PHOENIX TESTLAB

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Test Report

Report Number:

F200355E2

Equipment under Test (EUT):

HYPRO WATER

Applicant:

Hytecon Forschung und Entwicklung GmbH

Manufacturer:

Hytecon Forschung und Entwicklung GmbH

ilac-MRA

DAkkS
Deutsche
Akkreditierungsstelle
D-PL-17186-01-01
D-PL-17186-01-02
D-PL-17186-01-03

References

[1] **ANSI C63.10: 2013** American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

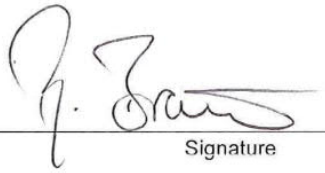
[2] **FCC CFR 47 Part 15** Radio Frequency Devices

[3] **RSS-210 Issue 10 (December 2019)**
Licence-exempt Radio Apparatus: Category I Equipment

[4] **RSS-Gen Issue 5 (March 2019) Amendment 1**
General Requirements for Compliance of Radio Apparatus

Test Result

The requirements of the tests performed as shown in the overview (clause 4) were fulfilled by the equipment under test. The complete test results are presented in the following.

Tested and written by:	Ruben BRAUN Name	 Signature	31.07.2020 Date
Reviewed and approved by:	Bernd STEINER Name	 Signature	31.07.2020 Date

This test report is only valid in its original form.

The test results herein refer only to the tested sample. PHOENIX TESTLAB GmbH is not responsible for any generalisations or conclusions drawn from these test results concerning further samples. Any modification of the tested samples is prohibited and leads to the invalidity of this test report. Each page necessarily contains the PHOENIX TESTLAB Logo and the TEST REPORT NUMBER.

Contents: Page

1 Identification

1.1 Applicant

Name:	Hytecon Forschung und Entwicklung GmbH
Address:	Oststr. 68, 32051 Herford
Country:	Germany
Name for contact purposes:	Mr. Ibrahim DALI
Phone:	+49 (0) 5221 284 00 75
eMail address:	ibrahim.dali@hytecon.com
Applicant represented during the test by the following person:	-

1.2 Manufacturer

Name:	Hytecon Forschung und Entwicklung GmbH
Address:	Oststr. 68, 32051 Herford
Country:	Germany
Name for contact purposes:	Mr. Ibrahim DALI
Phone:	+49 (0) 5221 284 00 75
eMail address:	ibrahim.dali@hytecon.com
Manufacturer represented during the test by the following person:	-

1.3 Test Laboratory

The tests were carried out by:

PHOENIX TESTLAB GmbH
Königswinkel 10
32825 Blomberg
Germany

Accredited by Deutsche Akkreditierungsstelle GmbH (DAkkS) in compliance with DIN EN ISO/IEC 17025 under Reg. No. D-PL-17186-01-06 and D-PL-17186-01-05, FCC Test Firm Designation Number DE0004, FCC Test Firm Registration Number 469623, CAB Identifier DE0003 and ISED# 3469A.

1.4 EUT (Equipment under Test)

Type of equipment: *	**Drinking water filtration and disinfection system**
PMN: *	**HYPRO WATER**
HVIN: *	HW20
Order number: *	N/A
Serial number: *	HW000084
FCC ID: *	2AVTQ-HW20
IC certification number: *	25976-HW20
PCB identifier: *	Hypro-CTR-v5, Hypro-RFID-v3
Hardware version: *	Hypro-CTR-v5.12, Hypro-RFID-v3
Software version (FVIN): *	V 116

* Declared by the applicant

Note: PHOENIX Testlab GmbH does not take samples. The samples used for tests are provided exclusively by the applicant.

1.5 Technical Data of Equipment

General:

Power supply EUT: *	AC					
Supply voltage EUT: *	U_{nom} =	120 V AC	U_{min} =	110 V AC	U_{max} =	240 V AC
Temperature range: *	+5 °C to +35 °C (+41 °F to 95 °F)					
Lowest / highest internal clock frequency: *	32.768 kHz / 2462 MHz					

RFID:

Number of channels: *	1
Antenna type: *	Internal loop antenna
Duty cycle: *	100 %
Data rate: *	106 kbit/s
Operating frequency range: *	13.56 MHz
Type of modulation: *	ASK

WLAN / Bluetooth module:

Manufacturer: *	ESPRESSIF SYSTEMS (SHANGHAI) PTE LTD					
Model name: *	ESP-WROOM-32					
Radio Standards: *	802.11 b/g/n Wireless LAN + Bluetooth / Bluetooth LE *1					
FCC ID: *	2AC7Z-ESPWROOM32					
IC: *	21098-ESPWROOM32					
Power supply module: *	DC					
Supply voltage module: *	U_{nom} =	3.3 V DC	U_{min} =	3.0 V DC	U_{max} =	3.6 V DC
Supported bands: *	WLAN b/g/n20 (2.4G): 1 – 11 WLAN n40 (2.4G): 3 – 9 Bluetooth classic + EDR: 0 – 78 (1 MHz channel spacing) *1 Bluetooth LE: 0 – 39 (2 MHz channel spacing) *1					
Antenna type: *	PCB antenna					
Antenna connector: *	-					
Antenna gain: *	2 dBi					

* Declared by the applicant
*1 Bluetooth and Bluetooth LE are not supported in the final application of the EUT, as declared by the applicant.

Ports / Connectors				
Identification			Length during test	Shielding (Yes / No)
	EUT	Ancillary		
AC plug	Screw terminal	AC plug	1.5 m	No

Ancillary Equipment
-

1.6 Dates

Date of receipt of test sample:	15.06.2020
Start of test:	15.06.2020
End of test:	09.07.2020

2 Operational States

Description of function of the EUT:

The EUT is a drinking water disinfection and filtration system. The EUT is equipped with an RFID module and a certified WLAN/BT/BLE module.

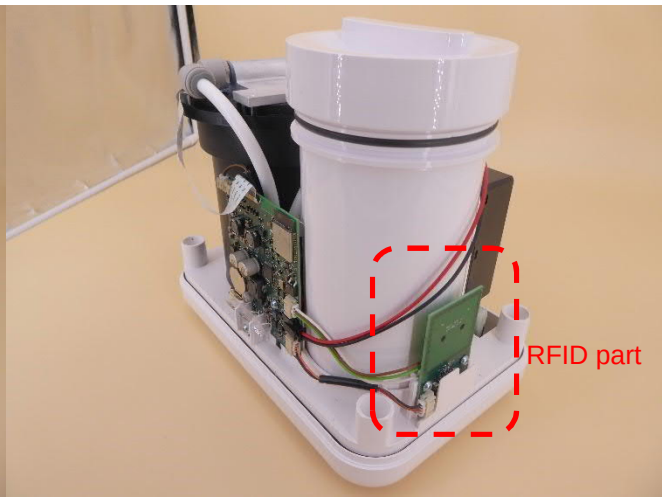
The eCFR §15.247 testcases were tested and documented separately in test report F200355E3 by PHOENIX TESTLAB GmbH.

The following states were defined as the operating conditions:

During all tests the EUT was supplied with 60 Hz 120 V AC and the TAG was placed onto the antenna of the RFID part of the EUT.
The tests were performed with an unmodified sample, except for the conducted emissions test (refer chapter 3 and 5.5).
The WLAN and disinfection function of the EUT were not active during the tests, except for the conducted emissions test (refer chapter 5.5), where WLAN was active simultaneously.

The physical boundaries of the EUT are shown below:

EUT



EUT, cover removed

TAG

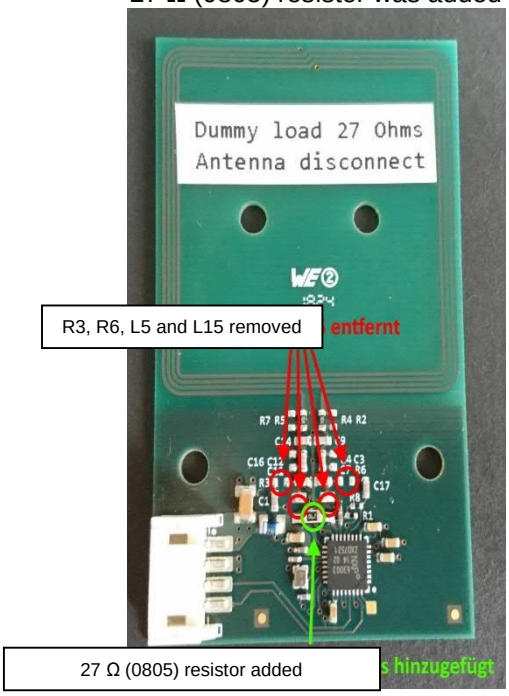
3 Additional Information

The EUT was not labeled as required by FCC / IC.

To fulfil the conducted emissions test, a dummy load as described below was used, according to KDB 174176 (06/2015):

The following components were changed to gain a suitable dummy load in lieu of the antenna:

R3, R6, L5 and L15 were removed
27 Ω (0805) resistor was added



4 Overview

Application	Frequency range [MHz]	FCC 47 CFR Part 15 section [2]	RSS-Gen, Issue 5 [4] and RSS-210, Issue 10 [3]	Status	Refer page
Spectrum mask	13.110 to 14.110	15.225 (a) – (d)	B.6 [3]	Passed	11 et seq.
20 dB bandwidth	13.560	15.215 (c)	N/A	Passed	13 et seq.
99 % bandwidth	13.56	-	6.7 [4]	Passed	15 et seq.
Frequency tolerance	13.560	15.225 (e)	6.11 [4] B.6 [3]	Passed	17 et seq
Conducted emissions on supply line	0.15 – 30	15.207 (a)	8.8 [4]	Passed	19 et seq
Radiated emissions	0.009 – 1000***	15.205 (a) 15.209 (a)	8.9 and 8.10 [4] 7.1 and 7.4 [3]	Passed	22 et seq.
Radiated emissions (receiver)	30 – 5.000	15.109 (a)	6.1 [4]	N/A **	-
Antenna requirement	-	15.203 [2]	6.8 [4]	Passed *	-
Simultaneous transmission tests ****	30 – 26,500	-	-	Passed	30 et seq.

*: Integrated antenna only, requirement fulfilled.

**: No measurement of the receiver spurious emissions was carried out, because of a continuously operating co-located transmitter.

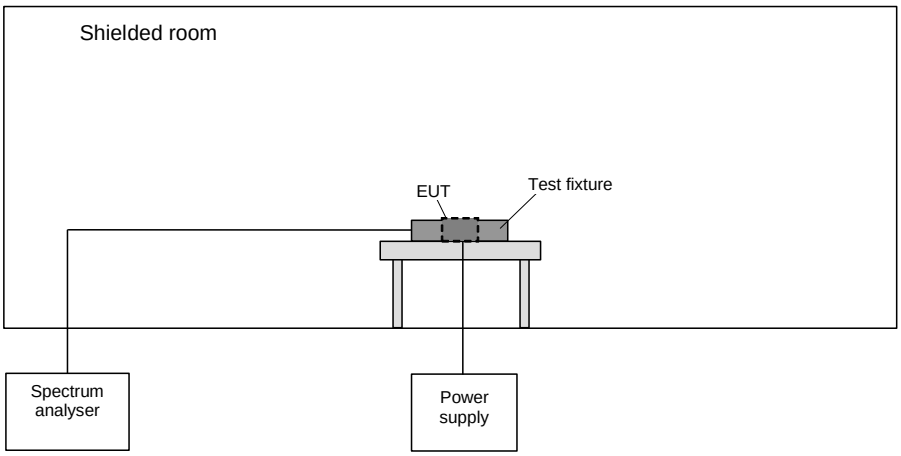
***: As declared by the applicant the highest radio clock frequency is below 108 MHz.
Therefore the radiated emission measurement must be carried out up to 10th of the highest radio clock frequency in this case 1 GHz.

****: According to KDB 996369 D04 Module Integration Guide v01, emission tests were done while the EUT was transmitting in WLAN and NFC mode simultaneously.

5 Results

5.1 Spectrum mask

5.1.1 Test method



The following procedure will be used for the spectrum mask measurement:

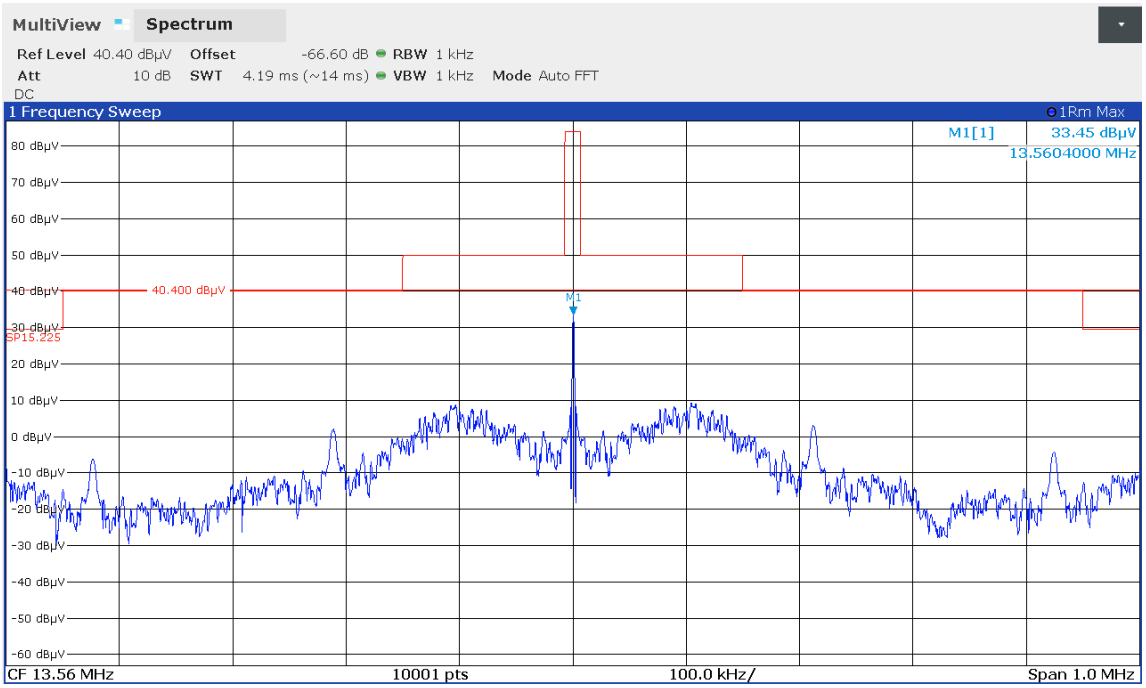
1) Place the EUT in the test fixture and switch it on.
2) Use the following spectrum analyser settings: RWB = VBW = 1 kHz, Span = wide enough to capture the whole 13 MHz band including the frequency ranges where the limit [2; 3] applies, Trace mode = MaxHold, select the limit line. The bandwidth usually has to be 10 kHz for the measurement [1]. Because a measurement with this bandwidth results into an envelope, which is too wide for the 14 kHz spectrum mask, the bandwidth was reduced. The amplitude was determined using the 10 kHz bandwidth.
3) After trace stabilisation, set the marker to the signal peak.
4) The Reference level will be calculated by the amount of the margin of the wanted signal to its 30 m emission limit plus the marker value.
5) The whole signal trace has to be below the limit line.

5.1.2 Test results

Ambient temperature:	22 °C	Relative humidity:	63 %
Date	09.07.2019	Test engineer:	R. Braun

Supply voltage: The EUT was supplied with 120 V 60 Hz.

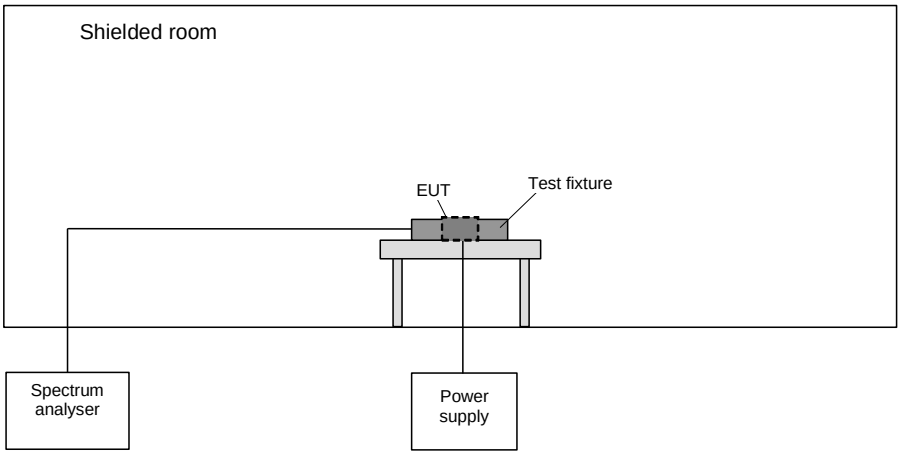
Test record: The test was carried out while the EUT was reading a TAG.



Test equipment (please refer to chapter 6 for details)
1 - 3

5.2 20 dB bandwidth

5.2.1 Test method



The following procedure will be used for the occupied bandwidth measurement [1]:

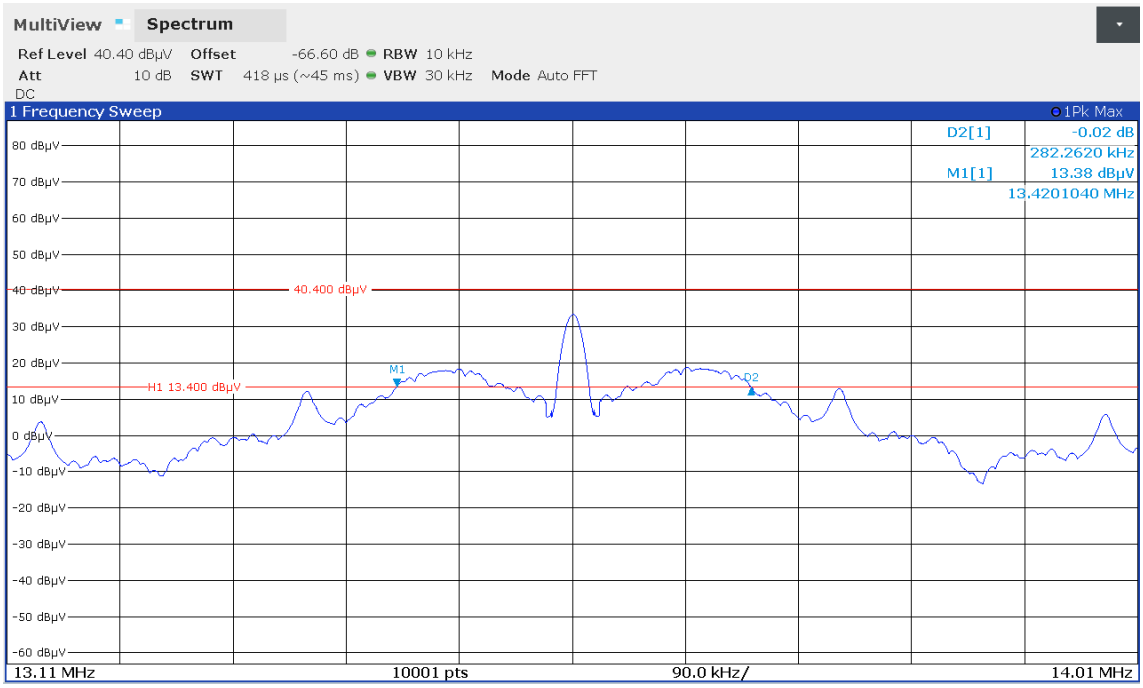
1) Place the EUT in the test fixture and switch it on.
2) Use the following spectrum analyser settings: RWB = 10 kHz and VBW = 30 kHz, Span = wide enough to capture app. 1.5 times the 20 dB bandwidth, Trace mode = MaxHold.
3) After trace stabilisation, set the first marker and the first display line to the signal peak. Set the second display line 20 dB below the first display line. The second marker and its delta marker shall be set to cross points of the spectrum line and the second display line and note these frequencies.
4) Alternatively, the 20 dB down function of the analyser could be used, if this function will be applicable to the displayed spectrum.

5.2.2 Test results

Ambient temperature:	22 °C	Relative humidity:	63 %
Date	09.07.2019	Test engineer:	R. Braun

Supply voltage: The EUT was supplied with 120 V 60 Hz.

Test record: The test was carried out while the EUT was reading a TAG.

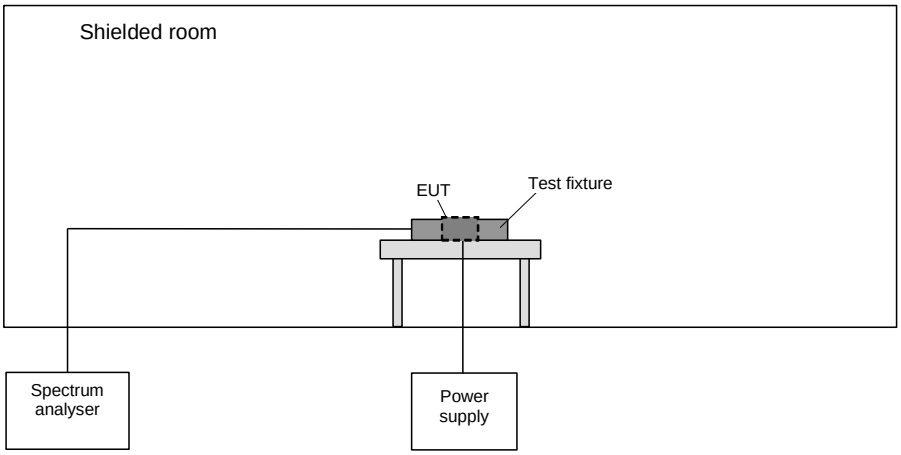


F_L	F_U	BW (F_U - F_L)
13.420104 MHz	13.702366 MHz	282.262 kHz
Measurement uncertainty		< $1*10^{-7}$

Test equipment (please refer to chapter 6 for details)
1 - 3

5.3 99 % bandwidth

5.3.1 Test method



The following procedure will be used for the occupied bandwidth measurement according to [1]:

The occupied bandwidth is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers are each equal to 0.5% of the total mean power of the given emission. The following procedure shall be used for measuring 99% power bandwidth:

a) The instrument center frequency is set to the nominal EUT channel center frequency. The frequency span for the spectrum analyzer shall be between 1.5 times and 5.0 times the OBW.

b) The nominal IF filter bandwidth (3 dB RBW) shall be in the range of 1% to 5% of the OBW, and VBW shall be approximately three times the RBW, unless otherwise specified by the applicable requirement.

c) Set the reference level of the instrument as required, keeping the signal from exceeding the maximum input mixer level for linear operation. In general, the peak of the spectral envelope shall be more than [10 log (OBW/RBW)] below the reference level. Specific guidance is given in 4.1.5.2.

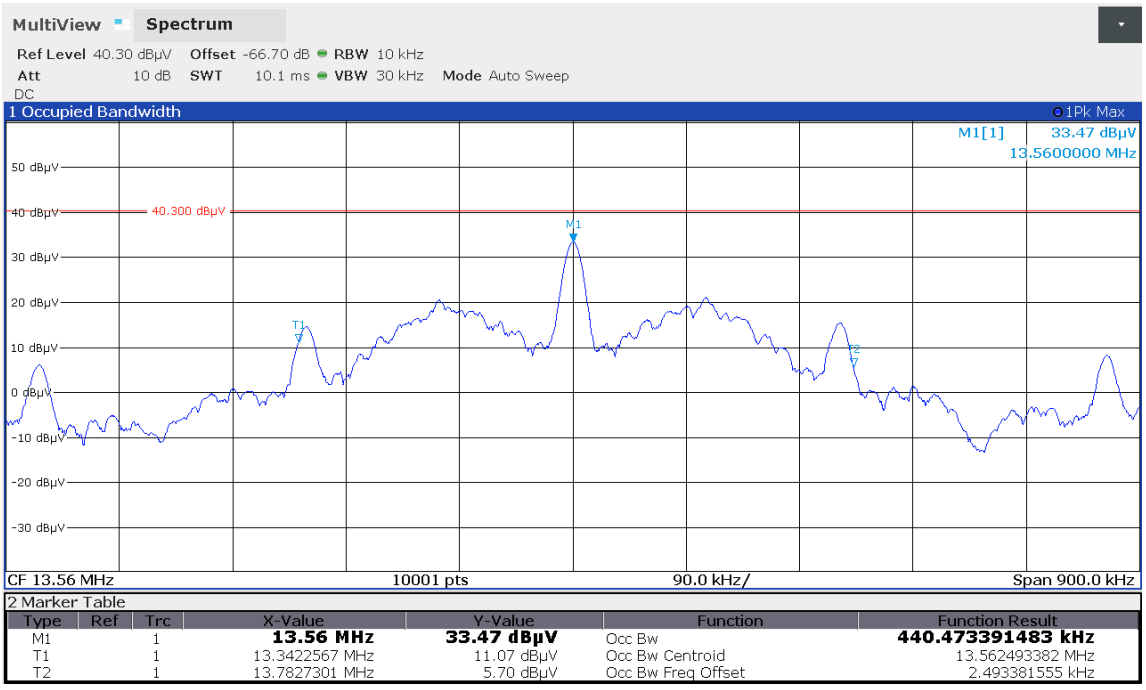
d) Step a) through step c) might require iteration to adjust within the specified range.

5.3.2 Test results

Ambient temperature:	22 °C	Relative humidity:	63 %
Date	09.07.2019	Test engineer:	R. Braun

Supply voltage: The EUT was supplied with 120 V 60 Hz.

Test record: The test was carried out while the EUT was reading a TAG.

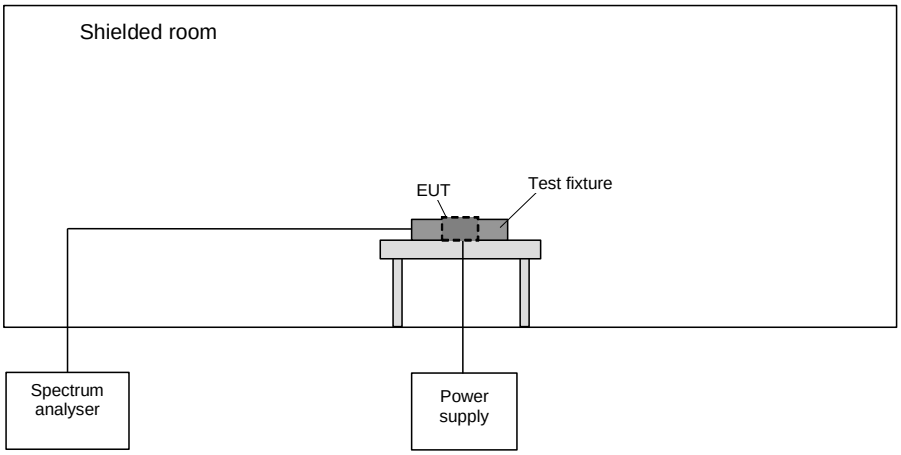


F_L	F_U	BW (F_U - F_L)
13.3422567 MHz	13.7827301 MHz	440.473 kHz
Measurement uncertainty		< $1*10^{-7}$

Test equipment (please refer to chapter 6 for details)
1 - 3

5.4 Frequency tolerance

5.4.1 Test method



The following procedure will be used for the spectrum mask measurement:

6) Place the EUT in the test fixture and switch it on.
7) Use the following spectrum analyser settings: RWB = VBW = 1 kHz, Span = wide enough to capture the whole 13 MHz band including the frequency ranges where the limit [2; 3] applies, Trace mode = MaxHold, select the limit line. The bandwidth usually has to be 10 kHz for the measurement [1]. Because a measurement with this bandwidth results into an envelope, which is too wide for the 14 kHz spectrum mask, the bandwidth was reduced. The amplitude was determined using the 10 kHz bandwidth.
8) After trace stabilisation, set the marker to the signal peak.
9) The Reference level will be calculated by the amount of the margin of the wanted signal to its 30 m emission limit plus the marker value.
10) The whole signal trace has to be below the limit line.

5.4.2 Test results

Ambient temperature:	22 °C	Relative humidity:	63 %
Date	09.07.2019	Test engineer:	R. Braun

Test set-up: For this test the EUT was placed inside a temperature chamber.

Temperature	Supply voltage	Minutes after switching on	Frequency In MHz	Allowed tolerance in kHz	Measured tolerance in Hz	Result
35 °C	120 V 60 Hz	0	13.560407	±1.356kHz	7	Passed
		2	13.560389	±1.356kHz	-11	Passed
		5	13.560382	±1.356kHz	-18	Passed
		10	13.560378	±1.356kHz	-22	Passed
30 °C	120 V 60 Hz	0	13.560422	±1.356kHz	22	Passed
		2	13.560403	±1.356kHz	3	Passed
		5	13.560394	±1.356kHz	-6	Passed
		10	13.560388	±1.356kHz	-12	Passed
20 °C	102 V 60 Hz	0	13.560409	±1.356kHz	9	Passed
	120 V 60 Hz		13.560400	-	0	-
	138 V 60 Hz		13.560413	±1.356kHz	13	Passed
10 °C	120 V 60 Hz	0	13.560463	±1.356kHz	63	Passed
		2	13.560448	±1.356kHz	48	Passed
		5	13.560438	±1.356kHz	38	Passed
		10	13.560436	±1.356kHz	36	Passed
5 °C	120 V 60 Hz	0	13.560471	±1.356kHz	70	Passed
		2	13.560461	±1.356kHz	61	Passed
		5	13.560455	±1.356kHz	55	Passed
		10	13.560451	±1.356kHz	51	Passed
Measurement uncertainty				< ± 1*10-7		

Test equipment (please refer to chapter 6 for details)
1 - 5

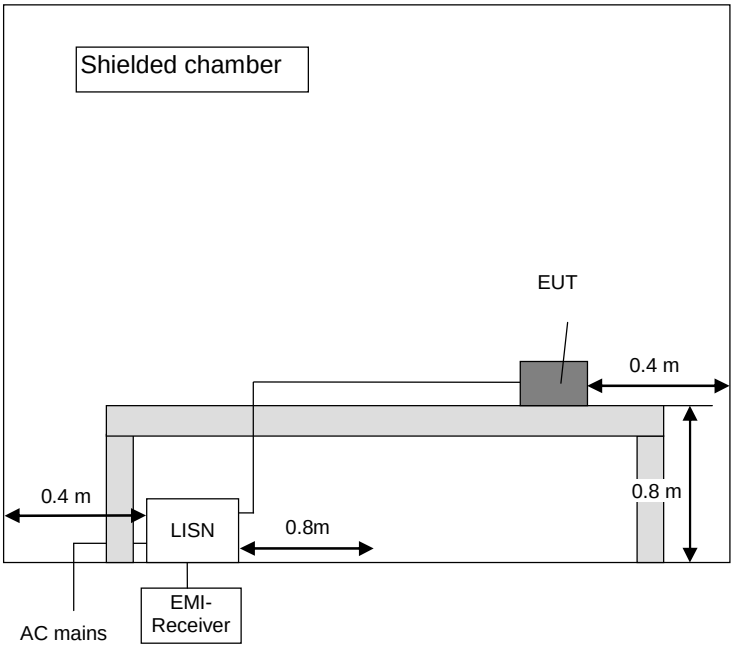
5.5 Conducted emissions on power supply lines

5.5.1 Test method

This test will be carried out in a shielded chamber. Table top devices will set up on a non-conducting support with a size of 1 m by 1.5 m and a height of 80 cm above the ground plane. Floor-standing devices will be placed directly on the ground plane. The setup of the Equipment under test will be in accordance to [1].

The frequency range 150 kHz to 30 MHz will be measured with an EMI Receiver set to MAX Hold mode with peak and average detector and a resolution bandwidth of 9 kHz. A scan will be carried out on the phase (or plus pole in case of DC powered devices) of the AC mains network. If levels detected 10 dB below the appropriable limit, this emission will be measured with the average and quasi-peak detector on all lines.

Frequency range	Resolution bandwidth
150 kHz to 30 MHz	9 kHz

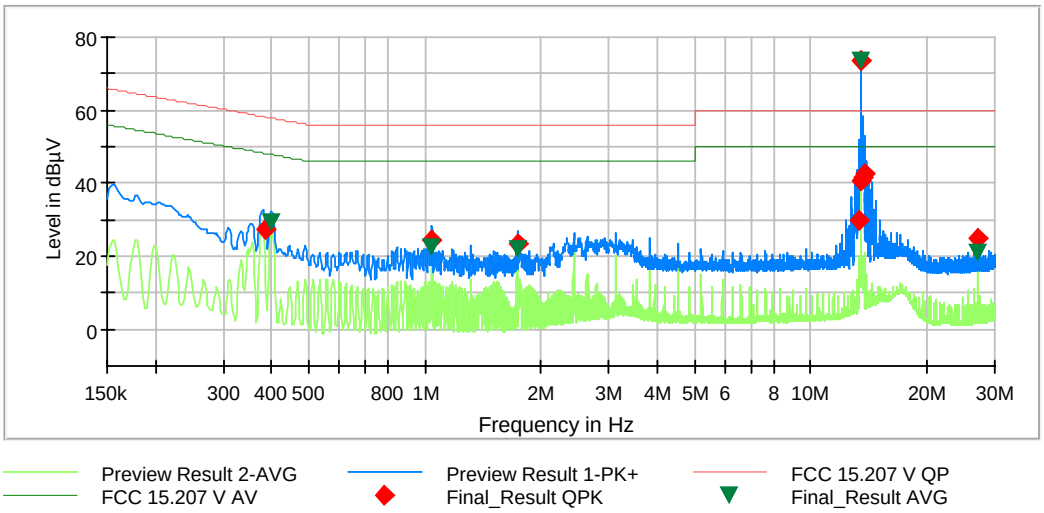


Remark: This test was carried out with dummy load according to KDB 174176 (06/2015).

5.5.2 Results conducted emission measurement on AC mains

Ambient temperature:	22 °C	Relative humidity:	56 %
Date	29.06.2020	Test engineer:	R. Braun

Test description:	Conducted emission measurement
EUT:	HYPRO WATER
Manufacturer:	Hytecon Forschung und Entwicklung GmbH
Operating conditions:	Reading TAG without dummy load, WLAN active, disinfection inactive
Test site:	PHOENIX TESTLAB GmbH, shielded room M155
Operator:	R. Braun
Comment:	120 VAC / 60 Hz

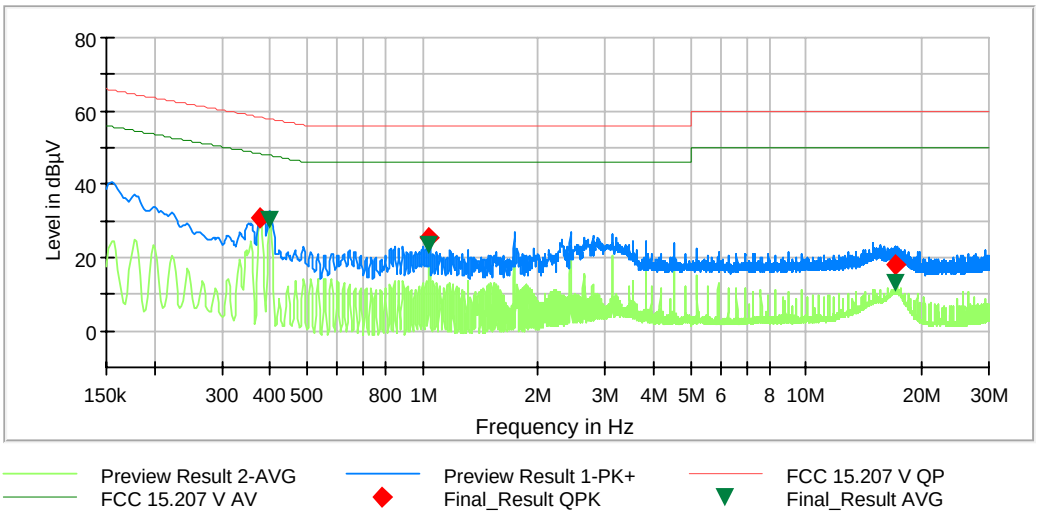


Remark: The plot while reading a TAG was carried out to show the AC power-line conducted tests with the antenna connected to determine compliance with Section 15.207 limits outside the RFID transmitter's fundamental emission band. The following test with a dummy load in lieu of the antenna was carried out to determine compliance with Section 15.207 limits within the RFID transmitter's fundamental emission band.

Ambient temperature:	22 °C	Relative humidity:	58 %
Date	02.07.2020	Test engineer:	R. Braun

Test description:	Conducted emission measurement
EUT:	HYPRO WATER
Manufacturer:	Hytecon Forschung und Entwicklung GmbH
Operating conditions:	27 Ohm dummy load, WLAN active, disinfection inactive
Test site:	PHOENIX TESTLAB GmbH, shielded room M155
Operator:	R. Braun
Comment:	120 VAC / 60 Hz

The curves in the diagrams below only represent for each frequency point the maximum measured value of all preliminary measurements which were made for each power supply line. The top measured curve represents the peak measurement and the bottom measured curve the average measurement. The quasi-peak measured points are marked by ◆ and the average measured points by ▼.



Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	PE	Transducer (dB)
0.378150	30.69	---	58.32	27.63	5000.0	9.000	L1	FLO	9.8
0.399750	---	30.48	47.86	17.38	5000.0	9.000	L1	FLO	9.8
1.042350	---	23.32	46.00	22.68	5000.0	9.000	L1	GND	9.8
1.043250	25.64	---	56.00	30.36	5000.0	9.000	L1	GND	9.8
17.025900	18.27	---	60.00	41.73	5000.0	9.000	L1	GND	10.7
17.027700	---	12.92	50.00	37.08	5000.0	9.000	L1	GND	10.7
Measurement uncertainty				+2.76 dB / -2.76 dB					

Test equipment (please refer to chapter 6 for details)
6 - 9

5.6 Radiated emissions

5.6.1 Test method

The radiated emission measurement is divided into 3 stages:

- A preliminary measurement carried out in a semi-anechoic chamber with a fixed antenna height in the frequency range 9 kHz to 30 MHz.
- A final measurement carried out on an outdoor test side without reflecting ground plane and a fixed antenna height in the frequency range 9 kHz to 30 MHz.
- A preliminary and final measurement carried out in a semi-anechoic chamber with a varying antenna height in the frequency range 30 MHz to 1 GHz.

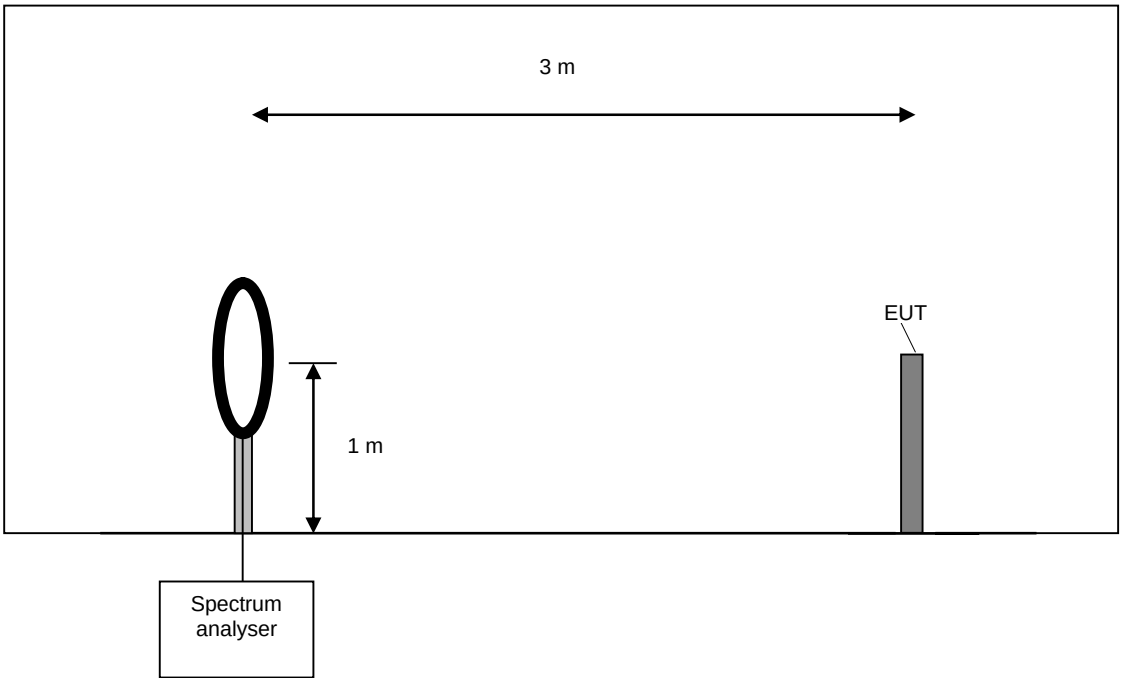
Preliminary measurement (9 kHz to 30 MHz):

In the first stage a preliminary measurement will be performed in a semi-anechoic chamber with a measuring distance of 3 meters. Table-top devices will set up on a non-conducting support with a size of 1 m by 1.5 m and a height of 80 cm. Floor-standing devices will be placed directly on the turntable/ground plane. The setup of the equipment under test will be in accordance to [1].

The frequency range 9 kHz to 30 MHz will be monitored with a spectrum analyser while the system and its cables will be manipulated to find out the configuration with the maximum emission levels if applicable. The spectrum analyser will be set to MAX Hold mode. The EUT and the measuring antenna will be rotated around their vertical axis to find the maximum emissions.

The resolution bandwidth of the spectrum analyser will be set to the following values:

Frequency range	Resolution bandwidth
9 kHz to 150 kHz	200 Hz
150 kHz to 30 MHz	10 kHz



Preliminary measurement procedure:

Pre-scans were performed in the frequency range 9 kHz to 150 kHz and 150 kHz to 30 MHz.

The following procedure will be used:

1) Monitor the frequency range at horizontal polarisation and a EUT azimuth of 0 °.
2) Manipulate the system cables within the range to produce the maximum level of emission.
3) Rotate the EUT by 360 ° to maximize the detected signals.
4) Make a hardcopy of the spectrum.
5) Measure the frequencies of highest detected emission with a lower span and resolution bandwidth to increase the accuracy and note the frequency value.
6) Repeat steps 1) to 5) with the other orthogonal axes of the EUT (if the EUT is a module and might be used in a handheld equipment application).
7) Rotate the measuring antenna and repeat steps 1) to 5).

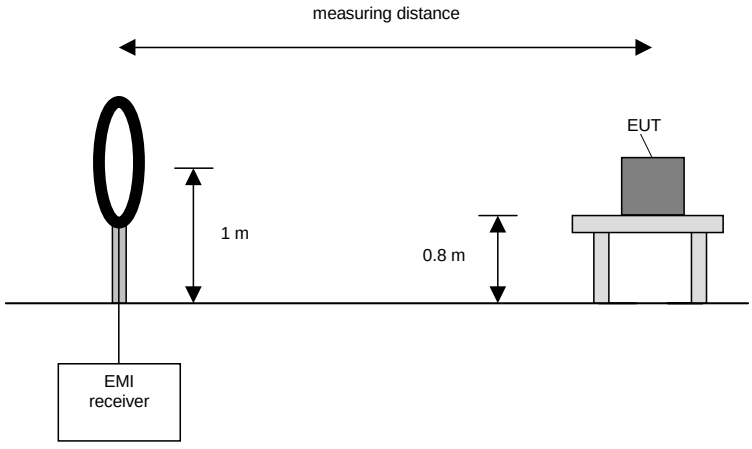
Final measurement (9 kHz to 30 MHz):

In the second stage a final measurement will be performed on an open area test site with no conducting ground plane in a measuring distances of 3 m, 10 m and 30 m. In the case where larger measuring distances are required the results will be extrapolated based on the values measured on the closer distances according to Section 15.31 (f) (2) [2]. The final measurement will be performed with an EMI Receiver set to Quasi Peak detector except for the frequency bands 9 kHz to 90 kHz and 110 kHz to 490 kHz where an average detector will be used according Section 15.209 (d) [2].

On the frequencies, which were detected during the preliminary measurements, the final measurement will be performed while rotating the EUT and the measuring antenna in the range of 0 ° to 360 ° around their vertical axis until the maximum value is found.

The resolution bandwidth of the EMI Receiver will be set to the following values:

Frequency range	Resolution bandwidth
9 kHz to 150 kHz	200 Hz
150 kHz to 30 MHz	9 kHz



Final measurement procedure:

The following procedure will be used:

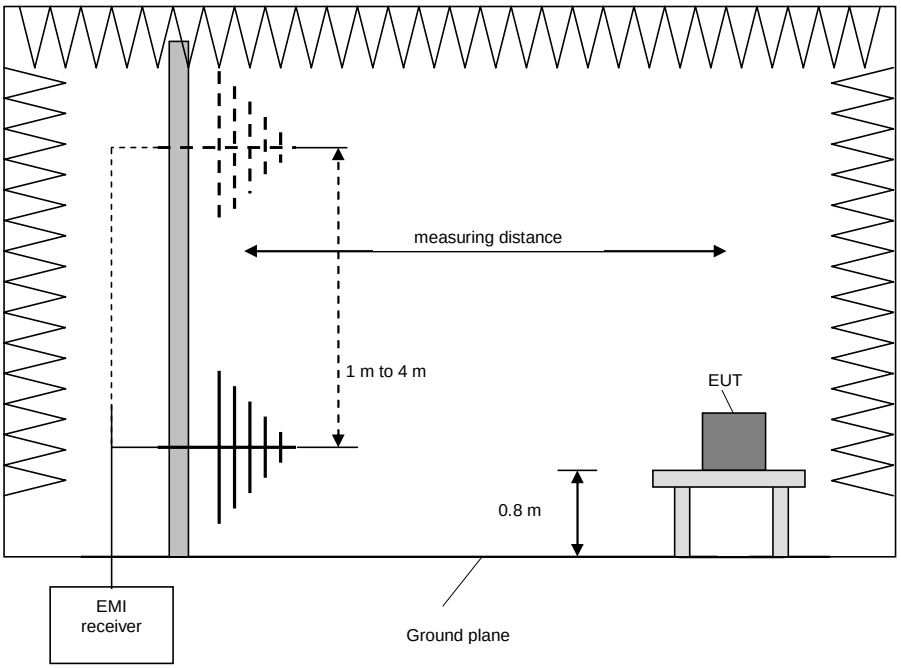
1) Monitor the frequency range with the measuring antenna at vertical orientation parallel to the EUT at an azimuth of 0 °.
2) Rotate the EUT by 360 ° to maximize the detected signals and note the azimuth and orientation.
3) Rotate the measuring antenna to find the maximum and note the value.
4) Repeat steps 1) to 3) with the other orthogonal axes of the EUT (if the EUT is a module and might be used in a handheld equipment application).

Preliminary and final measurement (30 MHz to 1 GHz)

The preliminary and final measurements were conducted in a semi-anechoic chamber with a metal ground plane. During the test the EUT will be rotated in the range of 0 ° to 360 °, the measuring antenna will be set to horizontal and vertical polarization and raised and lowered in the range from 1 m to 4 m to find the maximum level of emissions.

The resolution bandwidth of the EMI Receiver will be set to the following values:

Test	Frequency range	Resolution bandwidth
Preliminary measurement	30 MHz to 1 GHz	100 kHz
Frequency peak search	+ / - 1 MHz	10 kHz
Final measurement	30 MHz to 1 GHz	120 kHz



Procedure preliminary measurement:

The following procedure is used:

1. Set the measurement antenna to 1 m height.
2. Monitor the frequency range at vertical polarisation and a EUT azimuth of 0 °.
3. Rotate the EUT by 360° to maximize the detected signals.
4. Repeat 1) to 2) with the vertical polarisation of the measuring antenna.
5. Increase the height of the antenna for 0.5 m and repeat steps 2 – 4 until the final height of 4 m is reached.
6. The highest values for each frequency will be saved by the software, including the antenna height, measurement antenna polarization and turntable azimuth for that value.

Procedure final measurement:

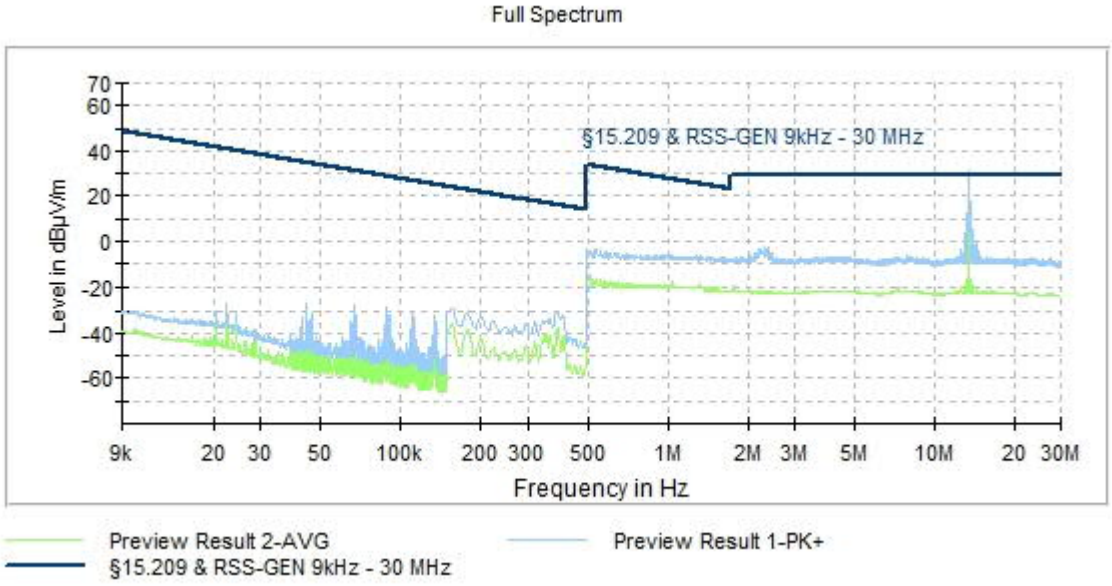
The following procedure is used:

1. Select the highest frequency peaks to the limit for the final measurement.
2. The software will determine the exact peak frequencies by doing a partial scan with reduced RBW with +/- 10 times the RBW of the pre-scan of the selected peaks.
3. If the EUT is portable or ceiling mounted, find the worst-case EUT position (x,y,z) for the final test.
4. The worst measurement antenna height is found by the measurement software by varying the measurement antenna height by +/- 0.5 m from the value obtained in the preliminary measurement, and to monitor the emission level.
5. The worst azimuth turntable position is found by varying the turntable azimuth by +/- 30° from the value obtained in the preliminary measurement, and to monitor the emission level.
6. The final measurement is performed at the worst-case antenna height and the worst-case turntable azimuth
7. Steps 2 – 6 will be repeated for each frequency peak selected in step 1.

5.6.2 Results preliminary measurement 9 kHz to 30 MHz

Ambient temperature:	21 °C	Relative humidity:	70 %
Date	15.06.2020	Test engineer:	R. Braun

Test description:	Radiated emission measurement
EUT:	HYPRO WATER
Manufacturer:	Hytecon Forschung und Entwicklung GmbH
Operating conditions:	Reading a TAG, WLAN inactive, disinfection inactive
Test site:	PHOENIX TESTLAB GmbH, shielded room M155
Operator:	R. Braun
Comment:	120 VAC / 60 Hz



Remark: In the shown plot a distance correction factor was added to the measurement results to account for the different measuring distances according to standard (9 kHz to 490 kHz @ 300 m; 490 kHz to 30 MHz @ 30 m).

The following emissions were found:

MHz
0.067
0.089
0.111
0.134
13.560

Test equipment (please refer to chapter 6 for details)
3, 10 - 17

5.6.3 Result final measurement from 9 kHz to 30 MHz

Ambient temperature:	17 °C	Relative humidity:	80 %
Date	18.06.2020	Test engineer:	R. Braun

Test description:	Radiated emission measurement
EUT:	HYPRO WATER
Manufacturer:	Hytecon Forschung und Entwicklung GmbH
Operating conditions:	Reading a TAG, WLAN inactive, disinfection inactive
Test site:	PHOENIX TESTLAB GmbH, open are test site
Operator:	R. Braun
Comment:	120 VAC / 60 Hz

The results of the standard subsequent measurement on the outdoor test site are indicated in the table below. The limits as well as the measured results (levels) refer to the above-mentioned standard while taking account of the specified requirements for a 30 m measuring distance.

Frequency [MHz]	Reading [dBµV]	Result* [dBµV/m]	Result* [dBµA/m]	Limit acc. 15.225 [dBµV/m]	Limit acc. RSS-210 B.6 [dBµV/m]	Margin** [dB]	Detector (acc. to §15.209 (d)	Antenna factor [dB/m]	Measuring Distance [m]	Distance correction factor*** [dB]
13.560000	32.3	33.4 @ 30m	-18.1 @ 30m	84	84	50.6	QP	20.2	10	19.1
Measurement uncertainty			+/- 4.69 dB							

Frequency [MHz]	Reading [dBµV]	Result* [dBµV/m]	Result* [dBµA/m]	Limit acc. 15.209 [dBµV/m]	Limit acc. RSS-Gen Table 6 [dBµA/m]	Margin** [dB]	Detector (acc. to §15.209 (d)	Antenna factor [dB/m]	Measuring Distance [m]	Distance correction factor*** [dB]
0.067000	28.7	-30.9 @ 300m	-82.4 @ 300m	31.1	-20.4	62.0	AV	20.4	3	80.0
0.089000	27.0	-32.6 @ 300m	-84.1 @ 300m	28.6	-22.9	61.2	AV	20.4	3	80.0
0.111000	25.7	-33.9 @ 300m	-85.4 @ 300m	26.7	-24.8	60.6	AV	20.4	3	80.0
0.134000	23.5	-36.1 @ 300m	-87.6 @ 300m	25.1	-26.5	61.2	AV	20.4	3	80.0
Measurement uncertainty			+/- 4.69 dB							

* Result @ norm dist = Reading + Antenna factor - Distance correction factor;
  Result [dBµA/m] = Result [dBµV/m] - 20*log(377 Ω)
** Margin = Limit [dBµ{V|A}/m] - Result @ norm dist
*** 40dB/decade according Part §15.31 (f) (2)

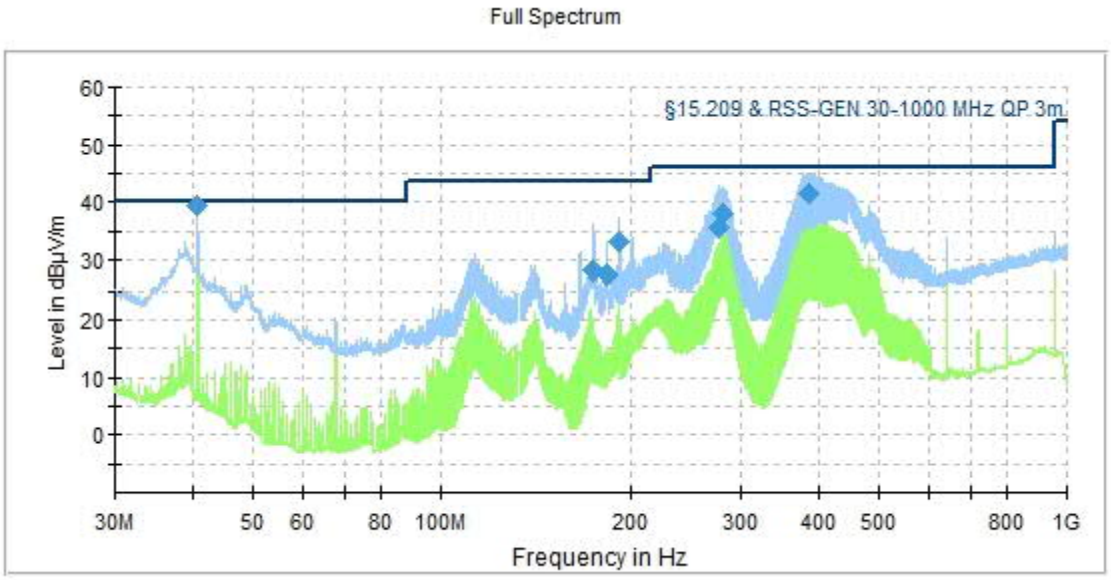
Test equipment (please refer to chapter 6 for details)
3, 18 - 20

5.6.4 Results measurement 30 MHz to 1 GHz

Ambient temperature:	21 °C	Relative humidity:	70 %
Date	15.06.2020	Test engineer:	R. Braun

Test description:	Radiated emission measurement
EUT:	HYPRO WATER
Manufacturer:	Hytecon Forschung und Entwicklung GmbH
Operating conditions:	Reading a TAG, WLAN inactive, disinfection inactive
Test site:	PHOENIX TESTLAB GmbH, semi-anechoic chamber M276
Operator:	R. Braun
Comment:	120 VAC / 60 Hz

The measured points and the limit line in the following diagram refer to the standard measurement of the emitted interference in compliance with the above-mentioned standard while taking account of the specified requirements for a 3 m measuring distance. The measured points marked with "◆" are the measured results of the standard subsequent measurement on SAC test site.



The result table can be found on the next page.

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
40.680000	39.55	40.00	0.45	1000.0	120.000	100.0	V	-16.0	19.4
174.300000	28.46	43.52	15.06	1000.0	120.000	188.0	H	-25.0	18.1
183.390000	27.65	43.52	15.87	1000.0	120.000	154.0	H	324.0	15.4
192.020000	33.10	43.52	10.42	1000.0	120.000	150.0	H	158.0	15.2
276.060000	35.78	46.02	10.24	1000.0	120.000	100.0	H	194.0	18.5
280.560000	38.04	46.02	7.98	1000.0	120.000	108.0	H	193.0	18.7
385.140000	41.54	46.02	4.48	1000.0	120.000	100.0	H	227.0	21.6
Measurement uncertainty				+/- 5.12 dB					

The correction factor was calculated as follows.

Corr. (dB) = cable attenuation (dB) + 6 dB attenuator (dB) + antenna factor (dB)

Therefore, the reading can be calculated as follows:

Reading (dBµV/m) = result QuasiPeak (dBµV/m) - Corr. (dB)

Test equipment (please refer to chapter 6 for details)
3, 10 - 17, 21

5.7 Simultaneous transmission measurements

According to KDB 996369 D04 Module Integration Guide v01, emission tests were done while the EUT was transmitting in WLAN and NFC mode simultaneously.
According to the applicant the BT and BLE capabilities are deactivated by software, no tests were done.

Testcases for WLAN were chosen from the original report of the module (see FCC ID 2AC7Z-ESPWROOM32).

5.7.1 Method of measurement (Maximum unwanted emissions)

The radiated emission measurement is subdivided into 2 stages.

- A preliminary and final measurement carried out in a semi-anechoic chamber with a fixed antenna distance and variable antenna height in the frequency range 30 MHz - 1 GHz.
- A preliminary and final measurement carried out in a semi-anechoic chamber with a fixed antenna distance and variable antenna height in the frequency range above 1 GHz.

Preliminary and final measurement (30 MHz to 1 GHz)

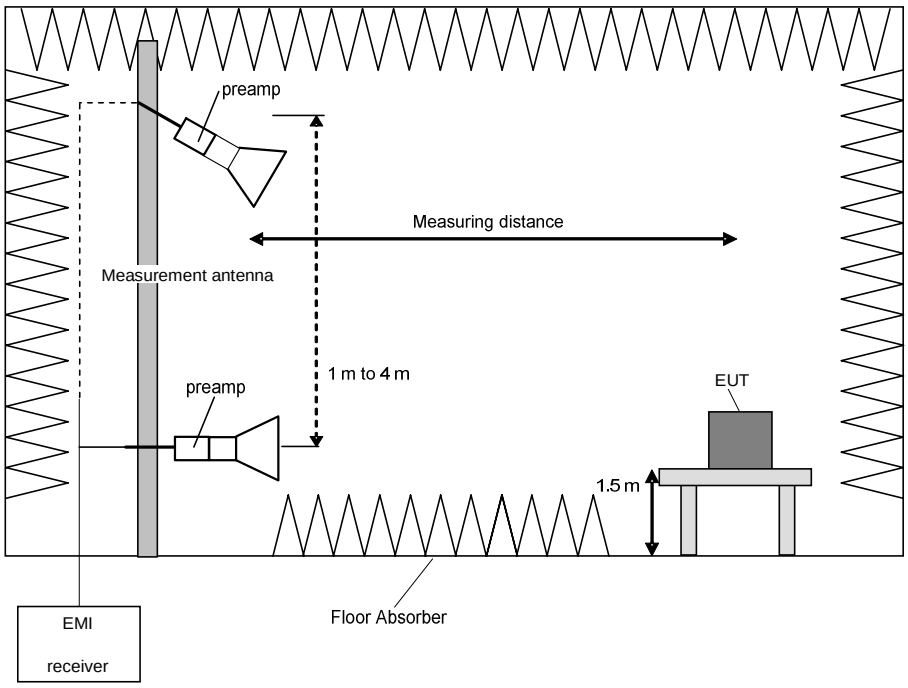
Refer chapter 5.6.1

Preliminary and final measurement (1 – 40 GHz)

The preliminary and final measurements were conducted in a semi-anechoic chamber with floor absorbers between EUT and measurement antenna.
During the test the EUT will be rotated in the range of 0 ° to 360 °, the measuring antenna will be set to horizontal and vertical polarization and raised and lowered in the range from 1 m to 4 m to find the maximum level of emissions. For each height the angle of the antenna will be tilted so that the measurement antenna is always aiming at the EUT.

The resolution bandwidth of the EMI Receiver will be set to the following values:

Test	Frequency range	Resolution bandwidth	Step size	Measurement time
Preliminary measurement	1 – 26.5 GHz	1 MHz	500 kHz	10 ms
Frequency peak search	+ / - 1 MHz	1 MHz	50 kHz	100 ms
Final measurement	1 - 12 GHz	1 MHz	-	10 x 100 ms



Procedure preliminary measurement:

The following procedure is used:

1. Set the measurement antenna to 1 m height.
2. Monitor the frequency range at vertical polarisation and a EUT azimuth of 0 °.
3. Rotate the EUT by 360° to maximize the detected signals.
4. Repeat 1) to 2) with the vertical polarisation of the measuring antenna.
5. Increase the height of the antenna for 0.5 m and repeat steps 2 – 4 until the final height of 4 m is reached.
6. The highest values for each frequency will be saved by the software, including the antenna height, measurement antenna polarization and turntable azimuth for the highest value.

Procedure final measurement:

The following procedure is used:

1. Select the highest frequency peaks to the limit for the final measurement.
2. The software will determine the exact peak frequencies by doing a partial scan with reduced step size with +/- 3 times the RBW of the pre-scan of the selected peaks.
3. If the EUT is portable or ceiling mounted, find the worst-case EUT orientation (x,y,z) for the final test.
4. The worst measurement antenna height is found by the measurement software by varying the measurement antenna height by +/- 0.5 m from the worst-case value obtained in the preliminary measurement, and to monitor the emission level.
5. The worst azimuth turntable position is found by varying the turntable azimuth by +/- 30° from the worst-case value obtained in the preliminary measurement, and to monitor the emission level.
6. The final measurement is performed at the worst-case antenna height and the worst-case turntable azimuth.
7. Steps 2 – 6 will be repeated for each frequency peak selected in step 1.

5.7.2 Preliminary and final test results (Maximum unwanted emissions) from 30 MHz to 1 GHz

Ambient temperature	23 ° C
Relative humidity	40 %

Date	07.07.2020
Tested by	R. BRAUN

Position of EUT: For tests between 30 MHz and 1 GHz, the EUT was set-up on a table with a height of 80 cm. The distance between EUT and antenna was 3 m.

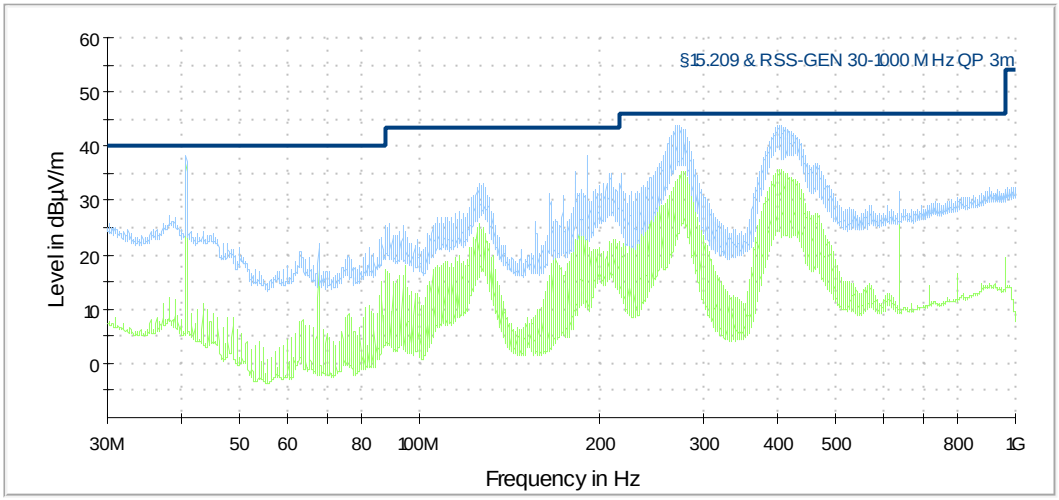
Cable guide: For detail information of test setup and the cable guide refer to the pictures in the annex A in the test report.

Test record: Operation mode: RFID active, WLAN b-mode, channel 6, 1 Mbps
Only the worst-case plot for each frequency range is submitted below.

Remark: -

Plots of the worst-case transmitter spurious emissions

200355_ch6_b1Mbps_30M–1G: Spurious emissions from 30 MHz to 1 GHz:



Results Table 30 MHz - 1 GHz								
Frequency	Quasi peak	Limit	Margin	Hight	Pol	Azimuth	Correction	Result
[MHz]	[dBµV/m]	[dBµV/m]	[dB]	[cm]		[°]	[dB/m]	
40.690000	36.49	40.00	3.51	105.0	V	349.0	19.4	Passed
128.320000	30.99	43.52	12.53	103.0	V	150.0	17.1	Passed
192.010000	33.93	43.52	9.59	175.0	H	167.0	15.2	Passed
270.810000	38.31	46.02	7.71	114.0	H	-10.0	18.4	Passed
276.120000	40.18	46.02	5.84	104.0	H	166.0	18.5	Passed
404.070000	40.77	46.02	5.25	189.0	H	50.0	22.2	Passed
Measurement uncertainty			+2.2 dB / -3.6 dB					

Test equipment (please refer to chapter 6 for details)
11 - 17, 21

5.7.3 Preliminary and final test results (Maximum unwanted emissions) from 1 GHz to 26.5 GHz

Ambient temperature	22 °C
Relative humidity	68 %

Date	16.06.2020
Tested by	B. ROHDE

Position of EUT: For tests between 1 GHz and the 10th harmonic, in this case 26.5 GHz, the EUT was set-up on a table with a height of 150 cm. The distance between EUT and antenna was 3 m.

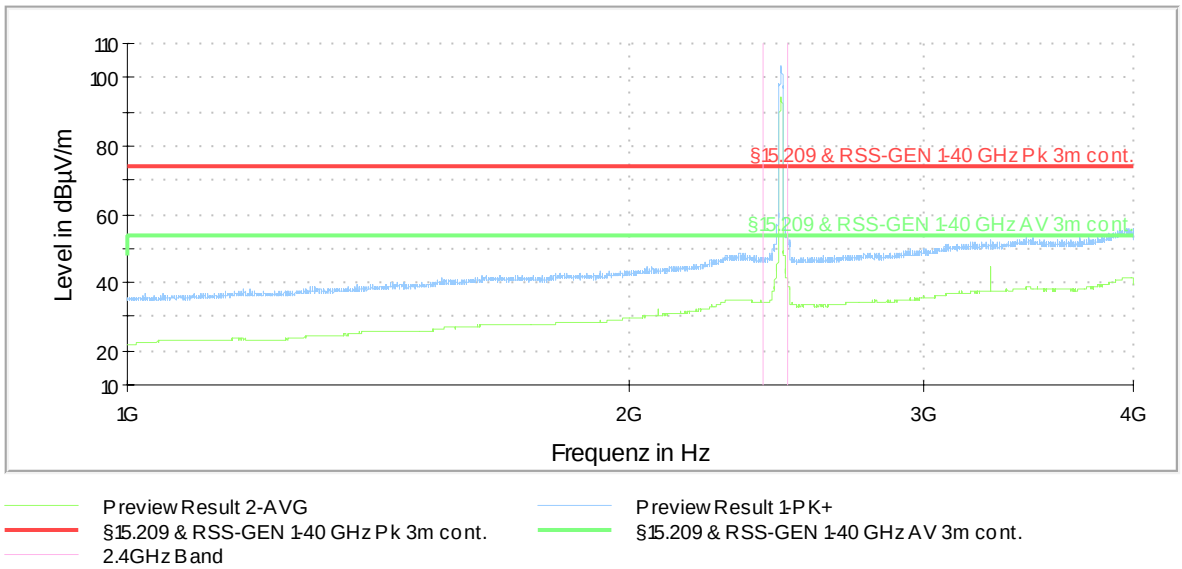
Cable guide: For detail information of test set-up and the cable guide refer to the pictures in the annex A in the test report.

Test record: Operation mode: RFID active, WLAN b-mode, channel 11, 1 Mbps
Only the worst-case plot for each frequency range is submitted below.

Remark: -

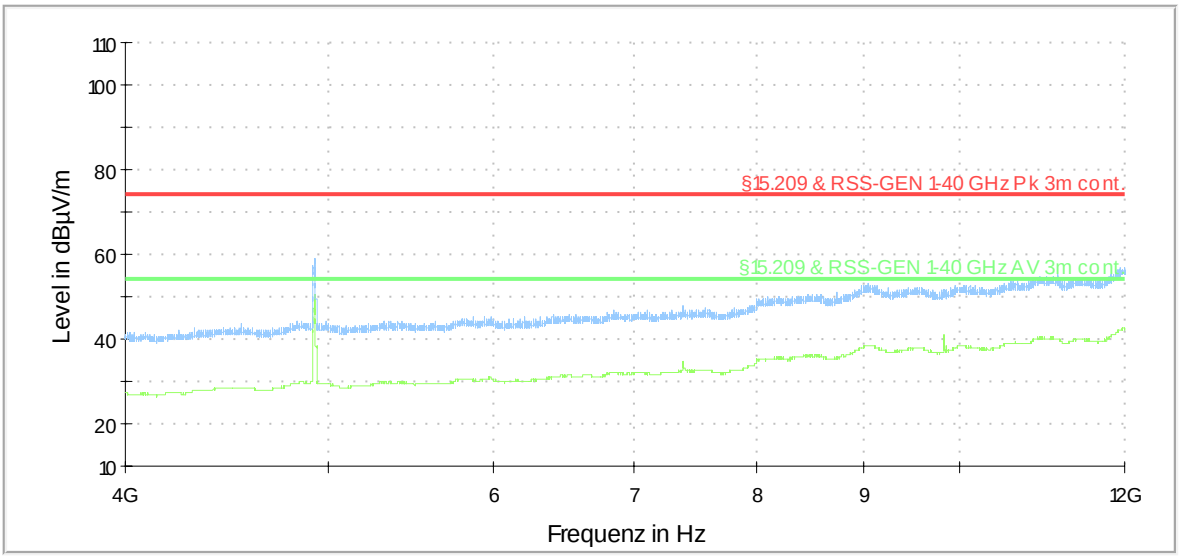
Plots of the worst-case transmitter spurious emissions

200355_ch11_b1Mbps_1-4G: Spurious emissions from 1 GHz to 4 GHz:

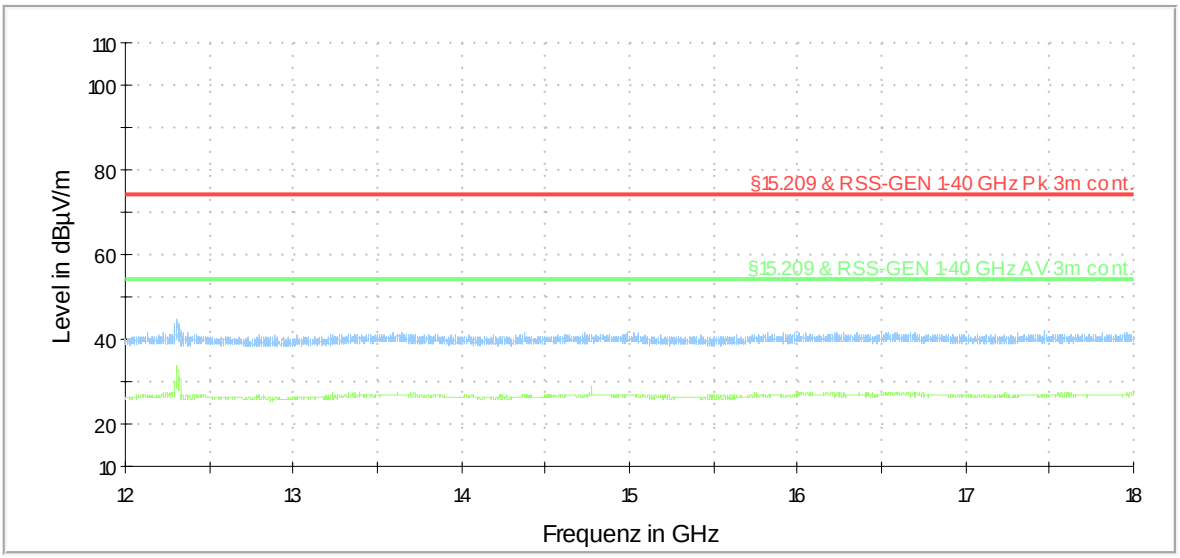


Remark: The emissions @ 2.462 GHz are caused by the wanted WLAN signal

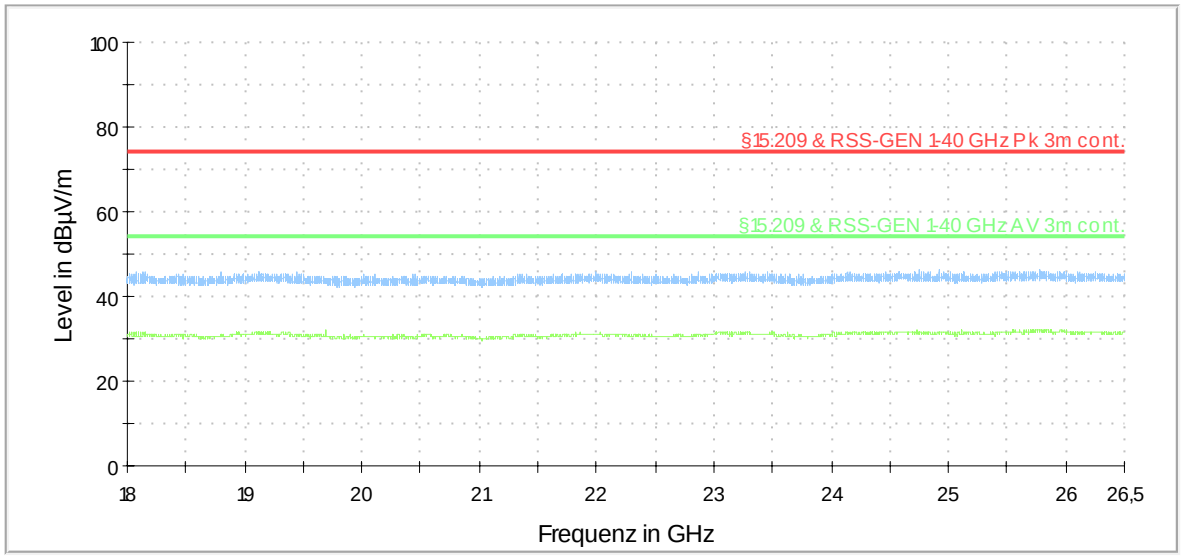
200355_ch11_b1Mbps_4-12G: Spurious emissions from 4 GHz to 12 GHz:



200355_ch11_b1Mbps_12-18G: Spurious emissions from 12 GHz to 18 GHz:



200355_ch11_b1Mbps_18-26G: Spurious emissions from 18 GHz to 26.5 GHz:



The result table can be found on the next page.

Results Table 1 - 26.5 GHz									
Frequency	Max Peak	Average	Limit	Margin	Hight	Pol	Azimuth	Correction	Result
[MHz]	[dBµV/m]	[dBµV/m]	[dBµV/m]	[dB]	[cm]		[°]	[dB/m]	
2335.900000	47.4	---	74	26.6	156	H	11	34.2	Passed
2335.900000	---	35.4	54	18.6	156	H	11	34.2	Passed
2462.450000	103.3	---	74	-29.3	123	H	353	34.6	Failed *
2462.450000	---	94.8	54	-40.8	123	H	353	34.6	Failed *
2482.650000	49.4	---	74	24.6	162	H	6	34.6	Passed
2482.650000	---	37.2	54	16.8	162	H	6	34.6	Passed
2489.250000	48.1	---	74	25.9	171	H	-2	34.6	Passed
2489.250000	---	35.2	54	18.8	171	H	-2	34.6	Passed
3282.650000	---	45.2	54	8.8	103	V	37	38	Passed
3282.650000	53.9	---	74	20.1	103	V	37	38	Passed
3995.250000	---	42.7	54	11.3	318	H	331	40.3	Passed
3995.250000	55.1	---	74	18.9	318	H	331	40.3	Passed
4924.050000	---	50.4	54	3.6	157	V	0	9.1	Passed
4924.050000	59.8	---	74	14.2	157	V	0	9.1	Passed
4924.100000	59.9	---	74	14.1	157	V	3	9.1	Passed
4924.100000	---	50.5	54	3.5	157	V	3	9.1	Passed
7385.950000	---	33.7	54	20.3	274	H	43	13.8	Passed
7385.950000	46.1	---	74	27.9	274	H	43	13.8	Passed
9847.950000	---	40.6	54	13.4	170	H	19	17.7	Passed
9847.950000	50.4	---	74	23.6	170	H	19	17.7	Passed
11954.400000	---	38.9	54	15.1	307	H	249	21.6	Passed
11954.400000	50.7	---	74	23.3	307	H	249	21.6	Passed
12309.750000	---	34.8	54	19.2	200	V	37	8.7	Passed
12309.750000	46.5	---	74	27.5	200	V	37	8.7	Passed
Measurement uncertainty				+2.2 dB / -3.6 dB					

* Fundamental of WLAN signal

Test equipment (please refer to chapter 6 for details)
11 - 17, 22 - 28

6 Test Equipment used for Tests

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal Due
1	Signal & Spectrum Analyzer	FSW43	Rohde & Schwarz	100586 & 100926	481720	04.03.2020	03.2022
2	Loop antenna	Loop antenna 22.5cm	PHOENIX TESTLAB GmbH	-	410085	Calibration not necessary	
3	AC Supply	AC6803A AC Quelle 2000VA	Keysight	JPVJ002509	482350	Calibration not necessary	
4	Multimeter	971A	Hewlett Packard	JP40010640	480724	15.01.2020	01.2022
5	Dynamic temperature chamber	MK 240	WTB Binder Labortechnik GmbH	05-79022	480462	10.07.2019	07.2020
6	EMI receiver	ESR7	Rohde & Schwarz	101939	482558	18.02.2020	02.2022
7	Shielded chamber M155	SK3	Albatross Projects	-	482786	Calibration not necessary	
8	Software	EMC32	Rohde & Schwarz	100619	483182	Calibration not necessary	
9	LISN	NSLK8128RC	Rohde & Schwarz	0412	483186	Calibration not necessary	
10	Loop antenna	HFH2-Z2	Rohde & Schwarz	832609/014	480059	14.02.2020	02.2022
11	Software	EMC32	Rohde & Schwarz	100970	482972	Calibration not necessary	
12	RF Switch Matrix	OSP220	Rohde & Schwarz		482976	Calibration not necessary	
13	Turntable	TT3.0-3t	Maturo	825/2612/.01	483224	Calibration not necessary	
14	Antenna support	BAM 4.5-P-10kg	Maturo	222/2612.01	483225	Calibration not necessary	
15	Controller	NCD	Maturo	474/2612.01	483226	Calibration not necessary	
16	Semi-anechoic chamber M276	SAC5-2	Albatross Projects	C62128-A540-A138-10-0006	483227	Calibration not necessary	
17	EMI test receiver ESW	ESW44	Rohde & Schwarz	101828	482979	12.04.2019	04.2021
18	Outdoor test site	-	PHOENIX TESTLAB GmbH	-	480293	Calibration not necessary	
19	EMI Receiver / Spectrum Analyser	ESI 40	Rohde & Schwarz	100064/040	480355	11.02.2020	02.2021
20	Loop antenna	HFH2-Z2	Rohde & Schwarz	100417	481912	05.02.2020	02.2021
21	Ultralog Antenna	HL562E	Rohde & Schwarz		482978	07.08.2019	08.2022
22	Low Noise Amplifier 100 MHz – 18 GHz	LNA-30-00101800-25-10P	Narda-Miteq	2110917	482967	18.02.2020	02.2022
23	Log Per Antenna	HL050	Rohde & Schwarz	4062.4063.02-100908	482977	13.08.2019	08.2022
24	Low Noise Amplifier 12 GHz – 18 GHz	LNA-30-12001800-13-10P	Narda-Miteq	2089798	482968	17.02.2020	02.2022
25	Standard Gain Horn 12 GHz-18 GHz	18240-20	Flann	267220	483025	Calibration not necessary	
26	Low Noise Amplifier 18 GHz – 26.5 GHz	LNA-30-18002650-20-10P	Narda-Miteq	2110911	482969	17.02.2020	02.2022
27	Standard Gain Horn 18 GHz -26.5 GHz	20240-20	Flann	266399	483026	Calibration not necessary	

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal Due
28	Highpass filter	WHKX4.0/18G-8SS	Wainwright	1	480587	Calibration not necessary	

7 Test site Validation

Test equipment	PM. No.	Frequency range	Type of validation	According to	Val. Date	Val Due
OATS Outdoor	480293	9 kHz – 30 MHz	-	ANSI C63.4-2014	-	-
Semi-anechoic chamber M276	483227	30 – 1000 MHz	NSA	ANSI C63.4a-2017	19.09.2019	18.09.2021

8 Report History

Report Number	Date	Comment
F200355E2	31.07.2020	Initial Test Report
-	-	-
-	-	-

9 List of Annexes

Annex A	Test Setup Photos	7 pages