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Test Report

Report Number:

F181323E2

Equipment under Test (EUT):

ANNA-B1 series

Applicant:

u-blox AG

Manufacturer:

u-blox AG

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-247 Issue 2 (February 2017)**, Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

[4] **RSS-Gen Issue 5 (April 2018)**, General Requirements for Compliance of Radio Apparatus

[5] **508074 D01 DTS Meas Guidance v04 (April 2017),** Guidance for performing compliance measurements on transmission systems (DTS) operating under section 15.247

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		28.09.2018
	Name	Signature	Date
Reviewed and approved by:	Bernd STEINER		28.09.2018
	Name	Signature	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.

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1 Identification

1.1 Applicant

Name:	u-blox AG
Address:	Zürcherstr. 68, 8800 Thalwil
Country:	Switzerland
Name for contact purposes:	Mr. Filip KRUZELA
Phone:	+46 40 630 71 70
Fax:	N/A
eMail address:	filip.kruzela@u-blox.com
Applicant represented during the test by the following person:	None

1.2 Manufacturer

Name:	u-blox AG
Address:	Zürcherstr. 68, 8800 Thalwil
Country:	Switzerland
Name for contact purposes:	Mr. Filip KRUZELA
Phone:	+46 40 630 71 70
Fax:	N/A
eMail address:	filip.kruzela@u-blox.com
Manufacturer represented during the test by the following person:	None

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-17186-01-02, FCC Test Firm Accreditation with the registration number 469623, designation number DE0004 and Industry Canada Test site registration SITE# IC3469A-1.

1.4 EUT (Equipment under Test)

EUT		
Test object: *	Stand-alone Bluetooth LE module	
Model series: *	ANNA-B1	
PMN / Model name: *	ANNA-B112	
FCC ID: *	XPYANNAB1	
IC-Number: *	8595A-ANNAB1	
HVIN: *	ANNA-B112	
FVIN: *	1.0	
Model number: *	ANNA-B112-00B-00	
Order number: *	ANNA-B112-00B	
Serial number: *	A8180172ZA	
PCB identifier: *	A25319-0	
Hardware version of the module: *	2	
Software version: *	Radio test modes:	radio_test_buttons_4dBm_anna_26jun.hex radio_test_buttons_4dBm_2Mbps_anna_26jun.hex dtm_test_anna-b1_23apr.hex

* Declared by the applicant

Module variant	EVB / REF variant	Hardware revision	Antenna	Software
ANNA-B112	EVB-ANNA-B112U	1.0	RF pin (U.FL)	See above
ANNA-B112	EVB-ANNA-B112C	1.0	AT1608-A2R4NAA	See above
ANNA-B112	REF-ANNA-B112E	1.0	AT1608-A2R4NAA	See above

Bluetooth Low Energy frequencies				
Channel 00	RX	2402 MHz	TX	2402 MHz
Channel 19	RX	2440 MHz	TX	2440 MHz
Channel 39*	RX	2480 MHz	TX	2480 MHz

Ancillary Equipment	
Cables (connected to the EUT):	USB 2.0 type A <-> USB 2.0 type B micro, ~0.2 m *[1] +2 m USB extension *[2]
Fiber optic converter:	Opto USB2.0, MK Messtechnik (PM. No. 482617) *[2]
Laptop PC:	Fujitsu Lifebook S760 (PM No. 200759) *[2]

*[1] Provided by the applicant
*[2] Provided by the laboratory

1.5 Technical Data of Equipment

Radio chip*		Nordic Semiconductor nRF52832				
Power supply EUT: *		DC				
Supply voltage EVB: *		U_{nom} =	9 V	U_{min} =	5 V	U_{max} = 12 V
Supply voltage radio module / REF board: *		U_{nom} =	3.3V	U_{min} =	1.7 V	U_{max} = 3.6 V
Temperature range: *		-40 °C to +85 °C				
Lowest / highest internal clock frequency: *		32.768 kHz to 2480 MHz				
Fulfils specification: *		Bluetooth Low Energy (BLE) 5.0; NFC				
BLE	Conducted output power: *	Typical +4 dBm				
BLE	Type of modulation: *	GFSK (1 Mbit/s; 2 Mbit/s)				
BLE	Operating frequency range: *	2402 – 2480 MHz				
BLE	Number of channels: *	40 (2 MHz channel spacing)				
BLE	Antenna type: *	See antenna list				
BLE	Antenna name: *	See antenna list				
BLE	Antenna gain: *	Max +2.5 dBi				
BLE	Antenna connector: *	EVB-ANNA-B112U (U.FL antenna connector) EVB-ANNA-B112C (None) REF-ANNA-B112E (None)				
NFC	Conducted output power: *	No transmitter, receiver only				
NFC	Type of modulation: *	Receiver uses load modulation to “transmit” data (106 kbit/s)				
NFC	Operating frequency range: *	13.56 MHz				
NFC	Number of channels: *	1				
NFC	Antenna type: *	Loop antenna				

* Declared by the applicant

1.5.1 Antenna List

Antenna name	Manufacturer	Type	Comment	Gain [dBi]
AT1608-A2R4NAA + EVB-ANNA-B112C	ACX	Internal SMD antenna	ANNA-B112 internal antenna AT1608-A2R4NAA + reference design EVB-ANNA-B112C (ANNA-B112 mounted in a corner)	0.5
AT1608-A2R4NAA + EVB-ANNA-B112E	ACX	Internal SMD antenna	ANNA-B112 internal antenna AT1608-A2R4NAA + reference design EVB-ANNA-B112E (ANNA-B112 mounted on the edge)	0.5
PC17.07.0070A	Taoglas	Patch, PCB	Patch, PCB 24 x 11 x 0.8 mm, 70 mm cable / U.FL	1
FXP75.07.0045B	Taoglas	Patch, Flexfilm	Patch, Felxfilm 5.9 x 4.1 x 0.24 mm, 45 mm cable / U.FL	2.5

1.6 Dates

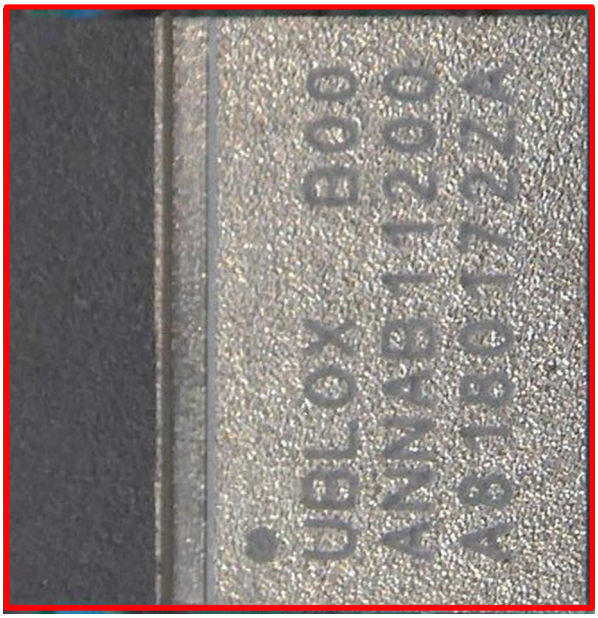
Date of receipt of test sample:	16.07.2018
Start of test:	18.07.2018
End of test:	06.09.2018

2 Operational States

Description of function of the EUT
The ANNA-B112 module is a small stand-alone Bluetooth low energy System in Package (SiP) module with an integrated antenna. The RF signal can also be connected to an external antenna connector.
The module is mouldered into plastic and the module (except the antenna area) is coated with a conducted surface which will serve as an RF shield. The shielding has electrical contact with the ground part of the module.
The radio includes Bluetooth low energy and an NFC receiver. The NFC receiver uses its own interface.
The module needs only a single supply voltage that can range from 1.7 – 3.6 V. The module has an extended temperature range from -40 to +85 °C.

Reference boards:
The ANNA-B112 SiP module has an integrated antenna mounted on the substrate. The RF signal pin can either be connected directly to the adjacent antenna pin and use the internal SMD antenna or routed to an external antenna or antenna connector.

The EUT and the integrated SMD antenna are shown in the following pictures:



ANNA-B112 module top view

ANNA-B112 module top view with removed cover

- EUT (radio module ANNA-B112)
- Internal SMD antenna AT1608-A2R4NAA

The internal SMD antenna requires a specific reference design on the carrier PCB. This design is different depending if the ANNA-B112 is mounted on the edge or in a corner of the carrier PCB.
There are 3 different reference designs used depending which case described above is used:

ANNA-B112 reference board with antenna connector (EVB-ANNA-B112U)
ANNA-B112 reference board with ANNA-B112 mounted in a corner with internal antenna (EVB-ANNA-B112C)
ANNA-B112 reference board with ANNA-B112 mounted on the edge with internal antenna (REF-ANNA-B112E)

The following states were defined as the operating conditions
Radio tests:

The ANNA-B112 modules can and will be put into a test mode, in which normal operation is not possible, but the full capabilities of the radio is unlocked and can be used in transmission tests. This mode is typically used during spurious emissions testing and requires special firmware to be enabled.

The applicable test firmware was loaded to the radio module:

Radio test modes:	radio_test_buttons_4dBm_anna_26jun.hex
	radio_test_buttons_4dBm_2Mbps_anna_26jun.hex
	dtm_test_anna-b1_23apr.hex

For the radio tests of the EVB-ANNA-B112U and EVB-ANNA-B112C variants the following settings were used:

The modules were flashed with the *dtm_test_anna-b1_23apr.hex* firmware.
A connection to the EUT was established via USB cable.
The USB connection was converted to a serial connection on the EUT.
The modules were programmed using python scripts provided by the applicant. With the Windows command prompt and the following commands, the EUTs could be set to transmit on a certain channel with a certain data rate.

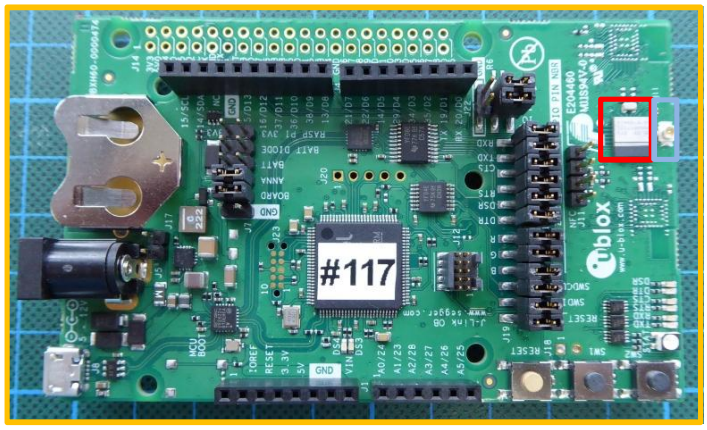
For the radio tests of the REF-ANNA-B112E variant the following settings were used:

The module was flashed with either the *radio_test_buttons_4dBm_anna_26jun.hex* or the *radio_test_buttons_4dBm_2Mbps_anna_26jun.hex* firmware respectively (1 Mbps / 2 Mbps data rate).
The EUT was powered with an external 3.3 V DC power supply.
The channels could be changed pressing a knob on the EUT.

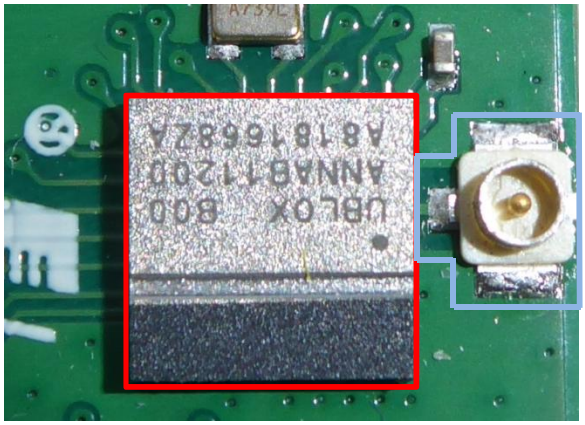
The EUT and its physical boundaries

The following samples were used for the testing:

EVB-ANNA-B112U#117
EVB-ANNA-B112C#143
REF-ANNA-B112E#6

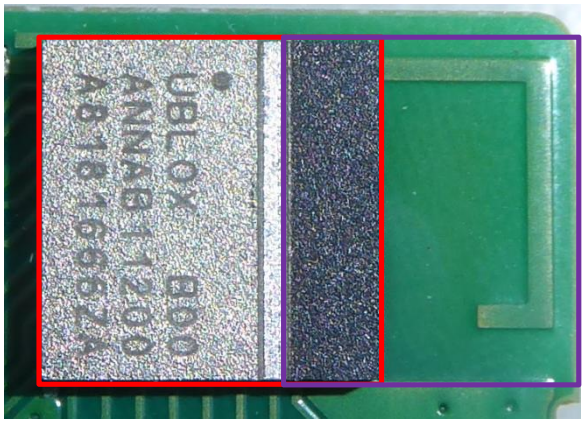


EVB-ANNA-B112U



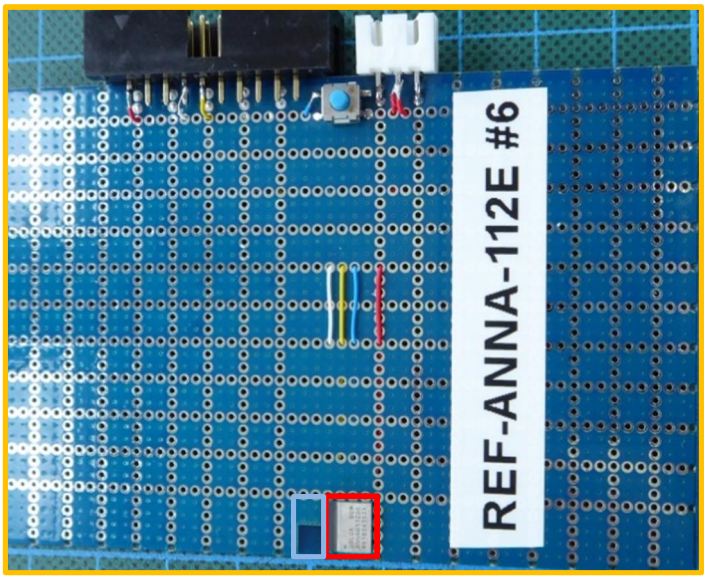
Detail view EVB-ANNA-B112U

EVB-ANNA-B112C

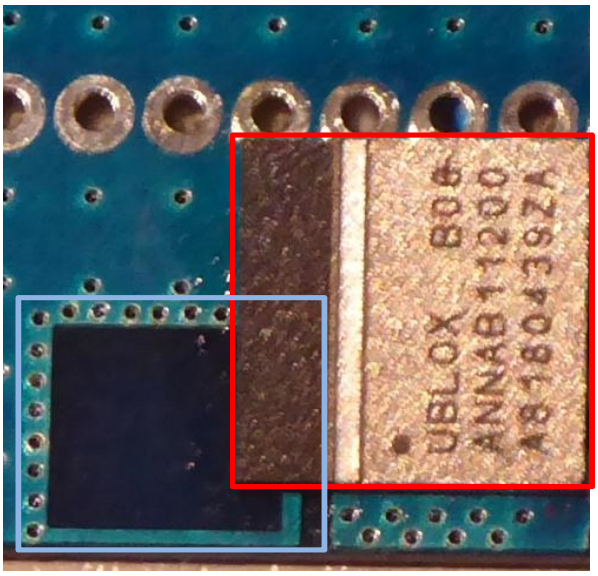


Detail view EVB-ANNA-B112C

- Evaluation board
- EUT (radio module ANNA-B112)
- Reference design for module with U.FL port
- Antenna reference design for module being mounted in the corner



REF-ANNA-B112E



Detail view REF-ANNA-B112E

- Evaluation board
- EUT (radio module ANNA-B112)
- Antenna reference design for module being mounted on the edge

3 Additional Information

According to the applicant, the final marking of the EUT is different from the marking of the EUTs in this test report. The main difference is that a 2D code is added for machine readability / tracing.

An example of the final marking is shown in the picture below:

Example of the final marking of the EUT

4 Overview

Application	Frequency range [MHz]	FCC 47 CFR Part 15 section [2]	RSS-247 [3] or RSS-Gen, Issue 5 [4]	Status	Refer page
Maximum Peak Output Power	2400.0 - 2483.5	15.247 (b) (3), (4)	5.4 (d) [3]	Passed	18 et seq.
DTS Bandwidth	2400.0 - 2483.5	15.247 (a) (2)	5.2 (a) [3]	Passed	25 et seq.
Peak Power Spectral Density	2400.0 - 2483.5	15.247 (e)	5.2 (b) [3]	Passed	27 et seq.
Band edge compliance	2400.0 - 2483.5	15.247 (d) 15.205 (a) 15.209 (a)	5.5 [3] 8.9 [4], 8.10 [4]	Passed	33 et seq.
Radiated emissions (transmitter)	0.009 – 26,500	15.247 (d) 15.205 (a) 15.209 (a)	5.5 [3] 8.9 [4], 8.10 [4]	Passed	42 et seq.
Conducted emissions on supply line	0.15 - 30	15.207 (a)	8.8 [4]	Passed	82 et seq.

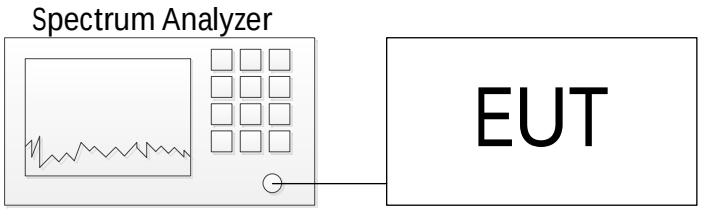
5 Results

5.1 Duty cycle

5.1.1 Method of measurement

The measurement was performed as an antenna port conducted measurement, as shown below.

Test Setup:



The method described in chapter 11.6.0 b) of document [1] or 6.0 b) of document [5] was used to perform the following test.

The following measurement technique was used:

The zero-span mode on a spectrum analyzer or EMI receiver if the response time and spacing between two bins on the sweep are sufficient to permit accurate measurements of the on and off times of the transmitted signal.

- Set the center frequency of the instrument to the center frequency of the transmission.
- Set RBW ≥ OBW if possible; otherwise, set RBW to the largest available value.
- Set VBW ≥ RBW.
- Set detector = peak or average.
- The zero-span measurement method shall not be used unless both RBW and VBW are > 50/T and the number of sweep points across duration T exceeds 100. (For example, if VBW and/or RBW are limited to 3 MHz, then the zero-span method of measuring duty cycle shall not be used if T ≤ 16.7 microseconds.)

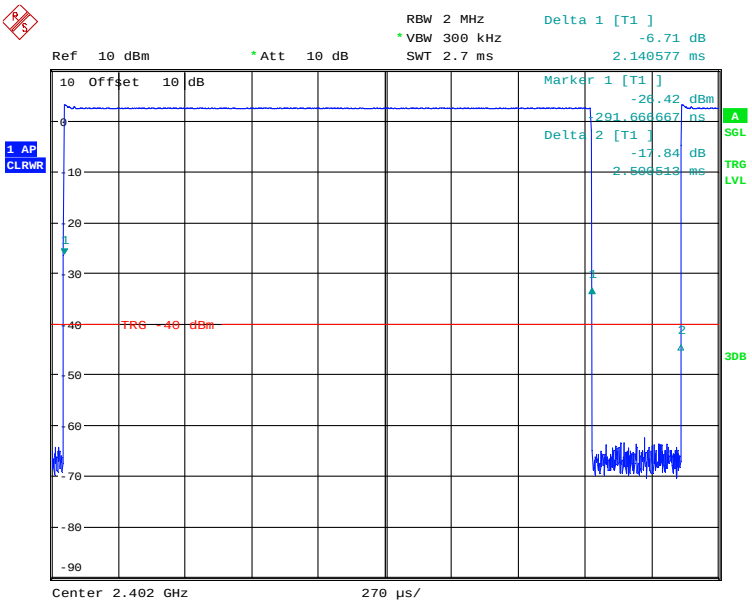
5.1.2 Test results

Ambient temperature	22 °C
Relative humidity	47 %

Date	18.07.2018
Tested by	Paul NEUFELD

The Duty Cycle was measured conducted with the EVB-ANNA-B112U#117 variant.

Example plot BLE 1 Mbps:



Operation mode	TX_on [µs]	TX_ges [µs]	RBW [MHz]	50/T [kHz]	50/T < RBW?
BLE 1 Mbps	2141	2501	2	23	Yes
BLE 2 Mbps	1081	1876	2	46	Yes

Operation mode	Sweep points	Sweep time [µs]	Meas points	Meas points >100?	Duty cycle %	DCCF [dB]
BLE 1 Mbps	10001	2700	9264	Yes	85.61	0.67
BLE 2 Mbps	10001	2000	9381	Yes	57.62	2.39

The DCCF (duty cycle correction factor) is calculated by:

$$DCCF = 10 * log_{10}\left(\frac{1}{Duty\ cycle}\right)$$

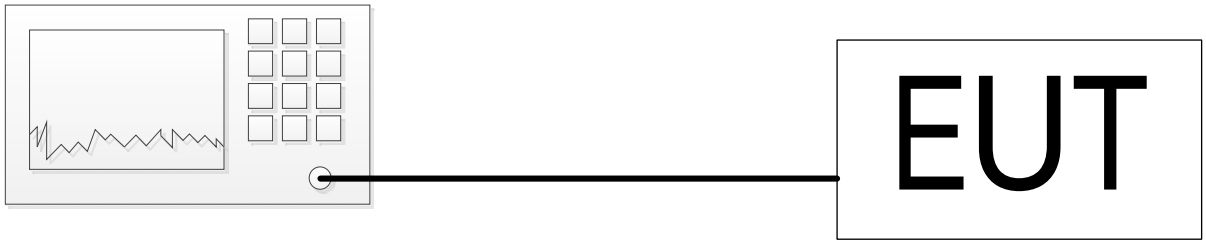
Therefore, for average measurements a correction factor of 0.67 dB is used for all tests in test mode BLE 1 Mbps.
Therefore, for average measurements a correction factor of 2.39 dB is used for all tests in test mode BLE 2 Mbps.

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

5.2 Maximum peak output power

5.2.1 Method of measurement (conducted)

The EUT was measured conducted at the antenna ports with the aid of a spectrum analyzer.



Acceptable measurement configurations

Peak power measurement:
Procedure 11.9.1.1 in [1] was used for the following test.

The following procedure shall be used when an instrument with a resolution bandwidth that is greater than the DTS bandwidth is available to perform the measurement:

- Set the RBW ≥ DTS bandwidth.
- Set VBW ≥ [3 × RBW].
- Set span ≥ [3 × RBW].
- Sweep time = auto couple.
- Detector = peak.
- Trace mode = max hold.
- Allow trace to fully stabilize.
- Use peak marker function to determine the peak amplitude level.

Average power measurement:

Procedure 11.9.2.2.4 in [1] was used for the following test.

Method AVGSA-2 uses trace averaging across ON and OFF times of the EUT transmissions, followed by duty cycle correction. The procedure for this method is as follows:

- Measure the duty cycle D of the transmitter output signal as described in 11.6 [1].
- Set span to at least 1.5 times the OBW.
- Set RBW = 1% to 5% of the OBW, not to exceed 1 MHz.
- Set VBW ≥ [3 × RBW].
- Number of points in sweep ≥ [2 × span / RBW]. (This gives bin-to-bin spacing ≤ RBW / 2, so that narrowband signals are not lost between frequency bins.)
- Sweep time = auto.
- Detector = RMS (i.e., power averaging), if available. Otherwise, use the sample detector mode.
- Do not use sweep triggering. Allow the sweep to “free run.”
- Trace average at least 100 traces in power averaging (rms) mode; however, the number of traces to be averaged shall be increased above 100 as needed such that the average accurately represents the true average over the ON and OFF periods of the transmitter.
- Compute power by integrating the spectrum across the OBW of the signal using the instrument’s band power measurement function with band limits set equal to the OBW band edges. If the instrument does not have a band power function, then sum the spectrum levels (in power units) at intervals equal to the RBW extending across the entire OBW of the spectrum.
- Add [10 log (1 / D)], where D is the duty cycle, to the measured power to compute the average power during the actual transmission times (because the measurement represents an average over both the ON and OFF times of the transmission). For example, add [10 log (1/0.25)] = 6 dB if the duty cycle is 25%.

The measurement was performed at the upper and lower end and the middle of the assigned frequency band.

Antenna gain below 6 dBi, therefore no power reduction was necessary.

5.2.1.1 Test results (conducted)

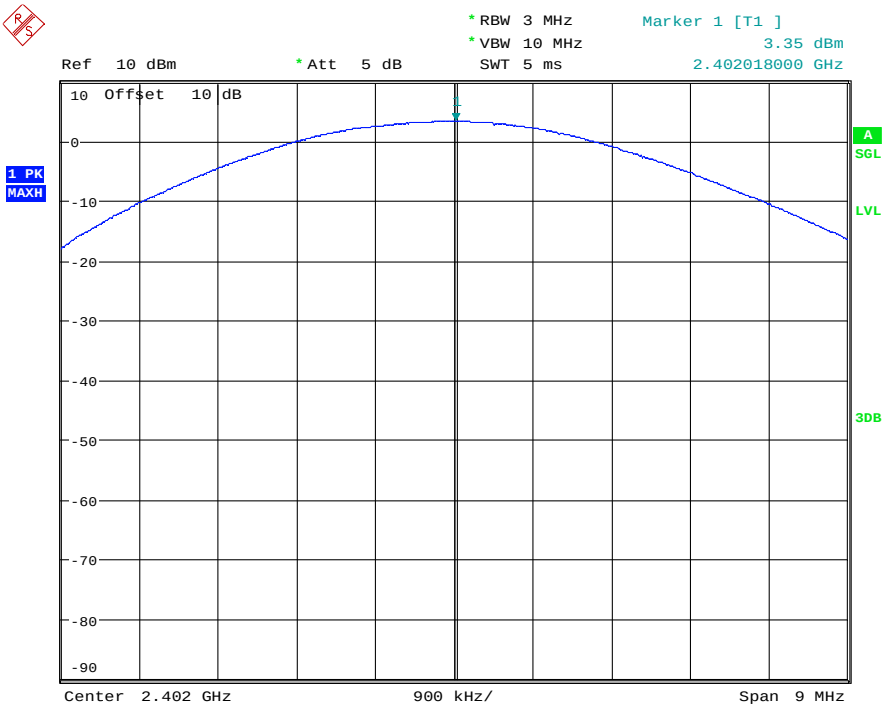
5.2.1.1.1 Tested sample EVB-ANNA-B112U#117

Ambient temperature	22 °C
Relative humidity	47 %

Date	18.07.2018
Tested by	Paul NEUFELD

Peak power measurement:

Example plot BLE 1 Mbps:

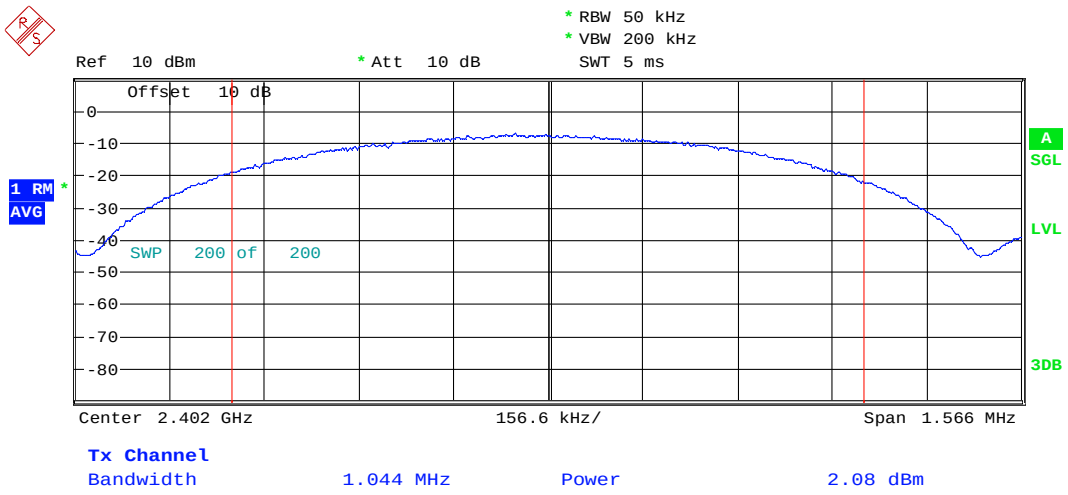


Operation mode	Data rate	Frequency [MHz]	Result [dBm]	Limit [dBm]
BLE	1 Mbps	2402	3.4	30
BLE	1 Mbps	2440	3.2	30
BLE	1 Mbps	2480	3.0	30
BLE	2 Mbps	2402	3.5	30
BLE	2 Mbps	2440	3.2	30
BLE	2 Mbps	2480	3.2	30

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

Average power measurement:

Example plot BLE 1 Mbps:



Operation mode	Data rate	Frequency [MHz]	Result [dBm]	Limit [dBm]
BLE	1 Mbps	2402	2.8	30
BLE	1 Mbps	2440	2.7	30
BLE	1 Mbps	2480	2.6	30
BLE	2 Mbps	2402	2.7	30
BLE	2 Mbps	2440	2.6	30
BLE	2 Mbps	2480	2.5	30

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

5.2.2 Method of measurement (radiated)

Procedure 11.9.2.2.4 in [1] was used for the following test.

Method AVGSA-2 uses trace averaging across ON and OFF times of the EUT transmissions, followed by duty cycle correction. The procedure for this method is as follows:

- Measure the duty cycle D of the transmitter output signal as described in 11.6 [1].
- Set span to at least 1.5 times the OBW.
- Set RBW = 1% to 5% of the OBW, not to exceed 1 MHz.
- Set VBW ≥ [3 × RBW].
- Number of points in sweep ≥ [2 × span / RBW]. (This gives bin-to-bin spacing ≤ RBW / 2, so that narrowband signals are not lost between frequency bins.)
- Sweep time = auto.
- Detector = RMS (i.e., power averaging), if available. Otherwise, use the sample detector mode.
- Do not use sweep triggering. Allow the sweep to “free run.”
- Trace average at least 100 traces in power averaging (rms) mode; however, the number of traces to be averaged shall be increased above 100 as needed such that the average accurately represents the true average over the ON and OFF periods of the transmitter.
- Compute power by integrating the spectrum across the OBW of the signal using the instrument’s band power measurement function with band limits set equal to the OBW band edges. If the instrument does not have a band power function, then sum the spectrum levels (in power units) at intervals equal to the RBW extending across the entire OBW of the spectrum.
- Add [10 log (1 / D)], where D is the duty cycle, to the measured power to compute the average power during the actual transmission times (because the measurement represents an average over both the ON and OFF times of the transmission). For example, add [10 log (1/0.25)] = 6 dB if the duty cycle is 25%.

The measurement was performed at the upper and lower end and the middle of the assigned frequency band.

Antenna gain below 6 dBi, therefore no power reduction was necessary.

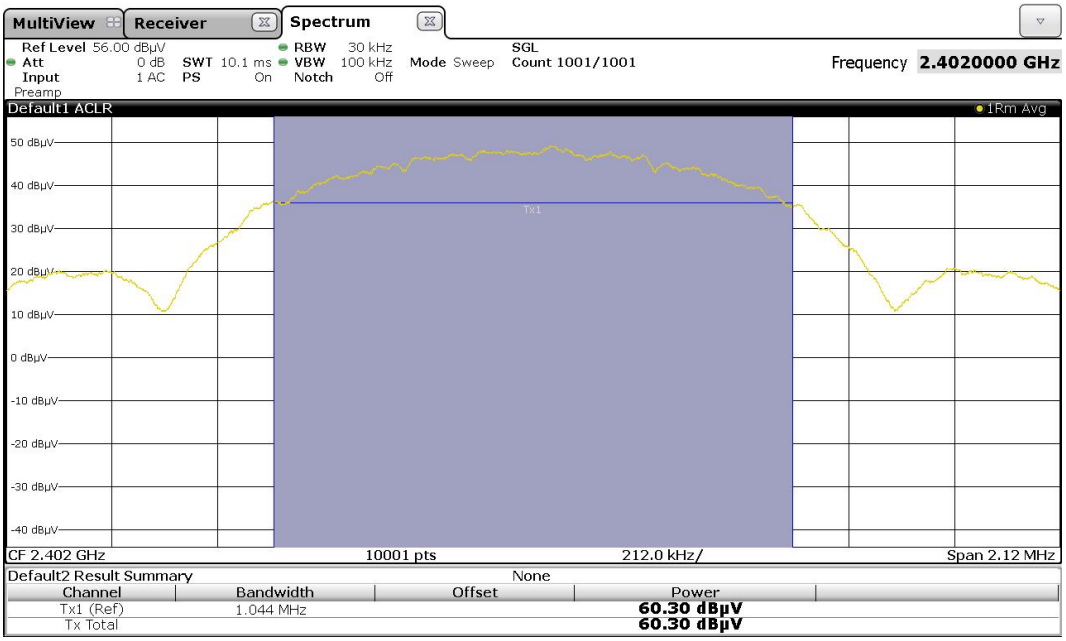
5.2.2.1 Test results (radiated)

5.2.2.1.1 Tested sample EVB-ANNA-B112C#143

Ambient temperature	23° C
Relative humidity	53 %

Date	06.09.2018
Tested by	Bernward ROHDE

Example plot BLE 1 Mbps:



Antenna gain of on board antenna according to the data sheet: 0.5 dBi

Operation mode	Data rate	Frequency [MHz]	Reading [dBµV]	Corr. Fact. [dB/m]	Field strength @3m [dBµV/m]	EIRP [dBm]	Result [dBm]	Limit [dBm]
BLE	1 Mbps	2402	60.30	33.8	94.1	-1.2	-1.0	30.00
BLE	1 Mbps	2440	60.01	34.1	94.1	-1.1	-1.0	30.00
BLE	1 Mbps	2480	58.31	34.0	92.3	-2.9	-2.8	30.00
BLE	2 Mbps	2402	58.29	33.8	92.1	-3.2	-3.7	30.00
BLE	2 Mbps	2440	57.79	34.1	91.9	-3.4	-3.9	30.00
BLE	2 Mbps	2480	56.20	34.0	90.2	-5.1	-5.6	30.00

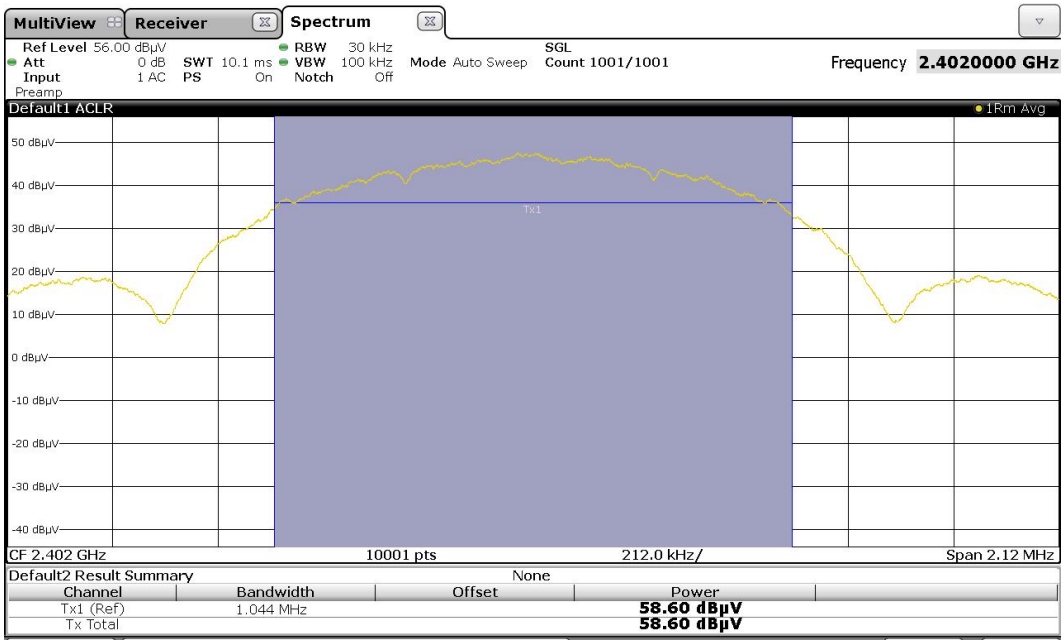
Test equipment (please refer to chapter 6 for details)
3-11, 15

5.2.2.1.2 Tested sample REF-ANNA-B112E#6

Ambient temperature	23° C
Relative humidity	53 %

Date	06.09.2018
Tested by	Bernward ROHDE

Example plot BLE 1 Mbps:



Antenna gain of on board antenna according to the data sheet: 0.5 dBi

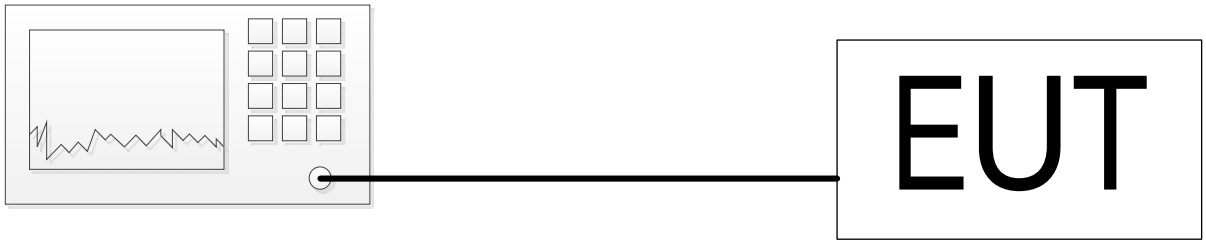
Operation mode	Data rate	Frequency [MHz]	Reading [dBµV]	Corr. Fact. [dB/m]	Field strength @3m [dBµV/m]	EIRP [dBm]	Result [dBm]	Limit [dBm]
BLE	1 Mbps	2402	58.60	33.8	92.4	-2.9	-2.7	30.00
BLE	1 Mbps	2440	54.19	34.1	88.3	-7.0	-6.8	30.00
BLE	1 Mbps	2480	53.19	34.0	87.2	-8.1	-7.9	30.00
BLE	2 Mbps	2402	56.67	33.8	90.5	-4.8	-5.3	30.00
BLE	2 Mbps	2440	52.54	34.1	86.6	-8.6	-9.1	30.00
BLE	2 Mbps	2480	51.61	34.0	85.6	-9.6	-10.1	30.00

Test equipment (please refer to chapter 6 for details)
3-11, 15

5.3 DTS Bandwidth / 99% Bandwidth

5.3.1 Method of measurement (conducted)

The EUT was tested with a spectrum analyzer connected directly to the EUT.



The measurement procedure refers to part 11.8.1 of document [1].

- Set RBW = 100 kHz.
- Set the video bandwidth (VBW) ≥ 3 x RBW.
- Detector = Peak.
- Trace mode = max hold.
- Sweep = auto couple.
- Allow the trace to stabilize.
- Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower frequencies) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission.

The following procedure was used for measuring the 99 % bandwidth:

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:

- 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.
- 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.
- 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.
- Step a) through step c) might require iteration to adjust within the specified range.
- e) Video averaging is not permitted. Where practical, a sample detection and single sweep mode shall be used. Otherwise, peak detection and max hold mode (until the trace stabilizes) shall be used.
- f) Use the 99% power bandwidth function of the instrument (if available) and report the measured bandwidth.
- g) If the instrument does not have a 99% power bandwidth function, then the trace data points are recovered and directly summed in linear power terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached; that frequency is recorded as the lower frequency. The process is repeated until 99.5% of the total is reached; that frequency is recorded as the upper frequency. The 99% power bandwidth is the difference between these two frequencies.
- The occupied bandwidth shall be reported by providing plot(s) of the measuring instrument display; the plot axes and the scale units per division shall be clearly labeled. Tabular data maybe reported in addition to the plot(s).

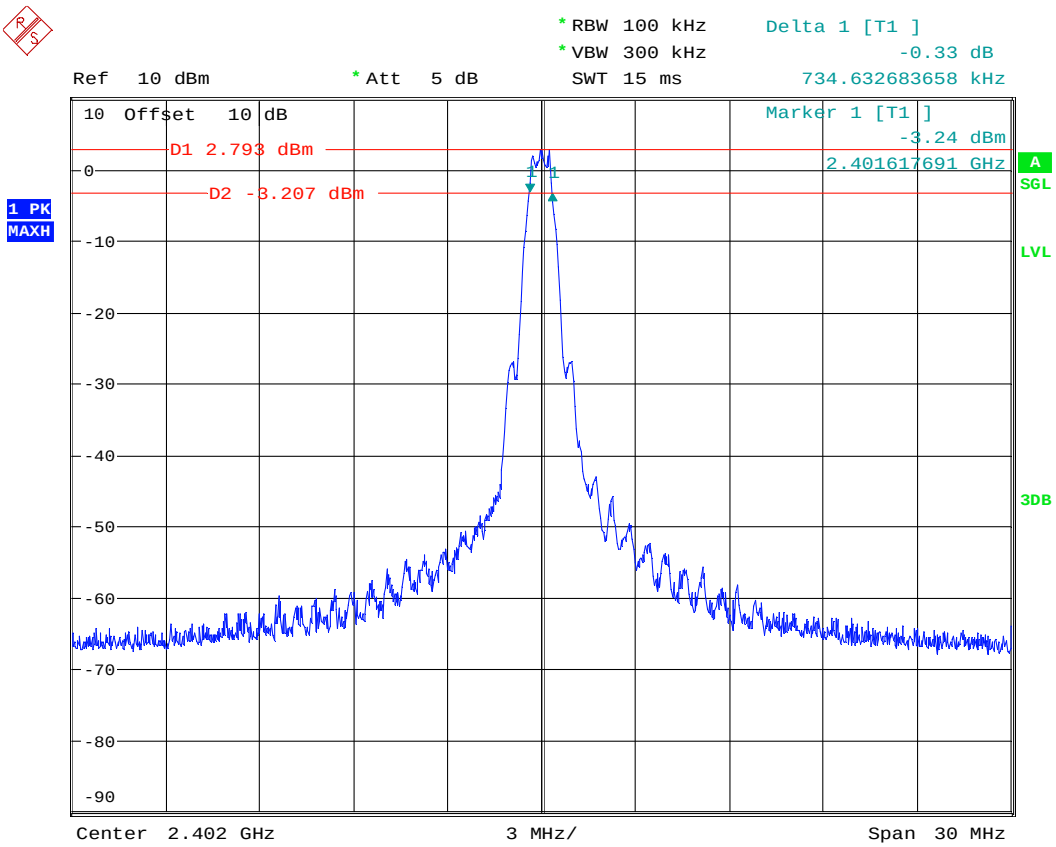
5.3.1.1 Test results (conducted)

5.3.1.1.1 Tested sample EVB-ANNA-B112U#117

Ambient temperature	22 °C
Relative humidity	47 %

Date	18.07.2018
Tested by	Paul NEUFELD

Example plot DTS-BW BLE 1 Mbps:



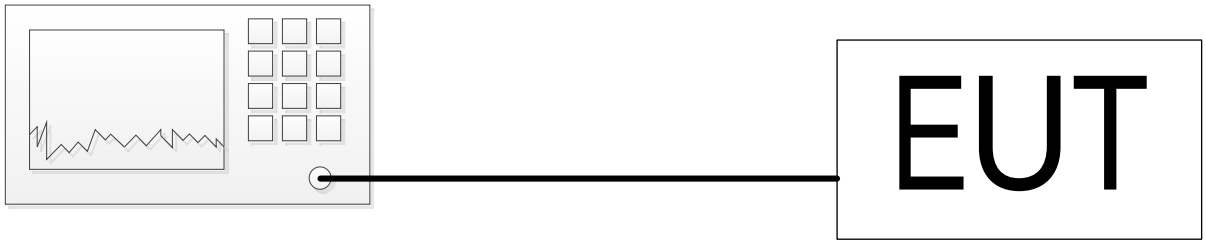
OP mode	Data rate	Center Frequency [MHz]	Minimum 6-dB Bandwidth Limit [MHz]	6 dB Bandwidth [MHz]	99 % Bandwidth [MHz]	Result
BLE	1 Mbps	2402	0.5	0.735	1.044	Passed
BLE	1 Mbps	2440	0.5	0.735	1.044	Passed
BLE	1 Mbps	2480	0.5	0.750	1.048	Passed
BLE	2 Mbps	2402	0.5	1.184	2.044	Passed
BLE	2 Mbps	2440	0.5	1.214	2.048	Passed
BLE	2 Mbps	2480	0.5	1.184	2.056	Passed

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

5.4 Peak Power Spectral Density

5.4.1 Method of measurement (conducted)

The EUT was tested with a spectrum analyzer connected directly to the EUT.



Peak PSD measurement:

The measurement procedure refers to part 11.10.2 of document [1].

- Set analyzer center frequency to DTS channel center frequency.
- Set the span to 1.5 times the DTS bandwidth.
- Set the RBW to 3 kHz ≤ RBW ≤ 100 kHz.
- Set the VBW ≥ [3 × RBW].
- Detector = peak.
- Sweep time = auto couple.
- Trace mode = max hold.
- Allow trace to fully stabilize.
- Use the peak marker function to determine the maximum amplitude level within the RBW.
- If measured value exceeds requirement, then reduce RBW (but no less than 3 kHz) and repeat.

Average PSD measurement:

Method AVGPSD-2 uses trace averaging across ON and OFF times of the EUT transmissions, followed by duty cycle correction.

- Measure the duty cycle (D) of the transmitter output signal as described in 11.6 [1].
- Set instrument center frequency to DTS channel center frequency.
- Set span to at least 1.5 times the OBW.
- Set RBW to: 3kHz ≤ RBW ≤ 100 kHz.
- Set VBW ≥ [3 x RBW].
- Detector = power averaging (rms) or sample detector (when rms not available).
- Ensure that the number of measurement points in the sweep ≥ [2 x span / RBW].
- Sweep time = auto couple.
- Do not use sweep triggering; allow sweep to “free run”.
- Employ trace averaging (rms) mode over a minimum of 100 traces.
- Use the peak marker function to determine the maximum amplitude level.
- Add [10log(1/D)], where D is the duty cycle, to the measured PSD to compute the average PSD during the actual transmission time.
- If measured value exceeds requirement specified by regulatory agency, then reduce RBW (but no less than 3 kHz) and repeat (note that this may require zooming in on the emissions of interest and reducing the span to meet the minimum measurement point requirement as the RBW is reduced).

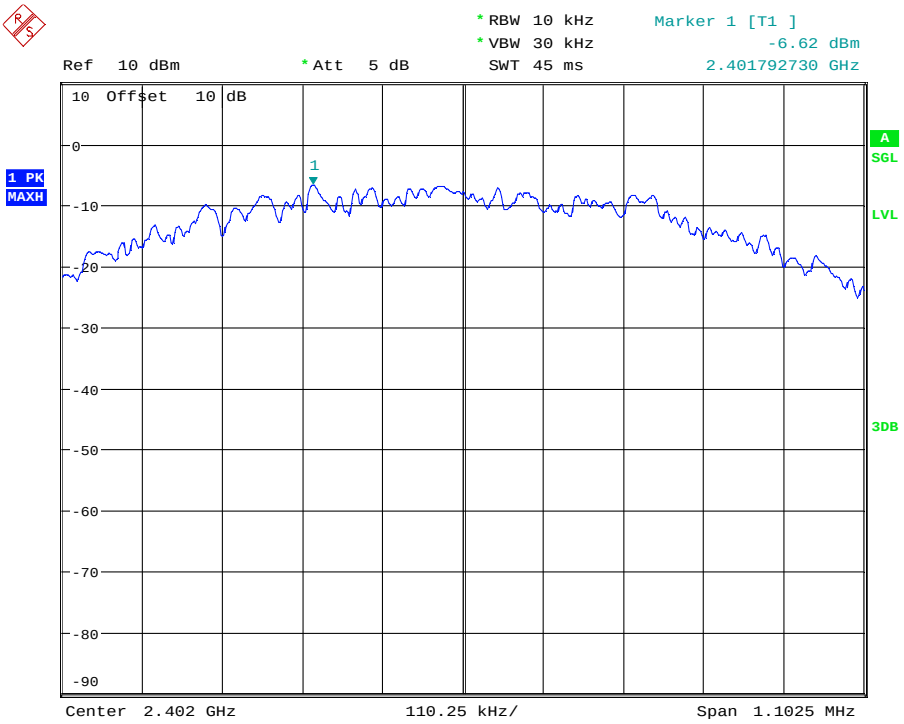
5.4.1.1 Test results (conducted)
5.4.1.1.1 Tested sample EVB-ANNA-B112U#117

Ambient temperature	22 °C
Relative humidity	47 %

Date	18.07.2018
Tested by	Paul NEUFELD

Peak PSD measurement:

Example plot BLE 1 Mbps:

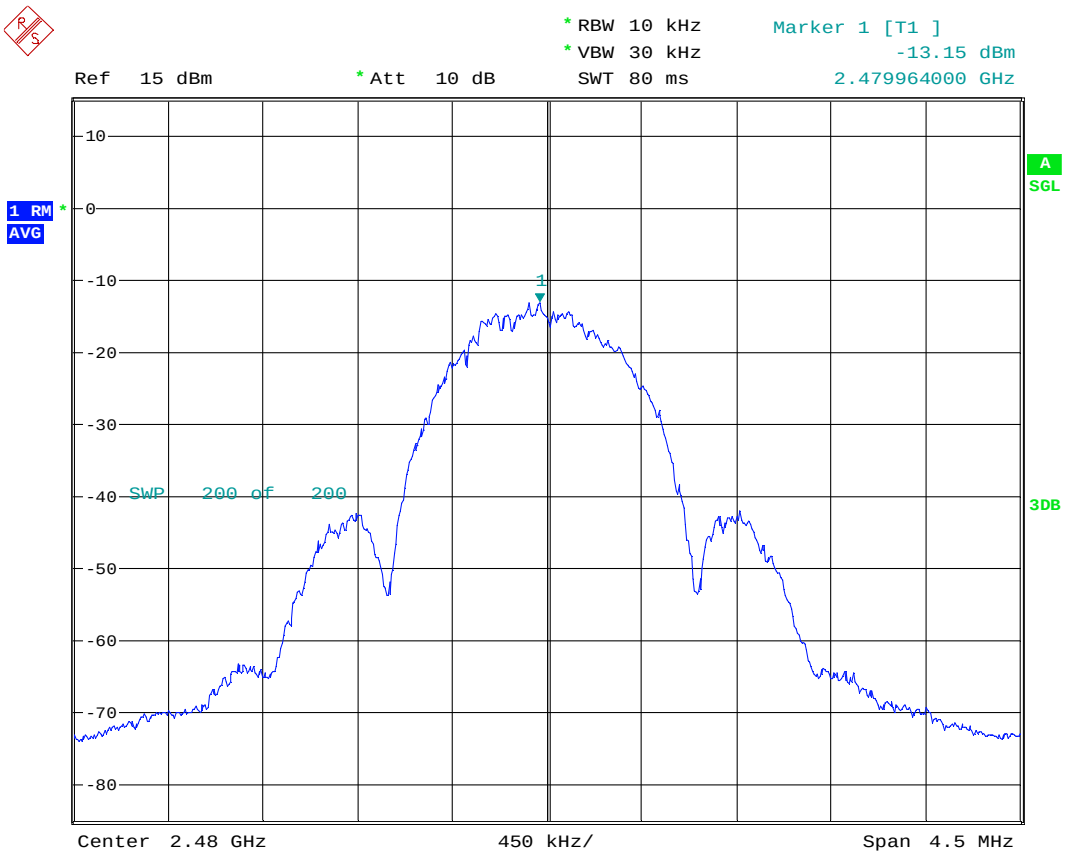


OP mode	Data rate	Peak Frequency [MHz]	Result [dBm / 10 kHz]	PSD Limit [dBm / 3 kHz]	Result
BLE	1 Mbps	2401.793	-6.6	8	Passed
BLE	1 Mbps	2439.793	-6.8	8	Passed
BLE	1 Mbps	2479.968	-6.9	8	Passed
BLE	2 Mbps	2401.975	-7.2	8	Passed
BLE	2 Mbps	2439.973	-7.4	8	Passed
BLE	2 Mbps	2479.973	-7.2	8	Passed

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

Average PSD measurement:

Example plot BLE 1 Mbps:



OP mode	Data rate	Peak Frequency [MHz]	Result [dBm / 10 kHz]	PSD Limit [dBm / 3 kHz]	Result
BLE	1 Mbps	2401.950	-12.2	8	Passed
BLE	1 Mbps	2439.950	-12.6	8	Passed
BLE	1 Mbps	2479.964	-12.5	8	Passed
BLE	2 Mbps	2401.995	-12.2	8	Passed
BLE	2 Mbps	2439.946	-12.4	8	Passed
BLE	2 Mbps	2479.991	-12.9	8	Passed

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

5.4.2 Method of measurement (radiated)

For the PSD measurement, the EUT was measured radiated in the anechoic chamber using the procedures described in 5.6.4.

The measurement procedure refers to part 11.10.5 of document [1].

Method AVGPSD-2 uses trace averaging across ON and OFF times of the EUT transmissions, followed by duty cycle correction.

- Measure the duty cycle (D) of the transmitter output signal as described in 11.6 [1].
- Set instrument center frequency to DTS channel center frequency.
- Set span to at least 1.5 times the OBW.
- Set RBW to: 3kHz ≤ RBW ≤ 100 kHz.
- Set VBW ≥ [3 x RBW].
- Detector = power averaging (rms) or sample detector (when rms not available).
- Ensure that the number of measurement points in the sweep ≥ [2 x span / RBW].
- Sweep time = auto couple.
- Do not use sweep triggering; allow sweep to “free run”.
- Employ trace averaging (rms) mode over a minimum of 100 traces.
- Use the peak marker function to determine the maximum amplitude level.
- Add [10log(1/D)], where D is the duty cycle, to the measured PSD to compute the average PSD during the actual transmission time.
- If measured value exceeds requirement specified by regulatory agency, then reduce RBW (but no less than 3 kHz) and repeat (note that this may require zooming in on the emissions of interest and reducing the span to meet the minimum measurement point requirement as the RBW is reduced).

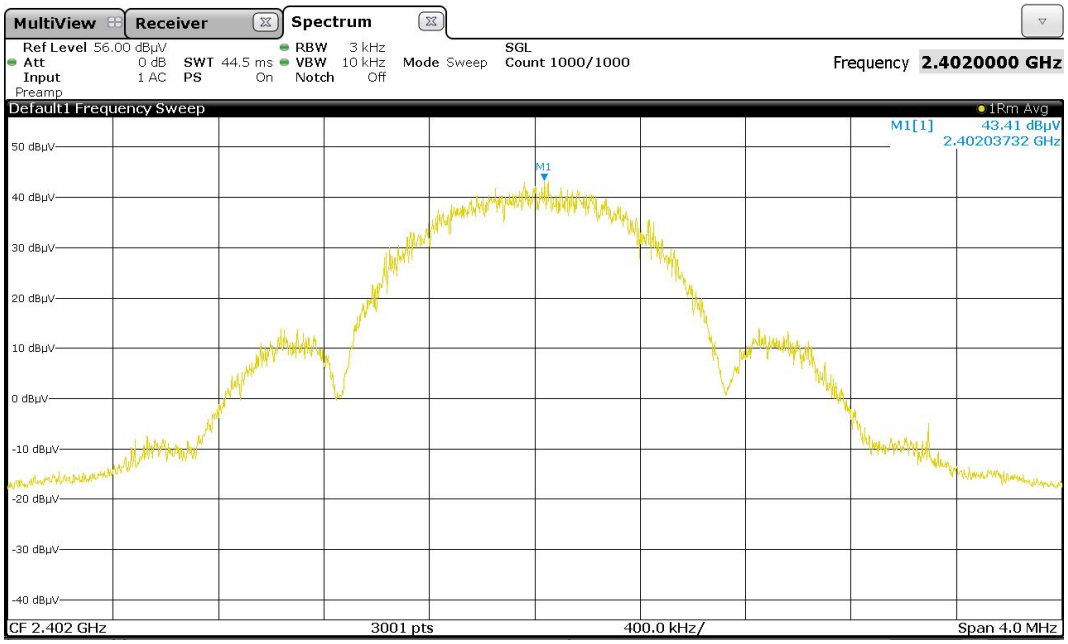
5.4.2.1 Test results (radiated)

5.4.2.1.1 Tested sample EVB-ANNA-B112C#143

Ambient temperature	23 °C
Relative humidity	53 %

Date	06.09.2018
Tested by	Bernward ROHDE

Example plot BLE 1 Mbps:



OP mode	Data rate	Peak Frequency [MHz]	Reading [dBµV]	Corr. Fact. [dB/m]	Field strength @3m [dBµV/m]	EIRP [dBm / 10 kHz]	Result [dBm / 10 kHz]	PSD Limit [dBm / 3 kHz]	Result
BLE	1 Mbps	2401.988	43.41	33.8	77.2	-18.0	-17.9	8	Passed
BLE	1 Mbps	2439.988	42.41	34.1	76.5	-18.7	-18.6	8	Passed
BLE	1 Mbps	2479.988	41.07	34.0	75.1	-20.2	-20.0	8	Passed
BLE	2 Mbps	2401.981	41.92	33.8	75.7	-19.5	-20.0	8	Passed
BLE	2 Mbps	2439.985	42.28	34.1	76.4	-18.9	-19.4	8	Passed
BLE	2 Mbps	2480.000	39.64	34.0	73.6	-21.6	-22.1	8	Passed

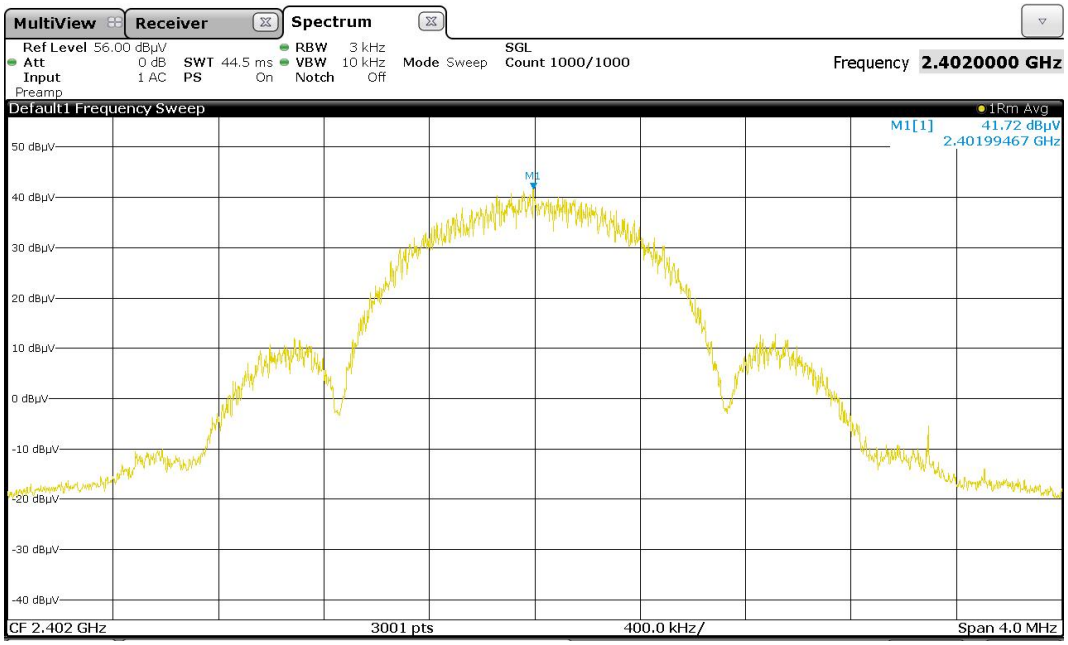
Test equipment (please refer to chapter 6 for details)
3-11, 15

5.4.2.1.2 Tested sample REF-ANNA-B112E#6

Ambient temperature	23 °C
Relative humidity	53 %

Date	06.09.2018
Tested by	Bernward ROHDE

Example plot BLE 1 Mbps:



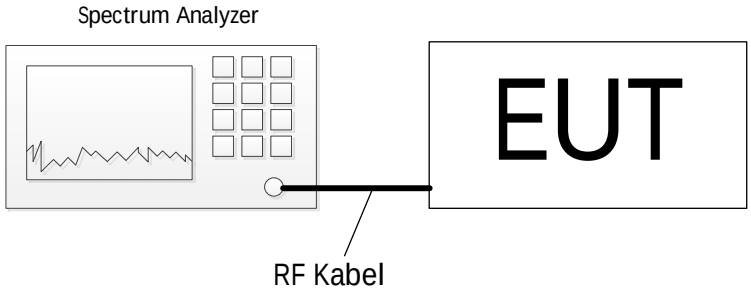
OP mode	Data rate	Peak Frequency [MHz]	Reading [dBµV]	Corr. Fact. [dB/m]	Field strength @3m [dBµV/m]	EIRP [dBm / 10 kHz]	Result [dBm / 10 kHz]	PSD Limit [dBm / 3 kHz]	Result
BLE	1 Mbps	2401.940	41.72	33.8	75.5	-19.7	-19.6	8	Passed
BLE	1 Mbps	2439.983	37.49	34.1	71.6	-23.7	-23.5	8	Passed
BLE	1 Mbps	2480.028	36.32	34.0	70.3	-24.9	-24.8	8	Passed
BLE	2 Mbps	2401.993	39.55	33.8	73.4	-21.9	-22.4	8	Passed
BLE	2 Mbps	2439.957	36.22	34.1	70.3	-24.9	-25.4	8	Passed
BLE	2 Mbps	2479.772	34.61	34.0	68.6	-26.6	-27.1	8	Passed

Test equipment (please refer to chapter 6 for details)
3-11, 15

5.5 Band-edge compliance

5.5.1 Method of measurement (band edges next to unrestricted bands (conducted))

The EUT was tested with a spectrum analyzer connected directly to the EUT.



The relating measurements were carried out in a conducting manner. Therefore, the antenna connector was directly connected to a spectrum analyzer. The measurement procedure refers to part 11.11.2 and 11.11.3 of document [1].

Measurement Procedure Reference – Reference Level:

- RBW = 100 kHz.
- VBW ≥ 300 kHz.
- Set the span to ≥ 1.5 times the DTS Bandwidth.
- Detector = Peak.
- Sweep time = auto couple.
- Trace mode = max hold.
- Allow trace to fully stabilize.
- Use the peak marker function to determine the maximum amplitude level.

Measurement Procedure – Unwanted Emissions

- Set the center frequency and span to encompass the frequency range to be measured.
- RBW = 100 kHz.
- VBW ≥ 300 kHz.
- Detector = Peak.
- Ensure that the number of measurement points ≥ span/RBW.
- Sweep time = auto couple.
- Trace Mode = max hold.
- Allow the trace to stabilize.
- Use the peak marker function to determine the maximum amplitude level.

The measurement procedure at the band edges was simplified by performing the measurement in just one plot. Both, the in-band-emission and the unwanted emission were be encompassed by the span. After trace stabilization, the maximum peak was be determined by a peak detector and the value was marked by an appropriate limit line. The second limit line, which is 20 dB below the first, marks the limit for the emissions in the unrestricted band. A maximum-peak-detector marks the highest emission in the unrestricted band next to the band edge.

The measurements were performed at the lower end of the 2.4 GHz band.

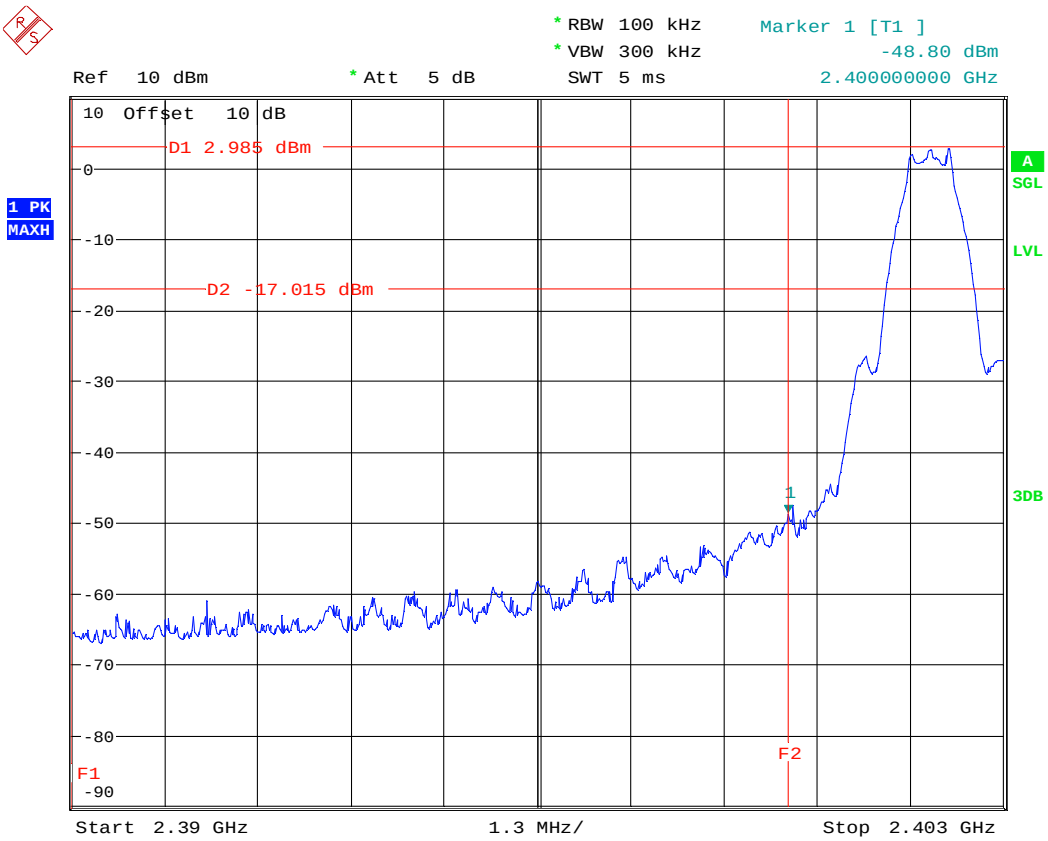
5.5.1.1 Test results (conducted)

5.5.1.1.1 Tested sample EVB-ANNA-B112U#117

Ambient temperature	22 °C
Relative humidity	47 %

Date	18.07.2018
Tested by	Paul NEUFELD

Example plot BLE 1 Mbps:

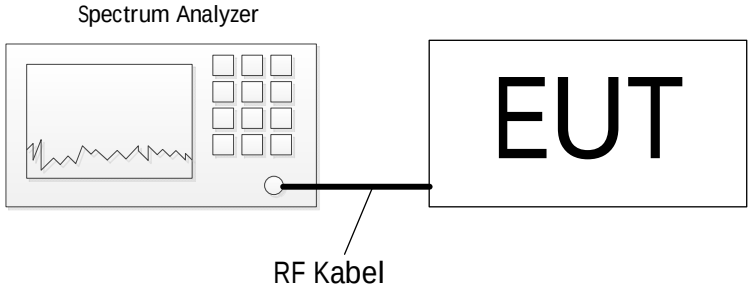


Operation mode	Data rate	Frequency [MHz]	Reference Level [dBm]	Limit [dBm]	Emission Level [dBm]	Margin [dB]	Result
BLE	1 Mbps	2400	3.0	-17.0	-48.8	31.8	Passed
BLE	2 Mbps	2400	2.8	-17.2	-29.5	12.3	Passed

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

5.5.2 Method of measurement (band edges next to restricted bands (conducted))

The EUT was tested with a spectrum analyzer connected directly to the EUT.



The same test set-up as used for the final conducted emission measurement shall be used (refer also sub-clause 5.6.1 of this test report).

After trace stabilization the marker shall be set on the signal peak. The frequency line shall be set on the edge of the assigned frequency band. Now set the second marker on the emission at the band-edge, or on the highest modulation product outside of the band, if this level is higher than that at the band-edge. The level of the measured field strength shall be compared to the general limits specified in § 15.205.

The measurement was performed at the lower and the upper end of the 2.4 GHz band.

The calculation was performed with the following formula as described in chapter 11.12.2.2 e) in [1]:

E [dBµV/m] = $EIRP$ [dBm] – 20log(d) + 104.8 + G_{Ant} [dBi] + G_{Array} [dB] + $Att_{MeasCable}$ [dB] + $Att_{RF\text{-}Switch}$ [dB]

E [dBµV/m] = Field Strength [dBuV/m]
$EIRP$ [dBm] = Reading [dBm]
d = measurement distance in m
G_{Ant} [dBi] = Gain of the EUT antenna
G_{Array} [dB] = Array Gain [in case of multiple transmitting antenna port]
$Att_{MeasCable}$ [dB] = Attenuation of the measurement cables
$Att_{RF\text{-}Switch}$ [dB] = Attenuation of the RF Switch

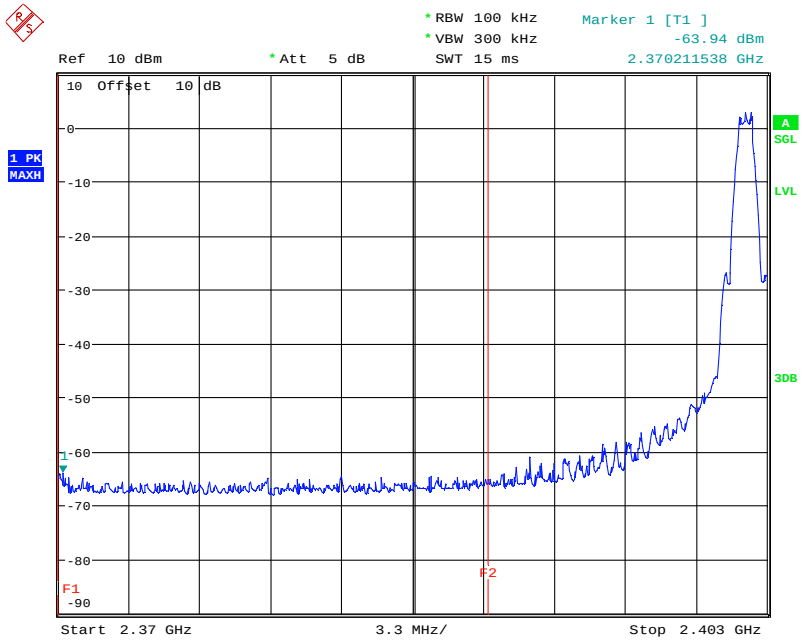
5.5.2.1 Test results (conducted)

5.5.2.1.1 Tested sample EVB-ANNA-B112U#117

Ambient temperature	22 °C
Relative humidity	47 %

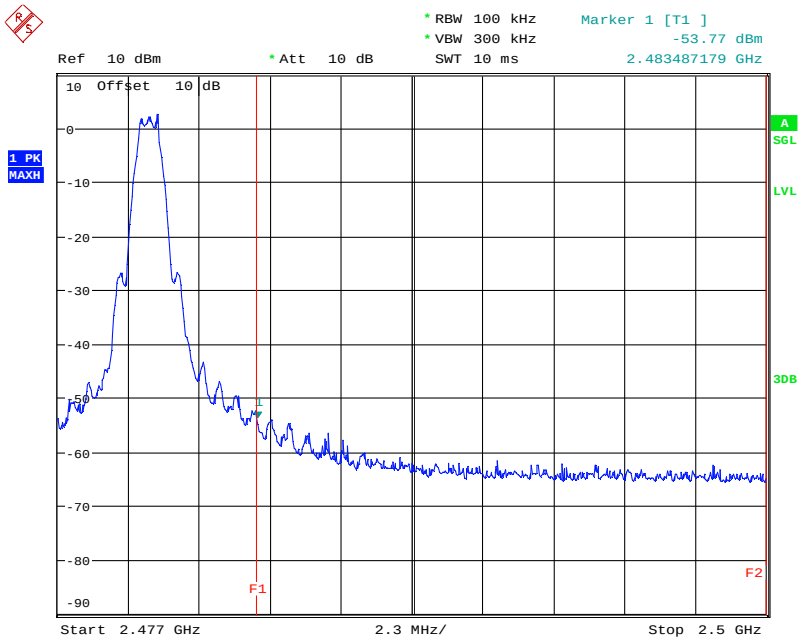
Date	18.07.2018
Tested by	Paul NEUFELD

Example plot BLE 1 Mbps:



Lower band edge							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
BLE 1 Mbps	2371.512	43.4	74	30.6	-54.4	2.5	Passed
BLE 2 Mbps	2389.99	49.5	74	24.5	-48.2	2.5	Passed
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
BLE 1 Mbps	2370.027	31.8	54	22.2	-66.6	2.5	Passed
BLE 2 Mbps	2389.995	35.0	54	19.0	-65.1	2.5	Passed
Measurement uncertainty				+0.66 dB / -0.72 dB			

Example plot BLE 1 Mbps:



Upper band edge							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
BLE 1 Mbps	2483.502	61.5	74	12.5	-36.3	2.5	Passed
BLE 2 Mbps	2483.5	62.2	74	11.8	-35.5	2.5	Passed

Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
BLE 1 Mbps	2483.502	39.7	54	14.3	-58.8	2.5	Passed
BLE 2 Mbps	2483.5	44.8	54	9.2	-55.4	2.5	Passed
Measurement uncertainty				+0.66 dB / -0.72 dB			

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

5.5.3 Method of measurement (band edges next to restricted bands (radiated))

For the measurement, the EUT was measured radiated in the anechoic chamber using the procedures described in 5.6.4.

The relating measurements were carried out radiated. The measurement procedure refers to part 6.10.5.2 of document [1].

5.5.3.1 Test results (radiated)

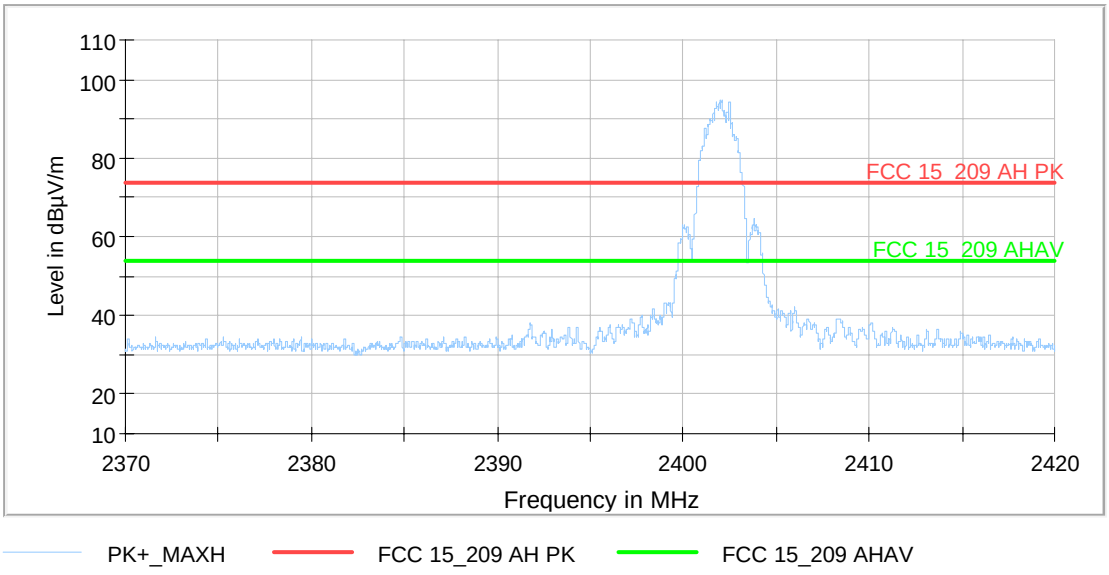
Remark: According to the results of the conducted measurements, only radiated band edge measurements using the 2 Mbps (worst case) modulation were carried out.

5.5.3.1.1 Tested sample EVB-ANNA-B112C#143

Ambient temperature	23 °C
Relative humidity	57 %

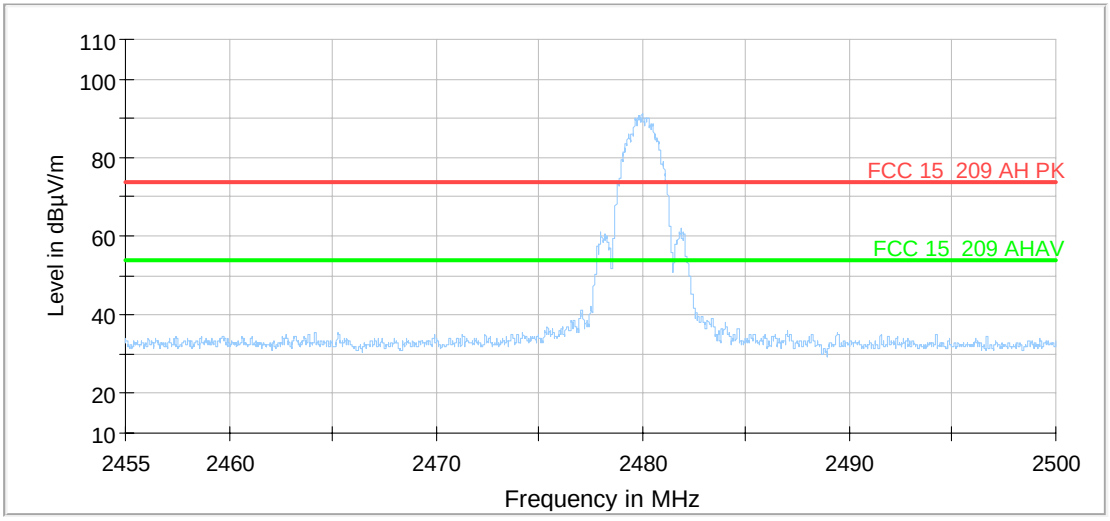
Date	24.07.2018
Tested by	Ruben BRAUN

BLE 2 Mbps:



Lower band edge									
			Duty cycle correction factor of 2.39 dB was applied for the Average reading						
Frequency	Max Peak	Average	Limit	Margin	Pol	Azimuth	Elevation	Correction	Result
[MHz]	[dBµV/m]	[dBµV/m]	[dBµV/m]	dB		[°]	[°]	[dB]	
2385.715000	---	33.9	54	20.1	V	233	60	35.9	Passed
2385.715000	48.3	---	74	25.7	V	233	60	33.5	Passed
Measurement uncertainty				+2.2 dB / -3.6 dB					

BLE 2 Mbps:



Upper band edge									
			Duty cycle correction factor of 2.39 dB was applied for the Average reading						
Frequency	Max Peak	Average	Limit	Margin	Pol	Azimuth	Elevation	Correction	Result
[MHz]	[dBµV/m]	[dBµV/m]	[dBµV/m]	dB		[°]	[°]	[dB]	
2487.562000	---	34.2	54	19.8	H	303	30	36.0	Passed
2487.562000	49.1	---	74	24.9	H	303	30	33.6	Passed
Measurement uncertainty				+2.2 dB / -3.6 dB					

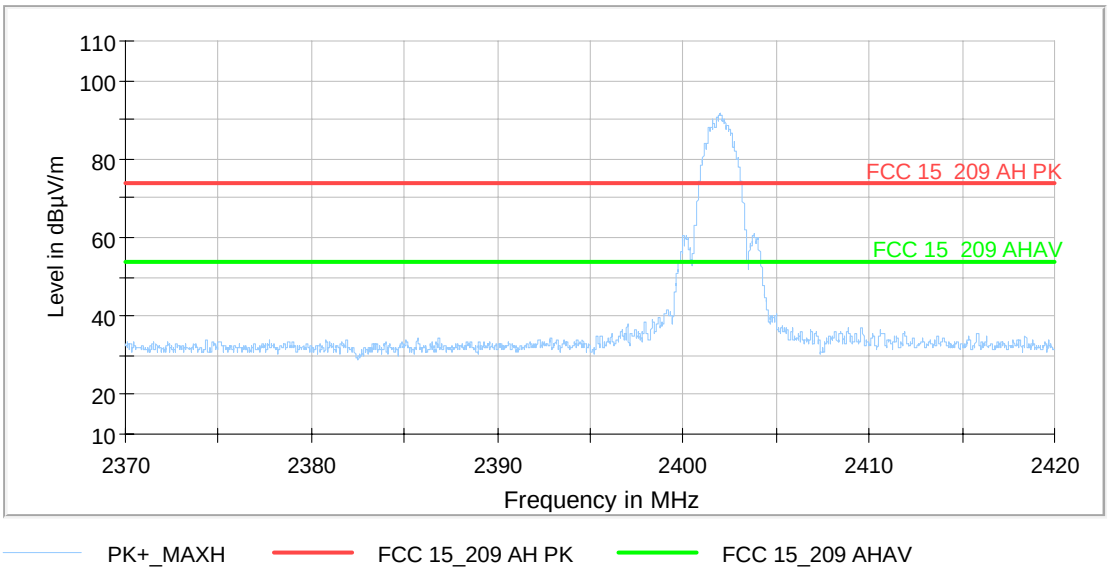
Test equipment (please refer to chapter 6 for details)
2-10, 15, 21

5.5.3.1.2 Tested sample REF-ANNA-B112E#6

Ambient temperature	23 °C
Relative humidity	57 %

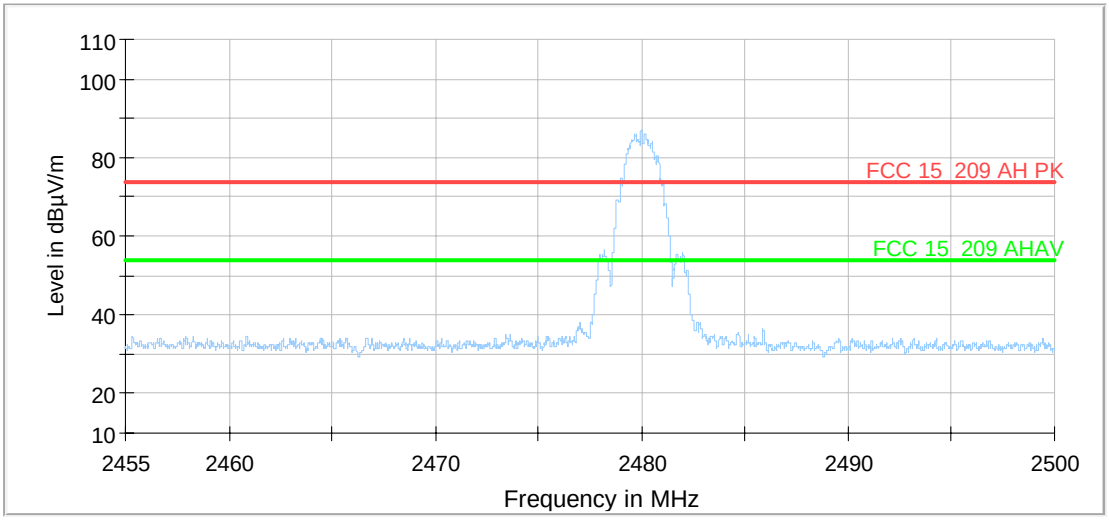
Date	24.07.2018
Tested by	Ruben BRAUN

BLE 2 Mbps:



Lower band edge									
			Duty cycle correction factor of 2.39 dB was applied for the Average reading						
Frequency	Max Peak	Average	Limit	Margin	Pol	Azimuth	Elevation	Correction	Result
[MHz]	[dBµV/m]	[dBµV/m]	[dBµV/m]	dB		[°]	[°]	[dB]	
2386.831667	---	33.7	54	20.3	V	338	59	35.9	Passed
2385.715000	47.4	---	74	26.6	V	338	59	33.5	Passed
Measurement uncertainty				+2.2 dB / -3.6 dB					

BLE 2 Mbps:



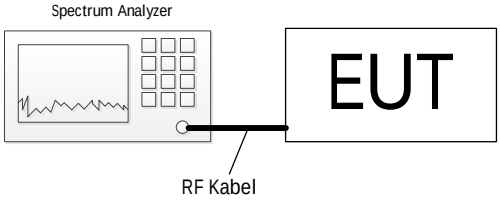
Upper band edge									
			Duty cycle correction factor of 2.39 dB was applied for the Average reading						
Frequency	Max Peak	Average	Limit	Margin	Pol	Azimuth	Elevation	Correction	Result
[MHz]	[dBµV/m]	[dBµV/m]	[dBµV/m]	dB		[°]	[°]	[dB]	
2484.454000	---	35.3	54	18.7	V	0	90	36.0	Passed
2484.454000	51.0	---	74	23.0	V	0	90	33.6	Passed
Measurement uncertainty			+2.2 dB / -3.6 dB						

Test equipment (please refer to chapter 6 for details)
2-10, 15, 21

5.6 Maximum unwanted emissions

5.6.1 Method of measurement (conducted emissions in the restricted bands)

The relating measurements were carried out in a conducting manner. Therefore, the antenna connector was directly mounted to a spectrum analyzer.



The measurement procedure refers to part 11.12.2.2 in document [1].

If emissions were detected during the preliminary measurements, they were measured using the following measurement procedures:

Procedure for average measurement: 11.12.2.5.2 – Trace averaging across ON and OFF times of the EUT transmissions followed by duty cycle correction:

If continuous transmission of the EUT (D ≥ 98%) cannot be achieved and the duty cycle is constant (duty cycle variations are less than ±2%), then the following procedure shall be used:

- The EUT shall be configured to operate at the maximum achievable duty cycle.
- Measure the duty cycle D of the transmitter output signal as described in 11.6 in [1].
- Set the RBW = 1 MHz (unless otherwise specified).
- Set the VBW ≥ 3 x RBW.
- Detector = power average (RMS).
- Ensure that the number of measurement points in the sweep to ≥ 2 x (span/RBW).
- Averaging type = power
- Sweep time = auto
- Perform a trace average of at least 100 traces
- Correct the resulting measurement value by adding the duty cycle correction value if applicable.

Peak measurement procedure: 11.12.2.4 in [1]

- Set the analyzer span to encompass the entire unwanted emission bandwidth.
- Set the RBW = specified in Table 1.
- Set the VBW ≥ RBW.
- Set sweep time = auto.
- Detector = peak.
- Trace mode = max hold.
- Allow the trace to stabilize.
- Use the peak marker function to determine the peak power over the emission bandwidth.

Table 1 RBW as a function of frequency

Frequency	RBW
9-150 kHz	200-300 Hz
0.15-30 MHz	9-10 kHz
30-1000 MHz	100-120 kHz
> 1000 MHz	1 MHz

5.6.1.1 Limit calculations

The following general procedure is described in chapter 11.12.2.2 in [1].

a) Measure the conducted output power (in dBm) using the detector specified by the appropriate regulatory agency (see 11.12.2.3 through 11.12.2.5 for guidance regarding measurement procedures for determining quasi-peak, peak, and average conducted output power, respectively).
b) Add the maximum transmit antenna gain (in dBi) to the measured output power level to determine the EIRP (see 11.12.2.6 for guidance on determining the applicable antenna gain).
c) Add the appropriate maximum ground reflection factor to the EIRP (6 dB for frequencies ≤ 30 MHz; 4.7 dB for frequencies between 30 MHz and 1000 MHz, inclusive; and 0 dB for frequencies > 1000 MHz).
d) For MIMO devices, measure the power of each chain and sum the EIRP of all chains in linear terms (i.e., watts and mW).
e) Convert the resultant EIRP to an equivalent electric field strength using the following relationship:

$$E. = EIRP - 20\log(d) + 104.8 \quad (1)$$

where

E is the electric field strength in dBµV/m
EIRP is the equivalent isotropically radiated power in dBm
d is the specified measurement distance in m

f) Compare the resultant electric field strength level with the applicable regulatory limit.
g) C Perform the radiated spurious emission test.

Chapter 14 in [1] states that for transmitters with multiple outputs in the same band, summing of emissions and accounting for array gain have to be considered.

For the case that both antenna ports transmit continuously, both results were summed as linear values as described in 14.3.2.2 in document [1].

To account for directional gain which might occur in case of N transmit antennas in the test mode spatial multiplexing, which is the mode the EUT uses, the directional has to be calculated as:

$$10log\left[\sum_{j=1}^{N_{SS}}\left\{\sum_{k=1}^{N_{Ant}} g_{j,k}\right\}^2 \Big/ N_{Ant}\right]$$

Whereby

N_{SS} is the number of independent spatial streams of data.
N_{Ant} is the total number of antennas
$g_{j,k}$ is $10^{Gk/20}$ if the *k*th antenna is being fed by spatial stream j, or zero if it is not
G_k is the gain in dBi of the kth antenna

Since the EUT has only 1 antenna, no array gain is applicable here.

5.6.2 Method of measurement (conducted emissions in the unrestricted bands)

In any 100 kHz outside the authorized frequency band, the power shall be attenuated by 20 dB, compared to the highest in band power in any 100 kHz. This shall be demonstrated by using the peak power procedure. The reference level shall be measured using the procedure described in 5.6.2.1 and the emission level according to procedure 5.6.2.2. The procedures are based on chapter 11.11.2 and 11.11.3 in [1].

For the operation modes in which both antenna ports transmit simultaneously, the level of the both ports were summed in linear value for each frequency step. The applicable plots show the result of that sum.

5.6.2.1 Reference level measurement

a) Set instrument center frequency to DTS channel center frequency.
b) Set the span to ≥ 1.5 times the DTS bandwidth.
c) Set the RBW = 100 kHz.
d) Set the VBW ≥ 3 x RBW.
e) Detector = peak.
f) Sweep time = auto couple.
g) Trace mode = max hold.
h) Allow trace to fully stabilize.
i) Use the peak marker function to determine the maximum PSD level.

5.6.2.2 Emission level measurement

a) Set the center frequency and span to encompass frequency range to be measured.
b) Set the RBW = 100 kHz.
c) Set the VBW ≥ 3 x RBW.
d) Detector = peak.
e) Ensure that the number of measurement points ≥ span/RBW
f) Sweep time = auto couple.
g) Trace mode = max hold.
h) Allow trace to fully stabilize.
i) Use the peak marker function to determine the maximum amplitude level.

5.6.3 Test results (conducted emissions)

5.6.3.1 Tested sample EVB-ANNA-B112U#117

5.6.3.1.1 Emissions below 1 GHz

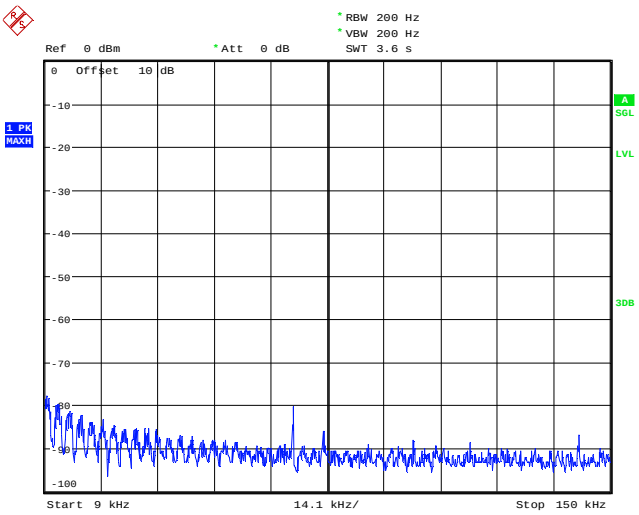
Ambient temperature	22 °C
Relative humidity	39 %

Date	19.07.2018
Tested by	Paul NEUFELD

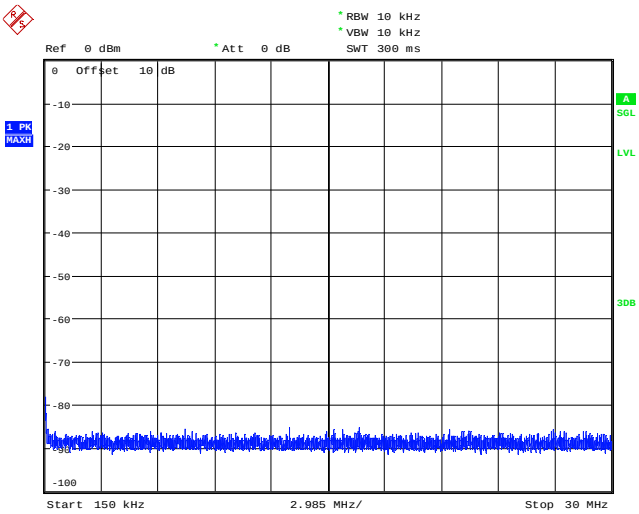
The following results were measured at antenna port of the EUT. Only the plots for the worst case emissions are submitted below.

No significant emissions were found below 1 GHz, therefore no result tables for this frequency range are submitted.

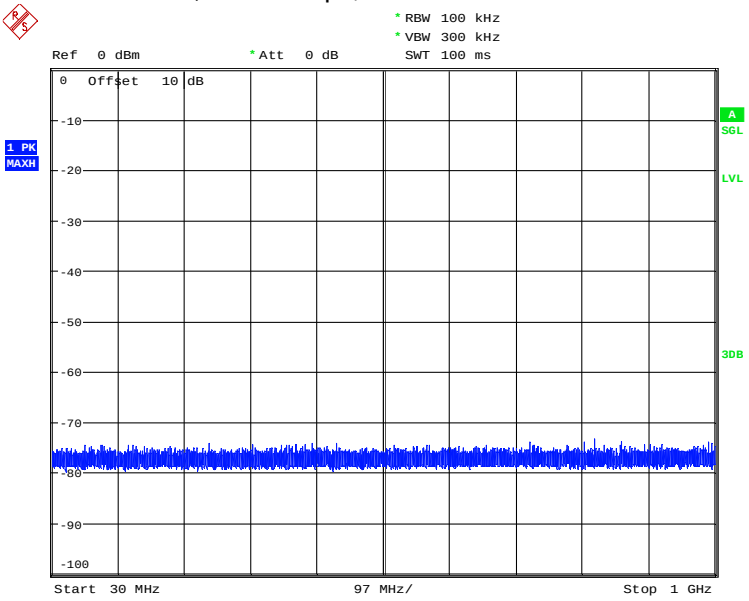
Conducted spurious from 9 – 150 kHz; BLE 1 Mbps, Ch 00:



Conducted spurious from 0.15 – 30 MHz; BLE 1 Mbps, Ch 00:



Conducted spurious from 30 – 1000 MHz; BLE 1 Mbps, Ch 00:



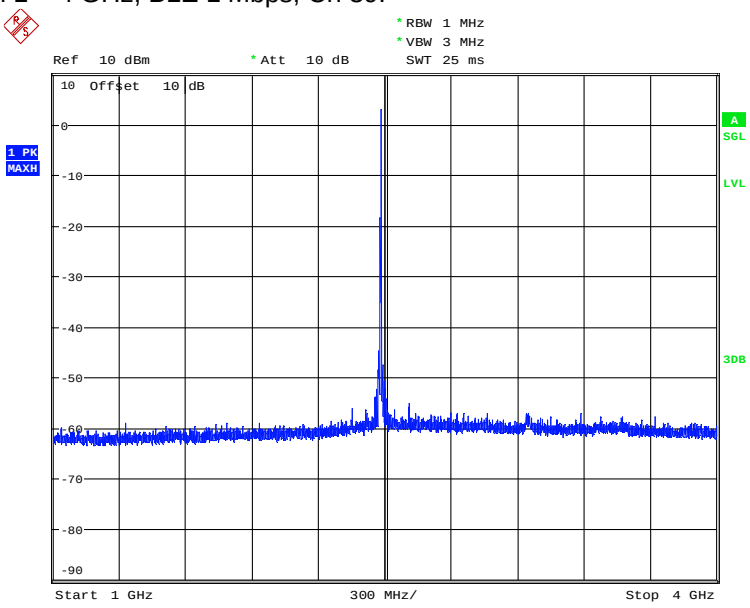
5.6.3.1.2 Emissions above 1 GHz

Ambient temperature	22 °C
Relative humidity	47 %

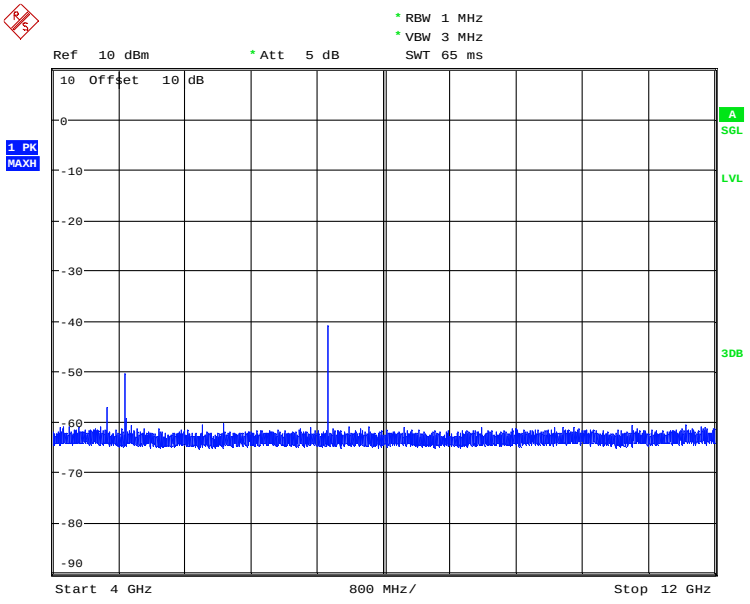
Date	18.07.2018
Tested by	Paul NEUFELD

The following results were measured at antenna port of the EUT. Only the plots for the worst case emissions are submitted below.

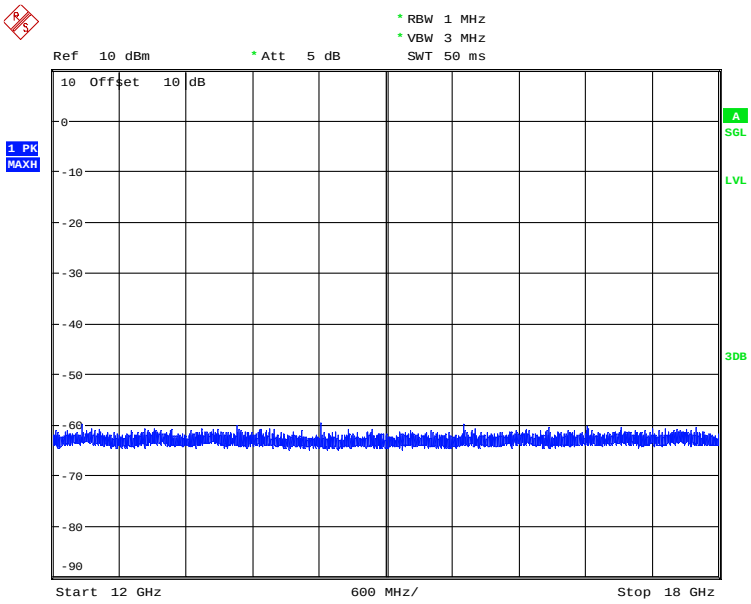
Conducted spurious from 1 – 4 GHz; BLE 1 Mbps, Ch 39:



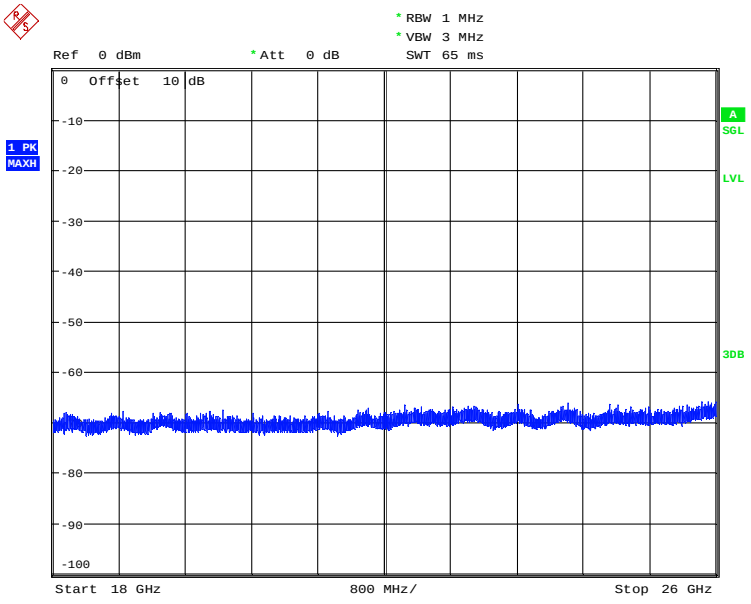
Conducted spurious from 4 – 12 GHz; BLE 1 Mbps, Ch 19:



Conducted spurious from 12 – 18 GHz; BLE 1 Mbps, Ch 00:



Conducted spurious from 18 – 26 GHz; BLE 1 Mbps, Ch 00:



Spurious Emissions (BLE 1 Mbps, Channel 00)							
Peak Emission – Restricted Band							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
BLE	4803.63	52.0	74	22.0	-45.8	2.5	Passed
Average Emission – Restricted Band							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
BLE	4803.86	46.6	54	7.4	-51.8	2.5	Passed

Emissions in the non-restricted Bands					
Operation Mode	Frequency [MHz]	Reading [dBm]	Limit [dBm]	Margin [dB]	Result
BLE	2402.24	3.0	-	-	-
BLE	2530.21	-60.2	-17	43.2	Passed
BLE	7206.72	-40.8	-17	23.8	Passed

Spurious Emissions (BLE 1 Mbps, Channel 19)							
Peak Emission – Restricted Band							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
BLE	2375.78	42.9	74	31.1	-54.9	2.5	Passed
BLE	2791.53	40.9	74	33.1	-56.8	2.5	Passed
BLE	4879.89	49.7	74	24.3	-48	2.5	Passed
BLE	7320.72	57.0	74	17.0	-40.8	2.5	Passed
Average Emission – Restricted Band							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
BLE	2375.93	34.8	54	19.2	-63.6	2.5	Passed
BLE	2788.441	30.3	54	23.7	-68.2	2.5	Passed
BLE	4879.77	44.3	54	9.7	-54.1	2.5	Passed
BLE	7320.5	53.0	54	1.0	-45.5	2.5	Passed

Emissions in the non-restricted Bands					
Operation Mode	Frequency [MHz]	Reading [dBm]	Limit [dBm]	Margin [dB]	Result
BLE	2440.24	2.6	-	-	-
BLE	2504.111	-61.1	-17.4	43.7	Passed
BLE	2567.939	-61.2	-17.4	43.8	Passed

Spurious Emissions (BLE 1 Mbps, Channel 39)							
Peak Emission – Restricted Band							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
BLE	2351.3	43.0	74	31.0	-54.8	2.5	Passed
BLE	7439.05	55.9	74	18.1	-41.9	2.5	Passed
BLE	4959.85	48.5	74	25.5	-49.2	2.5	Passed
BLE	13365.05	40.1	74	33.9	-57.6	2.5	Passed
Average Emission – Restricted Band							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
BLE	2351.82	35.8	54	18.2	-62.6	2.5	Passed
BLE	7439.37	51.8	54	2.2	-46.7	2.5	Passed
BLE	4960.01	42.7	54	11.3	-55.7	2.5	Passed
BLE	13371.91	29.3	54	24.7	-69.2	2.5	Passed

Emissions in the non-restricted Bands					
Operation Mode	Frequency [MHz]	Reading [dBm]	Limit [dBm]	Margin [dB]	Result
BLE	2480.23	2.5	-	-	-
BLE	2607.95	-59.6	-17.5	42.1	Passed
BLE	4416.12	-63.2	-17.5	45.8	Passed

Spurious Emissions (BLE 2 Mbps, Channel 00)							
Peak Emission – Restricted Band							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
BLE	2274.08	42.6	74	31.4	-55.2	2.5	Passed
BLE	2321.73	39.9	74	34.1	-57.8	2.5	Passed
BLE	4803.8	52.0	74	22.0	-45.8	2.5	Passed
Average Emission – Restricted Band							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
BLE	2273.9	35.0	54	19.0	-65.1	2.5	Passed
BLE	2322.56	31.1	54	22.9	-69	2.5	Passed
BLE	4803.06	44.7	54	9.3	-55.5	2.5	Passed
Emissions in the non-restricted Bands							
Operation Mode	Frequency [MHz]	Reading [dBm]	Limit [dBm]	Margin [dB]	Result		
BLE	2401.97	2.8	-	-	-		
BLE	2529.967	-61.1	-17.2	43.9	Passed		
BLE	2608.893	-62.4	-17.2	45.2	Passed		
BLE	7205.93	-41.5	-17.2	24.3	Passed		

Spurious Emissions (BLE 2 Mbps, Channel 19)							
Peak Emission – Restricted Band							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
BLE	2311.99	43.4	74	30.6	-54.3	2.5	Passed
BLE	4879.6	49.8	74	24.2	-48	2.5	Passed
BLE	4893.87	42.3	74	31.7	-55.4	2.5	Passed
BLE	7319.83	57.0	74	17.0	-40.7	2.5	Passed
Average Emission – Restricted Band							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
BLE	2312.01	34.7	54	19.3	-65.4	2.5	Passed
BLE	4879.16	42.2	54	11.8	-58	2.5	Passed
BLE	4894.01	30.3	54	23.7	-69.8	2.5	Passed
BLE	7318.74	52.4	54	1.6	-47.8	2.5	Passed
Emissions in the non-restricted Bands							
Operation Mode	Frequency [MHz]	Reading [dBm]	Limit [dBm]	Margin [dB]	Result		
BLE	2439.98	2.5	-	-	-		
BLE	2503.986	-59.6	-17.5	42.1	Passed		
BLE	17628.43	-62.1	-17.5	44.6	Passed		

Spurious Emissions (BLE 2 Mbps, Channel 39)							
Peak Emission – Restricted Band							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
BLE	2352.46	43.3	74	30.7	-54.5	2.5	Passed
BLE	4959.88	48.9	74	25.1	-48.9	2.5	Passed
BLE	7439.79	55.9	74	18.1	-41.8	2.5	Passed
Average Emission – Restricted Band							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
BLE	2351.92	35.8	54	18.2	-64.3	2.5	Passed
BLE	4960.6	41.1	54	12.9	-59	2.5	Passed
BLE	7441.14	50.6	54	3.4	-49.6	2.5	Passed
Emissions in the non-restricted Bands							
Operation Mode	Frequency [MHz]	Reading [dBm]	Limit [dBm]	Margin [dB]	Result		
BLE	2479.97	2.6	-	-	-		
BLE	1818.59	-63.7	-17.4	46.3	Passed		
BLE	2936.25	-63.2	-17.4	45.8	Passed		
BLE	13868.41	-63.8	-17.4	46.4	Passed		

Measurement uncertainty	+0.66 dB / -0.72 dB

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

5.6.4 Method of measurement (radiated emissions)

The radiated emission measurement is subdivided into five stages.

- A preliminary measurement carried out in a fully anechoic chamber with a fixed antenna height in the frequency range 9 kHz to 1 GHz.
- 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 final measurement carried out on an open area test side with reflecting ground plane and various antenna height in the frequency range 30 MHz to 1 GHz.
- A preliminary measurement carried out in a fully anechoic chamber with a variable antenna distance and height in the frequency range above 1 GHz.
- A final measurement carried out in a fully anechoic chamber with a fixed antenna height in the frequency range above 1 GHz.

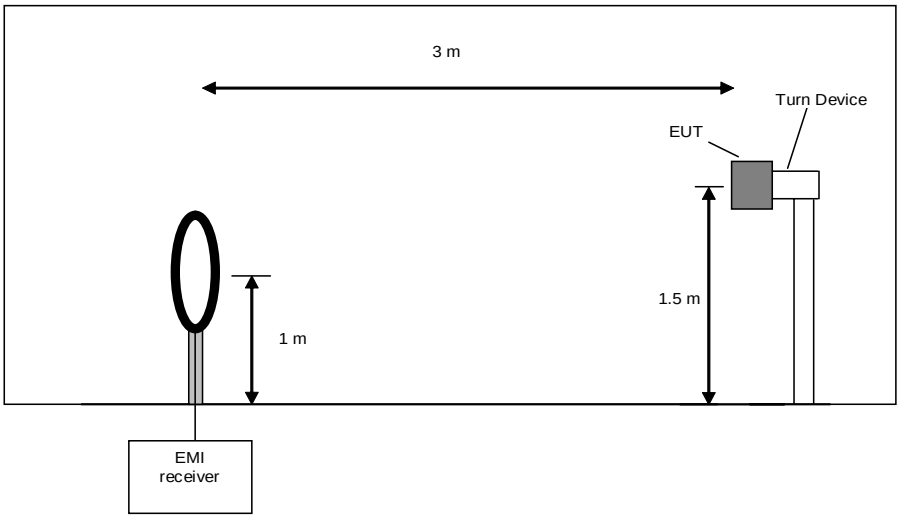
Preliminary measurement (9 kHz to 30 MHz):

In the first stage a preliminary measurement will be performed in a shielded room with a measuring distance of 3 meters. Table top devices will set up on a non-conducting turn device on the height of 1.5m. Floor-standing devices will be placed directly on the turntable/ground plane. The set-up 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 analyzer while the system and its cables will be manipulated to find out the configuration with the maximum emission levels if applicable. The EMI Receiver will be set to MAX Hold mode. The EUT and the measuring antenna will be rotated around their vertical axis to found the maximum emissions.

The resolution bandwidth of the spectrum analyzer 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.

Pre-scans were performed in the frequency range 30 MHz to 230 MHz and 230 MHz to 1 GHz.
The following procedure will be used:

1. Monitor the frequency range at horizontal polarization 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. Repeat 1) to 3) with the vertical polarization of the measuring antenna.
5. Make a hardcopy of the spectrum.
6. Repeat 1) to 5) with the EUT raised by an angle of 0° (45°, 90°) according to 6.6.5.4 in [1].
7. Measure the frequency of the detected emissions with a lower span and resolution bandwidth to increase the accuracy and note the frequency value.

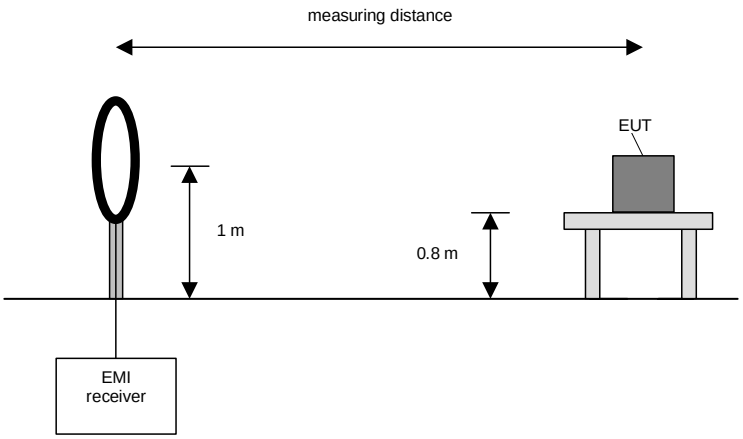
Final measurement (9 kHz to 30 MHz):

In the second stage a final measurement will be performed on an open area test site with no conducting ground plane in measuring distances of 3 m, 10 m and 30 m. In the case where larger measuring distances is 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 a 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) Rotate the measuring antenna and repeat steps 1) to 3) until the maximum value is found.
5) Repeat steps 1) to 4) with the other orthogonal axes of the EUT (if the EUT is a module and might be used in a handheld equipment application).

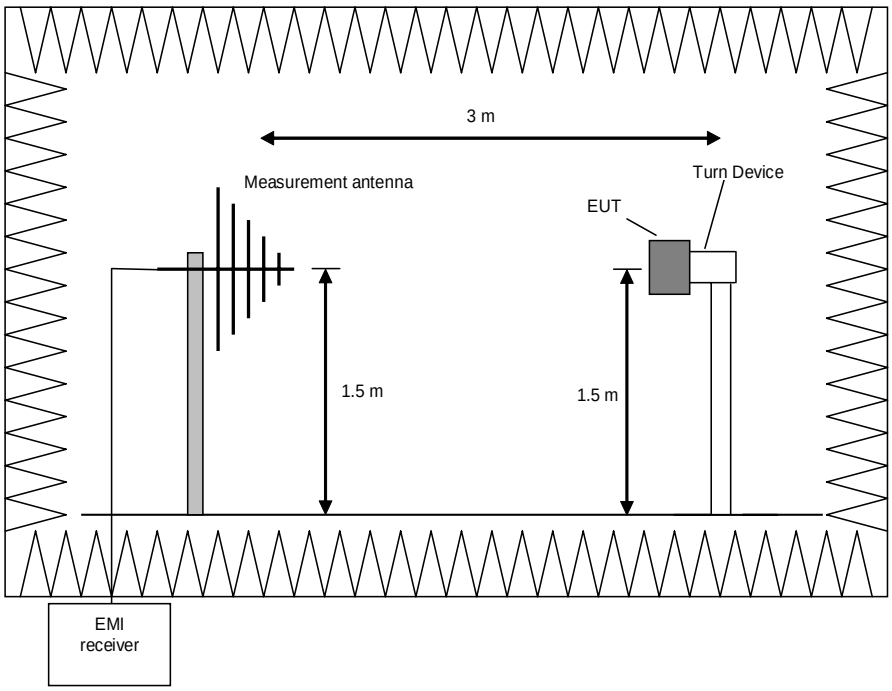
Preliminary measurement (30 MHz to 1 GHz)

In the first stage a preliminary measurement will be performed in a fully anechoic chamber with a measuring distance of 3 meter. Table top devices will set up on a non-conducting turn device on the height of 1.5m. 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 30 MHz to 1 GHz will be measured with an EMI Receiver set to MAX Hold mode and a resolution bandwidth of 100 kHz. The measurement will be performed in horizontal and vertical polarization of the measuring antenna and while rotating the EUT in its vertical axis in the range of 0 ° to 360 °. This measurement is repeated after raising the EUT in 30° steps according 6.6.5.4 in [1].

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

Frequency range	Resolution bandwidth
30 MHz to 230 MHz	100 kHz
230 MHz to 1 GHz	100 kHz



Procedure preliminary measurement:

Pre-scans were performed in the frequency range 30 MHz to 230 MHz and 230 MHz to 1 GHz.
The following procedure will be used:

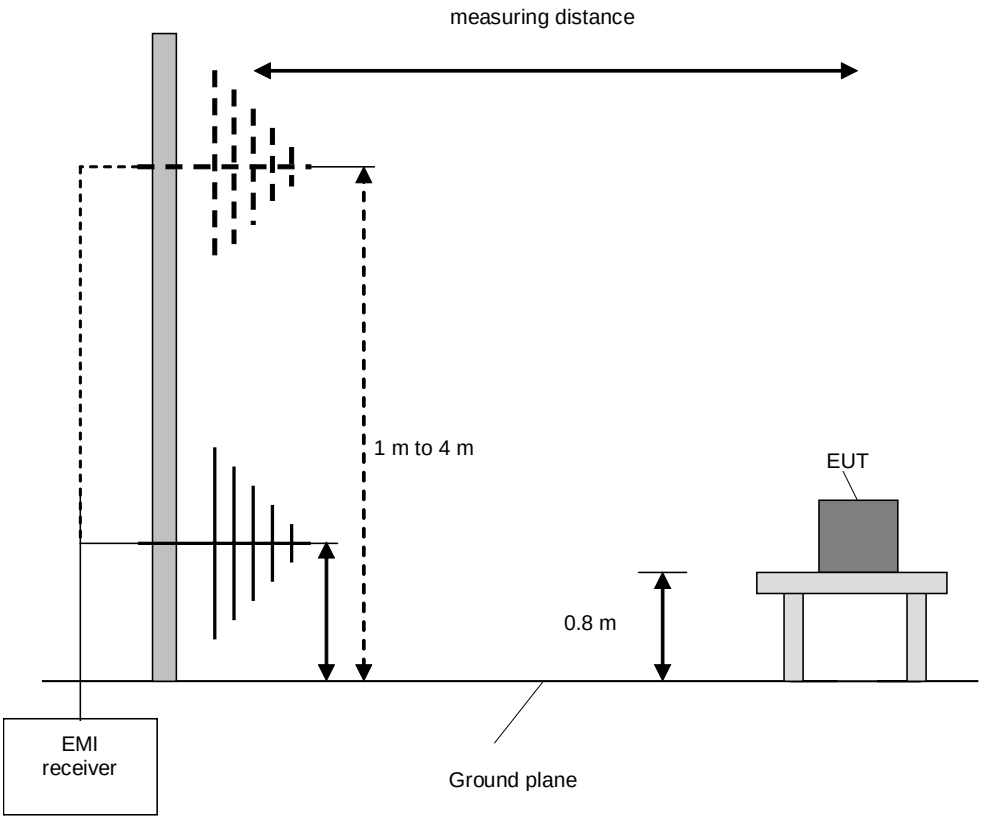
8. Monitor the frequency range at horizontal polarization and a EUT azimuth of 0 °.
9. Manipulate the system cables within the range to produce the maximum level of emission.
10. Rotate the EUT by 360 ° to maximize the detected signals.
11. Repeat 1) to 3) with the vertical polarization of the measuring antenna.
12. Make a hardcopy of the spectrum.
13. Repeat 1) to 5) with the EUT raised by an angle of 0° (45°, 90°) according to 6.6.5.4 in [1].
14. Measure the frequency of the detected emissions with a lower span and resolution bandwidth to increase the accuracy and note the frequency value.

Final measurement (30 MHz to 1 GHz)

A final measurement on an open area test site will be performed on selected frequencies found in the preliminary measurement. During this 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:

Frequency range	Resolution bandwidth
30 MHz to 1 GHz	120 kHz



Procedure final measurement:

The following procedure will be used:

1) Measure on the selected frequencies at an antenna height of 1 m and a EUT azimuth of 23 °.
2) Move the antenna from 1 m to 4 m and note the maximum value at each frequency.
3) Rotate the EUT by 45 ° and repeat 2) until an azimuth of 337 ° is reached.
4) Repeat 1) to 3) for the other orthogonal antenna polarization.
5) Move the antenna and the turntable to the position where the maximum value is detected.
6) Measure while moving the antenna slowly +/- 1 m.
7) Set the antenna to the position where the maximum value is found.
8) Measure while moving the turntable +/- 45 °.
9) Set the turntable to the azimuth where the maximum value is found.
10) Measure with Final detector (QP and AV) and note the value.
11) Repeat 5) to 10) for each frequency.
12) Repeat 1) to 11) for each orthogonal axes of the EUT (because of EUT is a module and might be used in a handheld equipment application).

Preliminary and final measurement (1 GHz to 40 GHz)

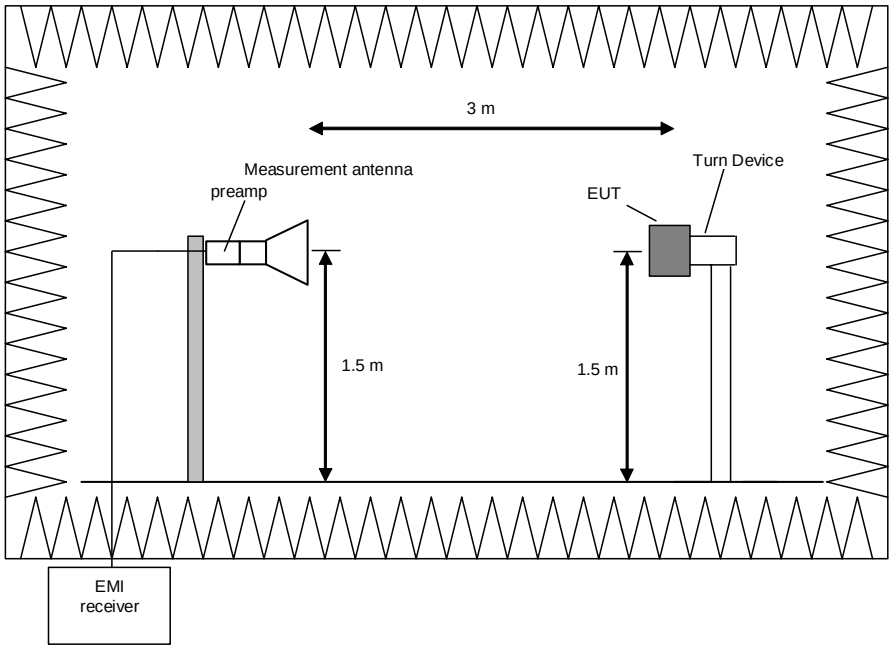
This measurement will be performed in a fully anechoic chamber. Table top devices will set up on a non-conducting turn device on the height of 1.5m. The set-up of the Equipment under test will be in accordance to [1].

Preliminary measurement (1 GHz to 40 GHz)

The frequency range will be divided into different sub ranges depending of the frequency range of the used horn antenna. The spectrum analyzer set to MAX Hold mode and a resolution bandwidth of 100 kHz. The measurement will be performed in horizontal and vertical polarization of the measuring antenna and while rotating the EUT in its vertical axis in the range of 0 ° to 360 °. This measurement is repeated after raising the EUT in 30° steps according 6.6.5.4 in [1].

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

Frequency range	Resolution bandwidth
1 GHz to 4 GHz	100 kHz
4 GHz to 12 GHz	100 kHz
12 GHz to 18 GHz	100 kHz
18 GHz to 25 / 26.5 GHz	100 kHz
26.5 GHz to 40 GHz	100 kHz



Procedure preliminary measurement:

Prescans were performed in the frequency range 1 to 40 GHz.
The following procedure will be used:

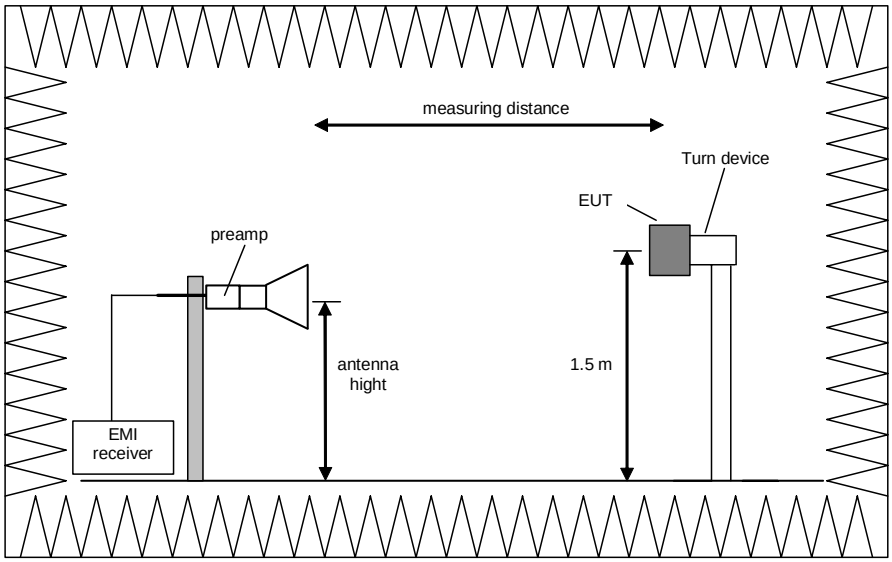
1. Monitor the frequency range at horizontal polarization and a EUT azimuth of 0 °.
2. Rotate the EUT by 360° to maximize the detected signals.
3. Repeat 1) to 2) with the vertical polarization of the measuring antenna.
4. Make a hardcopy of the spectrum.
5. Repeat 1) to 4) with the EUT raised by an angle of 30° (60°, 90°, 120° and 150°) according to 6.6.5.4 in [1].
6. Measure the frequency of the detected emissions with a lower span and resolution bandwidth to increase the accuracy and note the frequency value.
7. The measurement antenna polarization, with the according EUT position (Turntable and Turn device) which produces the highest emission for each frequency will be used for the final measurement. The six closest values to the applicable limit will be used for the final measurement.

Final measurement (1 GHz to 40 GHz)

The frequency range will be divided into different sub ranges depending of the frequency range of the used horn antenna. The EMI Receiver set to peak and average mode and a resolution bandwidth of 1 MHz. The measurement will be performed by rotating the turntable through 0 to 360° in the worst-case EUT orientation which was obtained during the preliminary measurements.

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

Frequency range	Resolution bandwidth
1 GHz to 4 GHz	1 MHz
4 GHz to 12 GHz	1 MHz
12 GHz to 18 GHz	1 MHz
18 GHz to 25 / 26.5 GHz	1 MHz
26.5 GHz to 40 GHz	1 MHz



Procedure of measurement:

The measurements were performed in the frequency ranges 1 GHz to 4 GHz, 4 GHz to 12 GHz, 12 GHz to 18 GHz, 18 GHz to 25 /26.5 GHz and 26.5 GHz to 40 GHz.
The following procedure will be used:

1) Set the turntable and the turn device to obtain the worst-case emission for the first frequency identified in the preliminary measurements.
2) Set the measurement antenna polarization to the orientation with the highest emission for the first frequency identified in the preliminary measurements.
3) Set the spectrum analyzer to EMI mode with peak and average detector activated.
4) Rotate the turntable from 0° to 360° to find the TT Pos. that produces the highest emissions.
5) Note the highest displayed peak and average values
6) Repeat the steps 1) to 5) for each frequency detected during the preliminary measurements.

5.6.4.1 Test results (radiated emissions)
5.6.4.1.1 Tested sample EVB-ANNA-B112U#117
5.6.4.1.1.1 Preliminary radiated emission measurement
5.6.4.1.1.1.1 Emissions below 1 GHz

Ambient temperature	22 °C
Relative humidity	58 %

Date	24.07.2018
Tested by	Ruben BRAUN

Position of EUT: The EUT was set-up on an EUT turn device of a height of 1.5 m. The distance between EUT and antenna was 3 m.

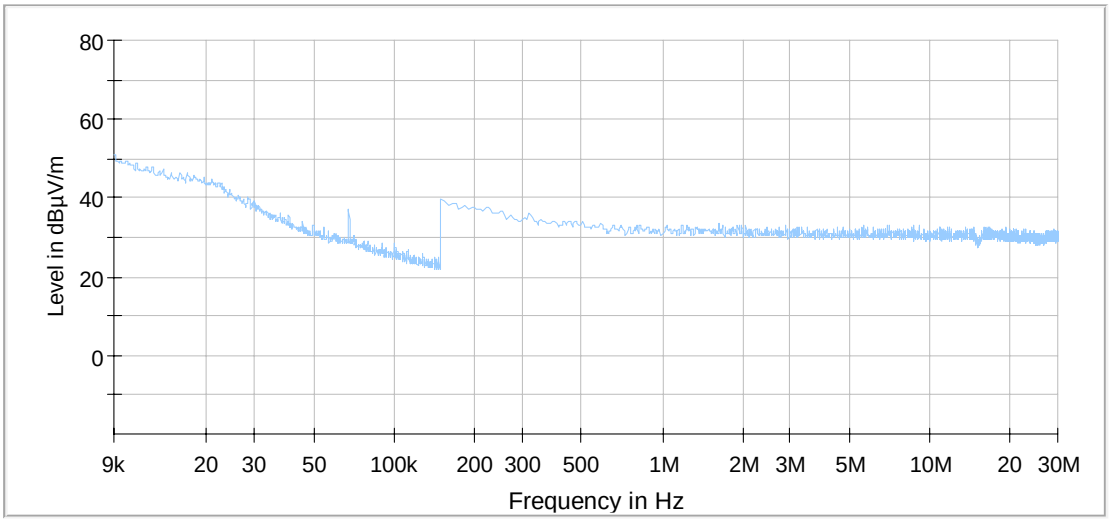
Cable guide: For detail information of test set-up and the cable guide refer to the pictures in Test setup Photo annex.

Test record: The results are shown in the following.

Supply voltage: During all measurements the host of the EUT was powered with 5 V DC via an USB cable.

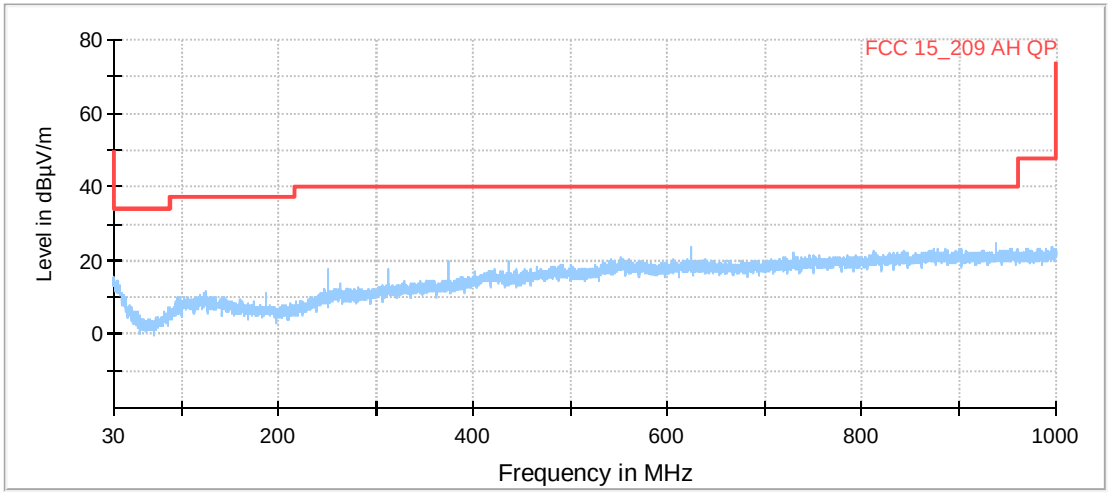
Remark: Document [1] states in 11.12.2.1, that in case of conducted measurements, additional radiated cabinet emission measurements must be performed.
The measurements for each frequency range were performed with the worst case modulation and transmit channel. The FXP75.07.0045B antenna was connected to the U.FL connector.

Spurious emissions from 9 kHz - 30 MHz; BLE 1 Mbps, Ch19
(Preliminary, no significant emission, no final measurement)



Remark: The emission at 68 kHz is caused by the measurement system and therefore not taken into account.

Spurious emissions from 30 MHz – 1 GHz; BLE 1 Mbps, Ch39



Preview Result 1-PK+
FCC 15_209 AH QP

5.6.4.1.1.2 Emissions above 1 GHz

Ambient temperature	22 °C
Relative humidity	45 %

Date	20.07.2018
Tested by	Ruben BRAUN

Position of EUT: The EUT was set-up on an EUT turn device of a height of 1.5 m. The distance between EUT and antenna was 3 m.

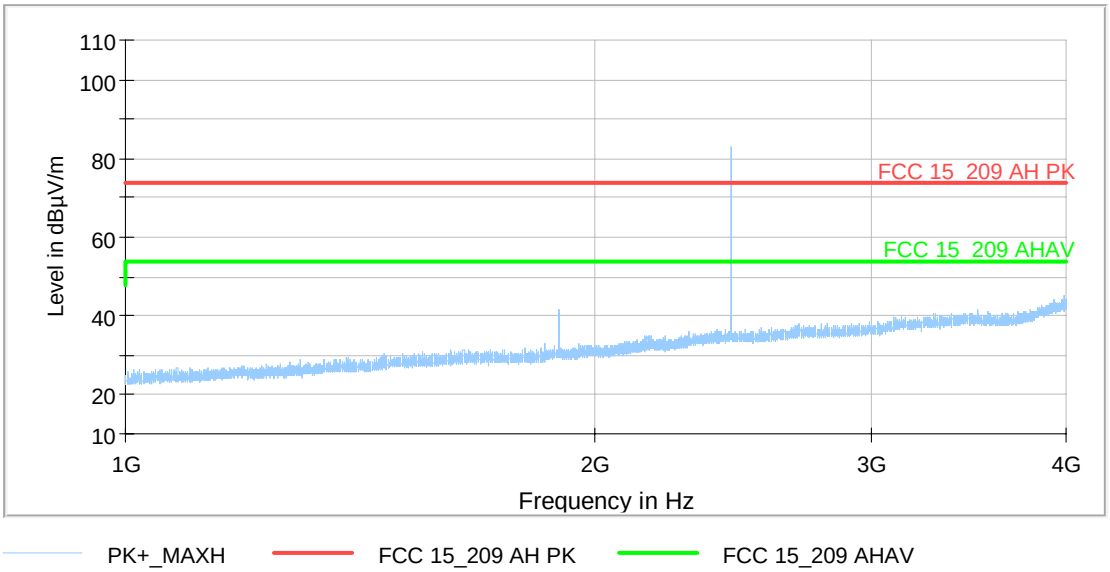
Cable guide: For detail information of test set-up and the cable guide refer to the pictures in Test setup Photo annex.

Test record: All results are shown in the following.

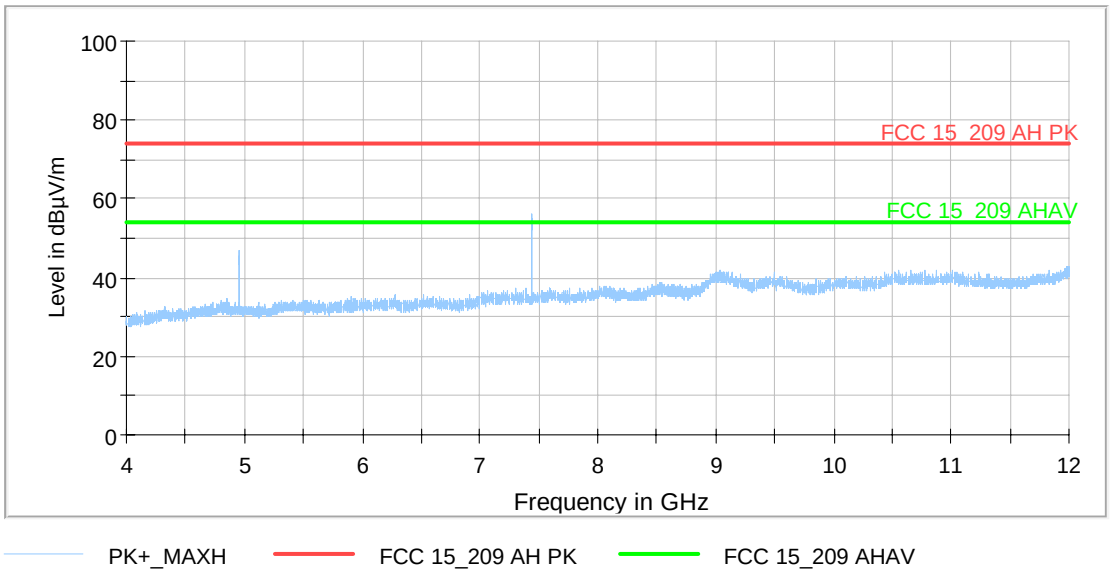
Supply voltage: During all measurements the host of the EUT was powered with 5 V DC via an USB cable.

Remark: Document [1] states in 11.12.2.1, that in case of conducted measurements, additional radiated cabinet emission measurements must be performed.
The measurements for each frequency range were performed with the worst case modulation and transmit channel. The FXP75.07.0045B antenna was connected to the U.FL connector.

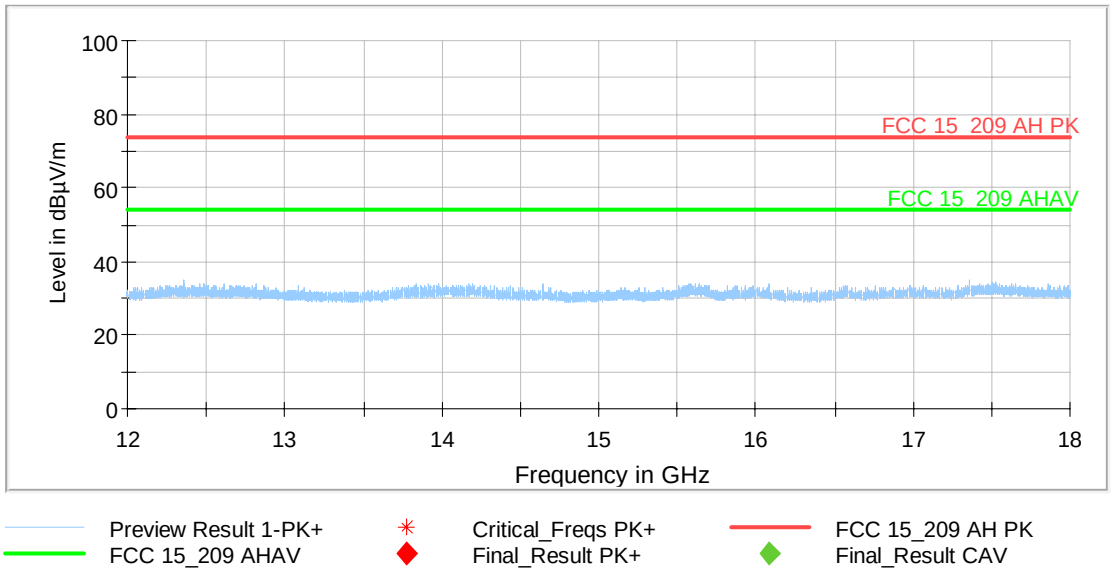
Spurious emissions from 1 – 4 GHz; BLE 1 Mbps, Ch19
(Preliminary and final plot)



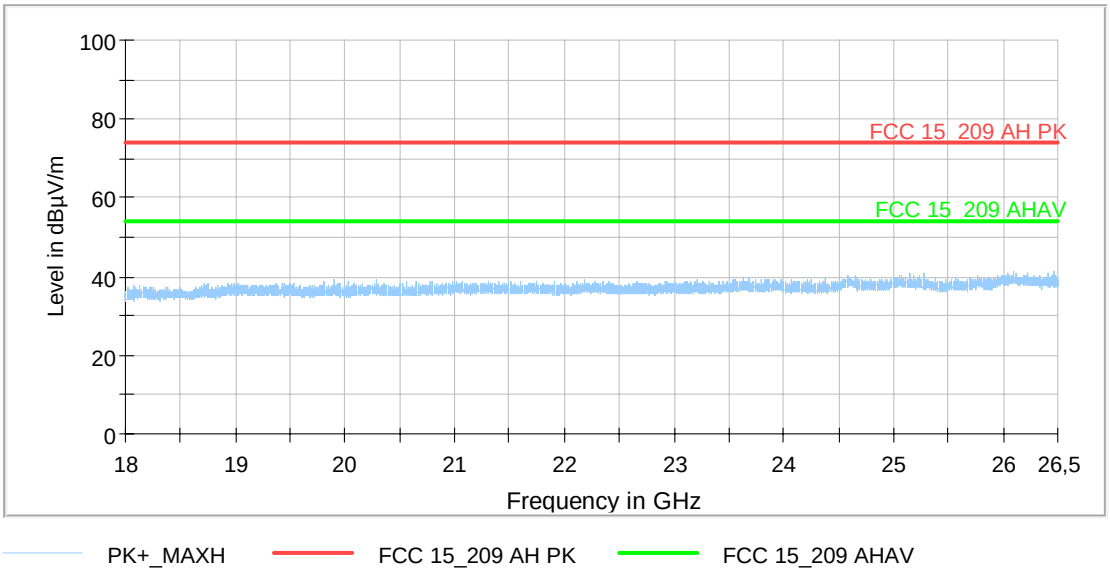
Spurious emissions from 4 – 12 GHz; BLE 1 Mbps, Ch39
(Preliminary and final plot)



Spurious emissions from 12 – 18 GHz; BLE 1 Mbps, Ch19
(Preliminary and final plot)



Spurious emissions from 18 – 26.5 GHz; BLE 1 Mbps, Ch19
(Preliminary and final plot)



Test equipment (please refer to chapter 6 for details)
2-10, 12-16, 21, 24-30

5.6.4.1.1.2 Final radiated emission measurement (9 kHz to 1 GHz)

Ambient temperature	29 °C	Date	23.08.2018
Relative humidity	56 %	Tested by	Paul NEUFELD

Position of EUT: The EUT was set-up on a non-conducting table of a height of 0.8 m. 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 test setup photos.

Test record: All results are shown in the following.

Supply voltage: During all measurements the host of the EUT was powered with 5 V DC via an USB cable.

Remark: The correction factor is calculated as Antenna Factor [dB] + Cable Attenuation [dB] - Amplifier Gain [dB]

The result Peak/Average is the result of Reading [dBµV/m] – Correction factor [dB]

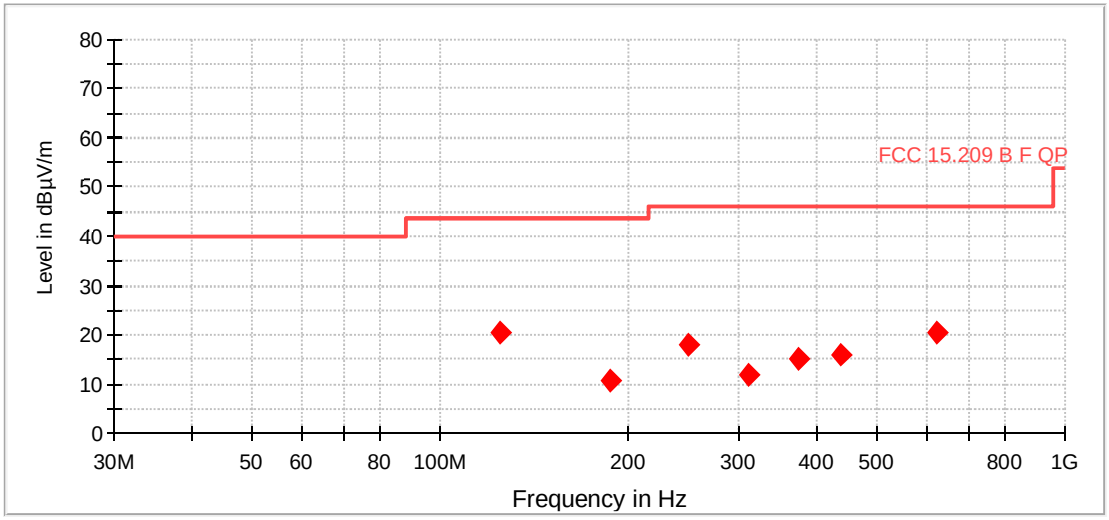
Document [1] states in 11.12.2.1, that in case of conducted measurements, additional radiated cabinet emission measurements must be performed.
The measurements for each frequency range were performed with the worst case modulation and transmit channel. The FXP75.07.0045B antenna was connected to the U.FL connector.

Spurious emissions from 9 kHz - 30 MHz; BLE 1 Mbps, Ch19

No significant emissions above the noise floor found below 30 MHz, no final measurement done.

Results 9kHz - 30 MHz								
Frequency [MHz]	Reading [dBµV]	Result [dBµV/m]	Limit acc. 15.209 [dBµV/m]	Margin [dB]	Detector (acc. to §15.209 (d)	Antenna factor [dB/m]	Measuring Distance [m]	Distance correction factor [dB]
No emission found								

Spurious emissions from 30 MHz – 1 GHz; BLE 1 Mbps, Ch39



FCC 15.209 B F QP Final_Result QPK

Results 30 MHz – 1 GHz									
Frequency [MHz]	QuasiPeak [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Meas. Time [ms]	Bandwidth [kHz]	Height [cm]	Pol	Azimuth [deg]	Corr. [dB]
124.999375	20.31	43.50	23.19	1000.0	120.000	109.0	V	77.0	19.0
187.503750	10.64	43.50	32.86	1000.0	120.000	109.0	V	306.0	16.4
249.947500	17.92	46.00	28.08	1000.0	120.000	115.0	V	61.0	20.5
312.451875	11.67	46.00	34.33	1000.0	120.000	372.0	V	245.0	21.9
375.016875	14.98	46.00	31.02	1000.0	120.000	107.0	V	277.0	23.6
437.521250	16.00	46.00	30.00	1000.0	120.000	365.0	V	250.0	25.8
624.973750	20.44	46.00	25.56	1000.0	120.000	393.0	V	315.0	30.2
Measurement uncertainty					+2.2 dB / -3.6 dB				

Test equipment (please refer to chapter 6 for details)
17-23

5.6.4.1.1.3 Final radiated emission measurement (1 GHz to 25 GHz)

Ambient temperature	22 °C
Relative humidity	45 %

Date	20.07.2018
Tested by	Ruben BRAUN

Position of EUT: The EUT was set-up on a EUT turn device of a height of 1.5 m. 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 test setup photos.

Test record: All results are shown in the following.

Supply voltage: During all measurements the host of the EUT was powered with 5 V DC via an USB cable.

Resolution bandwidth: For all measurements a resolution bandwidth of 1 MHz was used.

Additional information: For simplification all values were compared to the restricted band limits.

Remark: Document [1] states in 11.12.2.1, that in case of conducted measurements, additional radiated cabinet emission measurements must be performed.
The measurements for each frequency range were performed with the worst case modulation and transmit channel. The FXP75.07.0045B antenna was connected to the U.FL connector.

Results 1 – 25 GHz									
			Duty cycle correction factor of 0.67 dB was applied for the Average reading						
Frequency	Max Peak	Average	Limit	Margin	Pol	Azimuth	Elevation	Correction	Result
[MHz]	[dBµV/m]	[dBµV/m]	[dBµV/m]	dB		[°]	[°]	[dB]	
1893.600000	---	28.29	54.00	25.71	V	299.0	0.0	31.4	Passed
1893.600000	40.04	---	74.00	33.96	V	299.0	0.0	30.7	Passed
4880.400000	---	43.77	54.00	10.23	V	133.0	90.0	-0.8	Passed
4880.400000	51.43	---	74.00	22.57	V	133.0	90.0	-1.5	Passed
7320.640000	---	52.89	54.00	1.11	V	298.0	30.0	5.7	Passed
7320.640000	60.49	---	74.00	13.51	V	298.0	30.0	5.0	Passed
Measurement uncertainty			+2.2 dB / -3.6 dB						

Test equipment (please refer to chapter 6 for details)
2-10, 15, 21, 24-30

5.6.4.1.2 Tested sample EVB-ANNA-B112C#143

5.6.4.1.2.1 Preliminary radiated emission measurement

5.6.4.1.2.1.1 Emissions below 1 GHz

Ambient temperature	22 °C
Relative humidity	58 %

Date	24.07.2018
Tested by	Ruben BRAUN

Position of EUT: The EUT was set-up on an EUT turn device of a height of 1.5 m. 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 Test setup Photo annex.

Test record: All results are shown in the following.

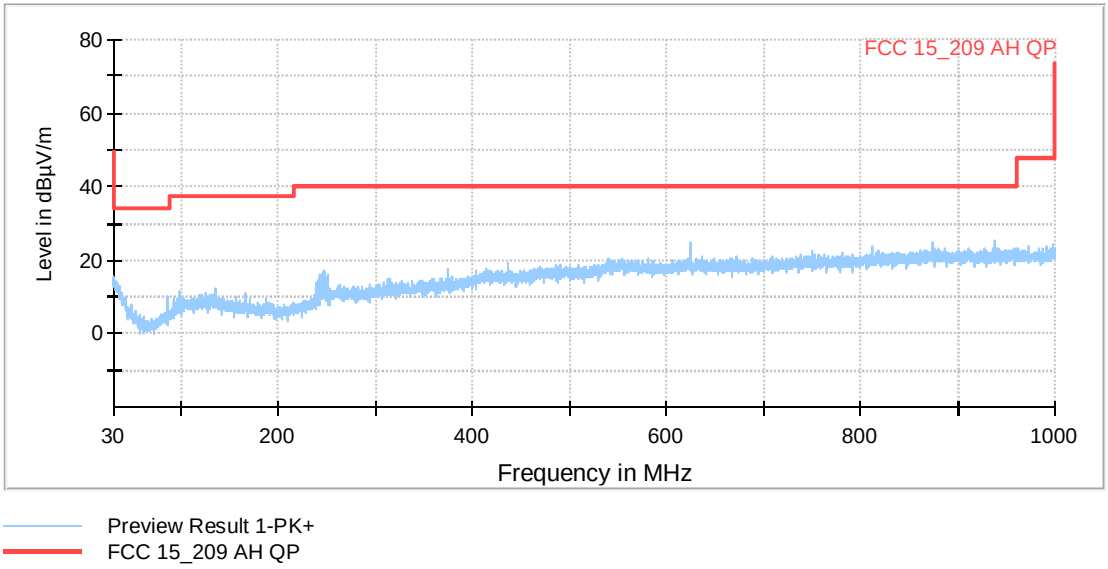
Supply voltage: During all measurements the host of the EUT was powered with 5 V DC via an USB cable.

Remark: The EVB-ANNA-B112C#143 with internal antenna was tested completely radiated.

The measurements for each frequency range were performed with the worst case modulation and transmit channel.

Because no emissions were found in the frequency range from 9 kHz to 30 MHz using the sample EVB-ANNA B112U#117, no measurements were carried out using the EVB-ANNA-B112C#143 sample.

Spurious emissions from 30 MHz – 1 GHz; BLE 1 Mbps, Ch00



5.6.4.1.2.1.2 Emissions above 1 GHz

Ambient temperature	22 °C
Relative humidity	45 %

Date	20.07.2018
Tested by	Ruben BRAUN

Position of EUT: The EUT was set-up on an EUT turn device of a height of 1.5 m. 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 Test setup Photo annex.

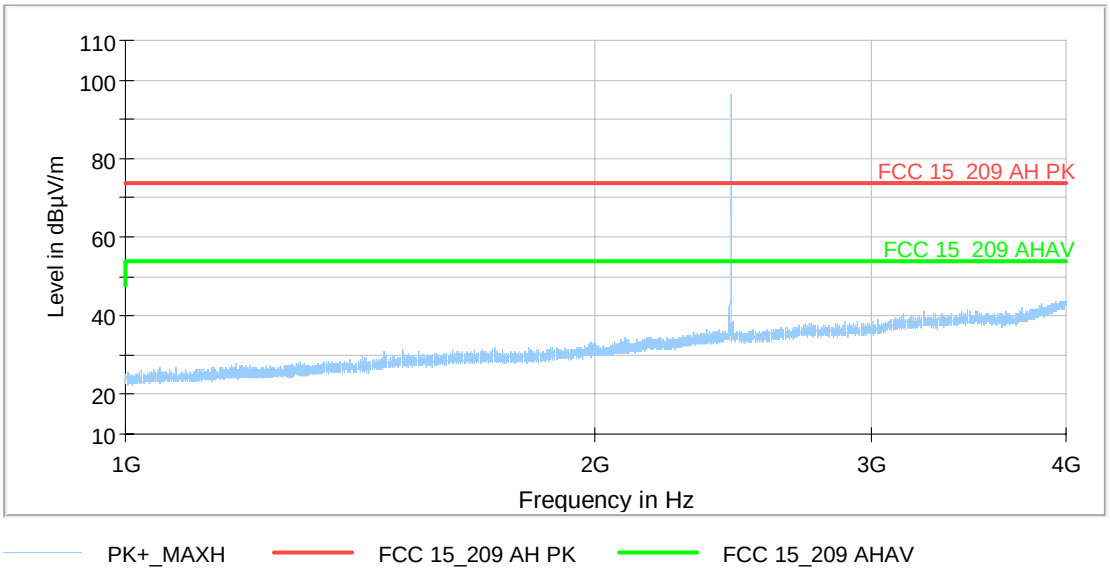
Test record: All results are shown in the following.

Supply voltage: During all measurements the host of the EUT was powered with 5 V DC via an USB cable.

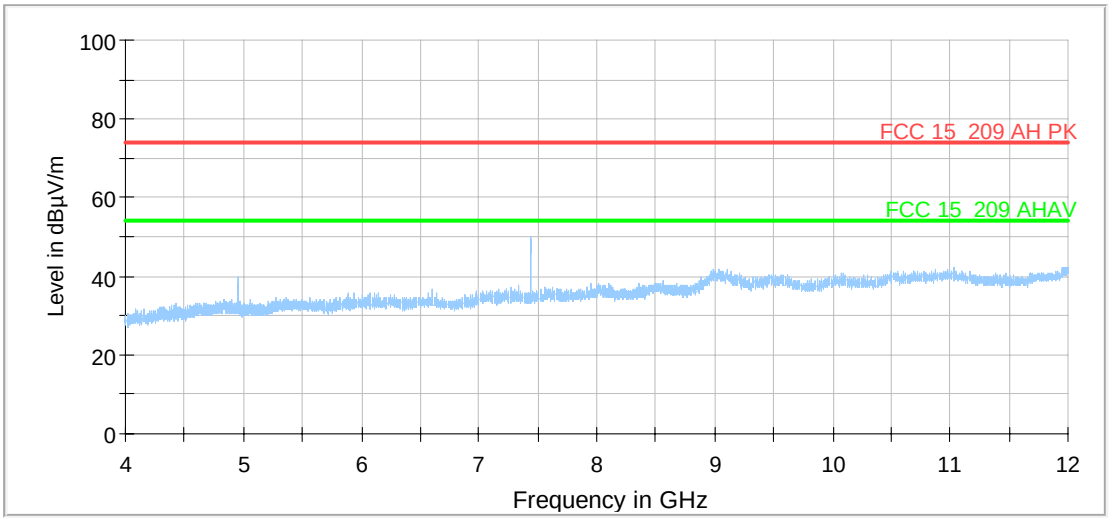
Remark: The EVB-ANNA-B112C#143 with internal antenna was tested completely radiated.

The measurements for each frequency range were performed with the worst case modulation and transmit channel.

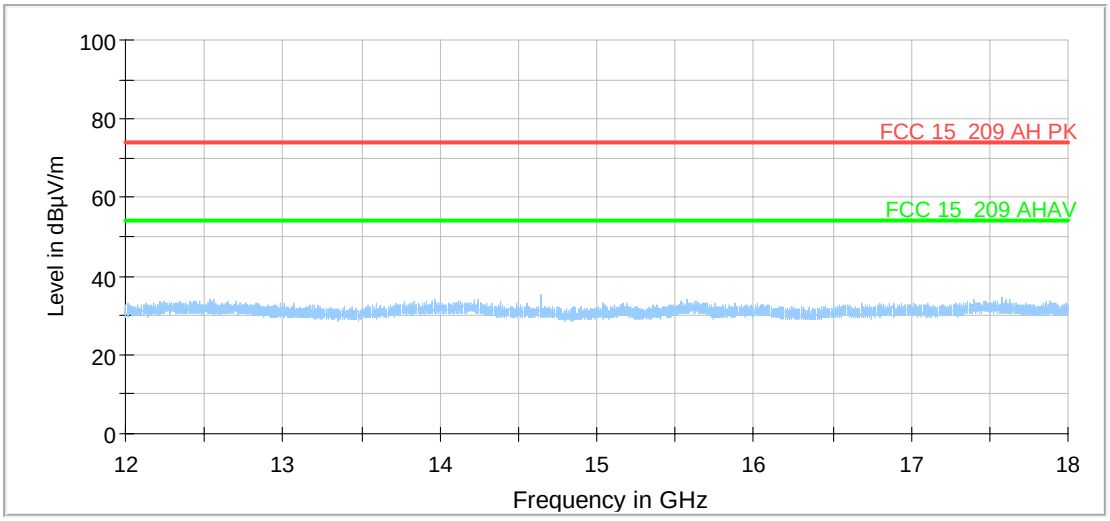
Spurious emissions from 1 – 4 GHz; BLE 1 Mbps, Ch19
(Preliminary and final plot)



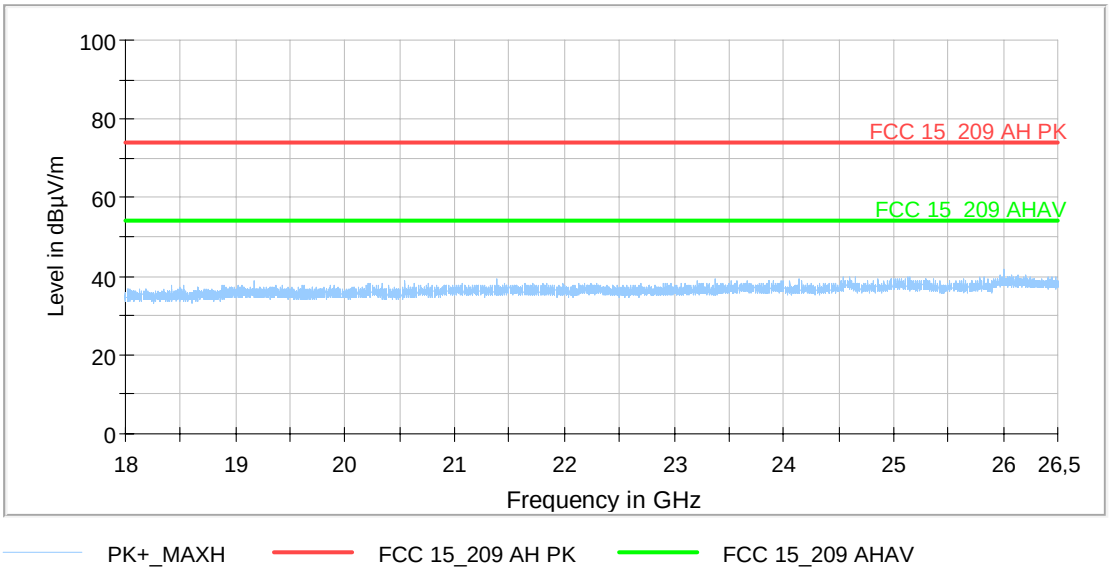
Spurious emissions from 4 – 12 GHz; BLE 1 Mbps, Ch39
(Preliminary and final plot)



Spurious emissions from 12 – 18 GHz; BLE 1 Mbps, Ch19
(Preliminary and final plot)



Spurious emissions from 18 – 26.5 GHz; BLE 1 Mbps, Ch19
(Preliminary and final plot)



Test equipment (please refer to chapter 6 for details)
2-10, 12-13, 15, 21, 24-30

5.6.4.1.2.2 Final radiated emission measurement (9 kHz to 1 GHz)

Ambient temperature	29 °C
Relative humidity	56 %

Date	23.08.2018
Tested by	Paul NEUFELD

Position of EUT: The EUT was set-up on a non-conducting table of a height of 0.8 m. 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 test setup photos.

Test record: All results are shown in the following.

Supply voltage: During all measurements the host of the EUT was powered with 5 V DC via an USB cable from the ancillary laptop.

Remark The correction factor is calculated as Antenna Factor [dB] + Cable Attenuation [dB] - Amplifier Gain [dB]

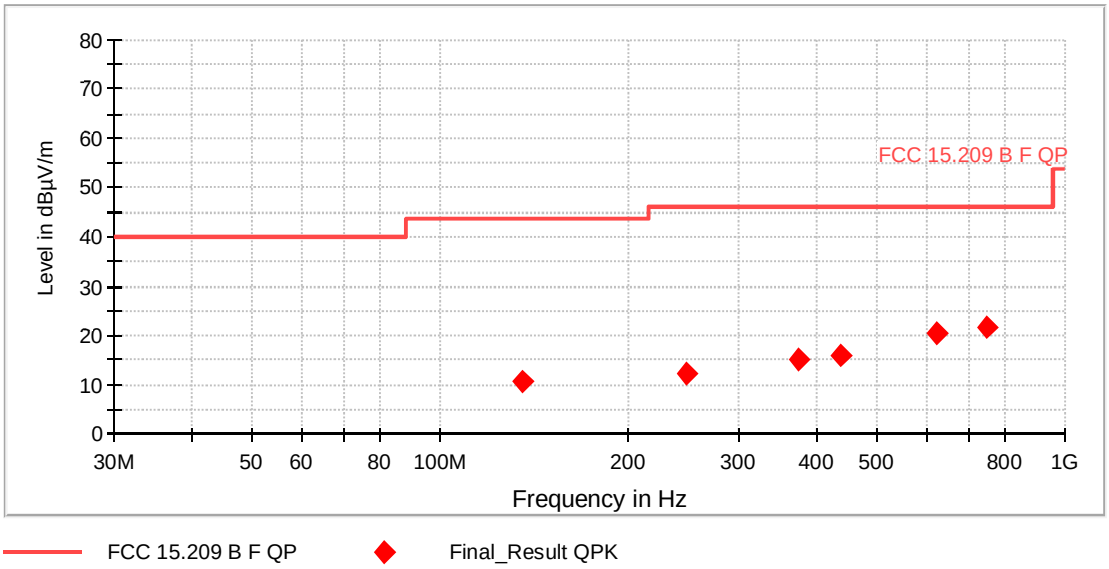
The result Peak/Average is the result of Reading [dBµV/m] – Correction factor [dB]

The EVB-ANNA-B112C#143 with internal antenna was tested completely radiated.

The measurements for each frequency range were performed with the worst case modulation and transmit channel.

Because no emissions were found in the frequency range from 9 kHz to 30 MHz using the sample EVB-ANNA B112U#117, no measurements were carried out using the EVB-ANNA-B112C#143 sample.

Spurious emissions from 30 MHz – 1 GHz; BLE 1 Mbps, Ch00



Results 30 MHz – 1 GHz									
Frequency [MHz]	QuasiPeak [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Meas. Time [ms]	Bandwidth [kHz]	Height [cm]	Pol	Azimuth [deg]	Corr. [dB]
135.730000	10.51	43.50	32.99	1000.0	120.000	389.0	V	196.0	19.0
247.401250	12.20	46.00	33.80	1000.0	120.000	100.0	H	319.0	20.1
375.016875	14.93	46.00	31.07	1000.0	120.000	104.0	V	42.0	23.6
437.460625	15.95	46.00	30.05	1000.0	120.000	374.0	V	156.0	25.8
624.973750	20.58	46.00	25.42	1000.0	120.000	366.0	V	154.0	30.2
750.043125	21.75	46.00	24.25	1000.0	120.000	400.0	H	94.0	32.2
Measurement uncertainty					+2.2 dB / -3.6 dB				

Test equipment (please refer to chapter 6 for details)
17-23

5.6.4.1.2.3 Final radiated emission measurement (1 GHz to 25 GHz)

Ambient temperature	22 °C
Relative humidity	45 %

Date	20.07.2018
Tested by	Ruben BRAUN

Position of EUT: The EUT was set-up on an EUT turn device of a height of 1.5 m. 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 test setup photos.

Test record: All results are shown in the following.

Supply voltage: During all measurements the host of the EUT was powered with 5 V DC via an USB cable.

Resolution bandwidth: For all measurements a resolution bandwidth of 1 MHz was used.

Additional information: For simplification all values were compared to the restricted band limits.

Remark: The EVB-ANNA-B112C#143 with internal antenna was tested completely radiated.

The measurements for each frequency range were performed with the worst case modulation and transmit channel.

Results 1 – 25 GHz									
			Duty cycle correction factor of 0.67 dB was applied for the Average reading						
Frequency [MHz]	Max Peak [dBµV/m]	Average [dBµV/m]	Limit [dBµV/m]	Margin dB	Pol	Azimuth [°]	Elevation [°]	Correction [dB]	Result
4959.474005	---	35.86	54.00	18.14	V	224.0	29.0	-0.8	4959.474005
4959.474005	46.51	---	74.00	27.49	V	224.0	29.0	-1.5	4959.474005
7440.654995	---	46.66	54.00	7.34	V	303.0	150.0	5.7	7440.654995
7440.654995	54.86	---	74.00	19.14	V	303.0	150.0	5.0	7440.654995
Measurement uncertainty				+2.2 dB / -3.6 dB					

Test equipment (please refer to chapter 6 for details)
2-10, 15, 21, 24-30

5.6.4.1.3 Tested sample REF-ANNA-B112E#6

5.6.4.1.3.1 Preliminary radiated emission measurement

5.6.4.1.3.1.1 Emissions below 1 GHz

Ambient temperature	22 °C
Relative humidity	58 %

Date	24.07.2018
Tested by	Ruben BRAUN

Position of EUT: The EUT was set-up on an EUT turn device of a height of 1.5 m. 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 Test setup Photo annex.

Test record: All results are shown in the following.

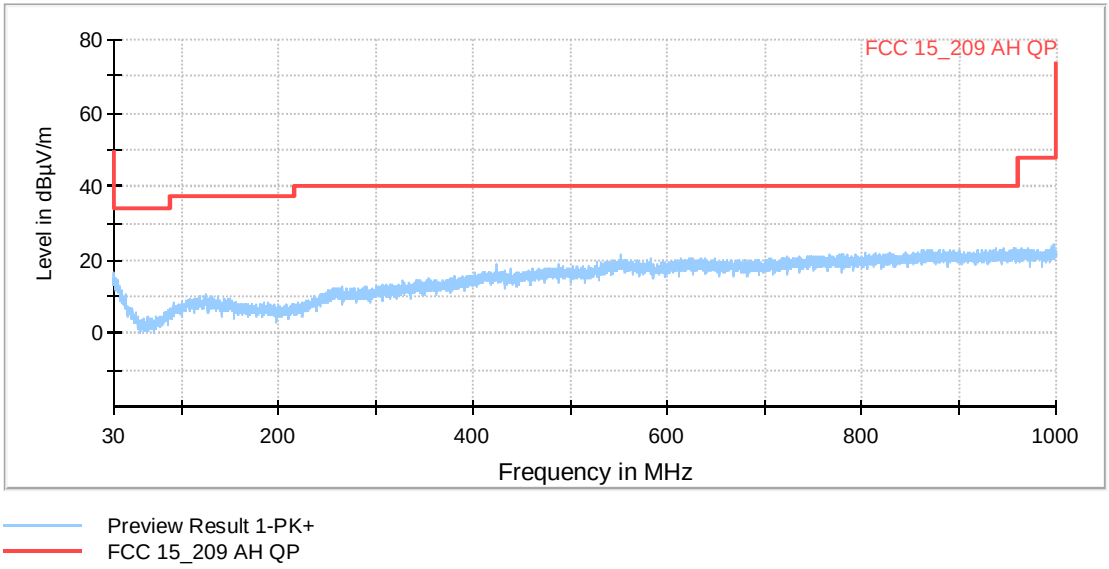
Supply voltage: During all measurements the host of the EUT was powered with 3.3 V DC via an external power supply.

Remark: The REF-ANNA-B112E#6 with internal antenna was tested completely radiated.

The measurements for each frequency range were performed with the worst case modulation and transmit channel.

Because no emissions were found in the frequency range from 9 kHz to 30 MHz using the sample EVB-ANNA B112U#117, no measurements were carried out using the REF-ANNA-B112E#6 sample.

Spurious emissions from 30 MHz – 1 GHz; BLE 1 Mbps, Ch19



5.6.4.1.3.1.2 Emissions above 1 GHz

Ambient temperature	22 °C
Relative humidity	56 %

Date	23.07.2018
Tested by	Ruben BRAUN

Position of EUT: The EUT was set-up on an EUT turn device of a height of 1.5 m. 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 Test setup Photo annex.

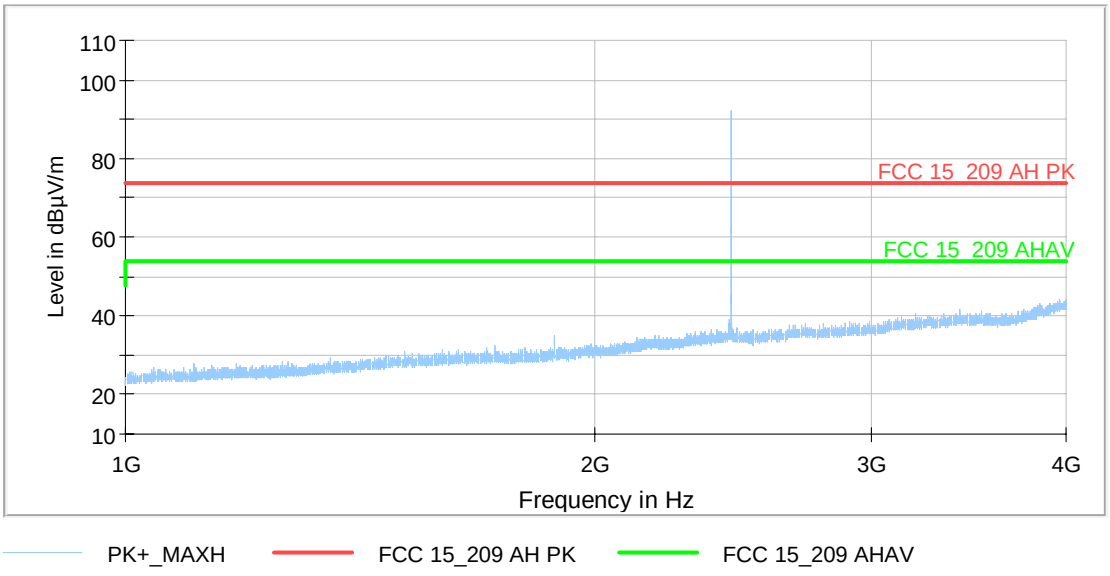
Test record: All results are shown in the following.

Supply voltage: During all measurements the host of the EUT was powered with 3.3 V DC via an external power supply.

Remark: The REF-ANNA-B112E#6 with internal antenna was tested completely radiated.

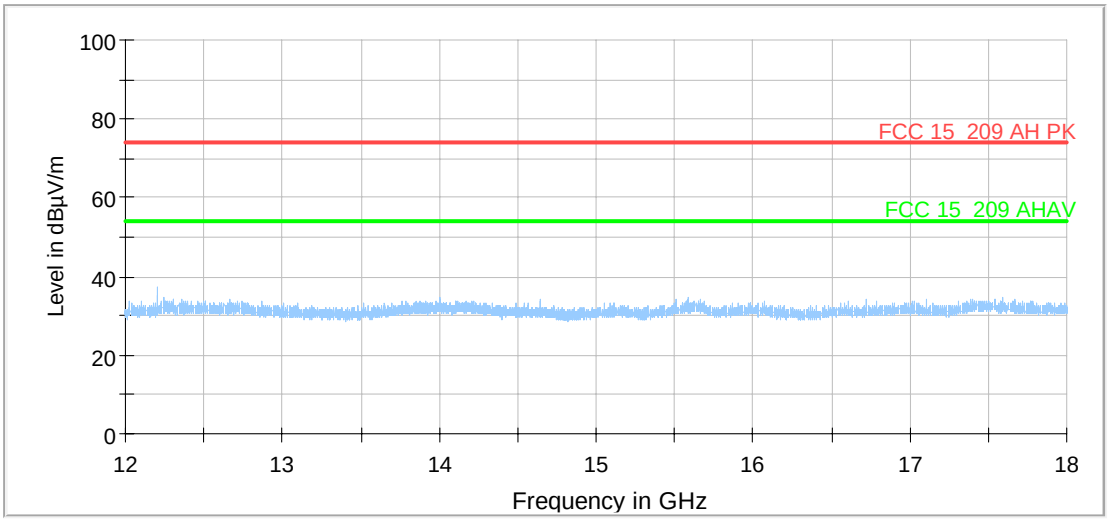
The measurements for each frequency range were performed with the worst case modulation and transmit channel.

Spurious emissions from 1 – 4 GHz; BLE 1 Mbps, Ch19
(Preliminary and final plot)

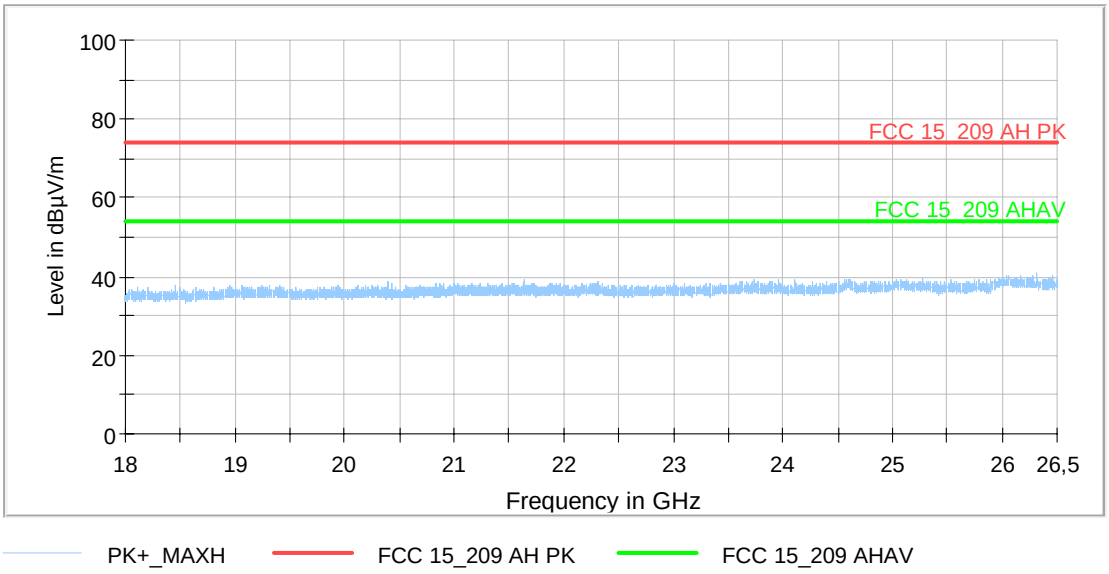


Spurious emissions from 4 – 12 GHz; BLE 1 Mbps, Ch00
(Preliminary and final plot)

Spurious emissions from 12 – 18 GHz; BLE 1 Mbps, Ch19
(Preliminary and final plot)



Spurious emissions from 18 – 26.5 GHz; BLE 1 Mbps, Ch19
(Preliminary and final plot)



Test equipment (please refer to chapter 6 for details)
2-10, 12-13, 15, 21, 24-30

5.6.4.1.3.2 Final radiated emission measurement (9 kHz to 1 GHz)

Ambient temperature	29 °C
Relative humidity	56 %

Date	23.08.2018
Tested by	Paul NEUFELD

Position of EUT: The EUT was set-up on a non-conducting table of a height of 0.8 m or an EUT turn device of a height of 1.5 m. 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 test setup photos.

Test record: All results are shown in the following.

Supply voltage: During all measurements the host of the EUT was powered with 3.3 V DC via an external power supply.

Remark The correction factor is calculated as Antenna Factor [dB] + Cable Attenuation [dB] - Amplifier Gain [dB]

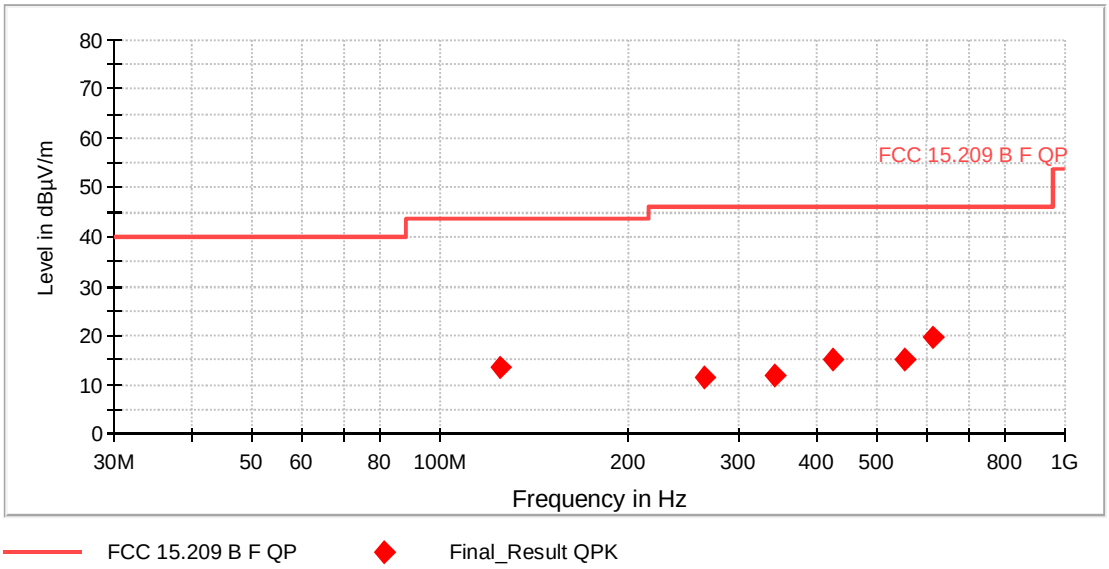
The result Peak/Average is the result of Reading [dBµV/m] – Correction factor [dB]

The REF-ANNA-B112E#6 with internal antenna was tested completely radiated.

The measurements for each frequency range were performed with the worst case modulation and transmit channel.

Because no emissions were found in the frequency range from 9 kHz to 30 MHz using the sample EVB-ANNA B112U#117, no measurements were carried out using the REF-ANNA-B112E#6 sample.

Spurious emissions from 30 MHz – 1 GHz; BLE 1 Mbps, Ch19



Results 30 MHz – 1 GHz									
Frequency [MHz]	QuasiPeak [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Meas. Time [ms]	Bandwidth [kHz]	Height [cm]	Pol	Azimuth [deg]	Corr. [dB]
124.575000	13.37	43.50	30.13	1000.0	120.000	134.0	V	332.0	19.0
264.800625	11.50	46.00	34.50	1000.0	120.000	130.0	V	289.0	21.4
342.461250	11.81	46.00	34.19	1000.0	120.000	160.0	V	136.0	22.7
424.244375	15.23	46.00	30.77	1000.0	120.000	107.0	V	338.0	25.6
552.466250	15.92	46.00	30.08	1000.0	120.000	246.0	V	160.0	29.7
613.273125	19.71	46.00	26.29	1000.0	120.000	108.0	V	283.0	29.7
Measurement uncertainty					+2.2 dB / -3.6 dB				

Remark: Due to an external interferer, the final measurement at 552.466 MHz could not be carried out. The result of the preliminary measurement were taken instead as the final result.

Test equipment (please refer to chapter 6 for details)
17-23

5.6.4.1.3.3 Final radiated emission measurement (1 GHz to 25 GHz)

Ambient temperature	22 °C
Relative humidity	56 %

Date	23.07.2018
Tested by	Ruben BRAUN

Position of EUT: The EUT was set-up on an EUT turn device of a height of 1.5 m. 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 test setup photos.

Test record: All results are shown in the following.

Supply voltage: During all measurements the host of the EUT was powered with 3.3 V DC via an external power supply.

Resolution bandwidth: For all measurements a resolution bandwidth of 1 MHz was used.

Additional information: For simplification all values were compared to the restricted band limits.

Remark: The REF-ANNA-B112E#6 with internal antenna was tested completely radiated.

The measurements for each frequency range were performed with the worst case modulation and transmit channel.

Results 1 – 25 GHz									
			Duty cycle correction factor of 0.67 dB was applied for the Average reading						
Frequency [MHz]	Max Peak [dBµV/m]	Average [dBµV/m]	Limit [dBµV/m]	Margin dB	Pol	Azimuth [°]	Elevation [°]	Correction [dB]	Result
1881.500000	---	27.59	54.00	26.41	H	76.0	0.0	30.6	1881.500000
1881.500000	40.08	---	74.00	33.92	H	76.0	0.0	30.6	1881.500000
4803.920000	---	35.54	54.00	18.46	H	64.0	0.0	-1.7	4803.920000
4803.920000	46.65	---	74.00	27.35	H	64.0	0.0	-1.7	4803.920000
7206.720000	59.54	---	74.00	14.46	V	264.0	89.0	4.4	7206.720000
7206.720000	---	51.61	54.00	2.39	V	264.0	89.0	4.4	7206.720000
Measurement uncertainty				+2.2 dB / -3.6 dB					

Test equipment (please refer to chapter 6 for details)
2-10, 15, 21, 24-30

5.7 Conducted emissions on power supply lines (150 kHz to 30 MHz)

Ambient temperature	22 °C
Relative humidity	54 %

Date	27.08.2018
Tested by	Ruben Braun

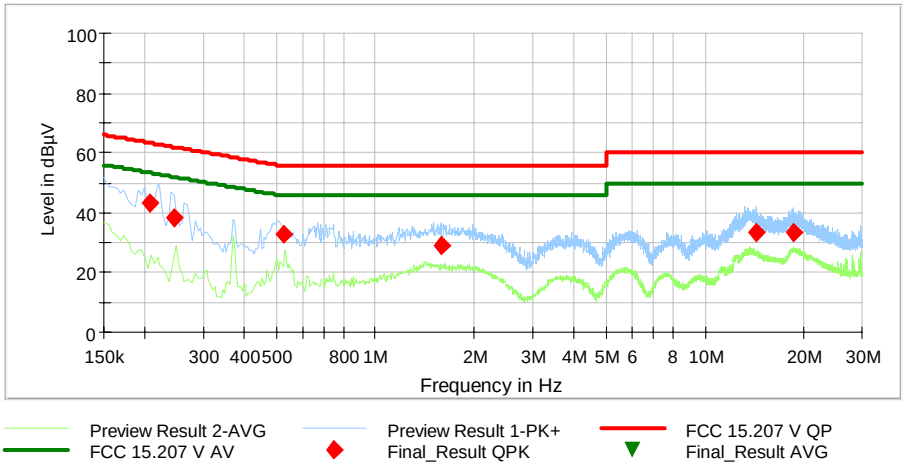
Position of EUT: Tabletop equipment, see photos in annex A of this test report

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

Test record: All results are shown in the following.

Supply voltage: Measurement performed with US 120V/60Hz. For the test the EUT was connected to an ancillary laptop (see *Ancillary Equipment*, chapter 1.4).
The power supply provided 19 V DC to the laptop.

The curves in the diagram 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	Corr. [dB]
0.205800	43.24	---	63.37	20.13	5000.0	9.000	L1	GND	9.8
0.243600	38.16	---	61.97	23.81	5000.0	9.000	L1	GND	9.9
0.524400	32.92	---	56.00	23.08	5000.0	9.000	L1	FLO	9.9
1.585500	29.02	---	56.00	26.98	5000.0	9.000	N	GND	9.9
14.277300	33.36	---	60.00	26.64	5000.0	9.000	L1	FLO	10.7
18.674700	33.53	---	60.00	26.47	5000.0	9.000	N	GND	10.9

Test equipment (please refer to chapter 6 for details)
31-34

6 Test Equipment used for Tests

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal Due
1	Spectrum Analyzer	FSU46	Rohde & Schwarz	200125	480956	01.03.2018	03.2019
2	Signal & Spectrum Analyzer	FSW43	Rohde & Schwarz	100586 & 100926	481720	15.03.2018	03.2020
3	Antenna mast	AS615P	Deisel	615/310	480187	Calibration not necessary	
4	Fully anechoic chamber M20	B83117-E2439-T232	Albatross Projects	103	480303	Calibration not necessary	
5	Turntable	DS420 HE	Deisel	420/620/00	480315	Calibration not necessary	
6	RF-cable No.3	Sucoflex 106B	Suhner	0563/6B / Kabel 3	480670	Calibration not necessary	
7	Multiple Control Unit	MCU	Maturo GmbH	MCU/043/971107	480832	Calibration not necessary	
8	Antenna (Log.Per.)	HL050	Rohde & Schwarz	100438	481170	09.10.2017	10.2020
9	RF-Cable No. 40	Sucoflex 106B	Suhner	0708/6B / Kabel 40	481330	Calibration not necessary	
10	HF-Cable	Sucoflex 104	Huber+Suhner	517406	482391	Calibration not necessary	
11	EMI Receiver / Spectrum Analyzer	ESW44	Rohde & Schwarz	101635	482467	22.06.2017	06.2019
12	Antenna (Bilog)	CBL6112B	Schaffner EMV GmbH (-Chase)	2688	480328	19.06.2017	06.2020
13	RF-cable No.36	Sucoflex 106B	Suhner	0587/6B / Kabel 36	480865	Calibration not necessary	
14	HF-Cable	Sucoflex 104	Huber+Suhner	517402	482392	Calibration not necessary	
15	Positioner	TDF 1.5- 10Kg	Maturo	15920215	482034	Calibration not necessary	
16	Loop antenna	HFH2-Z2	Rohde & Schwarz	100417	481912	19.12.2017	12.2018
17	Open area test site M6	Freifeld M6	Phoenix Contact	-	480085	Calibration not necessary	
18	Antenna mast	MA240-0	Inn-Co GmbH	MA240-0/030/6600603	480086	Calibration not necessary	
19	Turntable	DS412	Deisel	412/316	480087	Calibration not necessary	
20	Controller	HD100	Deisel	100/349	480139	Calibration not necessary	
21	Software	EMC32	Rohde & Schwarz	100061	481022	Calibration not necessary	
22	Antenna (Bilog)	CBL6111D	Schaffner Elektrotest GmbH / Teseq GmbH	25761	480894	19.10.2017	10.2020
23	EMI Measuring receiver	ESR7	Rohde & Schwarz	101939	482558	19.09.2017	09.2019
24	Standard gain horn antenna	18240-20	Flann Microwave	483	480294	Calibration not necessary	
25	Standard gain horn antenna	20240-20	Flann Microwave	411	480297	Calibration not necessary	
26	Microwave cable 2m	Insulated Wire Inc.	Insulated Wire	KPS-1533-800-KPS	480302	Calibration not necessary	
27	Preamplifier 100 MHz - 13 GHz	JS3-00101200-23-5A	MITEQ Hauppauge N.Y.	681851	480337	14.03.2018	03.2020
28	Preamplifier 18 GHz - 26 GHz	JS4-18002600-20-5A	MITEQ Hauppauge N.Y.	658697	480342	14.03.2018	03.2020

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal Due
29	Preamplifier 12 GHz - 18 GHz	JS3-12001800-16-5A	MITEQ Hauppauge N.Y.	571667	480343	14.03.2018	03.2020
30	High pass filter	WHKX4.0/18G-8SS	Wainwright Instruments GmbH	1	480587	Calibration not necessary	
31	LISN	NSLK8128	Schwarzbeck	8128161	480138	13.03.2018	03.2020
32	Shielded chamber M4	B83117-S1-X158	Siemens	190075	480088	Calibration not necessary	
33	EMI Receiver / Spectrum Analyzer	ESIB 26	Rohde & Schwarz	100292	481182	28.02.2018	02.2020
34	Transient Filter Limiter	CFL 9206A	Teseq GmbH	38268	481982	14.03.2018	03.2020

7 Report History

Report Number	Date	Comment
F181323E2	28.09.2018	Initial Test Report

8 List of Annexes

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181323_SetRadU1.JPG: Test setup fully anechoic chamber; EVB-ANNA-B112U#117
181323_SetRadU7.JPG: Test setup fully anechoic chamber; EVB-ANNA-B112U#117, 9 kHz – 30 MHz
181323_SetRadU8.JPG: Test setup fully anechoic chamber; EVB-ANNA-B112U#117, 30 MHz – 1 GHz
181323_SetRadU9.JPG: Test setup open area test site; EVB-ANNA-B112U#117, 30 MHz – 1 GHz
181323_SetRadU10.JPG: Test setup fully anechoic chamber; EVB-ANNA-B112U#117, 1 – 12 GHz
181323_SetRadU11.JPG: Test setup fully anechoic chamber; EVB-ANNA-B112U#117, 12 – 18 GHz
181323_SetRadU12.JPG: Test setup fully anechoic chamber; EVB-ANNA-B112U#117, 18 – 26.5 GHz
181323_SetRadC1.JPG: Test setup fully anechoic chamber; EVB-ANNA-B112C#143
181323_SetRadC7.JPG: Test setup fully anechoic chamber; EVB-ANNA-B112C#143, 30 MHz – 1 GHz
181323_SetRadC8.JPG: Test setup open area test site; EVB-ANNA-B112C#143, 30 MHz – 1 GHz
181323_SetRadC9.JPG: Test setup fully anechoic chamber; EVB-ANNA-B112C#143, 1 – 12 GHz
181323_SetRadC10.JPG: Test setup fully anechoic chamber; EVB-ANNA-B112C#143, 12 – 18 GHz
181323_SetRadC11.JPG: Test setup fully anechoic chamber; EVB-ANNA-B112C#143, 18 – 26.5 GHz
181323_SetRadE1.JPG: Test setup fully anechoic chamber; REF-ANNA-B112E#6
181323_SetRadE7.JPG: Test setup fully anechoic chamber; EVB-ANNA-B112E#6, 30 MHz – 1 GHz
181323_SetRadE8.JPG: Test setup open area test site; EVB-ANNA-B112E#6, 30 MHz – 1 GHz
181323_SetRadE9.JPG: Test setup fully anechoic chamber; EVB-ANNA-B112E#6,1 – 12 GHz
181323_SetRadE10.JPG: Test setup fully anechoic chamber; EVB-ANNA-B112E#6, 12 – 18 GHz
181323_SetRadE11.JPG: Test setup fully anechoic chamber; EVB-ANNA-B112E#143, 18 – 26.5 GHz
181323_SetMainsU1.JPG: Test setup mains conducted emissions; EVB-ANNA-B112U#117

Annex B External Photos 13 pages

181323_EUTU1.JPG: EVB-ANNA-B112U top view with NFC antenna
181323_EUTC2.JPG: EVB-ANNA-B112C top view with ANNA-B112 module (EUT), antenna reference design for module being mounted in the corner and without NFC antenna
181323_DetU1.JPG: Detail view of ANNA-B112 module (EUT) and U.FL port reference design
181323_EUTU3.JPG: EVB-ANNA-B112U bottom view
181323_EUTC1.JPG: EVB-ANNA-B112C top view with NFC antenna
181323_EUTC2.JPG: EVB-ANNA-B112C top view with ANNA-B112 module (EUT), antenna reference design for module being mounted in the corner and without NFC antenna
181323_DetC1.JPG: Detail view of ANNA-B112 module (EUT) and antenna reference design for module being mounted in the corner
181323_EUTC3.JPG: EVB-ANNA-B112C bottom view
181323_EUTE1.JPG: EVB-ANNA-B112E top view with ANNA-B112 module (EUT) and antenna reference design for module being mounted on the edge
181323_DetE1.JPG: Detail view of ANNA-B112 module (EUT) and antenna reference design for module being mounted on the edge
181323_EUTE2.JPG: EVB-ANNA-B112E bottom view
181323_NFCANT1.JPG: NFC antenna top view
181323_NFCANT2.JPG: NFC antenna bottom view

Annex C Internal Photos 3 pages

181323_EUT_Int1.JPG: EUT – Top view
181323_EUT_Int1.JPG: EUT – Bottom view
181323_EUT_Int3.JPG: EUT – Top view without shielding; Internal SMD antenna AT1608-A2R4NAA