN n 20 MHz MCS0 WLAN n 40 MHz MCS0 WLAN ac 20 MHz MCS0 WLAN ac 40 MHz MCS0
Special software used for testing	Labtool

4.2 EUT MAIN COMPONENTS

Sample Name	Sample Code	Description
Sample #aa01	DE1091016aa01	Sample for conducted testing #aa01
Sample Parameter	**Value**	
Serial No.	0UYUF103-59A	
HW Version	PRTD	
SW Version	TBM20H_CA11	
Comment	conducted sample TBM2-0H_3 ON (Cond) COND_WLAN_1	

Sample Name	Sample Code	Description
Sample #ab01	DE1091016ab01	Sample for radiated testing #ab01
Sample Parameter	**Value**	
Serial No.	0UYUF105C59A	
HW Version	PRTD	
SW Version	TBM20H_CA11	
Comment	radiated sample TBM2-0H_2 ON RADIATED_WLAN_1	

NOTE:The short description is used to simplify the identification of the EUT in this test report.

4.3 ANCILLARY EQUIPMENT

For the purposes of this test report, ancillary equipment is defined as equipment which is used in conjunction with the EUT to provide operational and control features to the EUT. It is necessary to configure the system in a typical fashion, as a customer would normally use it. But nevertheless Ancillary Equipment can influence the test results.

Device	Details (Manufacturer, Type Model, OUT Code)	Description
-	-	-

4.4 AUXILIARY EQUIPMENT

For the purposes of this test report, auxiliary equipment is defined as equipment which is used temporarily to enable operational and control features especially used for the tests of the EUT which is not used during normal operation or equipment that is used during the tests in combination with the EUT but is not subject of this test report. It is necessary to configure the system in a typical fashion, as a customer would normally use it.
But nevertheless Auxiliary Equipment can influence the test results.

Device	**Details (Manufacturer, Type Model, HW, SW, S/N)**	**Description**
AUX01	-, -, -, - , -	Media Converter
AUX02	-, -, -, - , -	Media Converter
AUX09	-, -, -, - , -	TLS
AUX14	-, -, -, - , -	Main Full Harness
AUX19	-, -, -, - , -	Main Reducted Harness
AUX24	-, -, -, - , -	Ethernet Cable Cat5E
AUX25	-, -, -, - , -	Ethernet Cable Cat5E
AUX29	-, -, -, - , -	Ethernet OABR Harness
AUX30	-, -, -, - , -	Ethernet OABR Harness
AUX34	-, -, -, - , -	LTE2 Antenna with Fakra Cable (2m)
AUX39	-, -, -, - , -	LTE1+GNSS Conic Antenna with Fakra Cable

4.5 EUT SETUPS

This chapter describes the combination of EUTs and equipment used for testing. The rationale for selecting the EUTs, ancillary and auxiliary equipment and interconnecting cables, is to test a representative configuration meeting the requirements of the referenced standards.

Setup	**Combination of EUTs**	**Description and Rationale**
S01_AB01	Sample #ab01, AUX14, AUX09, AUX30, AUX02, AUX25, AUX34, AUX39,	Setup #AB01
S01_AA01	Sample #aa01, AUX19, AUX24, AUX01, AUX29,	Setup #AA01

4.6 OPERATING MODES / TEST CHANNELS

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

U-NII-Subband 3 5725 - 5850 MHz			Nom. BW
low	mid	high	20 MHz
149	-	-	Ch.-No.
5745	-	-	MHz

low	mid	high	40 MHz
151	-	-	Ch.-No.
5755	-	-	MHz

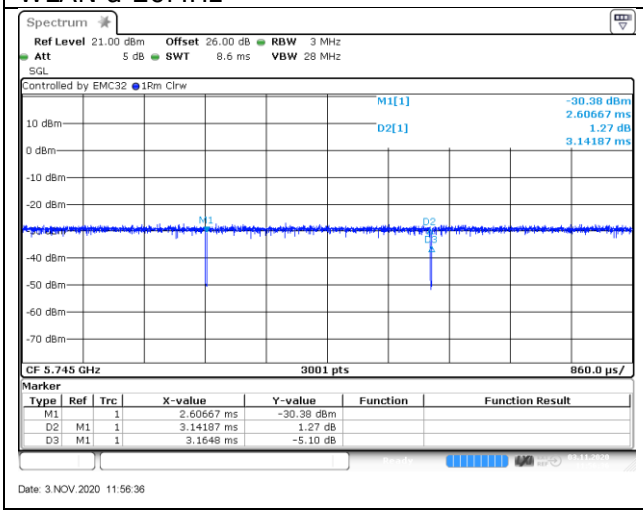
Following power settings provided by manufacturer are applied:

Ch149: 14
Ch151: 14

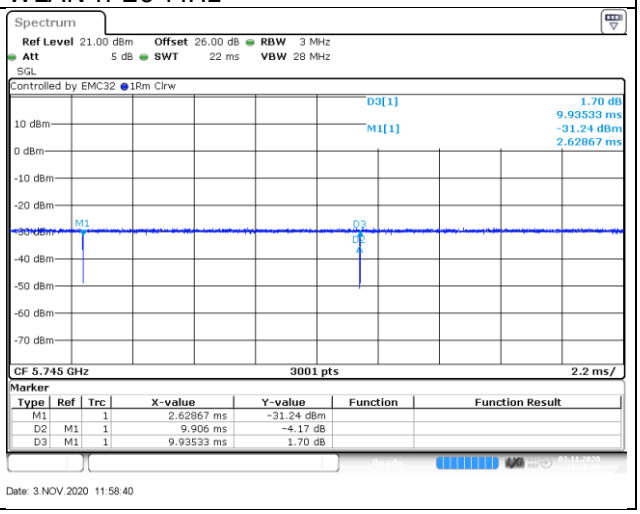
4.7 DUTY CYCLE OF TEST SIGNAL

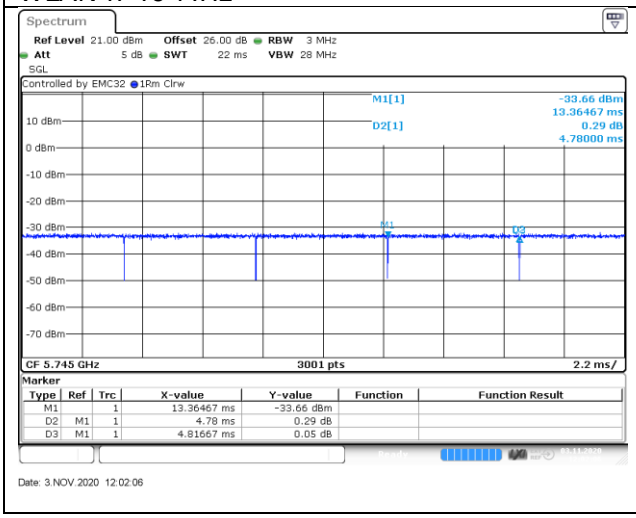
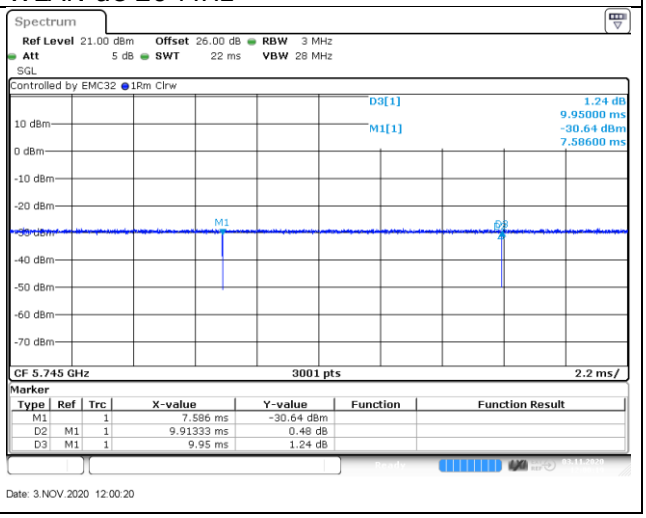
Test Mode	T_{on} (ms)	T_{on+off} (ms)	Duty cycle (%)
WLAN a 20 MHz	3.14	3.16	99.37
WLAN n 20 MHz	9.90	9.93	99.70
WLAN n 40 MHz	4.78	4.81	99.38
WLAN ac 20MH	9.91	9.95	99.60
WLAN ac 40 MHz	4.78	4.82	99.17

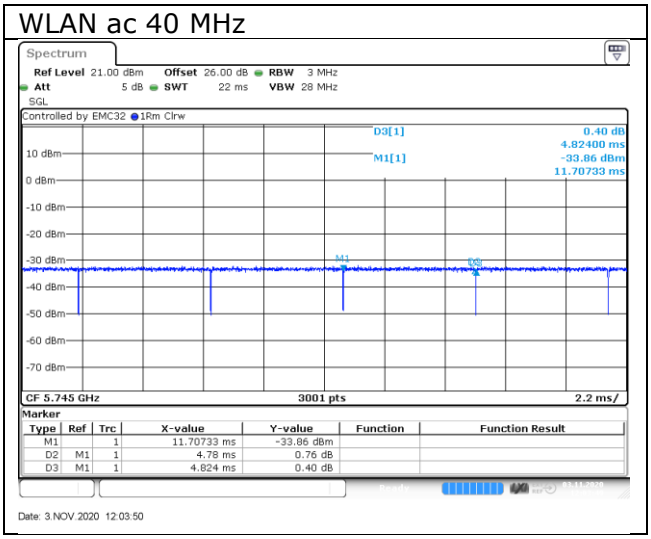
WLAN a 20MHz



WLAN n 20 MHz



WLAN n 40 MHz	WLAN ac 20 MHz
	

WLAN ac 40 MHz


4.8 PRODUCT LABELLING

4.8.1 FCC ID LABEL

Please refer to the documentation of the applicant.

4.8.2 LOCATION OF THE LABEL ON THE EUT

Please refer to the documentation of the applicant.

5 TEST RESULTS

5.1 26 DB BANDWIDTH

Standard **FCC Part 15 Subpart E**

The test was performed according to:
ANSI C63.10

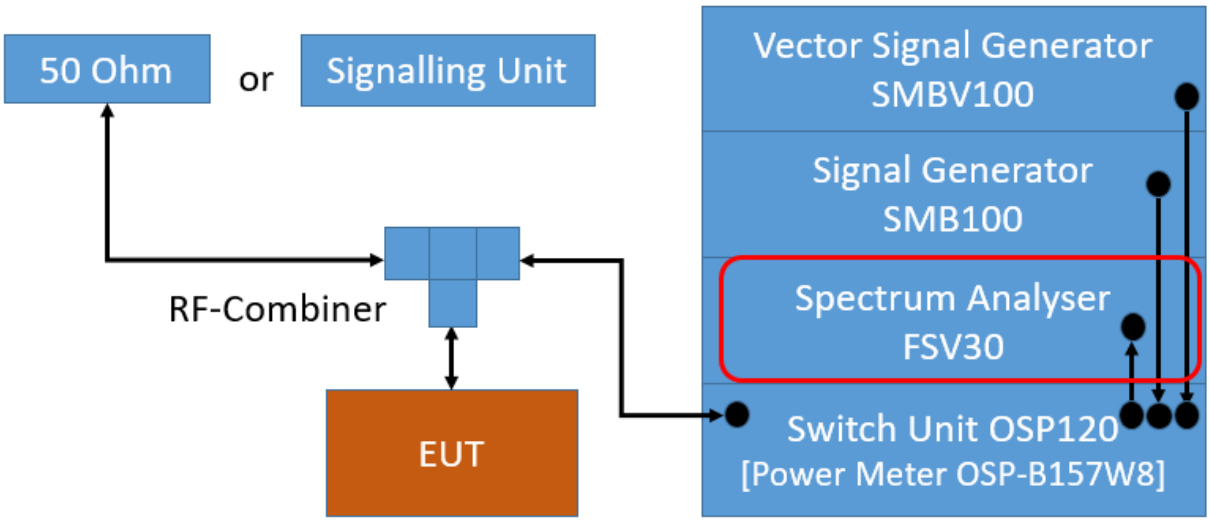
5.1.1 TEST DESCRIPTION

The Equipment Under Test (EUT) was set up to perform the occupied bandwidth measurements.
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.

The EUT was connected to the test system as described in the block diagram below. The complete attenuation of the measurement path is known and considered.

Analyzer settings:

- Resolution Bandwidth (RBW): initially approx. 1 % of nominal emission bandwidth
- Video Bandwidth (VBW): > RBW
- Span: 40 / 80 / 160 / 320 MHz (for 20 / 40 / 80 / 160 MHz nominal bandwidth)
- Trace: Maxhold
- Sweeps: Until the trace is stable
- Sweeptime: Auto
- Detector: Peak



TS8997; Occupied Channel Bandwidth 6 dB / 26 dB / 99 %

5.1.2 TEST REQUIREMENTS / LIMITS

FCC Part 15, Subpart E, §15.403 (i)
There exist no applicable limits for the U-NII subbands 1, 2A and 2C. The test was performed to determine the limits for the "Maximum Conducted Output Power" test case. Therefore no result was applied.

5.1.3 TEST PROTOCOL

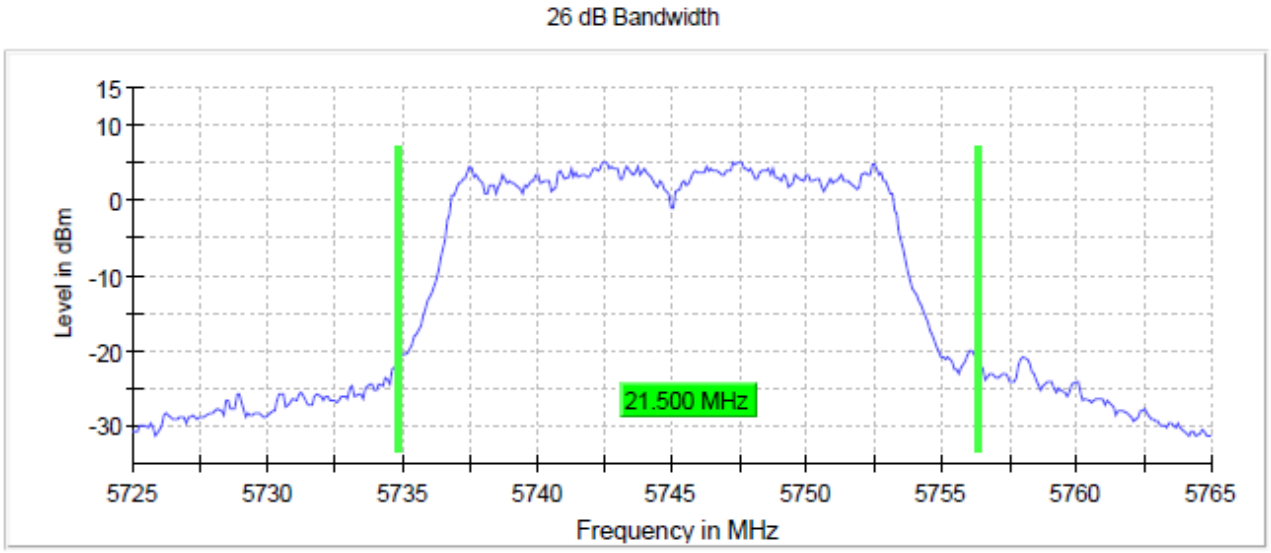
Ambient temperature: 24 °C
Air Pressure: 1010 hPa
Humidity: 41 %

Radio Technology	Operating Frequency	Subband	26 dB Bandwidth [MHz]
WLAN a	low	U-NII-3	21.5
WLAN n 20 MHz	low	U-NII-3	22.2
WLAN n 40 MHz	low	U-NII-3	41.1
WLAN ac 20 MHz	low	U-NII-3	21.5
WLAN ac 40 MHz	low	U-NII-3	41.6

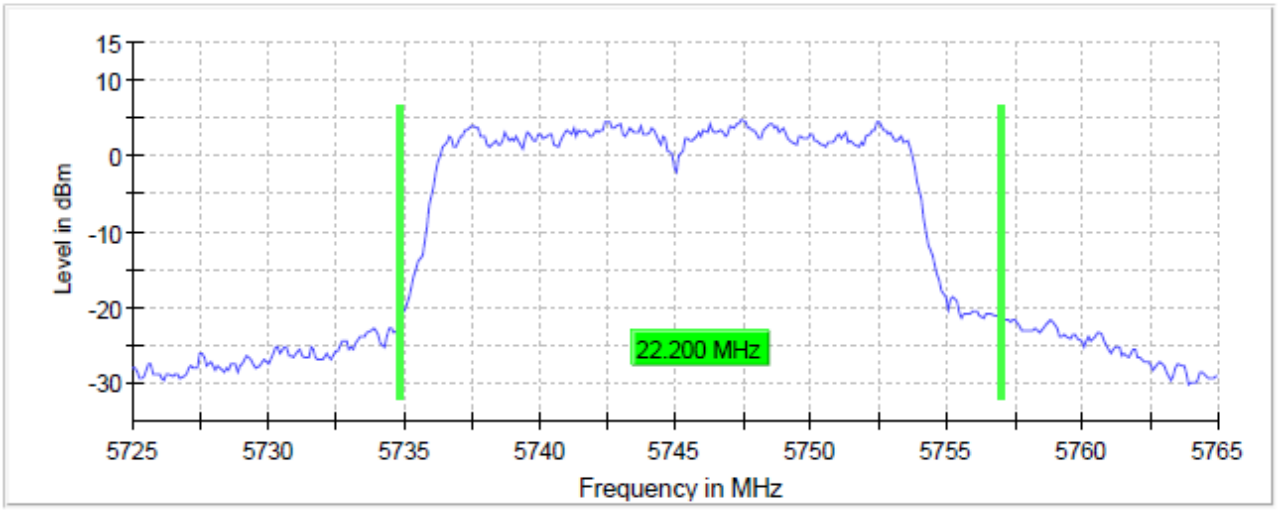
Remark: Please see next sub-clause for the measurement plot.

5.1.4 MEASUREMENT PLOT (EXAMPLE PLOT, SHOWING WORST CASE, IF APPLICABLE)

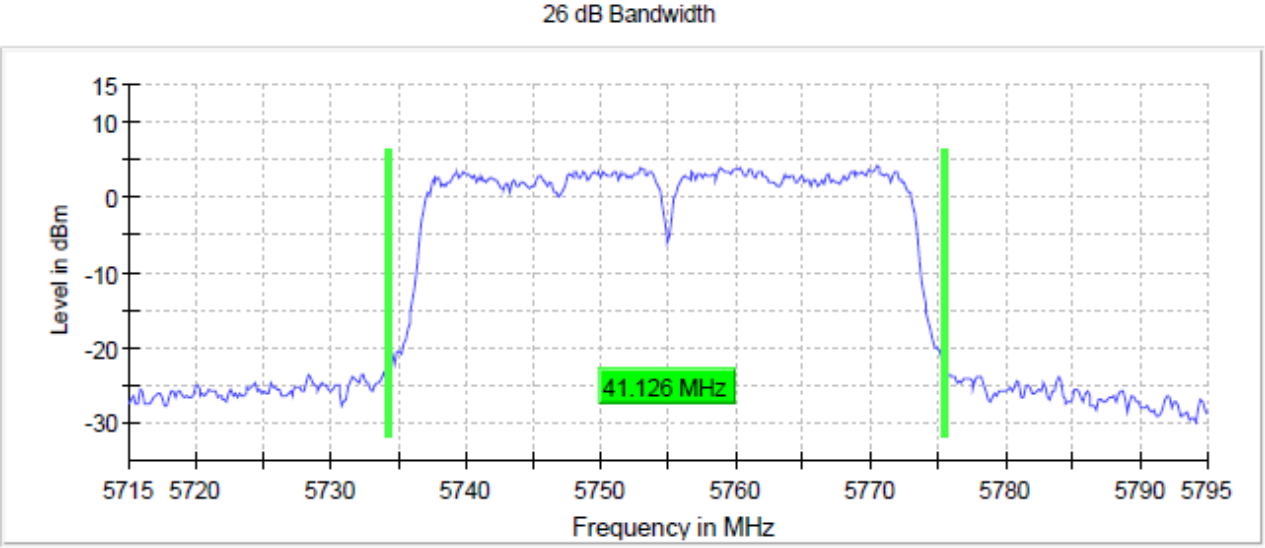
Radio Technology = WLAN a 20 MHz, Operating Frequency = low, Subband = U-NII-3 (S01_AA01)



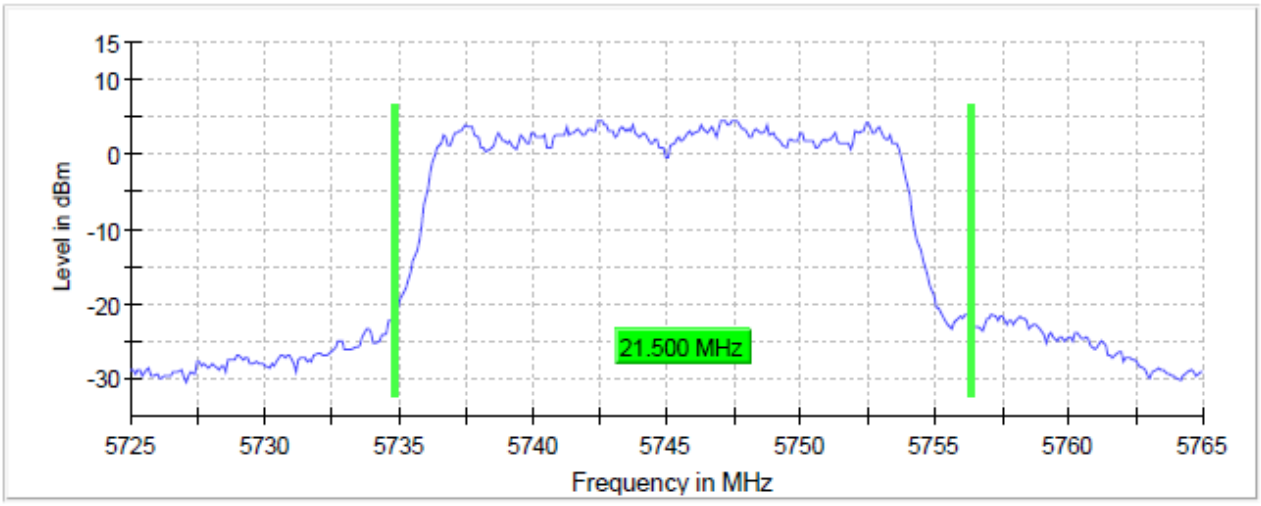
Radio Technology = WLAN n 20 MHz, Operating Frequency = low, Subband = U-NII-3 (S01_AA01)



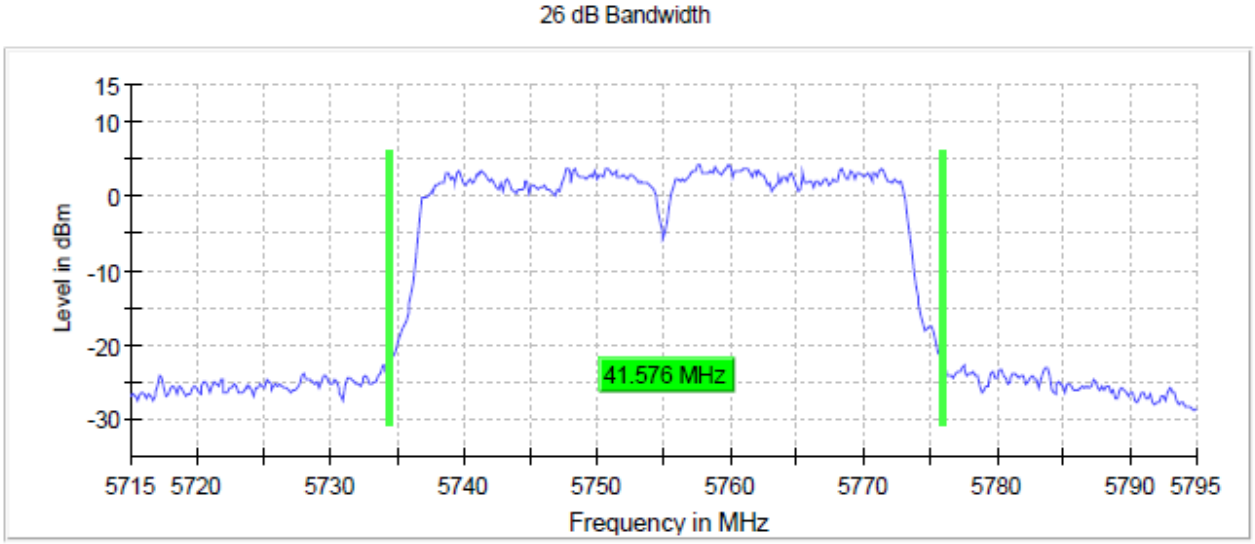
Radio Technology = WLAN n 40 MHz, Operating Frequency = low, Subband = U-NII-3 (S01_AA01)



Radio Technology = WLAN ac 20 MHz, Operating Frequency = low, Subband = U-NII-3 (S01_AA01)



Radio Technology = WLAN ac 40 MHz, Operating Frequency = low, Subband = U-NII-3 (S01_AA01



5.1.5 TEST EQUIPMENT USED

- R&S TS8997

5.2 6 DB BANDWIDTH

Standard **FCC Part 15 Subpart E**

The test was performed according to:
ANSI C63.10

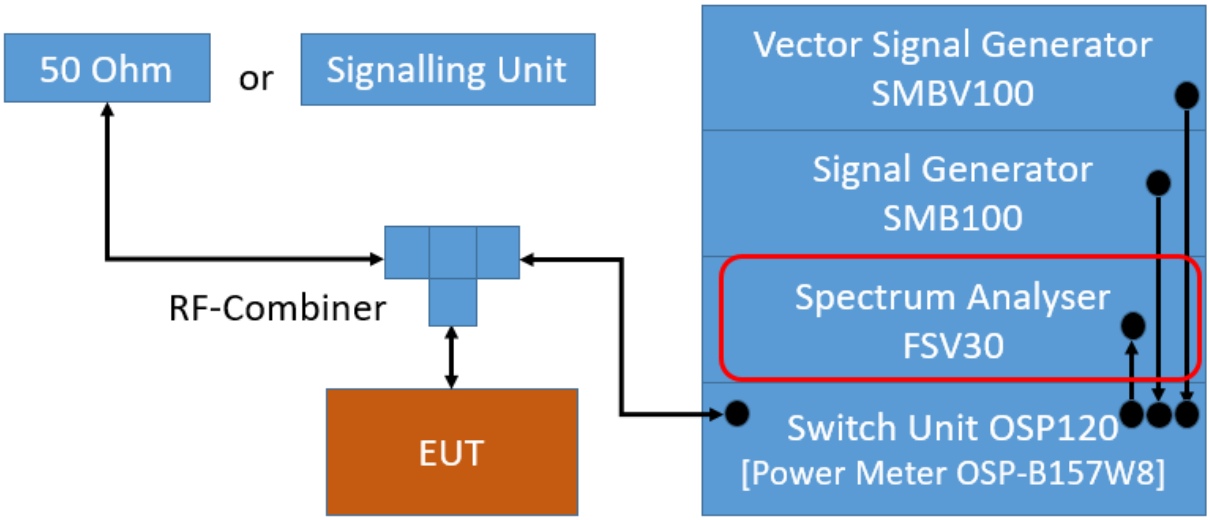
5.2.1 TEST DESCRIPTION

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

The EUT was connected to the test system as described in the block diagram below. The complete attenuation of the measurement path is known and considered.

Analyzer settings:

- Resolution Bandwidth (RBW): 100 kHz
- Video Bandwidth (VBW): 300 kHz
- Span: 40 / 80 / 160 / 320 MHz (for 20 / 40 / 80 / 160 MHz nominal bandwidth))
- Trace: Maxhold
- Sweeps: Until the trace is stable
- Sweeptime: Auto
- Detector: Peak



TS8997; Occupied Channel Bandwidth 6 dB / 26 dB / 99 %

5.2.2 TEST REQUIREMENTS / LIMITS

FCC Part 15, Subpart E, §15.407 (e)
Within the 5.725-5.850 GHz band, the minimum 6 dB bandwidth of U-NII devices shall be at least 500 kHz.

5.2.3 TEST PROTOCOL

Ambient temperature:	24 °C
Air Pressure:	1010 hPa
Humidity:	41 %

Radio Technology	Operating Frequency	6 dB Bandwidth [MHz]	Limit [MHz]	Margin [MHz]	Min. 6 dB Frequency [MHz]	Max. 6 dB Frequency [MHz]
WLAN a	low	16.40	0.5	15.90	5736.83	5753.23
WLAN n 20 MHz	low	17.40	0.5	16.90	5736.43	5753.83
WLAN n 40 MHz	low	35.55	0.5	35.05	5737.38	5772.93
WLAN ac 20 MHz	low	17.65	0.5	17.15	5736.18	5753.83
WLAN ac 40 MHz	low	35.55	0.5	35.05	5737.38	5772.93

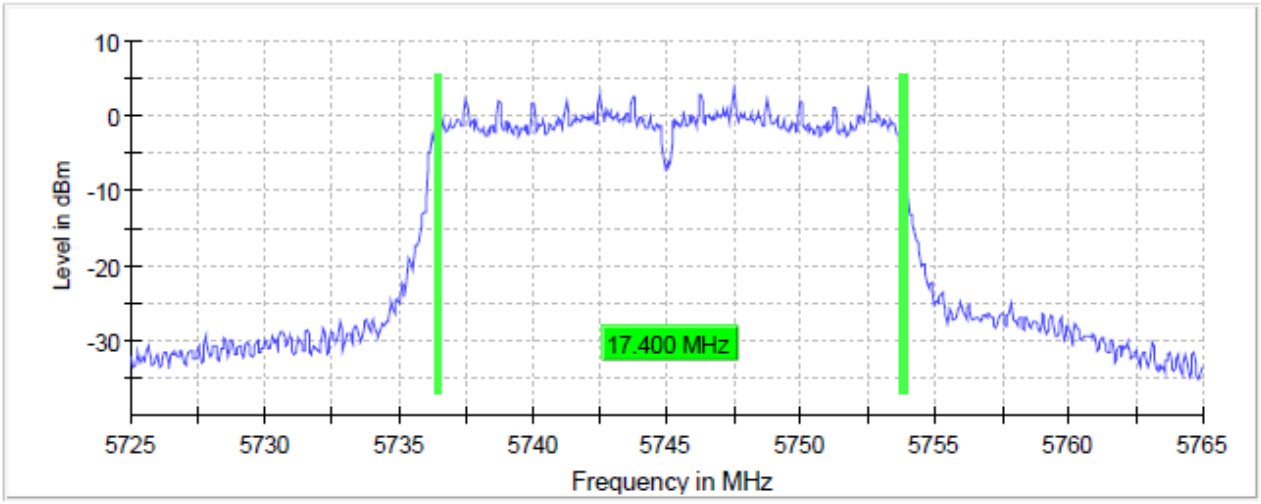
Remark: Please see next sub-clause for the measurement plot.

5.2.4 MEASUREMENT PLOT (EXAMPLE PLOT, SHOWING WORST CASE, IF APPLICABLE)

Radio Technology = WLAN a 20 MHz, Operating Frequency = low, Subband = U-NII-3 (S01_AA01)

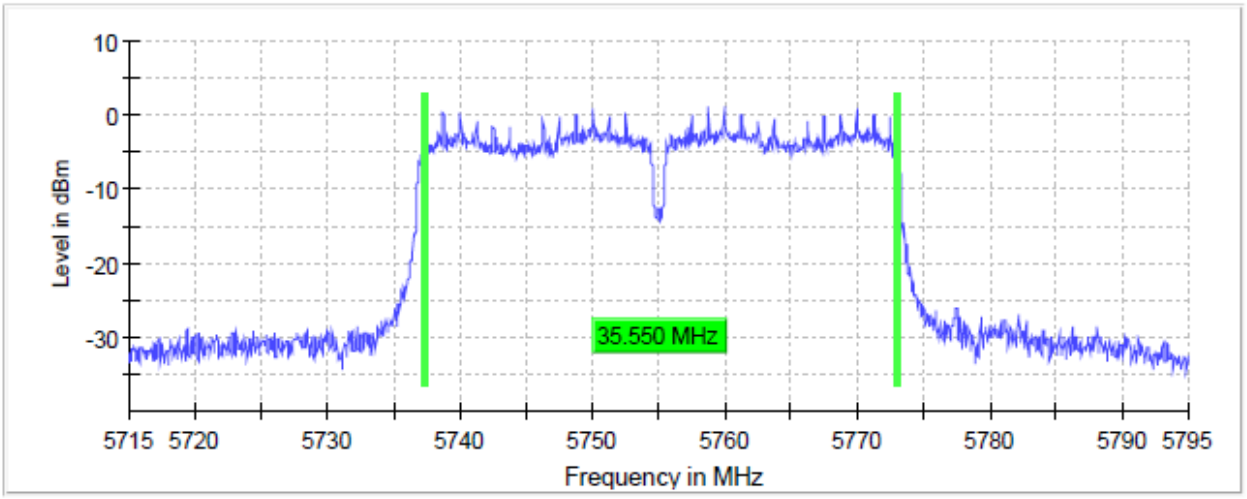
Radio Technology = WLAN n 20 MHz, Operating Frequency = low, Subband = U-NII-3 (S01_AA01)

6 dB Bandwidth

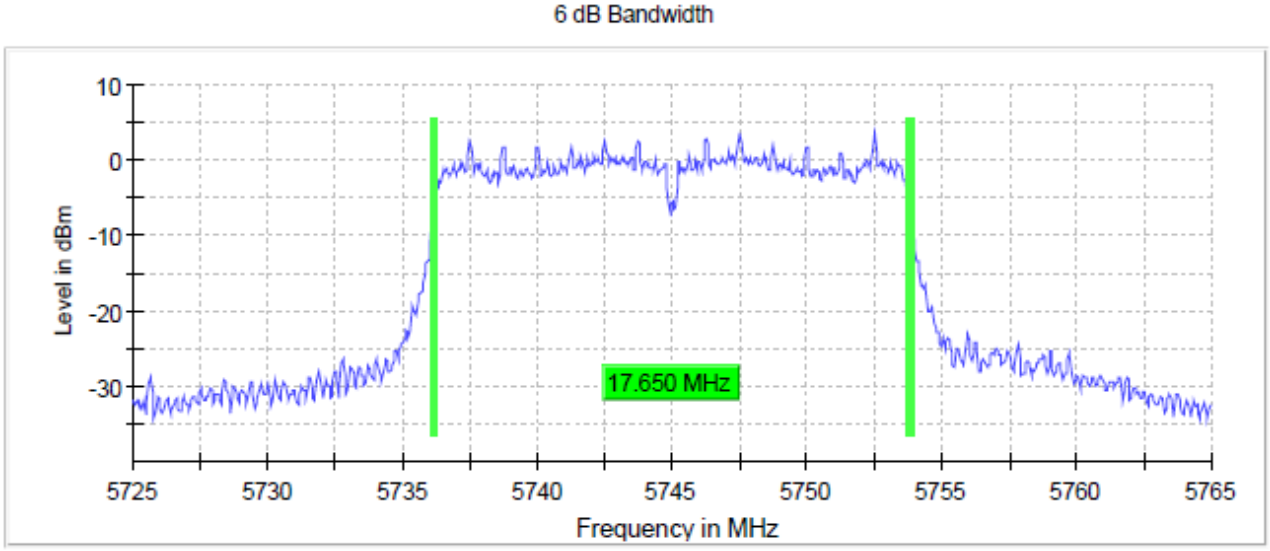


Radio Technology = WLAN n 40 MHz, Operating Frequency = low, Subband = U-NII-3(S01_AA01)

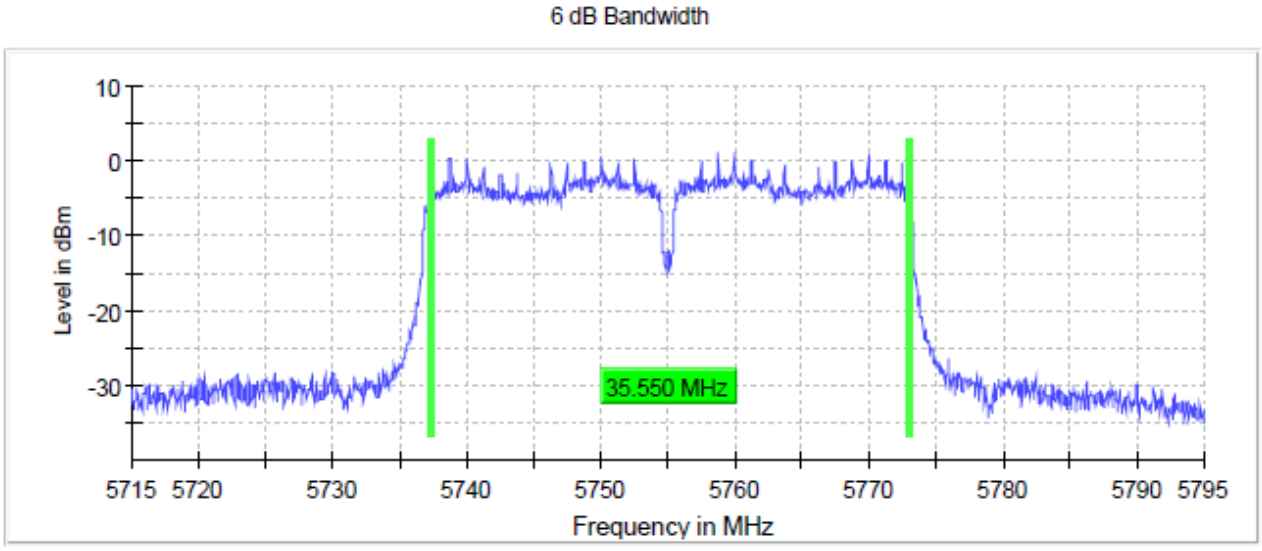
6 dB Bandwidth



Radio Technology = WLAN ac 20 MHz, Operating Frequency = low, Subband = U-NII-3 (S01_AA01)



Radio Technology = WLAN ac 40 MHz, Operating Frequency = low, Subband = U-NII-3 (S01_AA01)



5.2.5 TEST EQUIPMENT USED

- R&S TS8997

5.3 99 % BANDWIDTH

Standard **FCC Part 15 Subpart E**

The test was performed according to:
ANSI C63.10

5.3.1 TEST DESCRIPTION

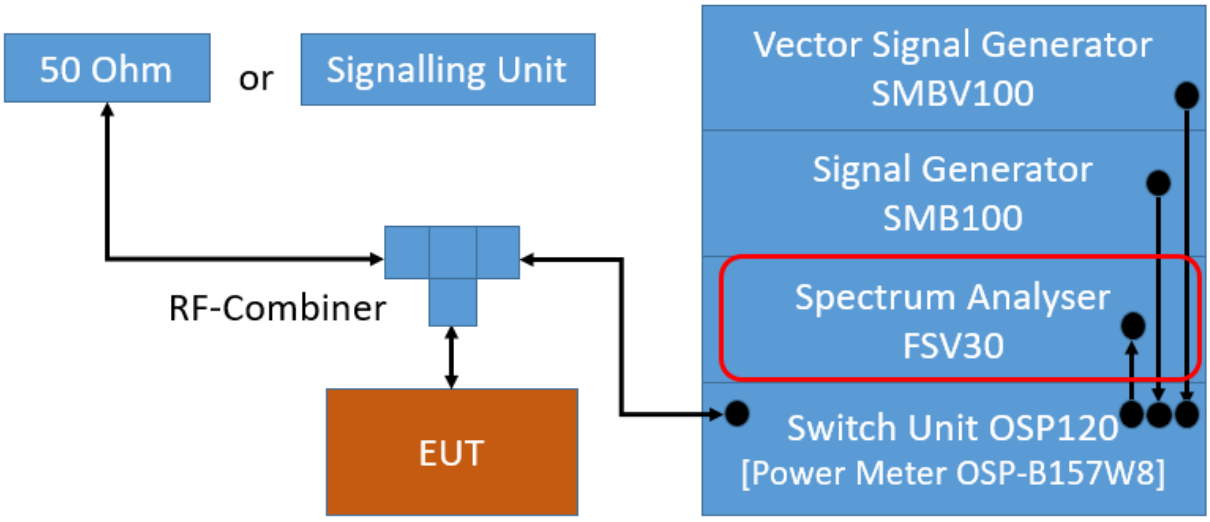
The Equipment Under Test (EUT) was set up to perform the occupied bandwidth measurements.
The reference level is the level of the highest amplitude signal observed from the transmitter at either the fundamental frequency or first-order modulation products in all typical modes of operation, including the unmodulated carrier, even if atypical.
The results recorded were measured with the modulation which produce the worst-case (widest) emission bandwidth.

The EUT was connected to the test system as described in the block diagram below. The complete attenuation of the measurement path is known and considered.

Analyzer settings:

- Resolution Bandwidth (RBW): approx. ≥ 1 % of the span, but not below
- Video Bandwidth (VBW): ≥ 3 times the RBW
- Span: 40 / 80 / 160 / 320 MHz (for 20 / 40 / 80 / 160 MHz nominal bandwidth)
- Trace: Maxhold
- Sweeps: Until the trace is stable
- Sweeptime: Auto
- Detector: Peak

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



TS8997; Occupied Channel Bandwidth 6 dB / 26 dB / 99 %

5.3.2 TEST REQUIREMENTS / LIMITS

No applicable limit:

5.3.3 TEST PROTOCOL

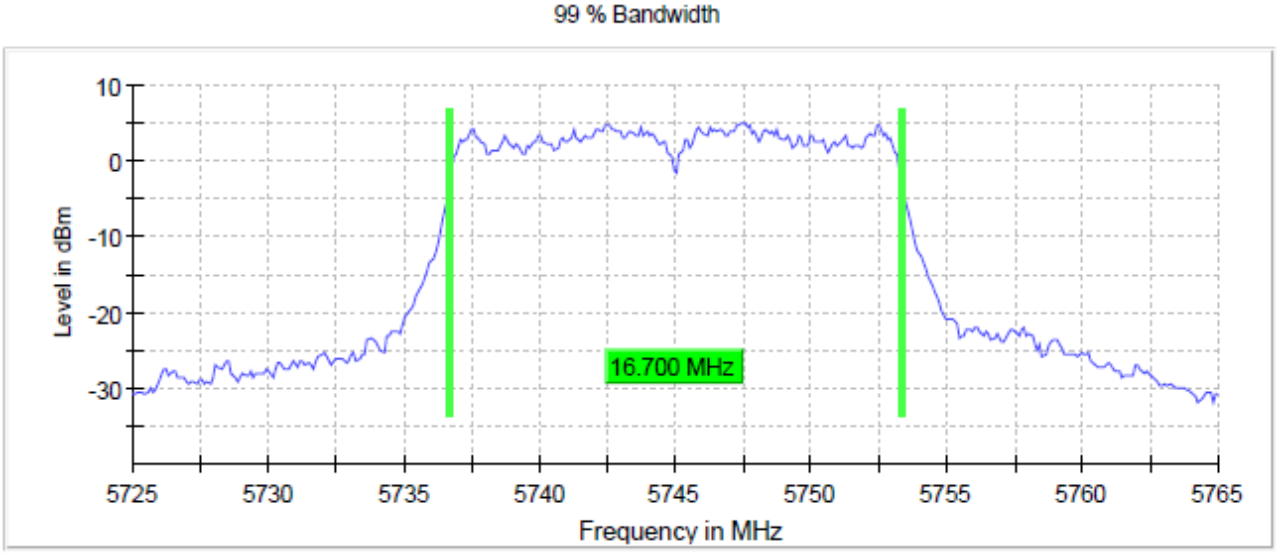
Ambient temperature: 24 °C
Air Pressure: 1010 hPa
Humidity: 41 %

Radio Technology	Operating Frequency	Subband	99% Bandwidth [MHz]
WLAN a	low	U-NII-3	16.7
WLAN n 20 MHz	low	U-NII-3	17.8
WLAN n 40 MHz	low	U-NII-3	36.5
WLAN ac 20 MHz	low	U-NII-3	17.7
WLAN ac 40 MHz	low	U-NII-3	36.5

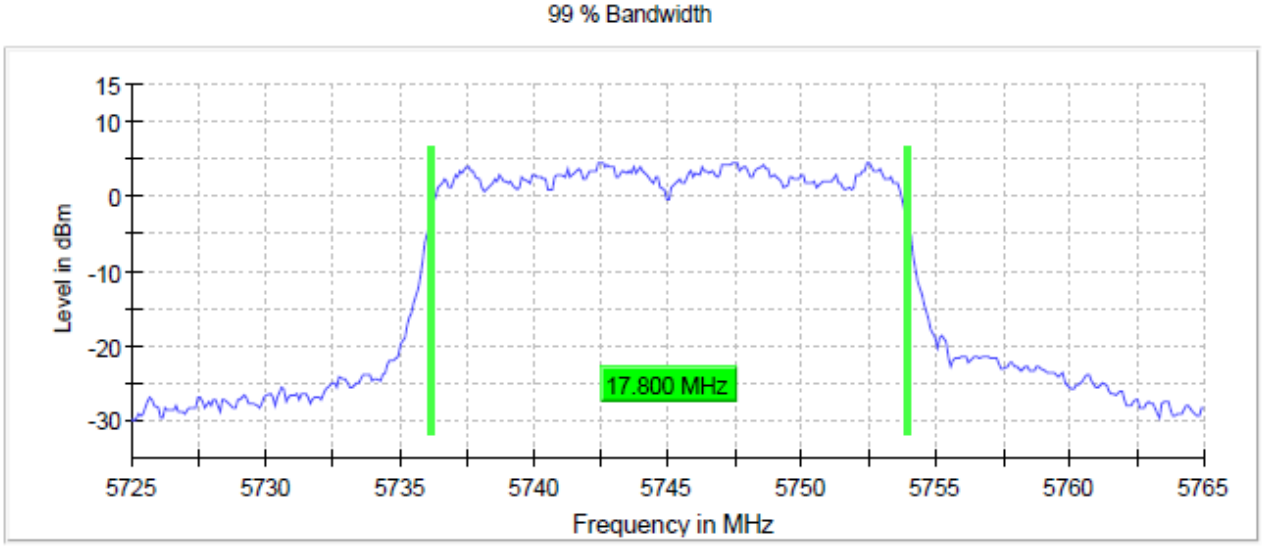
Remark: Please see next sub-clause for the measurement plot.

5.3.4 MEASUREMENT PLOT (EXAMPLE PLOT, SHOWING WORST CASE, IF APPLICABLE)

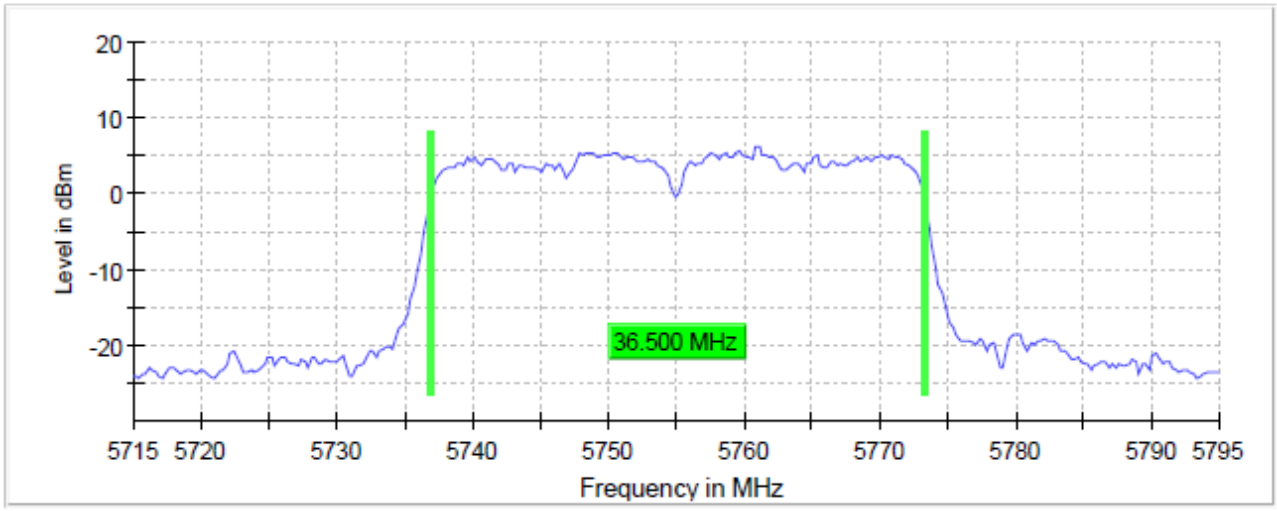
Radio Technology = WLAN a 20 MHz, Operating Frequency = low, Subband = U-NII-3 (S01_AA01)



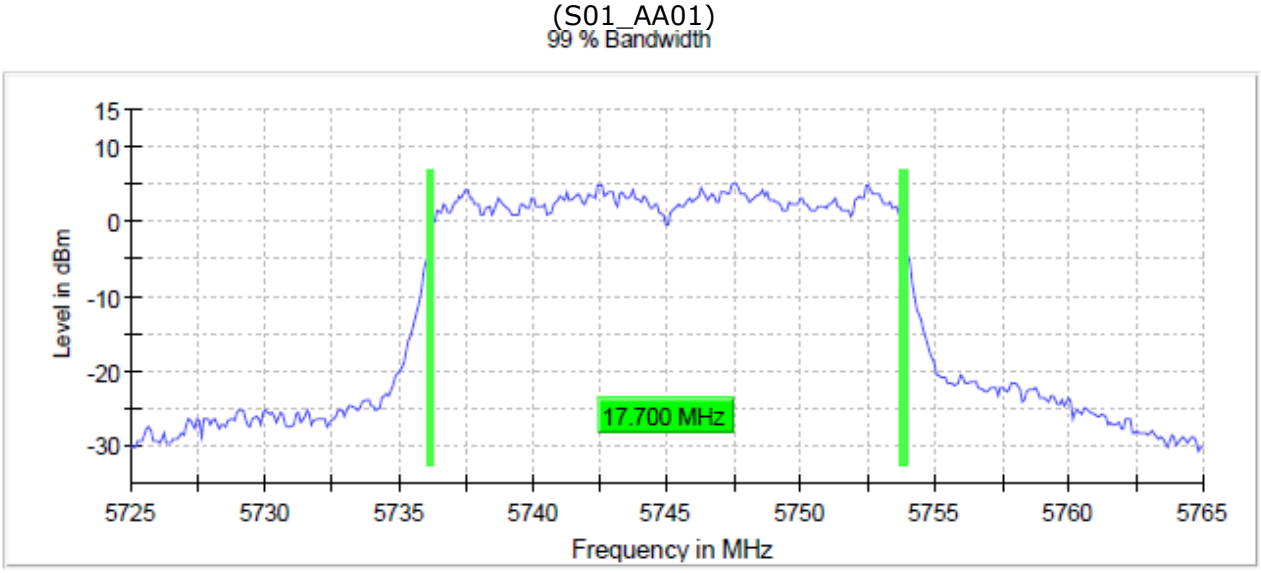
Radio Technology = WLAN n 20 MHz, Operating Frequency = low, Subband = U-NII-3 (S01_AA01)



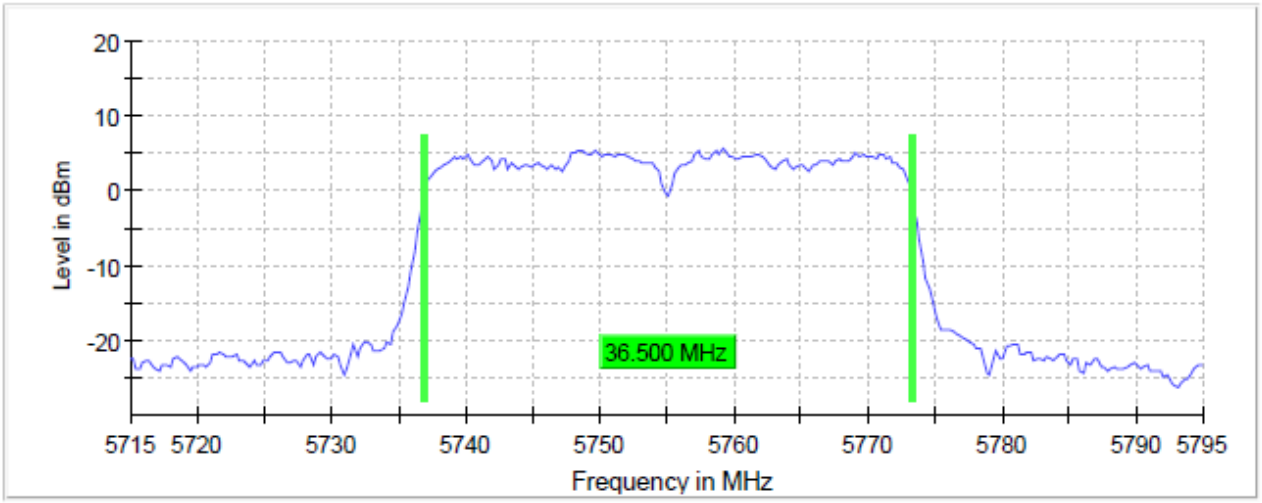
Radio Technology = WLAN n 40 MHz, Operating Frequency = low, Subband = U-NII-3 (S01_AA01)



Radio Technology = WLAN ac 20 MHz, Operating Frequency = low, Subband = U-NII-3 (S01_AA01)



Radio Technology = WLAN ac 40 MHz, Operating Frequency = low, Subband = U-NII-3 (S01_AA01)



5.3.5 TEST EQUIPMENT USED

- R&S TS8997

5.4 MAXIMUM CONDUCTED OUTPUT POWER

Standard **FCC Part 15 Subpart E**

The test was performed according to:
ANSI C63.10

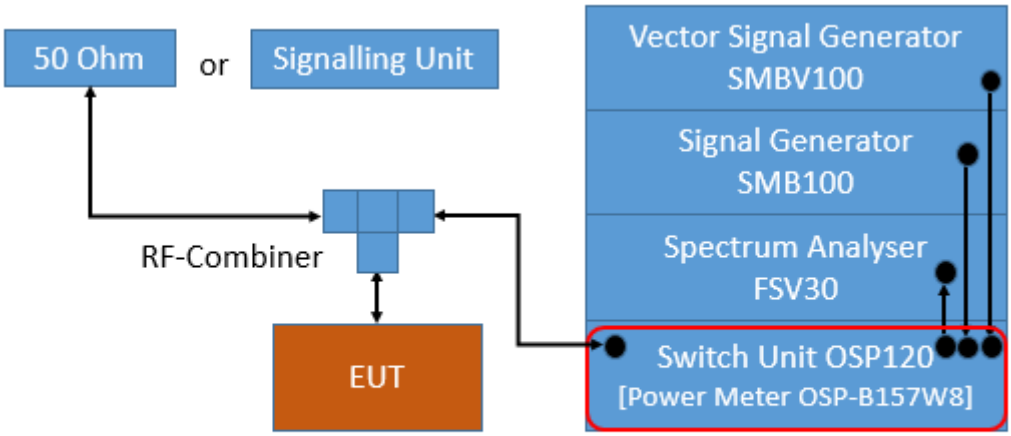
5.4.1 TEST DESCRIPTION

The Equipment Under Test (EUT) was set up to perform the output power measurements. The results recorded were measured with the modulation which produces the worst-case (highest) output power

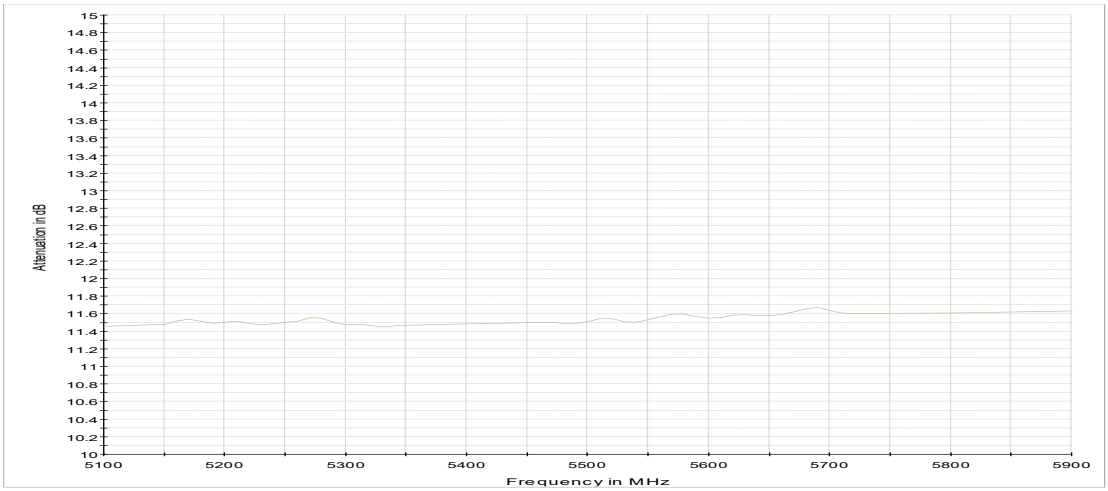
The EUT was connected to the test system as described in the block diagram below. The complete attenuation of the measurement path is known and considered.

The OSP-B157W is a gated RF average power meter with a signal bandwidth > 300 MHz.

Note:
The measurement was performed according FCC Public Note "Guidelines for Compliance Testing of Unlicensed National Information Infrastructure (U-NII) Devices - Part 15, Subpart E, 789033 D02", method **PM-G**.



TS8997; Maximum Conducted Output Power



Attenuation of measurement path

5.4.2 TEST REQUIREMENTS / LIMITS

A) FCC
For systems using digital modulation techniques in the 5.15 – 5.25 GHz bands:
§15.407 (a) (1)
Limit: 50 mW (17 dBm) or 4 dBm + 10 log (26 dB bandwidth/MHz) whatever is the lesser.
FCC ET Docket No. 13-49, FIRST REPORT AND ORDER, April 1, 2014 ("new rules"):
§15.407 (a) (1) (i): Outdoor access point:
Limit: 1 W (30 dBm) provided the maximum antenna gain does not exceed 6 dBi.
The maximum e.i.r.p. at any elevation angle above 30 degrees as measured from the horizon must not exceed 125 mW (21 dBm).
§15.407 (a) (1) (ii): Indoor access point:
Limit: 1 W (30 dBm) provided the maximum antenna gain does not exceed 6 dBi.
§15.407 (a) (1) (iv): Mobile and portable client devices:
Limit: 250 mW (24 dBm) provided the maximum antenna gain does not exceed 6 dBi.

For systems using digital modulation techniques in the 5.25 – 5.35 GHz and 5.47 – 5.725 GHz bands:
§15.407 (a) (2)
Limit: 250 mW (24 dBm) or 11 dBm + 10 log (26 dB bandwidth/MHz) whatever is the lesser.

For systems using digital modulation techniques in the 5.725 – 5.850 GHz bands:
§15.407 (a) (3)
Limit: 1 W (30 dBm) or 17 dBm + 10 log (26 dB bandwidth/MHz) whatever is the lesser.
FCC ET Docket No. 13-49, FIRST REPORT AND ORDER, April 1, 2014 ("new rules"):
§15.407 (a) (3):
Limit: 1 W (30 dBm).

§15.407 (a) (4):
The maximum conducted output power must be measured over any interval of continuous transmission using instrumentation calibrated in terms of an rms-equivalent voltage.

B) IC
Different frequency bands and limits apply, as compared to the FCC requirements.

RSS-247, 6.2.1 (1), Band 5150-5250 MHz, indoor operation only:
Limit (e.i.r.p.): 200 mW (23 dBm) or 10 + 10 log10 B [dBm], whichever power is less.
B is the 99% emission bandwidth in MHz.

RSS-247, 6.2.2 (1), Band 5250-5350 MHz:
Limits:
Maximum conducted Power: 250 mW (24 dBm) or 11 + 10 log10 B [dBm], whichever power is less.
e.i.r.p.: 1.0 W (30 dBm) or 17 + 10 log10 B [dBm], whichever power is less.

Note: For EUTs operating at a higher e.i.r.p. than 200 mW (23 dBm), compliance with the e.i.r.p. elevation mask is required.

RSS-247, 6.2.3 (1), Bands 5470-5600 MHz and 5650-5725 MHz:
Limits:
Maximum conducted Power: 250 mW (24 dBm) or 11 + 10 log10 B [dBm], whichever power is less.
e.i.r.p.: 1.0 W (30 dBm) or 17 + 10 log10 B [dBm], whichever power is less.

RSS-247, 6.2.4 (1), Band 5725-5825 MHz:
Limits:
Maximum conducted Power: 1W (30 dBm) or 17 + 10 log10 B [dBm], whichever power is less.
e.i.r.p.: 4.0 W (36 dBm) or 23 + 10 log10 B [dBm], whichever power is less.

All frequency bands: B is the 99% emission bandwidth in MHz.

5.4.3 TEST PROTOCOL

Ambient temperature: 24 °C
Air Pressure: 1010 hPa
Humidity: 41 %

WLAN a-Mode; 20 MHz; MCS 0					FCC		ISED			
U-NII-Subband	**Ch. No.**	**Freq. [MHz]**	**Cond. Power [dBm]**	**EIRP [dBm]**	**FCC Cond. Limit [dBm]**	**Margin [dB]**	**IC Cond. Limit [dBm]**	**Margin [dB]**	**IC EIRP Limit [dBm]**	**Margin [dB]**
3	149	5745	14.8	15.8	30.0	15.2	30.0	15.2	36.0	20.2

WLAN n-Mode; 20 MHz; MCS 0					FCC		ISED			
U-NII-Subband	**Ch. No.**	**Freq. [MHz]**	**Cond. Power [dBm]**	**EIRP [dBm]**	**FCC Cond. Limit [dBm]**	**Margin [dB]**	**IC Cond. Limit [dBm]**	**Margin [dB]**	**IC EIRP Limit [dBm]**	**Margin [dB]**
3	149	5745	14.9	15.9	30.0	15.1	30.0	15.1	36.0	20.1

WLAN n-Mode; 40 MHz; MCS 0					FCC		ISED			
U-NII-Subband	**Ch. No.**	**Freq. [MHz]**	**Cond. Power [dBm]**	**EIRP [dBm]**	**FCC Cond. Limit [dBm]**	**Margin [dB]**	**IC Cond. Limit [dBm]**	**Margin [dB]**	**IC EIRP Limit [dBm]**	**Margin [dB]**
3	151	5755	14.8	15.8	30.0	15.2	30.0	15.2	36.0	20.2

WLAN ac-Mode; 20 MHz; MCS 0					FCC		ISED			
U-NII-Subband	**Ch. No.**	**Freq. [MHz]**	**Cond. Power [dBm]**	**EIRP [dBm]**	**FCC Cond. Limit [dBm]**	**Margin [dB]**	**IC Cond. Limit [dBm]**	**Margin [dB]**	**IC EIRP Limit [dBm]**	**Margin [dB]**
3	149	5745	14.7	15.7	30.0	15.3	30.0	15.3	36.0	20.3

WLAN ac-Mode; 40 MHz; MCS 0					FCC		ISED			
U-NII-Subband	**Ch. No.**	**Freq. [MHz]**	**Cond. Power [dBm]**	**EIRP [dBm]**	**FCC Cond. Limit [dBm]**	**Margin [dB]**	**IC Cond. Limit [dBm]**	**Margin [dB]**	**IC EIRP Limit [dBm]**	**Margin [dB]**
3	151	5755	14.0	15.0	30.0	16.0	30.0	16.0	36.0	21.0

Remark: Please see next sub-clause for the measurement plot.

5.4.4 MEASUREMENT PLOT (EXAMPLE PLOT, SHOWING WORST CASE, IF APPLICABLE)

No plots provided (power meter measurement)

5.4.5 TEST EQUIPMENT USED

- R&S TS8997

5.5 PEAK POWER SPECTRAL DENSITY

Standard **FCC Part 15 Subpart E**

The test was performed according to:
ANSI C63.10

5.5.1 TEST DESCRIPTION

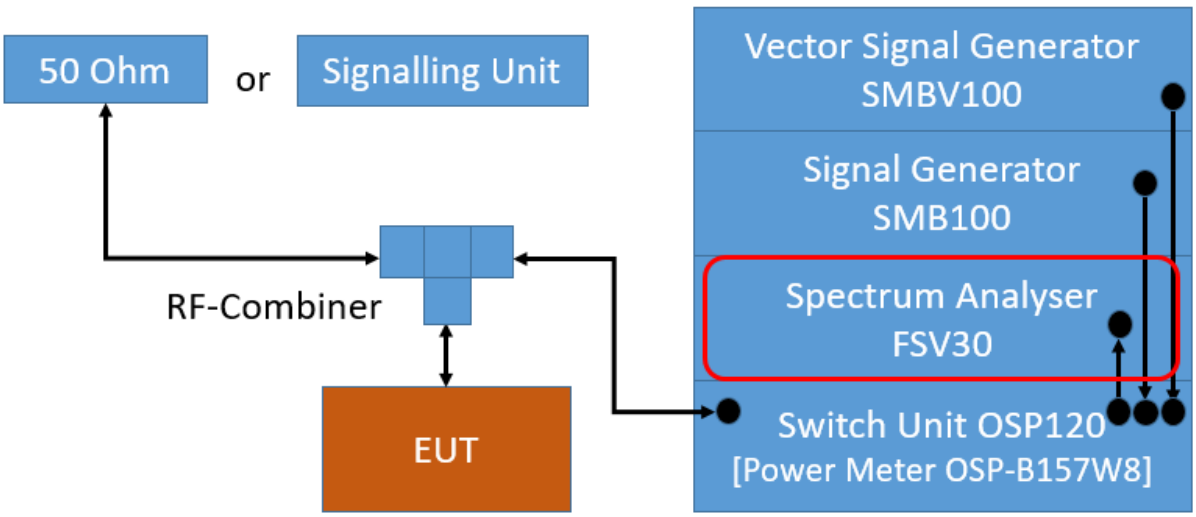
The Equipment Under Test (EUT) was set up in a shielded room to perform the Maximum Power Spectral Density measurements.
The results recorded were measured with the modulation which produces the worst-case (highest) output power.

The EUT was connected to the test system as described in the block diagram below. The complete attenuation of the measurement path is known and considered.

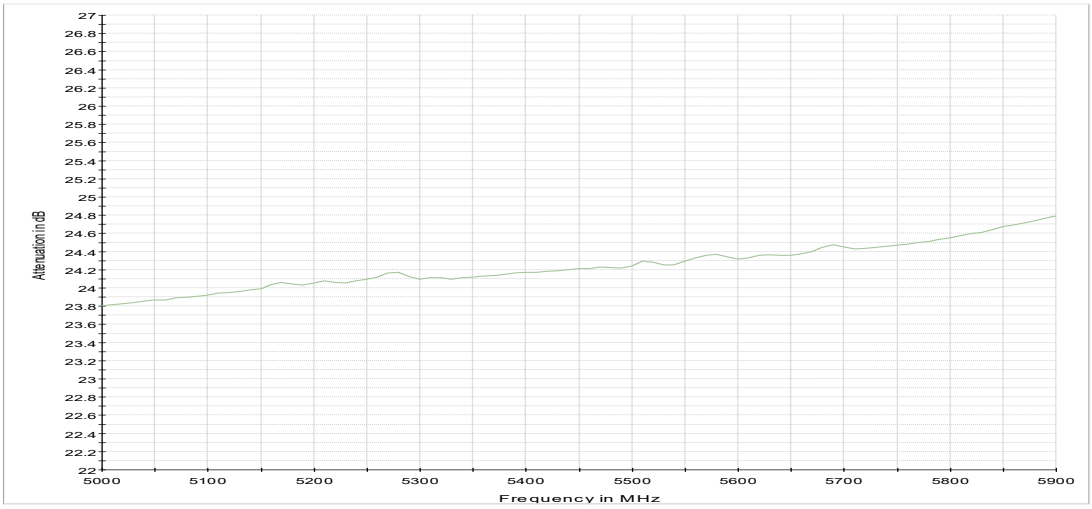
Analyzer settings:

- Resolution Bandwidth (RBW): 1 MHz (for subband 3: 500 kHz)
- Video Bandwidth (VBW): 3 MHz (for subband 3: 2 MHz)
- Trace: Average, RMS power averaging mode
- Sweeps: 100
- Sweeptime: 5 ms
- Detector: RMS
- Trigger: gated mode

Note:
The analyser settings are according FCC Public Note "Guidelines for Compliance Testing of Unlicensed National Information Infrastructure (U-NII) Devices - Part 15, Subpart E, 789033 D02", method **SA-3**.



TS8997; Maximum Power Spectral Density



Attenuation of the measurement path

5.5.2 TEST REQUIREMENTS / LIMITS

A) FCC
FCC Part 15, Subpart E, §15.407 (a) (1)
For systems using digital modulation techniques in the 5.15 – 5.25 GHz bands:
(i) and (ii), outdoor and indoor access points: Limit: 17 dBm/MHz.
(iv), mobile and portable client devices: Limit: 11 dBm/MHz.

FCC Part 15, Subpart E, §15.407 (a) (2)
For systems using digital modulation techniques in the 5.25 – 5.35 GHz and 5.47 – 5.725 GHz bands:
Limit: 11 dBm/MHz.

FCC Part 15, Subpart E, §15.407 (a) (3)
For systems using digital modulation techniques in the 5.725 – 5.850 GHz bands:
Limit: 30 dBm/500 kHz.

Note: The limit will be also fulfilled when measuring at any bandwidth greater than 500 kHz. This applies to signals where the maximum conducted output power was measured at a bandwidth exceeding 500 kHz and which fulfil that limit of 30 dBm.

B) IC
Different frequency bands and limits apply, as compared to the FCC requirements.

RSS-247, 6.2.1 (1), Band 5150-5250 MHz, indoor operation only:
Limit (e.i.r.p.): 10 dBm/MHz.

RSS-247, 6.2.2 (1), Band 5250-5350 MHz:
Limit: 11 dBm/MHz.

RSS-247, 6.2.3 (1), Bands 5470-5600 MHz and 5650-5725 MHz:
Limit: 11 dBm/MHz.

RSS-247, 6.2.4 (1), Band 5725-5850 MHz:
Limit: 30 dBm/500 kHz.

5.5.3 TEST PROTOCOL

Ambient temperature: 24 °C
Air Pressure: 1010 hPa
Humidity: 41 %
WLAN a-Mode; 20 MHz; Mbit/s

U-NII-Subband	Ch. No.	Freq. [MHz]	MPSD [dBm/MHz]	FCC Limit [dBm/MHz]	Margin [dB]	IC Limit [dBm/MHz]	Margin [dB]	IC EIRP MPSD
3	149	5745	0.9	30.0	29.1	30.0	29.1	

WLAN n-Mode; 20 MHz; x Mbit/s MCSx; SISO

U-NII-Subband	Ch. No.	Freq. [MHz]	MPSD [dBm/MHz]	FCC Limit [dBm/MHz]	Margin [dB]	IC Limit [dBm/MHz]	Margin [dB]	IC EIRP MPSD
3	149	5745	0.4	30.0	29.6	30.0	29.6	

WLAN n-Mode; 40 MHz; x Mbit/s MCSx; SISO

U-NII-Subband	Ch. No.	Freq. [MHz]	MPSD [dBm/MHz]	FCC Limit [dBm/MHz]	Margin [dB]	IC Limit [dBm/MHz]	Margin [dB]	IC EIRP MPSD
3	151	5755	1.4	30.0	28.6	30.0	28.6	

WLAN ac-Mode; 20 MHz; x Mbit/s MCSx; SISO

U-NII-Subband	Ch. No.	Freq. [MHz]	MPSD [dBm/MHz]	FCC Limit [dBm/MHz]	Margin [dB]	IC Limit [dBm/MHz]	Margin [dB]	IC EIRP MPSD
3	149	5745	0.7	30.0	29.3	30.0	29.3	

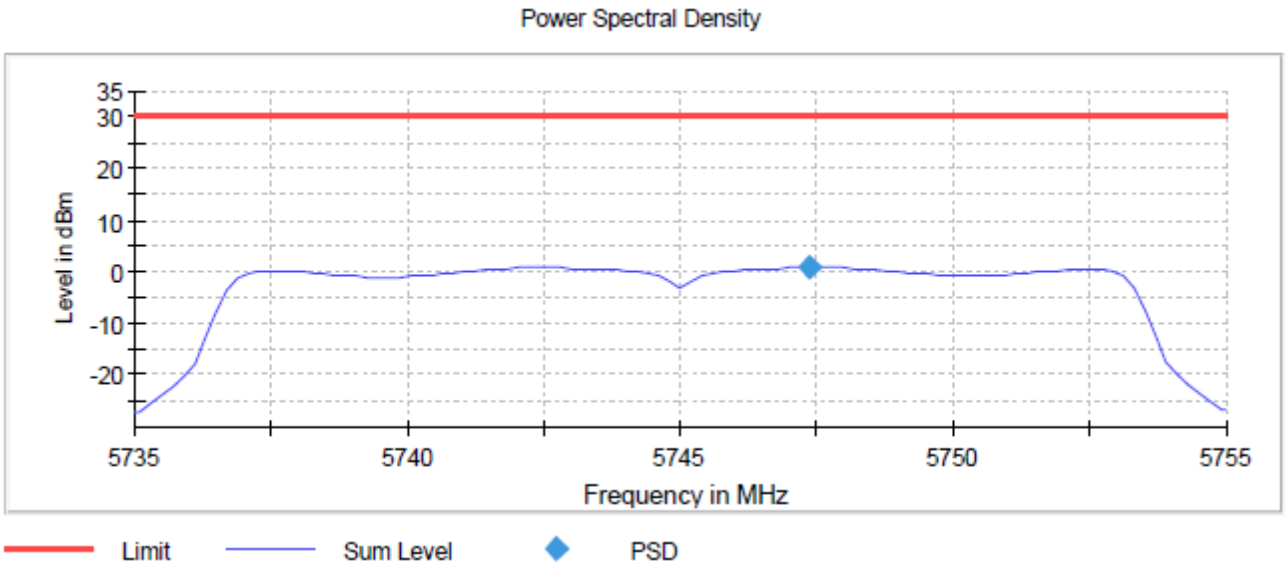
WLAN ac-Mode; 40 MHz; x Mbit/s MCSx; SISO

U-NII-Subband	Ch. No.	Freq. [MHz]	MPSD [dBm/MHz]	FCC Limit [dBm/MHz]	Margin [dB]	IC Limit [dBm/MHz]	Margin [dB]	IC EIRP MPSD
3	151	5755	2.8	30.0	27.2	30.0	27.2	

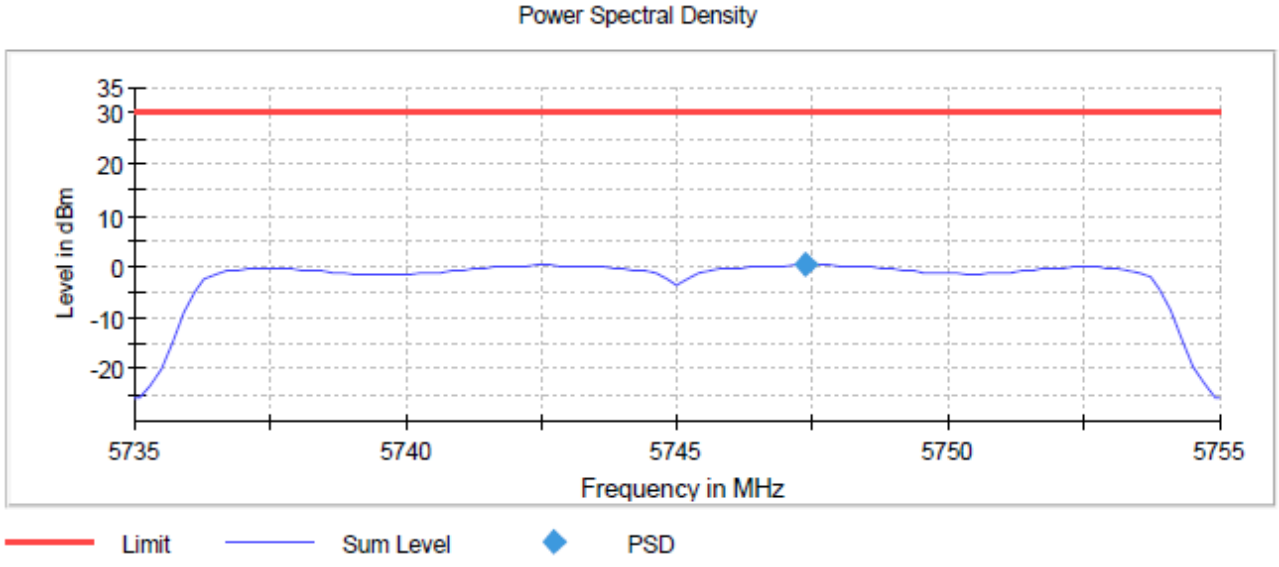
Remark: Please see next sub-clause for the measurement plot.

5.5.4 MEASUREMENT PLOT (EXAMPLE PLOT, SHOWING WORST CASE, IF APPLICABLE)

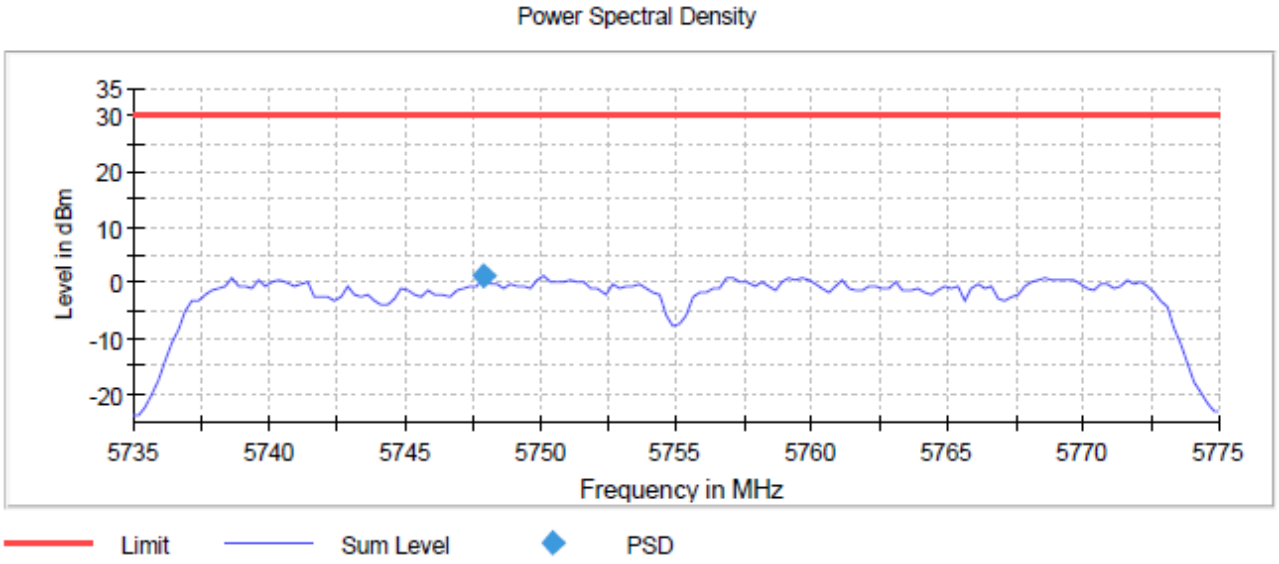
Radio Technology = WLAN a 20 MHz, Operating Frequency = low, Subband = U-NII-3 (S01_AA01)



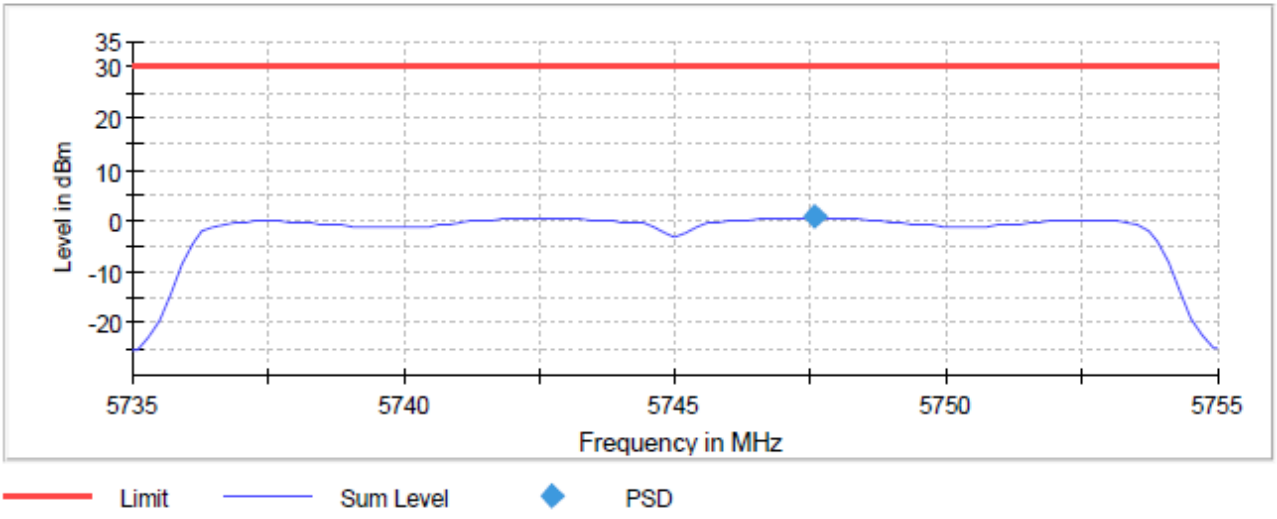
Radio Technology = WLAN n 20 MHz, Operating Frequency = low, Subband = U-NII-3 (S01_AA01)



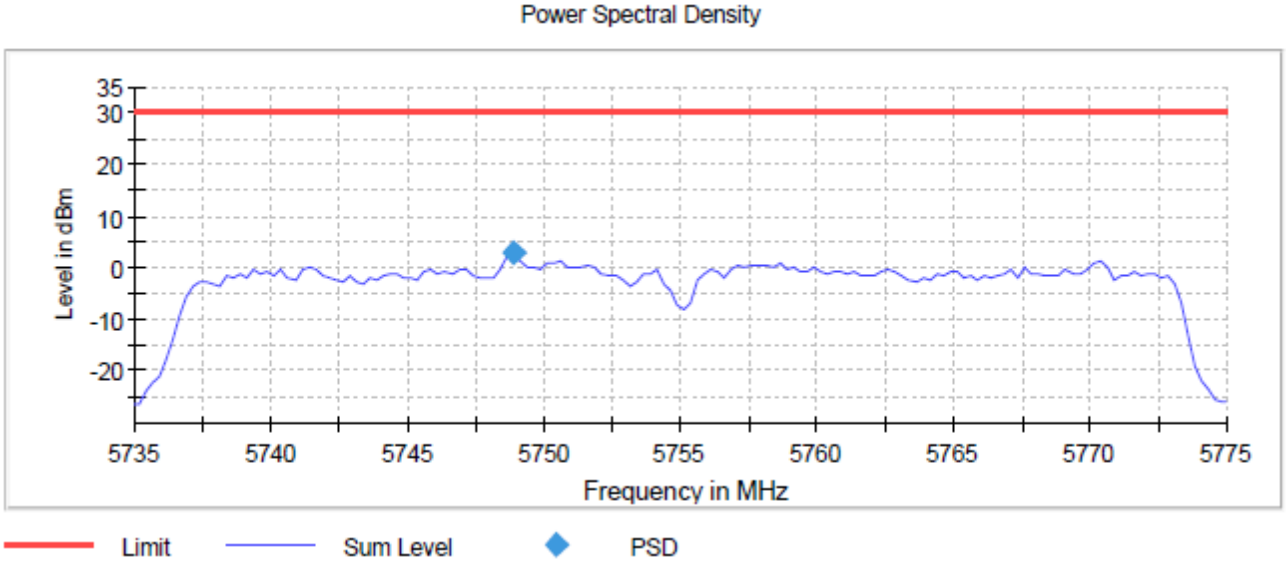
Radio Technology = WLAN n 40 MHz, Operating Frequency = low, Subband = U-NII-3 (S01_AA01)



Radio Technology = WLAN ac 20 MHz, Operating Frequency = low, Subband = U-NII-3 (S01_AA01)



Radio Technology = WLAN ac 40 MHz, Operating Frequency = low, Subband = U-NII-3 (S01_AA01)



5.5.5 TEST EQUIPMENT USED

- R&S TS8997

5.6 UNDESIRABLE EMISSIONS; GENERAL FIELD STRENGTH LIMITS

Standard **FCC Part 15 Subpart E**

The test was performed according to:
ANSI C63.10

5.6.1 TEST DESCRIPTION

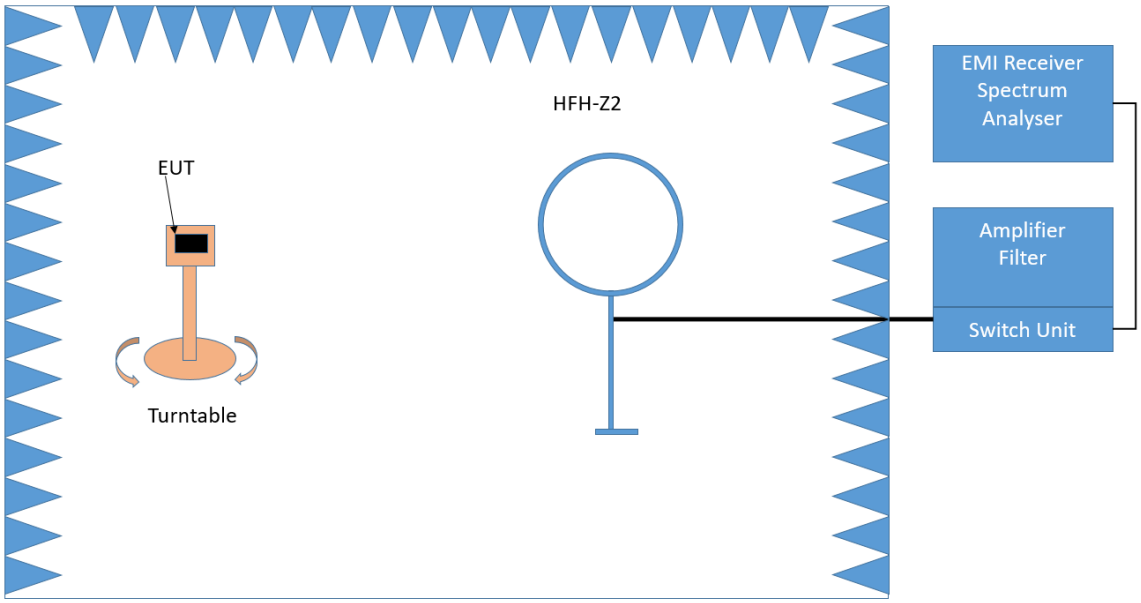
The test set-up was made in accordance to the general provisions of ANSI C63.10 in a typical installation configuration. The measurements were performed according the following sub-chapters of ANSI C63.10:
< 30 MHz: Chapter 6.4
30 MHz – 1 GHz: Chapter 6.5
> 1 GHZ: Chapter 6.6 (procedure according 6.6.5 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

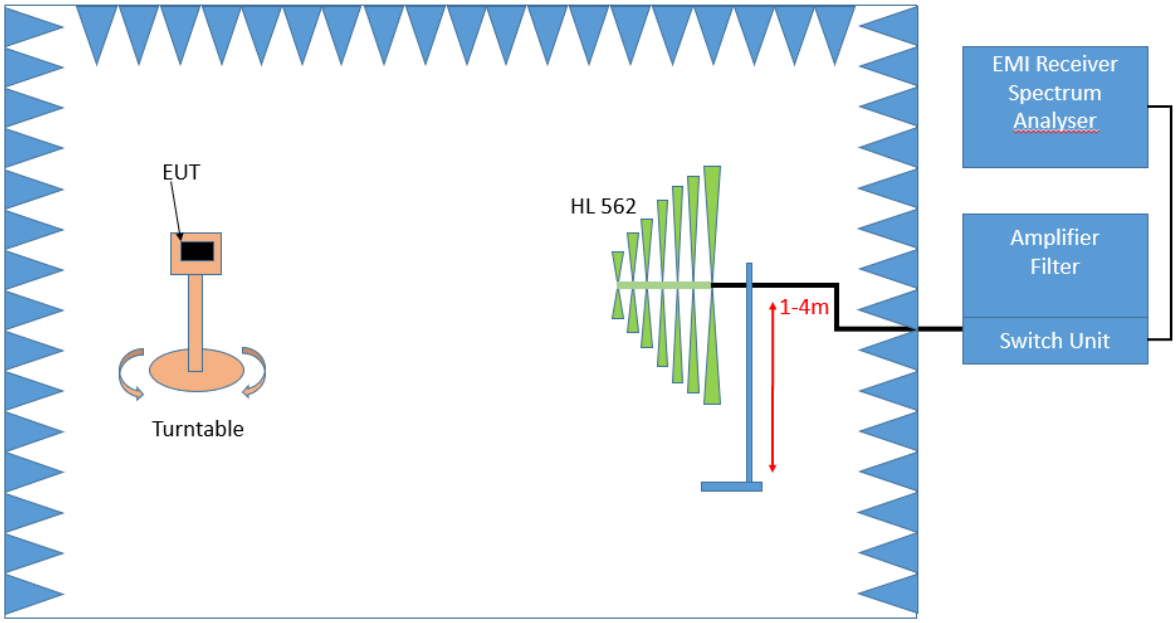


Test Setup; Spurious Emission Radiated (SAC), 9 kHz – 30 MHz

The Loop antenna HFH2-Z2 is used.

Step 1: pre measurement
Anechoic chamber
Antenna distance: 3 m
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



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-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 – 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° 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 1m and 4m. 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: 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:

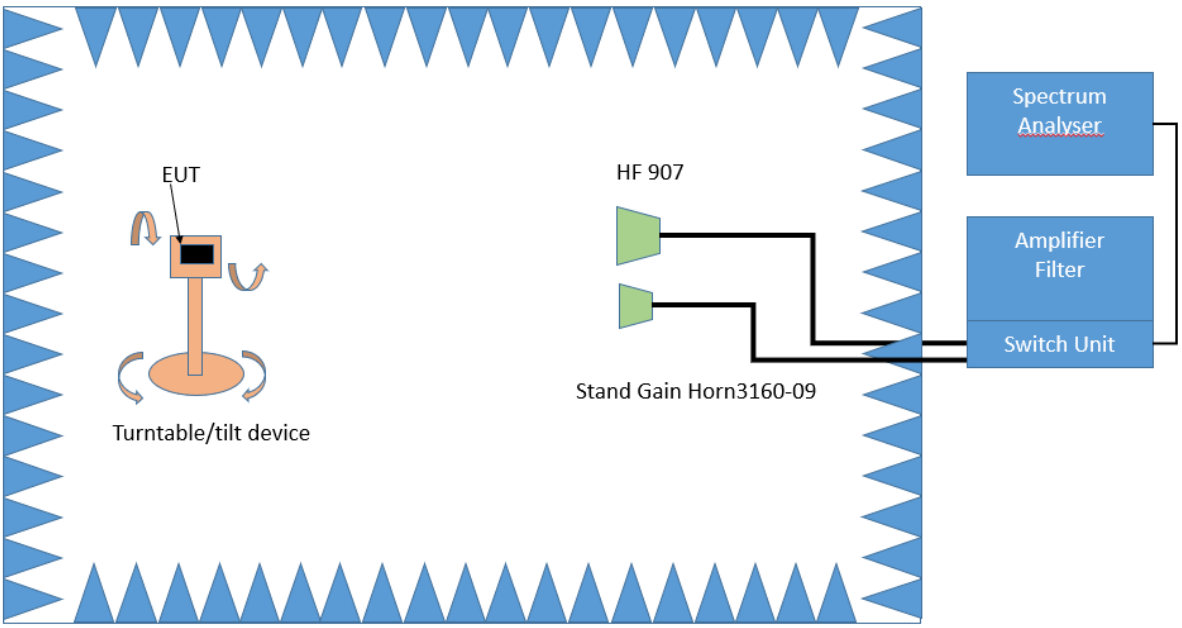
- Detector: Quasi-Peak (< 1 GHz)
- Measured frequencies: in step 1 determined frequencies
- IF – Bandwidth: 120 kHz
- Measuring time: 1 s

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.

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 1 GHz up to 26.5 GHz



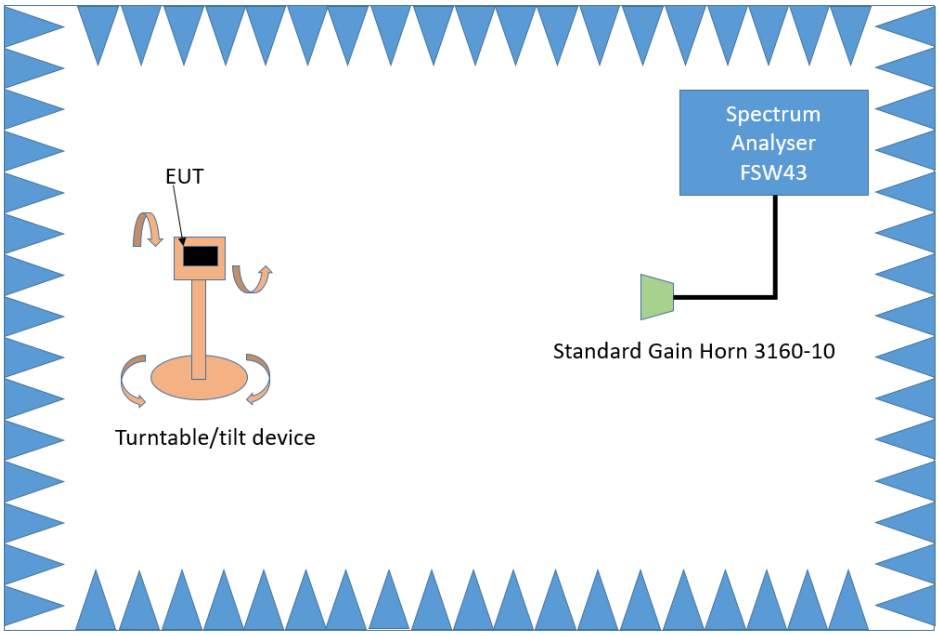
Test Setup; Spurious Emission Radiated (FAC), 1 GHz-26.5 GHz

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 (1.5 m) 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 ± 45° for the elevation axis is performed.
The turn table azimuth will slowly vary by ± 22.5°.
The elevation angle will slowly vary by ± 45°
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. Measurement above 26.5 GHz up to 40 GHz
The following modifications, compared to the frequency range 1 GHz – 26.5 GHz, apply to the measurement procedure for the frequency range above 26.5 GHz:
Measurement distance: 1m



Test Setup; Spurious Emission Radiated (FAC), 26.5 – 40 GHz

5.6.2 TEST REQUIREMENTS / LIMITS

A) FCC

FCC Part 15 Subpart E, §15.407 (b)(1)
For transmitters operating in the 5150–5250 MHz band:
Limit: –27 dBm/MHz EIRP outside of the band 5150–5350 MHz.

FCC Part 15 Subpart E, §15.407 (b)(2)
For transmitters operating in the 5250–5350 MHz band:
Limit: –27 dBm/MHz EIRP outside of the band 5150–5350 MHz.

FCC Part 15 Subpart E, §15.407 (b)(3)
For transmitters operating in the 5470–5725 MHz band:
Limit: –27 dBm/MHz EIRP outside of the band 5470–5725 MHz.

FCC Part 15 Subpart E, §15.407 (b)(4)
For transmitters operating in the 5725–5850 MHz band:
Limit: –27 dBm/MHz at 75 MHz or more above or below the band edge
increasing linearly to 10 dBm/MHz at 25 MHz above or below the band edge
increasing linearly to 15.6 dBm/MHz at 5 MHz above or below the band edge
increasing linearly to 27 dBm/MHz at the band edge.

B) IC

Different frequency bands and limits apply, as compared to the FCC requirements.

RSS-247, 6.2.1.2, Emissions outside the band 5150-5250 MHz, indoor operation only:
Limit: –27 dBm/MHz EIRP outside of the band 5150–5250 MHz.

RSS-247, 6.2.2.2, Emissions outside the band 5250-5350 MHz:
Limit: –27 dBm/MHz EIRP outside of the band 5250–5350 MHz.

RSS-247, 6.2.3.2, Emissions outside the bands 5470-5600 MHz and 5650-5725 MHz:
Limit: –27 dBm/MHz EIRP outside of the band 5470–5725 MHz.
However, devices with bandwidth overlapping the band edge of 5725 MHz can meet the emission limit of -27 dBm/MHz e.i.r.p.at 5850 MHz instead of 5725 MHz.
Note: No operation is permitted for the frequency range 5600–5650 MHz.

RSS-247, 6.2.4.2, Emissions outside the band 5725-5850 MHz:

a. 27 dBm/MHz at frequencies from the band edges decreasing linearly to 15.6 Bm/MHz at 5 MHz above or below the band edges;
b. 15.6 dBm/MHz at 5 MHz above or below the band edges decreasing linearly to 10 dBm/MHz at 25 MHz above or below the band edges;
c. 10 dBm/MHz at 25 MHz above or below the band edges decreasing linearly to -27 dBm/MHz at 75 MHz above or below the band edges; and
d. -27 dBm/MHz at frequencies more than 75 MHz above or below the band edges.

C) FCC & IC

FCC Part 15 Subpart E, §15.405
The provisions of §§ 15.203 and 15.205 are included.

§15.407 (b)(6)
Unwanted emissions below 1 GHz must comply with the general field strength limits set forth in § 15.209.

§15.407 (b)(7)
The provisions of §15.205 apply to intentional radiators operating under this section

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

Frequency in MHz	Limit (µV/m)	Measurement distance (m)	Limits (dBµV/m)
0.009 – 0.49	2400/F(kHz)@300m	3	(48.5 – 13.8)@300m
0.49 – 1.705	24000/F(kHz)@30m	3	(33.8 – 23.0)@30m
1.705 – 30	30@30m	3	29.5@30m

The measured values are corrected with an inverse linear distance extrapolation factor (40 dB/decade) according FCC 15.31 (2).

Frequency in MHz	Limit (µV/m)	Measurement distance (m)	Limits (dBµV/m)
30 – 88	100@3m	3	40.0@3m
88 – 216	150@3m	3	43.5@3m
216 – 960	200@3m	3	46.0@3m
960 - 26000	500@3m	3	54.0@3m
26000 - 40000	500@3m	1	54.0@3m

The measured values above 26 GHz are corrected with an inverse linear distance extrapolation factor (20 dB/decade).

§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 (dBµV/m) = 20 log (Limit (µV/m)/1µV/m)
- Limit (dBµV/m) = EIRP [dBm] – 20 log (d [m]) + 104.8

Limit types (in result tables on next page):
RB – Emissions falls into a "Restricted Band" according FCC §§15.205 and 15.209 *)
UE – "Undesirable Emission Limit" according FCC §15.407
BE-RB – Band Edge Limit basing on "Restricted Band Limits"
BE-UE – Band Edge Limit basing on "Undesirable Emission Limit"
*) Below 1 GHz the limits of §15.209 are applied for all frequencies.

5.6.3 TEST PROTOCOL

Ambient temperature: 23 - 25 °C
Air Pressure: 1000 – 1014 hPa
Humidity: 35 - 44 %
WLAN a-Mode; 20 MHz; 6 Mbit/s
Applied duty cycle correction (AV): 0.1 dB

Ch. No.	Ch. Center Freq. [MHz]	Spurious Freq. [MHz]	Spurious Level [dBµV/m]	Detec-tor	RBW [kHz]	Limit [dBµV/m]	Margin [dB]	Limit Type
149	5745	125.0	33.5	QP	120	43.5	10.0	RB
149	5745	375.0	41.1	QP	120	46.0	4.9	RB
149	5745	400.0	40.9	QP	120	46.0	5.1	RB
149	5745	500.0	42.1	QP	120	46.0	3.9	RB
149	5745	550.0	37.4	QP	120	46.0	8.6	RB
149	5745	625.0	40.2	QP	120	46.0	5.9	RB
149	5745	1621.7	44.6	PEAK	1000	74.0	29.4	RB
149	5745	1624.8	33.8	AV	1000	54.0	33.6	RB
149	5745	11489.8	41.8	AV	1000	54.0	12.2	RB
149	5745	11490.0	50.2	PEAK	1000	74.0	23.8	RB
149	5745	22979.4	51.5	PEAK	1000	74.0	22.5	RB
149	5745	22979.9	47.8	AV	1000	54.0	6.2	RB

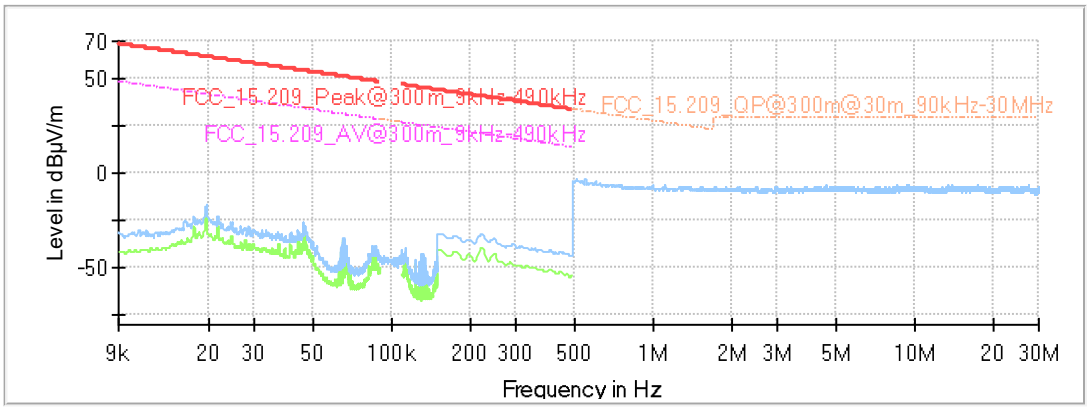
WLAN n-Mode; 40 MHz; MCS0
Applied duty cycle correction (AV): 0.1 dB

Ch. No.	Ch. Center Freq. [MHz]	Spurious Freq. [MHz]	Spurious Level [dBµV/m]	Detec-tor	RBW [kHz]	Limit [dBµV/m]	Margin [dB]	Limit Type
151	5755	33.3	18.1	QP	100	40.0	21.9	RB
151	5755	499.9	27.2	QP	100	46.0	18.8	RB
151	5755	624.9	27.3	QP	100	46.0	18.7	RB
151	5755	749.9	32.5	QP	100	46.0	13.6	RB
151	5755	874.9	26.4	QP	100	46.0	19.6	RB
151	5755	5724.8	65.8	PEAK	1000	121.7	55.9	BE

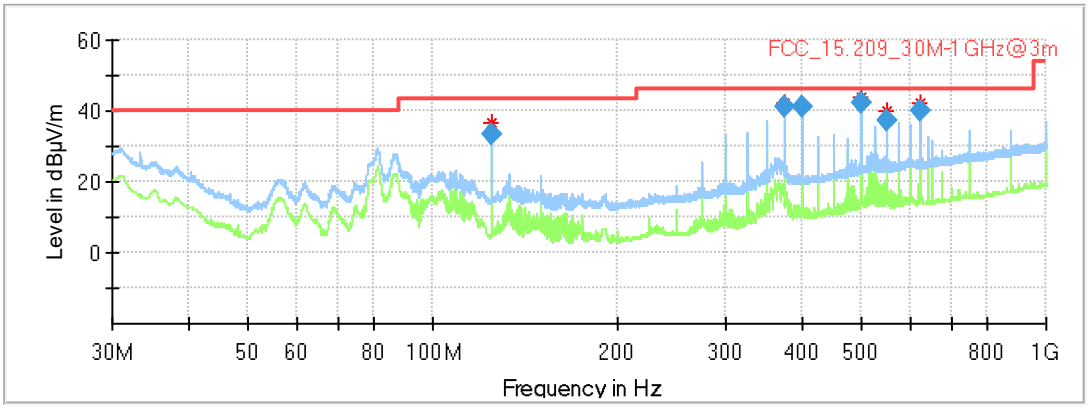
Remark: Please see next sub-clause for the measurement plot.

5.6.4 MEASUREMENT PLOT (EXAMPLE PLOT, SHOWING WORST CASE, IF APPLICABLE)

9 kHz – 30 MHz, WLAN a-mode 20 MHz, Ch 149



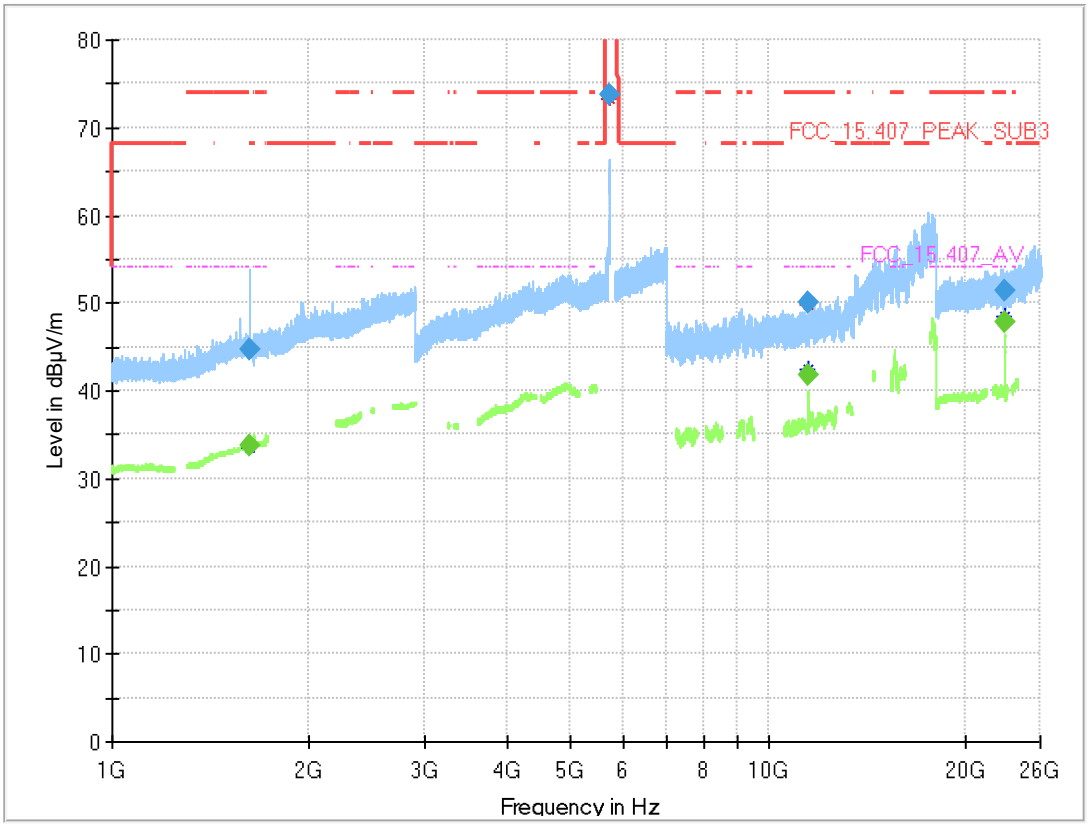
30 MHz – 1 GHz, WLAN a-mode 20 MHz, Ch 149



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin	Meas. Time (ms)	Bandwidth	Height	Pol	Azimuth	Corr. (dB/m)	Comment
125.010000	33.51	43.50	9.99	1000.0	120.000	103.0	V	5.0	10.9	
375.000000	41.13	46.00	4.87	1000.0	120.000	102.0	V	234.0	15.4	
399.990000	40.90	46.00	5.10	1000.0	120.000	105.0	V	-119.0	15.9	
499.980000	42.10	46.00	3.90	1000.0	120.000	102.0	V	-109.0	18.2	
549.990000	37.44	46.00	8.56	1000.0	120.000	107.0	V	-156.0	19.0	
624.990000	40.15	46.00	5.85	1000.0	120.000	103.0	V	-144.0	20.3	

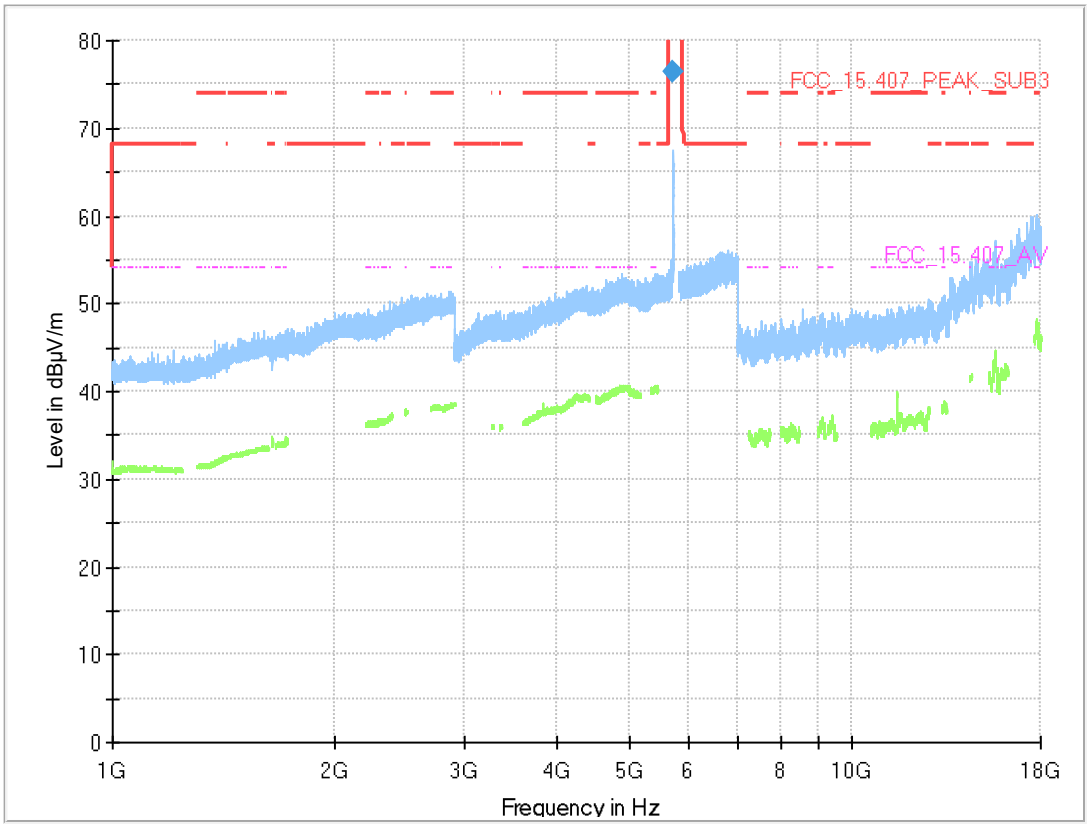
1 GHz – 26 GHz, WLAN a-mode 20 MHz, Ch 149



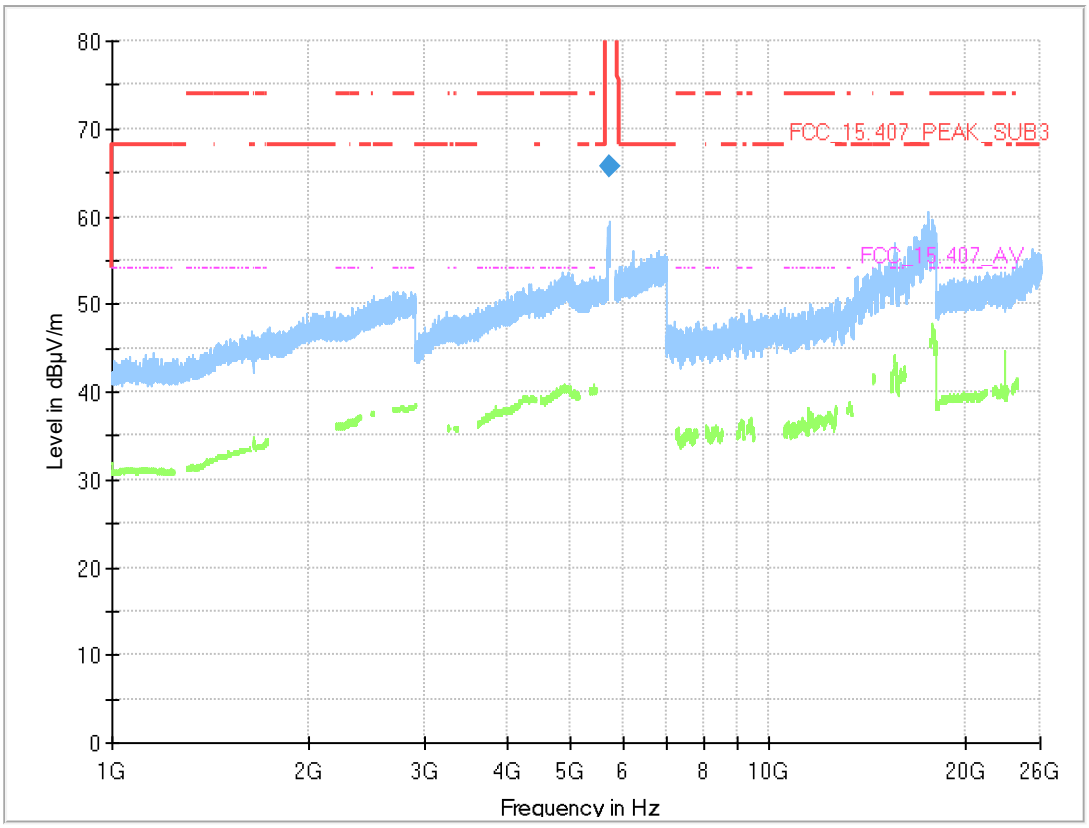
Final_Result

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)	Corr. (dB/m)
1621.713	44.6	---	74.00	29.41	1000.0	1000.000	150.0	H	-90.0	86.0	1.3
1624.777	---	33.7	54.00	20.31	1000.0	1000.000	150.0	V	146.0	78.0	1.3
5724.600	73.8	---	121.2	47.49	1000.0	1000.000	150.0	H	6.0	-5.0	14.1
11489.770	---	41.7	54.00	12.31	1000.0	1000.000	150.0	V	-146.0	-12.0	-9.4
11489.980	50.2	---	74.00	23.85	1000.0	1000.000	150.0	V	-178.0	85.0	-9.4
22979.363	51.5	---	74.00	22.55	1000.0	1000.000	150.0	H	132.0	96.0	19.7
22979.918	---	47.7	54.00	6.28	1000.0	1000.000	150.0	H	-128.0	78.0	19.7

1 GHz – 18 GHz, WLAN n-mode 20 MHz, Ch 149



1 GHz – 26 GHz, WLAN n-mode 40 MHz, Ch 151



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)	Corr. (dB/m)
5724.800	65.8	---	121.7	55.97	1000.0	1000.000	150.0	H	6.0	-2.0	14.1

26 GHz – 40 GHz, WLAN n 40MHz, Ch151

5.6.5 TEST EQUIPMENT USED

- Radiated Emissions

5.7 BAND EDGE

Standard **FCC Part 15 Subpart E**

The test was performed according to:
ANSI C63.10

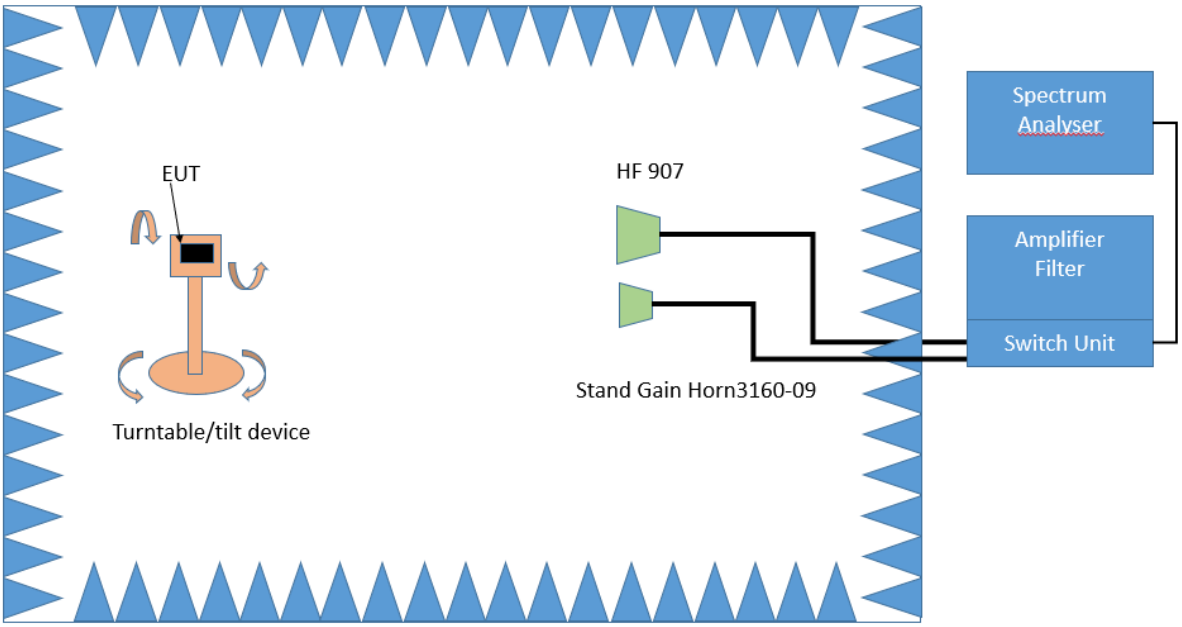
5.7.1 TEST DESCRIPTION

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

- Chapter 6.10.5

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 (procedure according ANSI C63.10, chapter 6.6.5.

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: 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

5.7.2 TEST REQUIREMENTS / LIMITS

For band edges connected to a restricted band, the limits are specified in Section 15.209(a)

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

Frequency in MHz	Limit (µV/m)	Measurement distance (m)	Limits (dBµV/m)
0.009 – 0.49	2400/F(kHz)@300m	3	(48.5 – 13.8)@300m
0.49 – 1.705	24000/F(kHz)@30m	3	(33.8 – 23.0)@30m
1.705 – 30	30@30m	3	29.5@30m

The measured values are corrected with an inverse linear distance extrapolation factor (40 dB/decade) according FCC 15.31 (2).

Frequency in MHz	Limit (µV/m)	Measurement distance (m)	Limits (dBµV/m)
30 – 88	100@3m	3	40.0@3m
88 – 216	150@3m	3	43.5@3m
216 – 960	200@3m	3	46.0@3m
960 - 26000	500@3m	3	54.0@3m
26000 - 40000	500@3m	1	54.0@3m

The measured values above 26 GHz are corrected with an inverse linear distance extrapolation factor (20 dB/decade).

§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 (dBµV/m) = 20 log (Limit (µV/m)/1µV/m)

5.7.3 TEST PROTOCOL

Ambient temperature: 22–25 °C
Air Pressure: 1004–1012 hPa
Humidity: 32 - 38 %
WLAN a-Mode; 20 MHz; 6 Mbit/s
Applied duty cycle correction (AV): 0.1 dB

U-NII-Subband	Ch. No.	Ch. Center Freq. [MHz]	Band Edge Freq. [MHz]	Spurious Level [dBµV/m]	Detec-tor	RBW [kHz]	Limit [dBµV/m]	Margin [dB]	Limit Type	FCC /IC?
3	149	5745	5725.0	73.8	PEAK	1000	121.2	47.4	BE-UE	FCC&IC

WLAN n-Mode; 20 MHz; MCS0; SISO
Applied duty cycle correction (AV): 0.1 dB

U-NII-Subband	Ch. No.	Ch. Center Freq. [MHz]	Band Edge Freq. [MHz]	Spurious Level [dBµV/m]	Detec-tor	RBW [kHz]	Limit [dBµV/m]	Margin [dB]	Limit Type	FCC /IC?
3	149	5745	5725.0	75.7	PEAK	1000	121.2	45.5	BE-UE	FCC&IC

WLAN n-Mode; 40 MHz; MCS0; SISO
Applied duty cycle correction (AV): 0.1 dB

U-NII-Subband	Ch. No.	Ch. Center Freq. [MHz]	Band Edge Freq. [MHz]	Spurious Level [dBµV/m]	Detec-tor	RBW [kHz]	Limit [dBµV/m]	Margin [dB]	Limit Type	FCC /IC?
3	151	5755	5725.0	65.8	PEAK	1000	121.2	55.4	BE-UE	FCC&IC

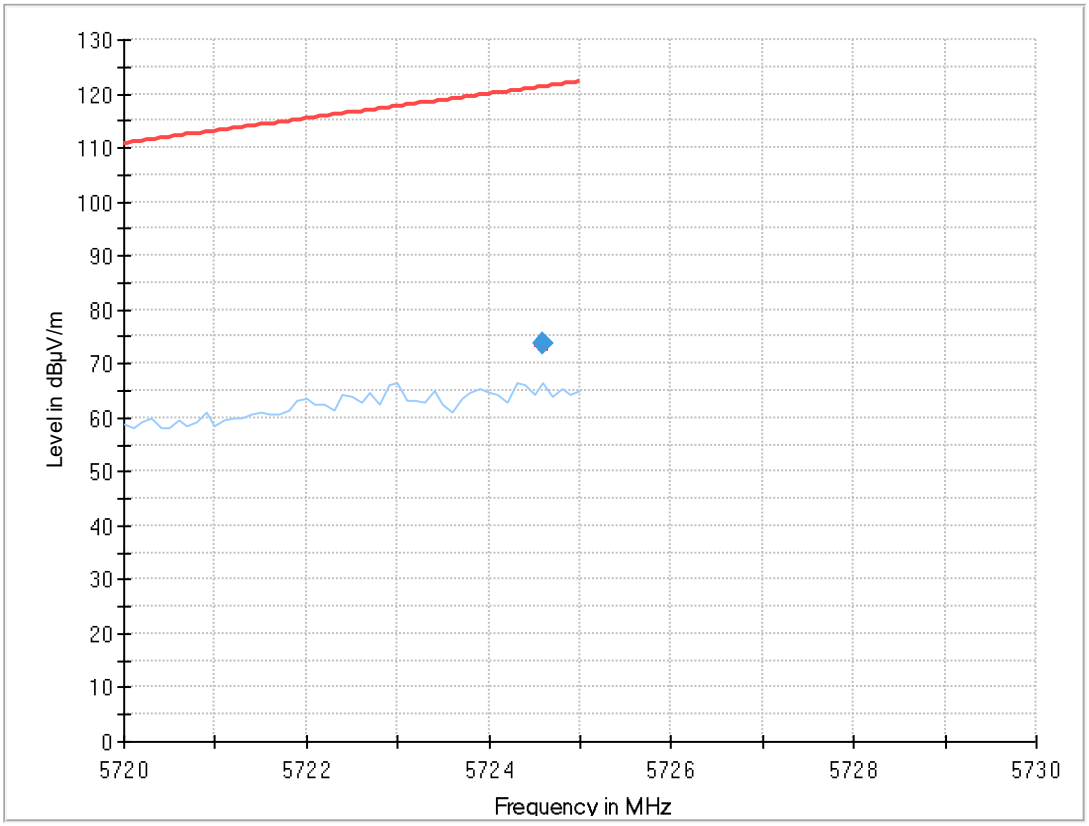
WLAN ac-Mode; 40 MHz; MCS0; SISO
Applied duty cycle correction (AV): 0.1 dB

U-NII-Subband	Ch. No.	Ch. Center Freq. [MHz]	Band Edge Freq. [MHz]	Spurious Level [dBµV/m]	Detec-tor	RBW [kHz]	Limit [dBµV/m]	Margin [dB]	Limit Type	FCC /IC?
3	151	5755	5725.0	59.8	PEAK	1000	120.1	60.3	BE-UE	FCC&IC

Remark: Please see next sub-clause for the measurement plot.

5.7.4 MEASUREMENT PLOT (EXAMPLE PLOT, SHOWING WORST CASE, IF APPLICABLE)

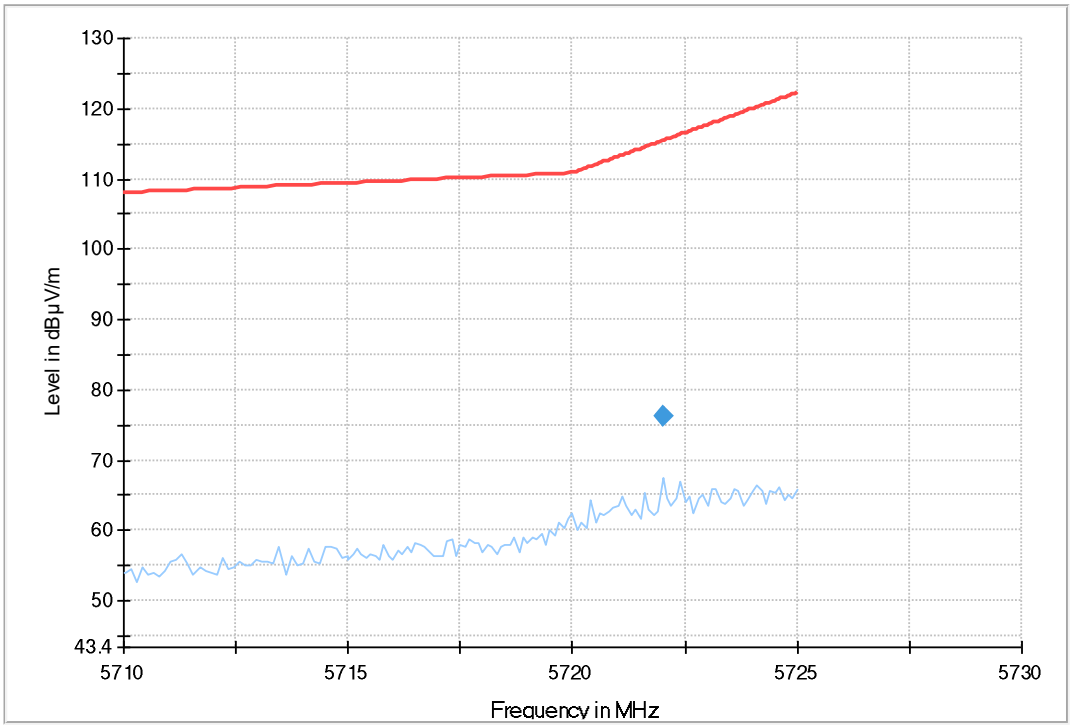
Radio Technology = WLAN a-mode, Channel 149



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)	Corr. (dB/m)
5724.600	73.8	---	121.2	47.49	1000.0	1000.000	150.0	H	6.0	-5.0	14.1

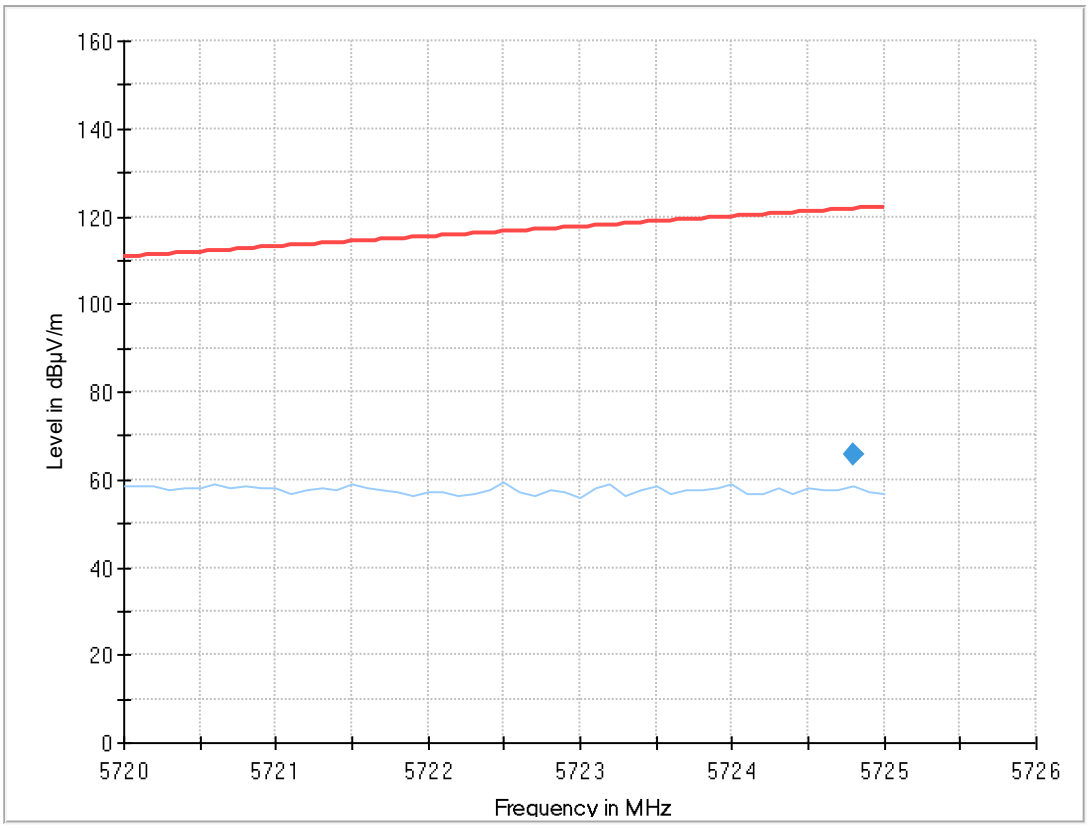
Radio Technology = WLAN n-mode 20 MHz, Channel 149



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)	Corr. (dB/m)
5722.000	76.3	---	115.36	39.02	1000.0	1000.000	150.0	H	5.0	-3.0	14.1

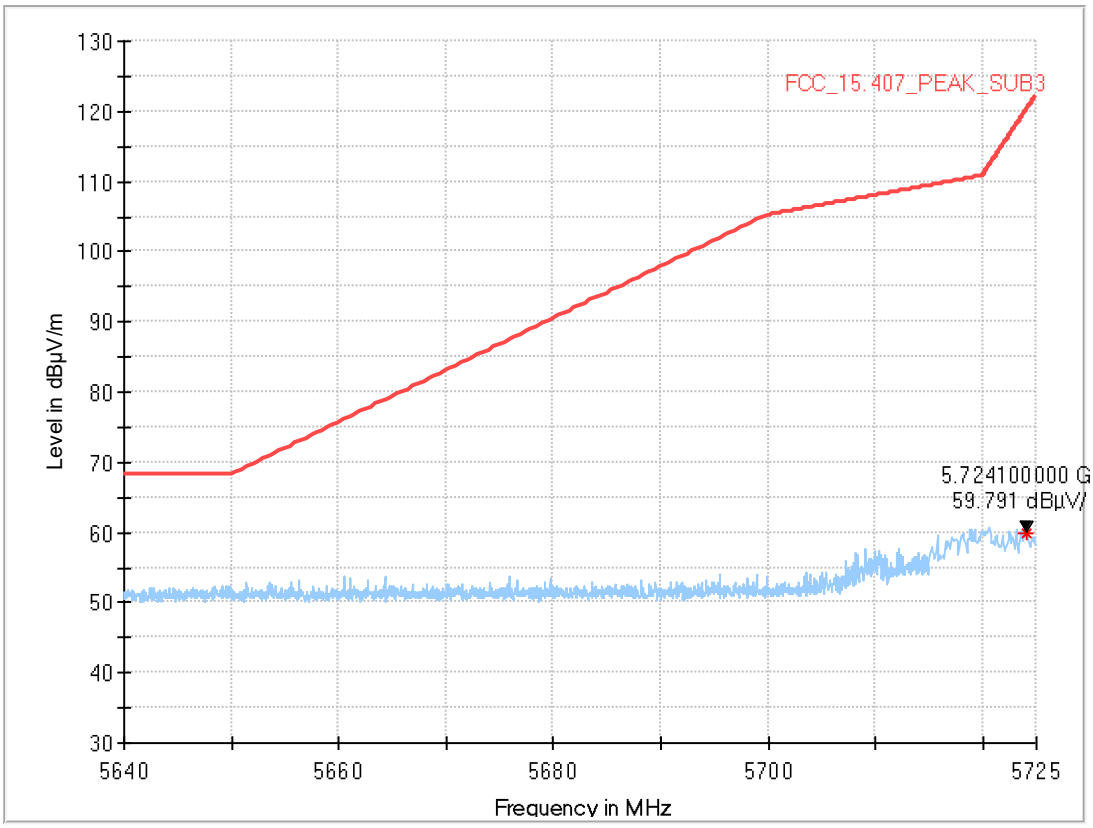
Radio Technology = WLAN n-mode 40 MHz, Channel 151



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)	Corr. (dB/m)
5724.800	65.8	---	121.7	55.97	1000.0	1000.000	150.0	H	6.0	-2.0	14.1

Radio Technology = WLAN ac-mode 40 MHz, Channel 151



Critical_Freqs

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB/m)
5724.100	59.8	---	120.1	60.36	---	---	150.0	H	0.0	0.0	14.1

5.7.5 TEST EQUIPMENT USED

- Radiated Emissions

6 TEST EQUIPMENT

1 R&S TS8997
2.4 and 5 GHz Bands Conducted 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	2020-08	2023-08
1.2	EX520	Digital Multimeter 12	Extech Instruments Corp	05157876	2020-04	2022-04
1.3	FSV30	Signal Analyzer 10 Hz - 30 GHz	Rohde & Schwarz	103005	2020-05	2022-05
1.4	Opus10 THI (8152.00)	T/H Logger 15	Lufft Mess- und Regeltechnik GmbH	13985	2019-06	2021-06
1.5	NGSM 32/10	Power Supply	Rohde & Schwarz GmbH & Co. KG	3456	2020-01	2022-01
1.6	Temperature Chamber KWP 120/70	Temperature Chamber Weiss 01	Weiss	59226012190010	2020-05	2022-05
1.7	SMB100A	Signal Generator 100 kHz - 40 GHz	Rohde & Schwarz Vertriebs-GmbH	181486	2019-11	2021-11
1.8	Temperature Chamber VT 4002	Temperature Chamber Vötsch 03	Vötsch	58566002150010	2020-05	2022-05
1.9	Opus10 THI (8152.00)	T/H Logger 14	Lufft Mess- und Regeltechnik GmbH	13993	2019-06	2021-06
1.10	Opus10 THI (8152.00)	T/H Logger 03	Lufft Mess- und Regeltechnik GmbH	7482	2019-06	2021-06
1.11	SMBV100A	Vector Signal Generator 9 kHz - 6 GHz	Rohde & Schwarz	259291	2019-11	2022-11
1.12	OSP120	Contains Power Meter and Switching Unit OSP-B157W8	Rohde & Schwarz	101158	2018-05	2021-05
1.13	Temperature Chamber VT 4002	Temperature Chamber Vötsch 05	Vötsch	58566080550010	2020-05	2022-05

2 Radiated Emissions
Lab to perform radiated emission tests

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
2.1	MFS	Rubidium Frequency Normal MFS	Datum GmbH	002	2020-11	2021-11
2.2	N5000/NP	Filter for EUT, 2 Lines, 250 V, 16 A	ETS-LINDGREN	241515		
2.3	Opus10 TPR (8253.00)	T/P Logger 13	Lufft Mess- und Regeltechnik GmbH	13936	2019-05	2021-05
2.4	ESW44	EMI Receiver / Spectrum Analyzer	Rohde & Schwarz GmbH & Co. KG	101603	2019-12	2021-12

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
2.5	Anechoic Chamber 01	SAC/FAR, 10.58 m x 6.38 m x 6.00 m	Frankonia	none		
2.6	HL 562 ULTRALOG	Biconical-log-per antenna (30 MHz - 3 GHz) with HL 562E biconicals	Rohde & Schwarz GmbH & Co. KG	830547/003	2018-07	2021-07
2.7	AMF-7D00101800-30-10P-R	Broadband Amplifier 100 MHz - 18 GHz	Miteq			
2.8	5HC2700/12750-1.5-KK	High Pass Filter	Trilithic	9942012		
2.9	ASP 1.2/1.8-10 kg	Antenna Mast	Maturo GmbH	-		
2.10	Anechoic Chamber 03	FAR, 8.80m x 4.60m x 4.05m (l x w x h)	Albatross Projects	P26971-647-001-PRB		
2.11	SMBV100A	Vector Signal Generator 9 kHz - 3.2 GHz (GNSS / Broadcast Signalling Unit)	Rohde & Schwarz GmbH & Co. KG	260001	2018-01	2021-01
2.12	WRD1920/1980-5/22-5EESD	Tunable Band Reject Filter	Wainwright Instruments GmbH	11		
2.13	TDS 784C	Digital Oscilloscope [SA2] (Aux)	Tektronix	B021311		
2.14	Opus10 THI (8152.00)	T/H Logger 10	Lufft Mess- und Regeltechnik GmbH	12488	2019-06	2021-06
2.15	foRS232 Unit 2	Fibre optic link RS232	PONTIS Messtechnik GmbH	4031516037		
2.16	PONTIS Con4101	PONTIS Camera Controller		6061510370		
2.17	NRVD	Power Meter	Rohde & Schwarz GmbH & Co. KG	828110/016	2020-08	2021-08
2.18	OLS-1 R	Fibre optic link USB 1.1	Ingenieurbüro Scheiba	018		
2.19	HF 906	Double-ridged horn	Rohde & Schwarz	357357/002	2018-09	2021-09
2.20	JS4-18002600-32-5P	Broadband Amplifier 18 GHz - 26 GHz	Miteq	849785		
2.21	FSW 43	Spectrum Analyzer	Rohde & Schwarz	103779	2019-02	2021-02
2.22	EP 1200/B, NA/B1	AC Source, Amplifier with integrated variable Oscillator	Spitzenberger & Spies GmbH & Co. KG	B6278		

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
2.23	3160-09	Standard Gain / Pyramidal Horn Antenna 26.5 GHz	EMCO Elektronic GmbH	00083069		
2.24	foRS232 Unit 1	Fibre optic link RS232	PONTIS Messtechnik GmbH	4021516036		
2.25	FSP3	Spectrum Analyzer	Rohde & Schwarz GmbH & Co. KG	836722/011		
2.26	WHKX 7.0/18G-8SS	High Pass Filter	Wainwright Instruments GmbH	09		
2.27	DS 420S	Turn Table 2 m diameter	HD GmbH	420/573/99		
2.28	4HC1600/12750-1.5-KK	High Pass Filter	Trilithic	9942011		
2.29	foUSB-M Converter 2	Fibre optic link USB 2.0	PONTIS Messtechnik GmbH	4471520061		
2.30	WRCD1879.8-0.2/40-10EE	Notch Filter Ultra Stable	Wainwright Instruments GmbH	16		
2.31	Temperature Chamber KWP 120/70	Temperature Chamber Weiss 01	Weiss	59226012190010	2020-05	2022-05
2.32	FSIQ26	Signal Analyser 20 Hz to 26.5 GHz	Rohde & Schwarz GmbH & Co. KG	840061/005	2019-06	2021-06
2.33	SMB100A	Signal Generator 100 kHz - 40 GHz	Rohde & Schwarz Vertriebs-GmbH	181486	2019-11	2021-11
2.34	JS4-00102600-42-5A	Broadband Amplifier 30 MHz - 26 GHz	Miteq	619368		
2.35	TT 1.5 WI	Turn Table	Maturo GmbH	-		
2.36	HL 562 ULTRALOG	Biconical-log-per Antenna (30 MHz - 3 GHz)	Rohde & Schwarz GmbH & Co. KG	100609	2019-05	2022-05
2.37	HF 906	Double-ridged horn	Rohde & Schwarz	357357/001	2018-03	2021-03
2.38	foCAN (v 4.0)	Fibre optic link CAN	Audivo GmbH (PONTIS EMC)	492 1607 014		
2.39	FS-Z325	Harmonic Mixer 220 - 325 GHz	Rohde & Schwarz Messgerätebau GmbH	101006	2020-03	2023-03
2.40	3160-10	Standard Gain / Pyramidal Horn Antenna 40 GHz	EMCO Elektronic GmbH	00086675		
2.41	MA4985-XP-ET	Bore Sight Antenna Mast	innco systems GmbH	none		
2.42	Temperature Chamber VT 4002	Temperature Chamber Vötsch 03	Vötsch	58566002150010	2020-05	2022-05
2.43	A8455-4	4 Way Power Divider (SMA)		-		
2.44	VLFX-650+	Low Pass Filter DC650 MHz	Mini-Circuits	15542		
2.45	JUN-AIR Mod. 6-15	Air Compressor	JUN-AIR Deutschland GmbH	612582		

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
2.46	foEthernet_M	Fibre optic link Ethernet / Gb-LAN	PONTIS Messtechnik GmbH	4841516023		
2.47	5HC3500/18000-1.2-KK	High Pass Filter	Trilithic	200035008		
2.48	OLS-1 M	Fibre optic link USB 1.1	Ingenieurbüro Scheiba	018		
2.49	HFH2-Z2	Loop Antenna	Rohde & Schwarz	829324/006	2018-01	2021-01
2.50	Voltcraft M-3860M	Digital Multimeter 01 (Multimeter)	Conrad	IJ096055		
2.51	SB4-100.OLD20-3T/10 Airwin 2 x 1.5 kW	Air compressor (oil-free)	airWin Kompressoren UG	901/00503		
2.52	foEthernet_M	Fibre optic link Ethernet / Gb-LAN	PONTIS Messtechnik GmbH	4841516022		
2.53	JS4-00101800-35-5P	Broadband Amplifier 30 MHz - 18 GHz	Miteq	896037		
2.54	AS 620 P	Antenna Mast (pneumatic polarisation)	HD GmbH	620/37		
2.55	6005D (30 V / 5 A)	Laboratory Power Supply 120 V 60 Hz	PeakTech	81062045		
2.56	TD1.5-10kg	EUT Tilt Device (Rohacell)	Maturo GmbH	TD1.5-10kg/024/3790709		
2.57	SGH-03	Standard Gain / Pyramidal Horn Antenna (220 - 325 GHz)	RPG-Radiometer Physics GmbH	060		
2.58	foUSB-M Converter 1	Fibre optic link USB 2.0	Audivo GmbH (PONTIS EMC)	4461520060		
2.59	FS-Z90	Harmonic Mixer 60 - 90 GHz	Rohde & Schwarz Messgerätebau GmbH	101686	2020-03	2023-03
2.60	Innco Systems CO3000	Controller for bore sight mast SAC	innco systems GmbH	CO3000/967/39371016/L		
2.61	NRV-Z1	Sensor Head B	Rohde & Schwarz GmbH & Co. KG	827753/006	2020-08	2021-08
2.62	HF 907-2	Double-ridged horn	Rohde & Schwarz	102817	2019-04	2022-04
2.63	foCAN (v 4.0)	Fibre optic link CAN	Audivo GmbH (PONTIS EMC)	492 1607 013		
2.64	PAS 2.5 - 10 kg	Antenna Mast	Maturo GmbH	-		
2.65	AFS42-00101800-25-S-42	Broadband Amplifier 25 MHz - 18 GHz	Miteq	2035324		
2.66	WRCA800/960-0.2/40-6EEK	Tunable Notch Filter	Wainwright Instruments GmbH	20		
2.67	AM 4.0	Antenna Mast 4 m	Maturo GmbH	AM4.0/180/11920513		

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
2.68	HF 907	Double-ridged horn	Rohde & Schwarz	102444	2018-07	2021-07

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

7 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.

7.1 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.

7.2 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

7.3 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.

7.4 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.

7.5 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.

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

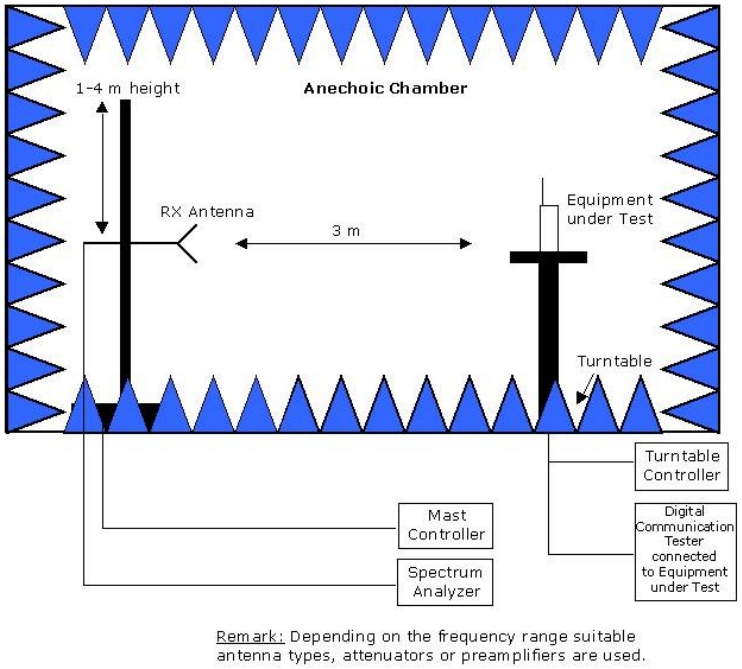
Frequency	AF EMCO 3160-10	Corr.
GHz	dB (1/m)	dB
26.5	43.4	-11.2
27.0	43.4	-11.2
28.0	43.4	-11.1
29.0	43.5	-11.0
30.0	43.5	-10.9
31.0	43.5	-10.8
32.0	43.5	-10.7
33.0	43.6	-10.7
34.0	43.6	-10.6
35.0	43.6	-10.5
36.0	43.6	-10.4
37.0	43.7	-10.3
38.0	43.7	-10.2
39.0	43.7	-10.2
40.0	43.8	-10.1

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
4.4				-9.5	3	1.0
4.4				-9.5	3	1.0
4.5				-9.5	3	1.0
4.6				-9.5	3	1.0
4.7				-9.5	3	1.0
4.7				-9.5	3	1.0
4.8				-9.5	3	1.0
4.9				-9.5	3	1.0
5.0				-9.5	3	1.0
5.1				-9.5	3	1.0
5.1				-9.5	3	1.0
5.2				-9.5	3	1.0
5.3				-9.5	3	1.0
5.4				-9.5	3	1.0
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.

8 SETUP DRAWINGS

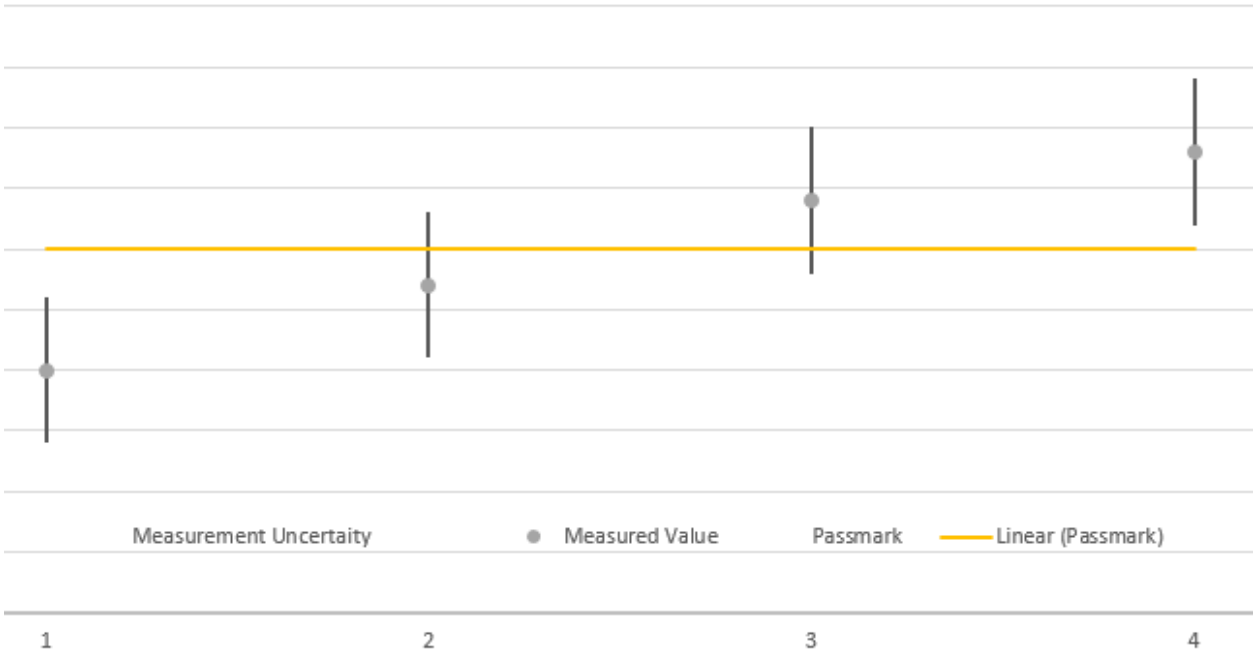


Drawing 1: Setup in the Anechoic chamber. For measurements below 1 GHz the ground was replaced by a conducting groundplane.

9 MEASUREMENT UNCERTAINTIES

Test Case	Parameter	Uncertainty
AC Power Line	Power	± 3.4 dB
Field Strength of spurious radiation	Power	± 5.5 dB
6 dB / 26 dB / 99% Bandwidth	Power Frequency	± 2.9 dB ± 11.2 kHz
Conducted Output Power	Power	± 2.2 dB
Band Edge Compliance	Power Frequency	± 2.2 dB ± 11.2 kHz
Frequency Stability	Frequency	± 25 Hz
Power Spectral Density	Power	± 2.2 dB

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	above pass mark	within pass mark	Failed
4	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

Please see separate photo report.