FCC Measurement/Technical Report on

Host-based multiradio module with Wi-Fi, Bluetooth and NFC

EMMY-W163

in WLAN 2.4 GHz mode

FCC ID: EMMY-W161: XPYEMMYW163
IC: EMMY-W161: 8595A-EMMYW163

Test Report Reference: MDE_LESSW_1701_FCCa

Test Laboratory:
7layers GmbH
Borsigstrasse 11
40880 Ratingen
Germany

Deutsche Akkreditierungsstelle D-PL-12140-01-00

Note:
The following test results relate only to the devices specified in this document. This report shall not be reproduced in parts without the written approval of the test laboratory.

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1 APPLIED STANDARDS AND TEST SUMMARY

1.1 APPLIED STANDARDS

Type of Authorization
Certification for an Intentional Radiator.

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 (10-1-15 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

§ 15.247 Operation within the bands 902-928 MHz, 2400-2483.5 MHz

Note 1:
The tests were selected and performed with reference to the FCC Public Notice "GUIDANCE FOR PERFORMING COMPLIANCE MEASUREMENTS ON DIGITAL TRANSMISSION SYSTEMS (DTS) OPERATING UNDER §15.247, 558074 D01 DTS Meas Guidance v04, 2017-04-05". ANSI C63.10–2013 is applied.

Note 2:
Not all possible operating modes were tested. Worst case operating modes were determined at the beginning of the test period.

Summary Test Results:

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

1.2 FCC-IC CORRELATION TABLE

Correlation of measurement requirements for DTS (e.g. WLAN 2.4 GHz, BT LE) equipment from FCC and IC

DTS equipment

Measurement	FCC reference	IC reference
Conducted emissions on AC Mains	§ 15.207	RSS-Gen Issue 4: 8.8
Occupied bandwidth	§ 15.247 (a) (2)	RSS-247 Issue 2: 5.2 (a)
Peak conducted output power	§ 15.247 (b) (3), (4)	RSS-247 Issue 2: 5.4 (d)
Transmitter spurious RF conducted emissions	§ 15.247 (d)	RSS-Gen Issue 4: 6.13 / 8.9/8.10; RSS-247 Issue 2: 5.5
Transmitter spurious radiated emissions	§ 15.247 (d); § 15.209 (a)	RSS-Gen Issue 4: 6.13 / 8.9/8.10; RSS-247 Issue 2: 5.5
Band edge compliance	§ 15.247 (d)	RSS-247 Issue 2: 5.5
Power density	§ 15.247 (e)	RSS-247 Issue 2: 5.2 (b)
Antenna requirement	§ 15.203 / 15.204	RSS-Gen Issue 4: 8.3
Receiver spurious emissions	–	–

1.3 MEASUREMENT SUMMARY / SIGNATURES

47 CFR CHAPTER I FCC PART 15 Subpart C §15.247 **§ 15.247 (d)**

Transmitter Spurious Radiated Emissions
The measurement was performed according to ANSI C63.10 **Final Result**

OP-Mode	**Setup**	**FCC**	**IC**
Radio Technology, Operating Frequency, Measurement range			
WLAN n, high, 1 GHz - 24 GHz	DE1072001 aa01	Passed	Passed

47 CFR CHAPTER I FCC PART 15 Subpart C §15.247 **§ 15.247 (d)**

Band Edge Compliance Radiated
The measurement was performed according to ANSI C63.10 **Final Result**

OP-Mode	**Setup**	**FCC**	**IC**
Radio Technology, Operating Frequency, Band Edge			
b-Mode_2467MHz_15dBm_2Mbit_20MHzBW	DE1072001 aa01	Passed	Passed
g-Mode_2462MHz_13dBm_9Mbit_20MHzBW			
g-Mode_2467MHz_9dBm_48Mbit_20MHzBW			
n-Mode_2447MHz_13dBm_MCS0_40MHzBW			
n-Mode_2447MHz_13dBm_MCS6_40MHzBW			
n-Mode_2452MHz_11dBm_MCS6_40MHzBW			
n-Mode_2462MHz_7dBm_MCS6_40MHzBW			
n-Mode_2462MHz_12dBm_MCS6_20MHzBW			
n-Mode_2467MHz_9dBm_MCS6_20MHzBW			
n-Mode_2467MHz_10dBm_MCS2_20MHzBW			

Remark:

Reduced test plan has been used as it is a Class II Permissive Change

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(responsible for accreditation scope)
Dipl.-Ing. Marco Kullik

(responsible for testing and report)
Dipl.-Ing. Imad Hjije

2 ADMINISTRATIVE DATA

2.1 TESTING LABORATORY

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

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

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

Laboratory accreditation no:	DAkkS D-PL-12140-01-00
FCC Designation Number:	DE0015
FCC Test Firm Registration:	929146
Responsible for accreditation scope:	Dipl.-Ing. Marco Kullik
Report Template Version: Company Name:	2017-07-14 7layers GmbH
Address:	Borsigstr. 11 40880 Ratingen Germany

2.2 PROJECT DATA

Responsible for testing and report:	Dipl.-Ing. Imad Hjije
Employees who performed the tests:	documented internally at 7Layers
Date of Report:	2018-03-21
Testing Period:	2018-02-15 to 2018-02-16

2.3 APPLICANT DATA

Company Name:	u-blox AG
Address:	Zürcherstrasse 68 8800 Thalwil Switzerland
Contact Person:	Mr. Giulio Comar

2.4 MANUFACTURER DATA

Company Name: please see applicant data

Address:

Contact Person:

3 TEST OBJECT DATA

3.1 GENERAL EUT DESCRIPTION

Kind of Device product description	WLAN 2.4 GHz, 5 GHz, BT, NFC, SRD (5.8 GHz) - Single Antenna
Product name	Host-based multiradio module with Wi-Fi, Bluetooth and NFC for "Mercedes-Benz-Link"
Type	EMMY-W163
Declared EUT data by the supplier	
Voltage Type	DC
Voltage Level	normal: 3.3 V DC low: 3.0 V DC high: 3.6 V DC
Modulation Type	Bluetooth LE: GFSK WLAN: DSSS, OFDM, HT20 MCS0 – MCS7, HT40 MCS0 –MCS7, VHT. Please see each test protocol
General product description	EMMY-W163 are ultra-compact multi-radio modules providing Wi-Fi, Classic Bluetooth, Bluetooth low energy and NFC mode of operation. It is designed for both simultaneous and independent operations of: • Wi-Fi IEEE 802.11ac and a/b/g/n • Dual-mode Bluetooth 4.2 • NFC
Specific product description for the EUT	Shielded module, single antenna pin for WLAN 802.11 ac/a/b/g/n and Bluetooth communication
The EUT provides the following ports:	- DC power supply - antenna port - signal ports
Data rates	Bluetooth LE, GFSK: 1 Mbit/s WLAN b: please see chapter "WLAN Power Table" WLAN g: please see chapter "WLAN Power Table" WLAN n 20 MHz: please see chapter "WLAN Power Table" WLAN n 40 MHz: please see chapter "WLAN Power Table"
Power levels	Bluetooth LE: 5 dBm WLAN: please see chapter "WLAN Power Table"

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

3.2 EUT MAIN COMPONENTS

Sample Name	**Sample Code**	**Description**
DE1072001aa01	aa01	
Sample Parameter	**Value**	
Antenna	- SR42W001 - Dual-Band Chip Antenna, 2.4..2.5GHz (2.0dBi), 4.9..5.9GHz (3.0dBi), 11.3x5.0x0.8mm, -40..+125°C - W800 - Antenova SR42W001	
Serial No.	D4CA6E50CAC4	
HW Version	-	
SW Version	15.68.7.p101	
Comment	-	

3.3 WLAN POWER TABLE

Declared Power limits vs channel for FCC

Modulation group	WLAN TX Power in dBm at frequency in MHz												
	2412	2417	2422	2427	2432	2437	2442	2447	2452	2457	2462	2467	2472
DSSS 1, 2, 5.5, 11 Mbps	18	18	18	18	18	18	18	18	18	18	18	15	13
OFDM 6, 9, 12, 18 Mbps	13	16	16	16	16	16	16	16	16	15	13	10	9
OFDM 24, 36 Mbps	13	16	16	16	16	16	16	16	16	15	13	10	9
OFDM 48, 54 Mbps	13	13	13	13	13	13	13	13	13	13	13	9	9
HT20 MCS0, MCS1, MCS2	13	15	16	16	16	16	16	16	16	16	12	10	9
HT20 MCS3, MCS4	13	15	16	16	16	16	16	16	16	16	12	9	9
HT20 MCS5, MCS6, MCS7	13	13	13	13	13	13	13	13	13	13	12	9	9

Modulation group	WLAN TX Power in dBm at frequency in MHz								
	2422	2427	2432	2437	2442	2447	2452	2457	2462
HT40 MCS0, MCS1, MCS2	11	11	13	14	14	13	10	7	6
HT40 MCS3, MCS4	11	11	13	14	14	13	10	7	6
HT40 MCS5, MCS6, MCS7	11	12	13	13	13	13	11	8	7

Remark: Please see detailed EUT settings in the test protocols.

3.4 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**
Evaluation board (target platform)	lesswire GmbH, MB Link,	telematics unit

3.5 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, HW, SW, S/N)**	**Description**
AC/DC power supply (115 V 60 Hz)	PeakTech, -, -, 081062045	PeakTech 6005D

3.6 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**
DE1072001aa01	evaluation board, AC/DC power supply	Setup for radiated measurement

3.7 OPERATING MODES

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

3.7.1 TEST CHANNELS

WLAN	2.4 GHz ISM 2400 - 2483.5 MHz		
20 MHz Test Channels:	**low**	**mid**	**high**
Channel:	1	6	13
Frequency [MHz]	2412	2437	2472

40 MHz Test Channels:	**low**	**mid**	**high**
Channel:	3	6	11
Frequency [MHz]	2422	2437	2462

In case of testing another channel, the measurement summary state "additional channel" and the channel or centre frequency of the operating frequency is stated in the test protocol.

Duty cycle = 100 %

3.8 PRODUCT LABELLING

3.8.1 FCC ID LABEL

Please refer to the documentation of the applicant.

3.8.2 LOCATION OF THE LABEL ON THE EUT

Please refer to the documentation of the applicant.

4 TEST RESULTS

4.1 TRANSMITTER SPURIOUS RADIATED EMISSIONS

Standard **FCC Part 15 Subpart C**

The test was performed according to:
ANSI C63.10

4.1.1TEST DESCRIPTION

The test set-up was made in accordance to the general provisions of ANSI C63.10 in a typical installation configuration. The Equipment Under Test (EUT) was set up on a non-conductive table 1.0 x 2.0 m² in the semi-anechoic chamber. The influence of the EUT support table that is used between 30–1000 MHz was evaluated.
The measurement procedure is implemented into the EMI test software EMC32 from R&S. Exploratory tests are performed at 3 orthogonal axes to determine the worst-case orientation of a body-worn or handheld EUT. The final test on all kind of EUTs is also performed at 3 axes. A pre-check is performed while the EUT is powered from a DC power source.

1. Measurement up to 30 MHz
The Loop antenna HFH2-Z2 is used.

Step 1: pre measurement
- Anechoic chamber
- Antenna distance: 3 m
- Detector: Peak-Maxhold
- Frequency range: 0.009 - 0.15 MHz and 0.15 – 30 MHz
- Frequency steps: 0.05 kHz and 2.25 kHz
- IF–Bandwidth: 0.2 kHz and 9 kHz
- Measuring time / Frequency step: 100 ms (FFT-based)

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

Step 2: final measurement
For the relevant emissions determined in step 1, an additional measurement with the following settings will be performed. Intention of this step is to find the maximum emission level.
- Open area test side
- Antenna distance: according to the Standard
- Detector: Quasi-Peak
- Frequency range: 0.009 – 30 MHz
- Frequency steps: measurement at frequencies detected in step 1
- IF–Bandwidth: 0.2 - 10 kHz
- Measuring time / Frequency step: 1 s

2. Measurement above 30 MHz and up to 1 GHz

Step 1: Preliminary scan
This is a preliminary test to identify the highest amplitudes relative to the limit.
Settings for step 1:
- Antenna distance: 3 m
- Detector: Peak-Maxhold / Quasipeak (FFT-based)

- Frequency range: 30 – 1000 MHz
- Frequency steps: 30 kHz
- IF–Bandwidth: 120 kHz
- Measuring time / Frequency step: 100 ms
- Turntable angle range: –180° to 90°
- Turntable step size: 90°
- Height variation range: 1 – 3 m
- Height variation step size: 2 m
- Polarisation: Horizontal + Vertical

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

Step 2: Adjustment measurement
In this step the accuracy of the turntable azimuth and antenna height will be improved. This is necessary to find out the maximum value of every frequency.
For each frequency, which was determined the turntable azimuth and antenna height will be adjusted. The turntable azimuth will slowly vary by ± 45° around this value. During this action, the value of emission is continuously measured. The turntable azimuth at the highest emission will be recorded and adjusted. In this position, the antenna height will also slowly vary by ± 100 cm around the antenna height determined. During this action, the value of emission is also continuously measured. The antenna height of the highest emission will also be recorded and adjusted.
- Detector: Peak – Maxhold
- Measured frequencies: in step 1 determined frequencies
- IF – Bandwidth: 120 kHz
- Measuring time: 100 ms
- Turntable angle range: ± 45 ° around the determined value
- Height variation range: ± 100 cm around the determined value
- Antenna Polarisation: max. value determined in step 1

Step 3: Final measurement with QP detector
With the settings determined in step 3, the final measurement will be performed:
EMI receiver settings for step 4:
- Detector: Quasi-Peak (< 1 GHz)
- Measured frequencies: in step 1 determined frequencies
- IF – Bandwidth: 120 kHz
- Measuring time: 1 s

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

3. Measurement above 1 GHz
The following modifications apply to the measurement procedure for the frequency range above 1 GHz:
Step 1:
The Equipment Under Test (EUT) was set up on a non-conductive support (tilt device) at 1.5 m height in the fully-anechoic chamber.
All steps were performed with one height (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

4.1.2TEST REQUIREMENTS / LIMITS

FCC Part 15, Subpart C, §15.247 (d)
... In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(c)).

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

Frequency in MHz	Limit (µV/m)	Measurement distance (m)	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)

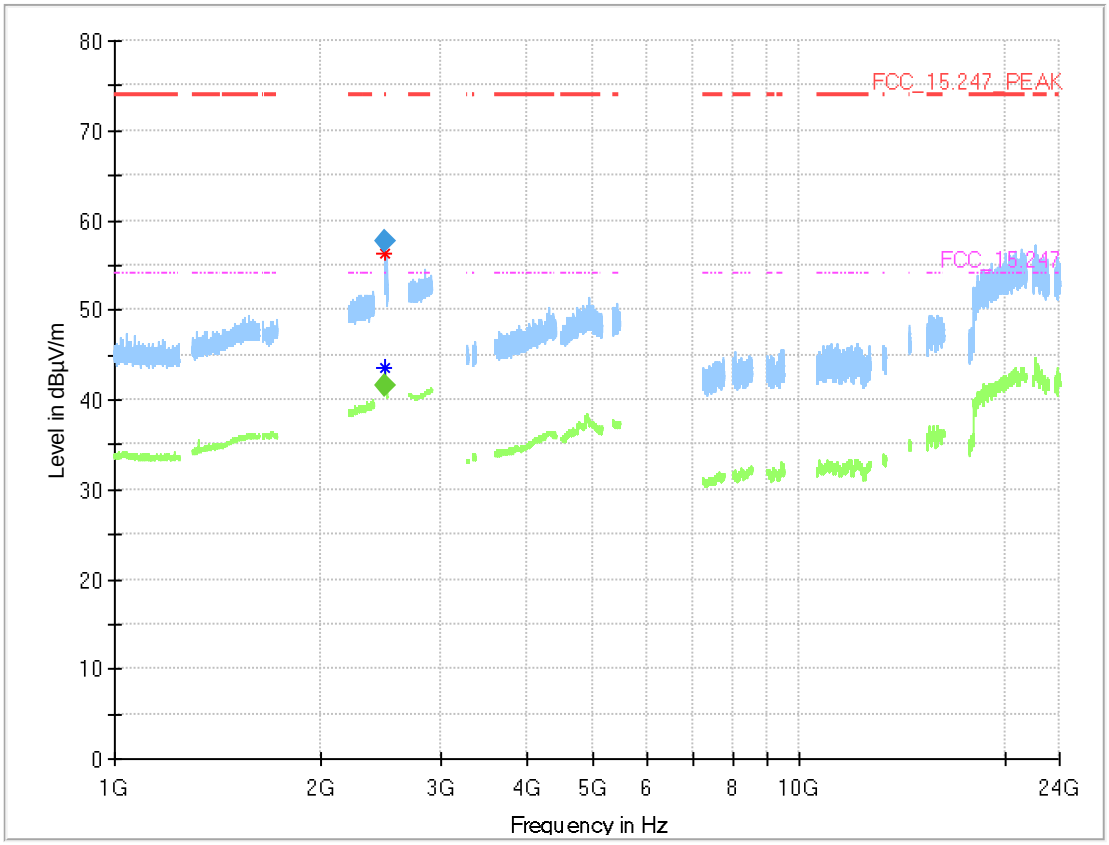
4.1.3TEST PROTOCOL

Ambient temperature: 21–25 °C
Air Pressure: 1002–1020 hPa
Humidity: 38–45 %
WLAN b-Mode; 20 MHz

Mode / Set EUT target power	Ch. Center Freq. [MHz]	Spurious Freq. [MHz]	Spurious Level [dBµV/m]	Detec-tor	RBW [kHz]	Limit [dBµV/m]	Margin to Limit [dB]	Limit Type
n-mode, MCS6 / 13 dBm	2472.0	2483.58	57.59	PEAK	1000	74.00	16.41	RB
n-mode, MCS6 / 13 dBm	2472.0	2483.91	41.55	AV	1000	54	12.45	RB

4.1.4MEASUREMENT PLOT (SHOWING THE HIGHEST VALUE, "WORST CASE")

Radio Technology = WLAN n-Mode, MCS6 / 13 dBm, 40 MHz, Operating Frequency = HIGH



4.1.5TEST EQUIPMENT USED

Radiated Emissions

4.2 BAND EDGE COMPLIANCE RADIATED

Standard **FCC Part 15 Subpart C**

The test was performed according to:
ANSI C63.10

4.2.1TEST DESCRIPTION

Please see test description for the test case "Spurious Radiated Emissions"

4.2.2TEST 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)

4.2.3TEST PROTOCOL

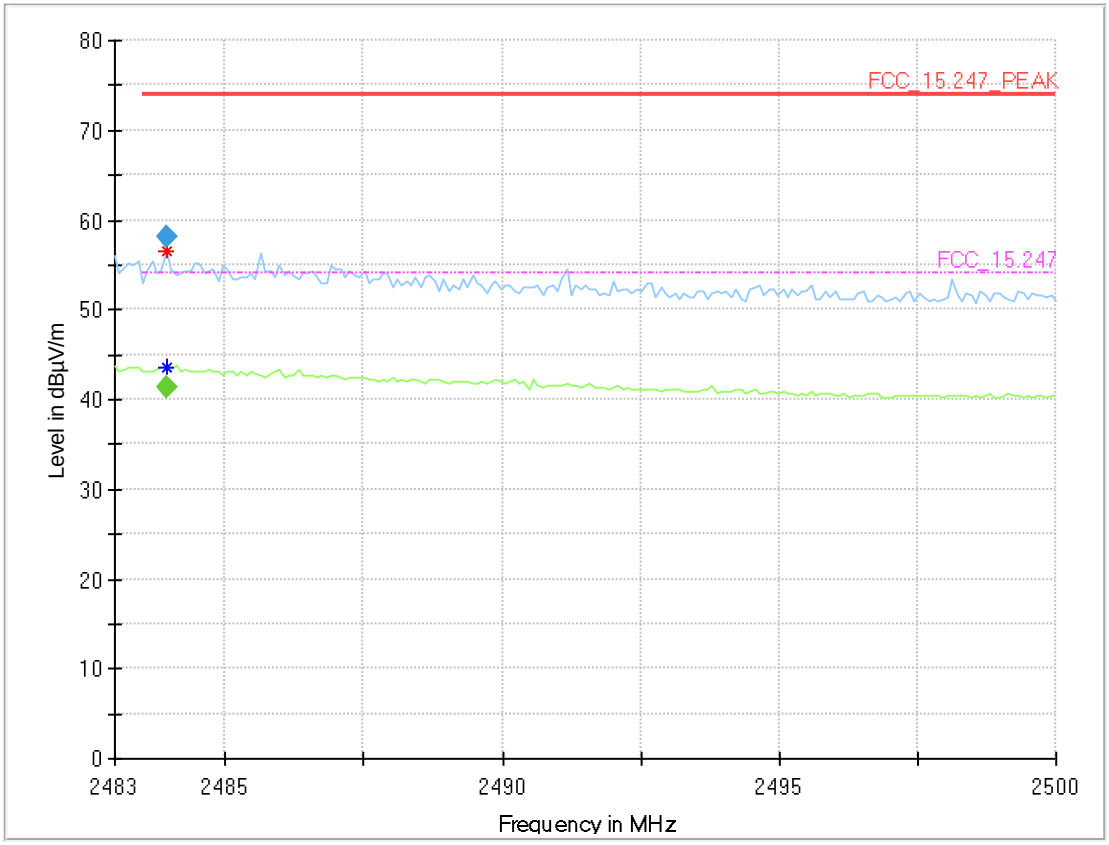
Ambient temperature: 21–25 °C
Air Pressure: 1002–1020 hPa
Humidity: 38–45 %
WLAN b-Mode; 20 MHz

Mode / Set EUT target power	Ch. Center Freq. [MHz]	Spurious Freq. [MHz]	Spurious Level [dBµV/m]	Detec-tor	RBW [kHz]	Limit [dBµV/m]	Margin to Limit [dB]	Limit Type
b-mode, 2Mbit / 15 dBm	2467.0	2483.93	38.01	AV	1000	54	15.99	RB
b-mode, 2Mbit / 15 dBm	2467.0	2483.93	49.55	PEAK	1000	74	24.45	RB
g-mode, 9Mbit / 13 dBm	2462.0	2483.85	38.14	AV	1000	54	15.86	RB
g-mode, 9Mbit / 13 dBm	2462.0	2483.85	52.76	PEAK	1000	74	21.24	RB
g-mode, 48Mbit / 9 dBm	2467.0	2483.51	38.94	AV	1000	54	15.06	RB
g-mode, 48Mbit / 9 dBm	2467.0	2483.51	53.35	PEAK	1000	74	20.65	RB
n-mode, HT40/MSC0 / 13 dBm	2447	2483.93	41.25	AV	1000	54	**12.74**	RB
n-mode, HT40/MSC0 / 13 dBm	2447	2483.93	57.99	PEAK	1000	74	16.01	RB
n-mode, HT40/MSC6 / 13 dBm	2447	2483.51	40.15	AV	1000	54	13.85	RB
n-mode, HT40/MSC6 / 13 dBm	2447	2483.51	56.77	PEAK	1000	74	17.23	RB
n-mode, HT40/MSC6 / 11 dBm	2452	2483.76	40.04	AV	1000	54	13.96	RB
n-mode, HT40/MSC6 / 11 dBm	2452	2483.76	54.41	PEAK	1000	74	19.59	RB
n-mode, HT20/MSC6 / 7 dBm	2462	2483.76	38.09	AV	1000	54	15.91	RB
n-mode, HT40/MSC6 / 7 dBm	2462	2483.76	53.31	PEAK	1000	74	20.69	RB
n-mode HT20/MSC6 / 9 dBm	2462	2484.78	38.69	AV	1000	54	15.31	RB
n-mode HT20/MSC6 / 9 dBm	2462	2484.78	54.47	PEAK	1000	74	19.53	RB

n-mode HT20/MSC6 / 9 dBm	2467	2485.04	39.15	AV	1000	54	14.84	RB
n-mode HT20/MSC6 / 9 dBm	2467	2485.04	54.22	PEAK	1000	74	19.78	RB
n-mode HT20/MSC6 / 10 dBm	2467	2483.6	40.09	AV	1000	54	13.91	RB
n-mode HT20/MSC6 / 10 dBm	2467	2483.6	53.32	PEAK	1000	74	20.68	RB

Remark: Antenna port of EUT terminated with 50 Ohm.

4.2.4MEASUREMENT PLOT (SHOWING THE HIGHEST VALUE, "WORST CASE")



4.2.5TEST EQUIPMENT USED

Radiated Emissions

5 TEST EQUIPMENT

1 Radiated Emissions
Lab to perform radiated emission tests

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
1.1	NRV-Z1	Sensor Head A	Rohde & Schwarz	827753/005	2017-05	2018-05
1.2	MFS	Rubidium Frequency Normal MFS	Datum GmbH	002	2017-10	2018-10
1.3	Opus10 TPR (8253.00)	ThermoAirpressure Datalogger 13 (Environ)	Lufft Mess- und Regeltechnik GmbH	13936	2017-04	2019-04
1.4	Anechoic Chamber	10.58 x 6.38 x 6.00 m³	Frankonia	none	2016-05	2019-05
1.5	HL 562	Ultralog new biconicals	Rohde & Schwarz	830547/003	2015-06	2018-06
1.6	5HC2700/12750-1.5-KK	High Pass Filter	Trilithic	9942012		
1.7	ASP 1.2/1.8-10 kg	Antenna Mast	Maturo GmbH	-		
1.8	Fully Anechoic Room	8.80m x 4.60m x 4.05m (l x w x h)	Albatross Projects	P26971-647-001-PRB	2015-06	2018-06
1.9	Fluke 177	Digital Multimeter 03 (Multimeter)	Fluke Europe B.V.	86670383	2016-02	2018-02
1.10	JS4-18002600-32-5P	Broadband Amplifier 18 GHz - 26 GHz	Miteq	849785		
1.11	FSW 43	Spectrum Analyzer	Rohde & Schwarz	103779	2016-12	2018-12
1.12	3160-09	Standard Gain / Pyramidal Horn Antenna 26.5 GHz	EMCO Elektronic GmbH	00083069		
1.13	WHKX 7.0/18G-8SS	High Pass Filter	Wainwright	09		
1.14	4HC1600/12750-1.5-KK	High Pass Filter	Trilithic	9942011		
1.15	Chroma 6404	AC Power Source	Chroma ATE INC.	64040001304		
1.16	JS4-00102600-42-5A	Broadband Amplifier 30 MHz - 26 GHz	Miteq	619368		
1.17	TT 1.5 WI	Turn Table	Maturo GmbH	-		
1.18	HL 562 Ultralog	Log.-per. Antenna	Rohde & Schwarz	100609	2016-04	2019-04
1.19	3160-10	Standard Gain / Pyramidal Horn Antenna 40 GHz	EMCO Elektronic GmbH	00086675		
1.20	5HC3500/18000-1.2-KK	High Pass Filter	Trilithic	200035008		

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
1.21	HFH2-Z2	Loop Antenna	Rohde & Schwarz	829324/006	2014-11	2017-11
1.22	Opus10 THI (8152.00)	ThermoHygro Datalogger 12 (Environ)	Lufft Mess- und Regeltechnik GmbH	12482	2017-03	2019-03
1.23	ESR 7	EMI Receiver / Spectrum Analyzer	Rohde & Schwarz	101424	2016-11	2018-11
1.24	JS4-00101800-35-5P	Broadband Amplifier 30 MHz - 18 GHz	Miteq	896037		
1.25	AS 620 P	Antenna mast	HD GmbH	620/37		
1.26	Tilt device Maturo (Rohacell)	Antrieb TD1.5-10kg	Maturo GmbH	TD1.5-10kg/024/3790709		
1.27	ESIB 26	Spectrum Analyzer	Rohde & Schwarz	830482/004	2015-12	2017-12
1.28	PAS 2.5 - 10 kg	Antenna Mast	Maturo GmbH	-		
1.29	AM 4.0	Antenna mast	Maturo GmbH	AM4.0/180/11920513		
1.30	HF 907	Double-ridged horn	Rohde & Schwarz	102444	2015-05	2018-05

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

6 ANTENNA FACTORS, CABLE LOSS AND SAMPLE CALCULATIONS

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

6.1 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.

6.2 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

6.3 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.

6.4 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.

6.5 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.

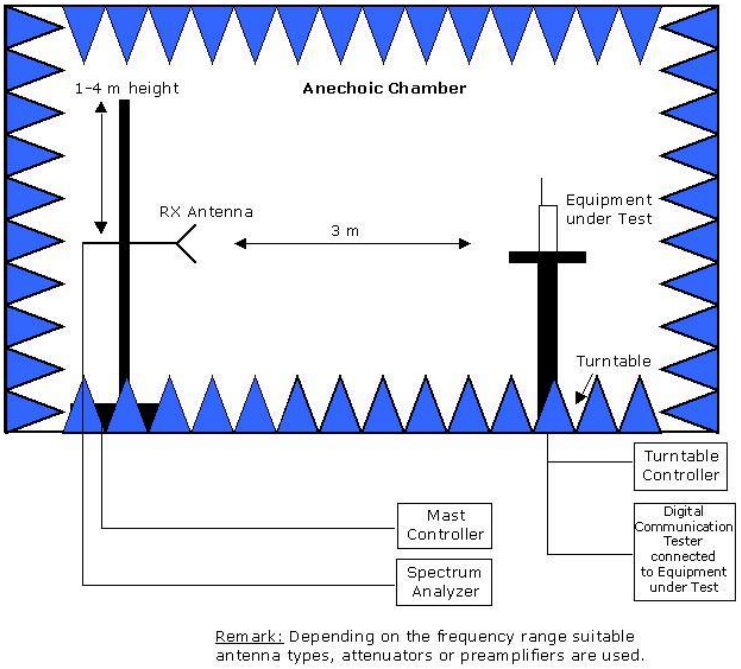
6.6 ANTENNA EMCO 3160-10 (26.5 GHZ – 40 GHZ)

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				-15,6	3	0,5
27,0	43,4	-11,2	4,4				-15,6	3	0,5
28,0	43,4	-11,1	4,5				-15,6	3	0,5
29,0	43,5	-11,0	4,6				-15,6	3	0,5
30,0	43,5	-10,9	4,7				-15,6	3	0,5
31,0	43,5	-10,8	4,7				-15,6	3	0,5
32,0	43,5	-10,7	4,8				-15,6	3	0,5
33,0	43,6	-10,7	4,9				-15,6	3	0,5
34,0	43,6	-10,6	5,0				-15,6	3	0,5
35,0	43,6	-10,5	5,1				-15,6	3	0,5
36,0	43,6	-10,4	5,1				-15,6	3	0,5
37,0	43,7	-10,3	5,2				-15,6	3	0,5
38,0	43,7	-10,2	5,3				-15,6	3	0,5
39,0	43,7	-10,2	5,4				-15,6	3	0,5
40,0	43,8	-10,1	5,5				-15,6	3	0,5

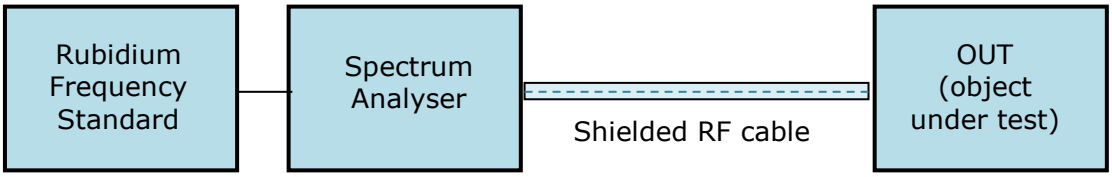
Sample calculation

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 interpolarisation 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.

7 SETUP DRAWINGS



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



Drawing 2: Setup for conducted radio tests.

8 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

9 PHOTO REPORT

Please see separate photo report.