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Test Report

Report Number:

F200507E1

Equipment under Test (EUT):

KROHNE Display 5 Bluetooth
Optimass Series

Applicant:

Krohne Messtechnik GmbH

Manufacturer:

Krohne Messtechnik GmbH

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

References

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

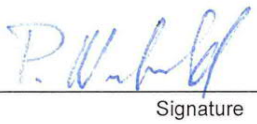
[2] **FCC CFR 47 Part 15**, Radio Frequency Devices

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

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

Test Result

The requirements of the tests performed as shown in the overview (clause 0) were fulfilled by the equipment under test.
The complete test results are presented in the following.

Test engineer:	Paul NEUFELD		14.08.2020
	Name	Signature	Date
Authorized reviewer:	Bernd STEINER		14.08.2020
	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.

This test report is valid in hardcopy form as well as in electronic form.

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1 Identification

1.1 Applicant

Name:	Krohne Messtechnik
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Country:	Germany
Name for contact purposes:	Mr. Wolfgang Kösters
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Applicant represented during the test by the following person:	Wolfgang Kösters

1.2 Manufacturer

Name:	Krohne Messtechnik
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Country:	Germany
Name for contact purposes:	Mr. Wolfgang Kösters
Phone:	+49 0203-301-4475
eMail Address:	w.koesters@krohne.com
Applicant represented during the test by the following person:	Wolfgang Kösters

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-17186-01-05 and D-PL-17186-01-06, FCC Test Firm Accreditation designation number DE0004, FCC Test Firm Registration Number 469623, CAB Identifier DE0003 and ISED# 3469A.

1.4 EUT (Equipment Under Test)

Test object: *	KROHNE Display 5 Bluetooth
Type / PMN: *	Optimass Series
FCC ID: *	2AV6K-KD5B
IC: *	1991B-KD5B
Serial number: *	Sample w. internal antenna: 014113892-078 Sample w. temporary antenna port: 014116162-013
EUT marking: *	014116754
PCB identifier: *	BOT-4007032202
HMN (Host Marketing Name): *	NA
HVIN (Hardware Version Identification Number): *	KD5B
FVIN (Firmware Version Identification Number): *	KD5B
Hardware version: *	4007844801
Software version: *	V1.0.0_00000592

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

Bluetooth Low Energy radio channels:

Channel 0	RX:	2402 MHz	TX:	2402 MHz
Channel 19	RX:	2440 MHz	TX:	2440 MHz
Channel 39	RX:	2480 MHz	TX:	2480 MHz

1.5 Technical Data of Equipment

Fulfills specifications: *	only Bluetooth 5 low energy					
Antenna type: *	OnBoard SMD Antenna					
Antenna name: *	PRO-OB-440					
Antenna gain: *	4.9 dBi					
Antenna connector: *	None					
Supply voltage 1 EUT: *	U_{nom}=	3.3 V DC	U_{min}=	3.1 V DC	U_{max}=	3.5 V DC
Supply voltage 2 EUT: *	U_{nom}=	10.0 V DC	U_{min}=	7.5 V DC	U_{max}=	12.5 V DC
Type of modulation: *	GFSK (1 Mbps only)*2					
Operating frequency range:*	Both units: 2402 – 2480 MHz					
Number of channels: *	40					
Temperature range: *	-40 °C to +85 °C					
Lowest / highest Internal clock frequency: *	32 kHz / 2480 MHz					

* Declared by the applicant
*2 As declared by the applicant, only the 1 Mbps mode will be activated and used in the firmware.

Ancillary Equipment	
Cables (connected to the EUT): *1	Serial cable connected to USB-Adapter Plus (XN00 02 110 0) by Krohne Messtechnik GmbH
Power adaptor: *1	Ribbon cable for power supply (3.3 + 10 V DC) During the test a 470 µF electrolyte capacitor was applied between the 3.3 V cable and ground to buffer the current draw of the EUT*4
Laptop PC:*1	Latitude E6520 by Dell Inc.
Host device:*1*3	Converter MFS400 connected to a remote sensor device (Optimass 6400)

*1 Provided by the applicant
*2 Provided by the test laboratory
*3 Only used for the power line conducted measurements.
*4 This capacitor was only necessary during the radiated measurements, since the filter of the anechoic chamber prevented the draw of fast current from the laboratory power supply outside the anechoic chamber.

1.6 Dates

Date of receipt of test sample:	06.05.2020
Start of test:	06.05.2020
End of test:	17.06.2020

2 Operational States

The EUT is a display unit with integrated Bluetooth Low Energy capability, which is intended to be implemented in various sensor devices for process automation. This test contains the test results on the EUT without a housing.

A connection to the EUT was established via a USB-Adapter Plus (XN00 02 110 0) by Krohne Messtechnik GmbH. The test modes were started using test software named “KROHNE xFC400S – Bluetooth Direct Test Mode Control” which was installed on a laptop PC provided by the applicant.

During the test PN9 pseudo random data was transmitted with 255 bytes packet length.

Maximum power Settings for all measurements:

Modulation	Power setting ch. 0 - 39
GFSK, 1 Mbps	9.6 dBm

Operation mode	Description of the operation mode	mode	channel	Modulation	Data rate / Mbps
1	Continuous transmitting on 2402 MHz	BLE	0	GFSK	1 Mbps
2	Continuous transmitting on 2440 MHz	BLE	19	GFSK	1 Mbps
3	Continuous transmitting on 2480 MHz	BLE	39	GFSK	1 Mbps

3 Additional Information

All tests were performed with an unmodified sample.

The in-band and unrestricted band-edge tests were performed using a sample with temporary antenna connector, which was provided by the applicant.

4 Overview

Application	Frequency range [MHz]	FCC 47 CFR Part 15 section [2]	RSS-247 [3] or RSS-Gen [4]	Status	Refer page
Maximum conducted output power	2400.0 - 2483.5	15.247 (b) (3), (4)	5.4 (d) [3]	Passed	9 et seq
DTS Bandwidth / 99% Bandwidth	2400.0 - 2483.5	15.247 (a) (2)	5.2 (a) [3]	Passed	11 et seq
Average Power Spectral Density	2400.0 - 2483.5	15.247 (e)	5.2 (b) [3]	Passed	14 et seq
Band edge compliance	2400.0 - 2483.5	15.247 (d) 15.205 (a) 15.209 (a)	5.5 [3]	Passed	16 et seq.
Maximum unwanted emissions	0.009 – 26,500	15.247 (d) 15.205 (a) 15.209 (a)	5.5 [3] 8.9 [4], 8.10 [4]	Passed	20 et seq.
Conducted emissions on supply line	0.15 - 30	15.207 (a)	8.8 [4]	Passed	31 et seq.

5 Results

5.1 Duty cycle

Since all tests were performed using a continuous signal without interruptions, no duty cycle measurement had to be performed

5.2 Maximum conducted output power

5.2.1 Method of measurement

The EUT was measured conducted on a sample with a temporary antenna connector, which was provided by the applicant.

Acceptable measurement configurations

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:

a) Measure the duty cycle D of the transmitter output signal as described in 11.6.
b) Set span to at least 1.5 times the OBW.
c) Set RBW = 1% to 5% of the OBW, not to exceed 1 MHz.
d) Set VBW ≥ [3 × RBW].
e) 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.)
f) Sweep time = auto.
g) Detector = RMS (i.e., power averaging), if available. Otherwise, use the sample detector mode.
h) Do not use sweep triggering. Allow the sweep to “free run.”
i) 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.
j) 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.
k) 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.

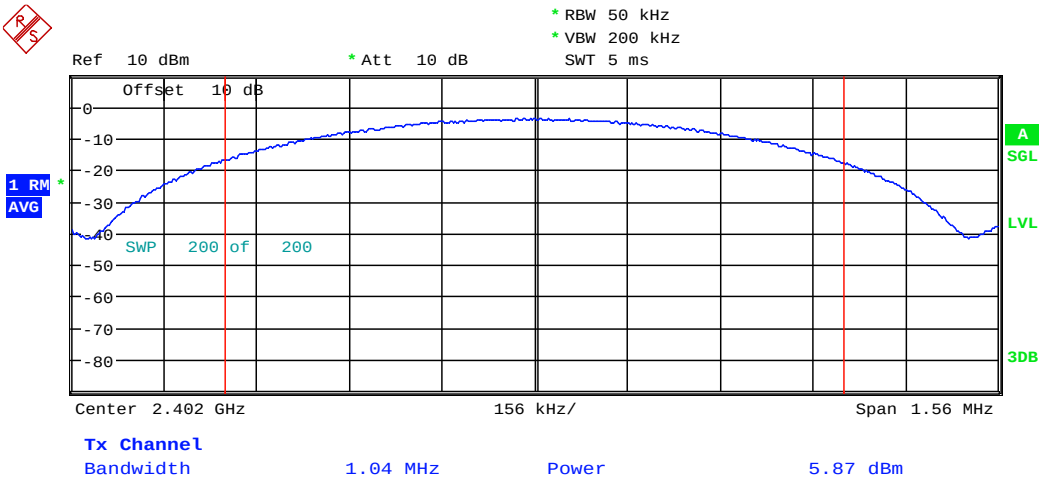
5.2.2 Test results

Ambient temperature	22 °C

Relative humidity	62 %

The plot below shows the worst case result. All other results are submitted in the table below

200507_AvOutpPwr_BTLE_BT1.wmf: Maximum output power measured on channel 1 (operation mode 1):



Since the antenna gain of the EUT is below 6 dBi, no limit correction is necessary.

Operation mode		Frequency [MHz]	Reading [dBm]	DC Corr. [dB]	Corr. Reading [dBm]	Margin [dB]	Limit [dBm]
1	GFSK	2402	5.9	0.0	5.9	24.1	30
2	GFSK	2440	5.8	0.0	5.8	24.2	30
3	GFSK	2480	5.7	0.0	5.7	24.3	30

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

23 - 25

5.3 DTS Bandwidth / 99% Bandwidth

5.3.1 Method of measurement

The EUT was measured conducted on a sample with a temporary antenna connector, which was provided by the applicant.

Acceptable measurement configurations

The measurement for the DTS bandwidth 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:

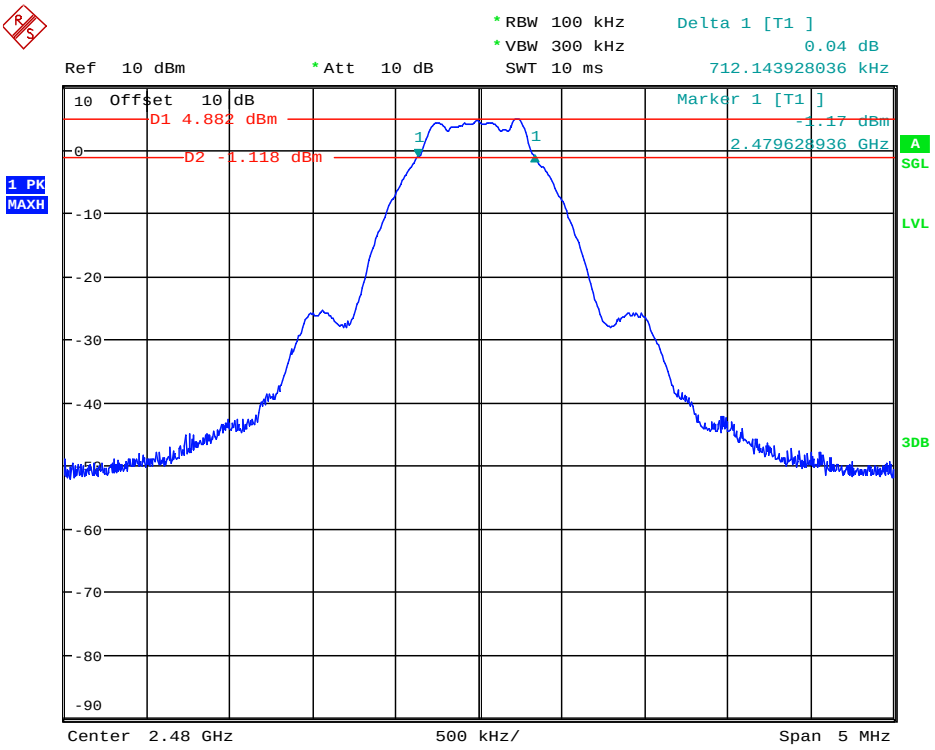
- The instrument center frequency is set to the nominal EUT channel center frequency. The frequency span for the spectrum analyzer shall be between 1.5 times and 5.0 times the OBW.
- The nominal IF filter bandwidth (3 dB RBW) shall be in the range of 1% to 5% of the OBW, and VBW shall be approximately 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 labelled. Tabular data maybe reported in addition to the plot(s).

5.3.2 Test result

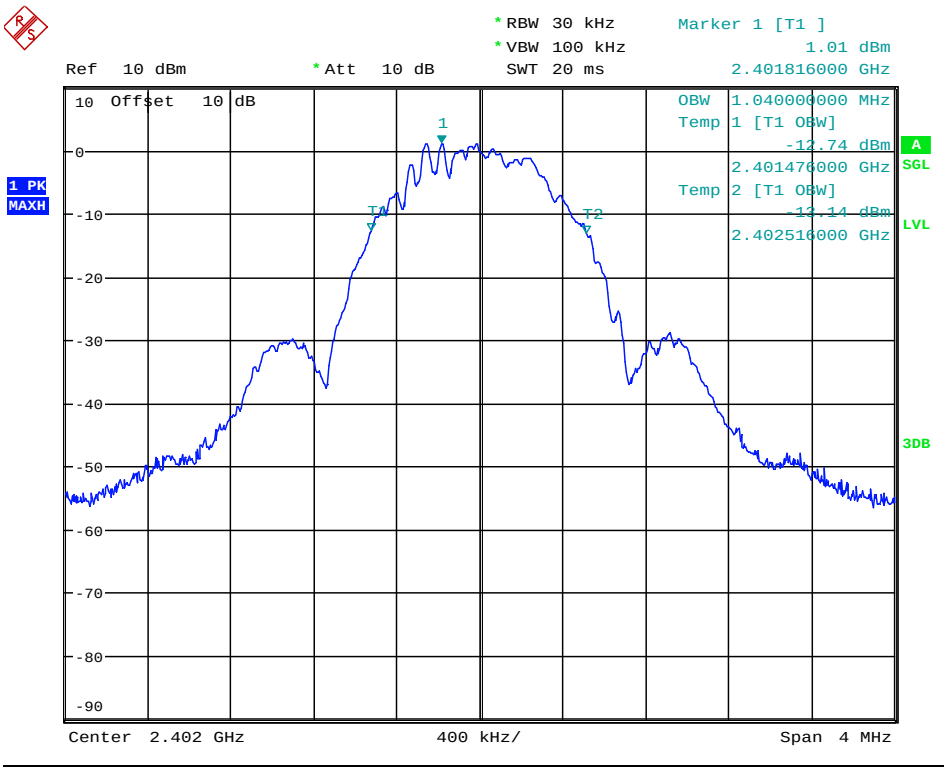
Ambient temperature	22 °C	Relative humidity	59 %

The plots show an exemplary measurement result for the worst documented case. The other results are listed in the following tables.

200507_6dB-BW_BTLE_BTLE39.wmf: 6-dB Bandwidth (operation mode 3):



200507_99%BW_BTLE_BT1.wmf: 99% Bandwidth (operation mode 1):



Operation Mode		Center Frequency [MHz]	Minimum 6-dB Bandwidth Limit [MHz]	6 dB Bandwidth [MHz]	99 % Bandwidth [MHz]	Result
1	GFSK	2402	0.5	0.717	1.040	Passed
2	GFSK	2440	0.5	0.715	1.036	Passed
3	GFSK	2480	0.5	0.712	1.040	Passed

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

23 - 25

5.4 Average Power Spectral Density

5.4.1 Method of measurement

The EUT was measured conducted on a sample with a temporary antenna connector, which was provided by the applicant.

Acceptable measurement configurations

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.

The following procedure is applicable when the EUT cannot be configured to transmit continuously (i.e., D < 98%), when sweep triggering/signal gating cannot be used to measure only when the EUT is transmitting at its maximum power control level, and when the transmission duty cycle is constant (i.e., duty cycle variations are less than ±2%):

- Measure the duty cycle (D) of the transmitter output signal as described in 11.6.
- Set instrument center frequency to DTS channel center frequency.
- Set span to at least 1.5 times the OBW.
- Set RBW to: 3 kHz ≤ RBW ≤ 100 kHz.
- Set VBW ≥ [3 × RBW].
- Detector = power averaging (rms) or sample detector (when rms not available).
- Ensure that the number of measurement points in the sweep ≥ [2 × 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 [10 log (1 / D)], where D is the duty cycle measured in step a), 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 emission of interest and reducing the span to meet the minimum measurement point requirement as the RBW is reduced).

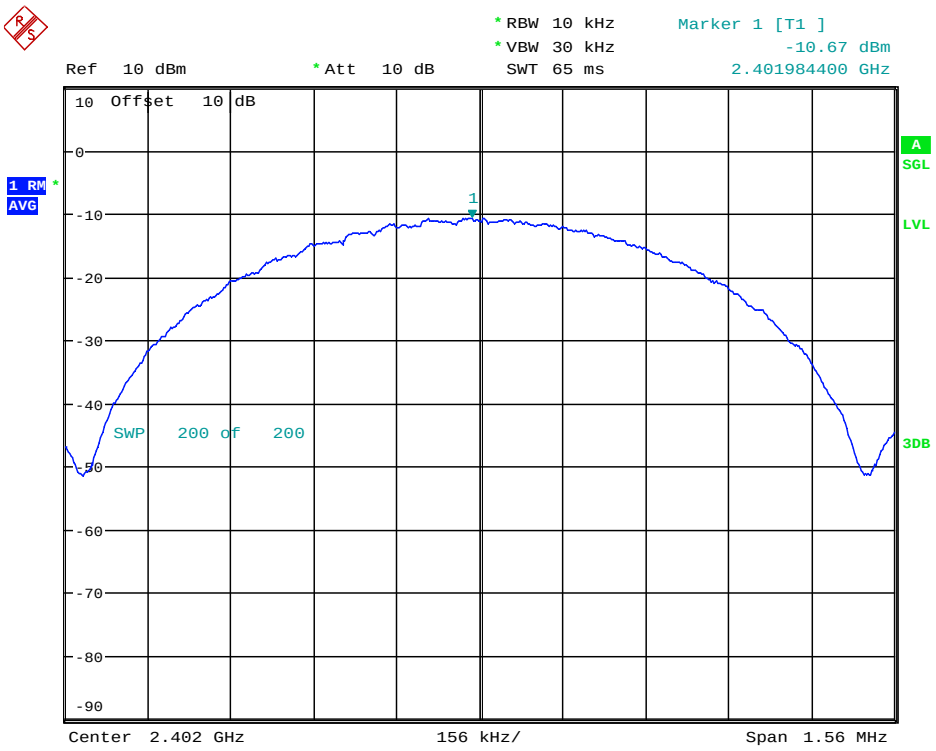
The measurement was performed at the upper and lower end and the middle of the assigned frequency band.

5.4.2 Test result

Ambient temperature	22 °C	Relative humidity	59 %

The plots show an exemplary measurement result for the worst documented case. The other results are listed in the following tables.

200507_AVPwrSpecDens_BTLE_BT1.wmf: Average Power Spectral Density (operation mode 1):



The antenna gain is below 6 dBi, therefore no conducted output limit reduction is necessary.

Operation Mode		Peak Frequency [MHz]	AvPSD Reading [dBm/10 kHz]	Duty Cycle Corr. [dB]	Corr. Reading [dBm /10 kHz]	Margin [dB]	AvPSD Limit [dBm/3kHz]
1	GFSK	2401.984	-10.7	0.0	-10.7	18.7	8
2	GFSK	2439.972	-10.7	0.0	-10.7	18.7	8
3	GFSK	2479.978	-10.8	0.0	-10.8	18.8	8

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

23 - 25

5.5 Band-edge compliance

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

The EUT was measured conducted on a sample with a temporary antenna connector, which was provided by the applicant.

Acceptable measurement configurations

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 stabilise.
- Use the peak marker function to determine the the maximum PSD level.

Measurement Procedure – Unwanted Emissions

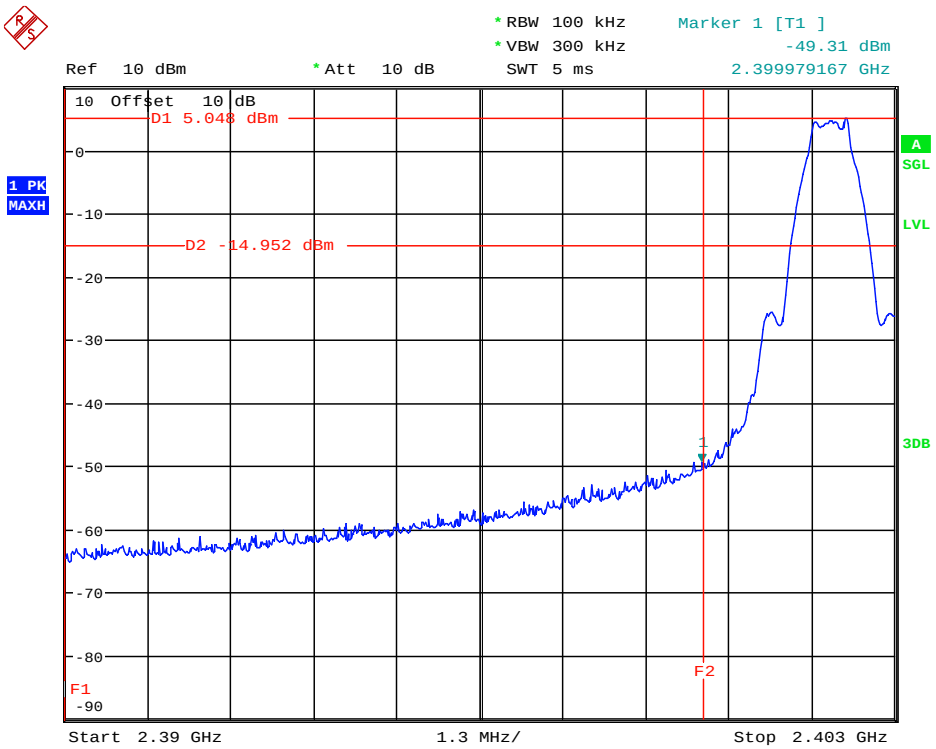
- Set the center frequency and span to encompass the frequency range to be measured.
- RBW = 100 kHz.
- VBW ≥ 300 kHz.
- Detector = Peak.
- Ensure that the number of measurement points ≥ span/RBW.
- Sweep time = auto couple.
- Trace Mode = max hold.
- Allow the trace to stabilise.
- Use the peak marker 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 measurement were performed at the lower end of the 2.4 GHz band.

5.5.2 Test result (band edges next to unrestricted bands (radiated))

190625_LowBE.wmf: Radiated band-edge compliance at an unrestricted band-edge (operation mode 1):



Operation Mode		Tx Frequency [MHz]	Emission Frequency [MHz]	Reference Level [dBm]	Limit [dBm]	Emisson Level [dBm]	Margin [dB]	Result
1	GFSK	2402	2399.979	5.0	-15.0	-49.3	34.3	Passed

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

23 - 25

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

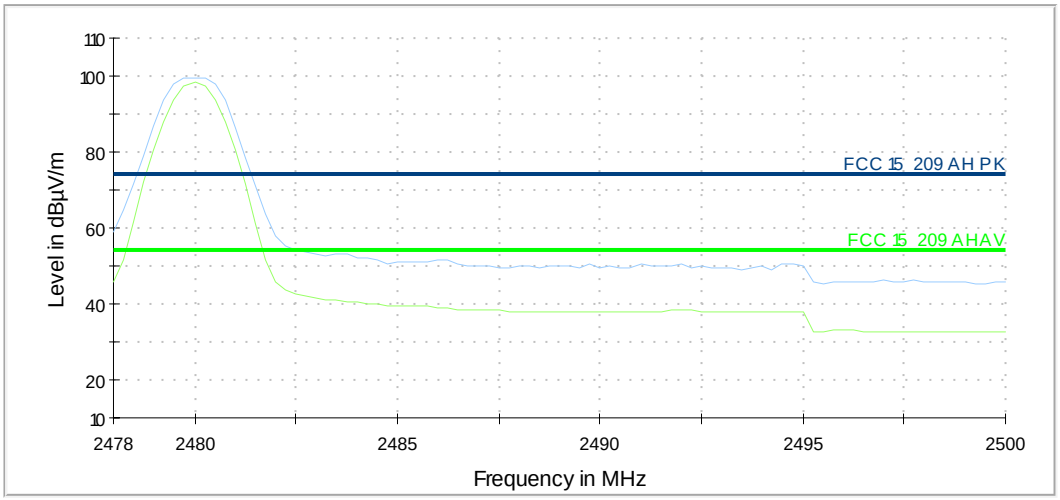
The EUT was measured radiated in the anechoic chamber using the procedures described in 5.6.1.

Acceptable measurement configurations

The same measurement configurations as described in 5.6.1. were used for the preview and final measurement.

5.5.4 Test result (band edges next to restricted bands (radiated))

Tx_ch39_1-4G: radiated band-edge compliance at a restricted band-edge (operation mode 3):



Transmitter operates at the lower end of the assigned frequency band (operation mode 1 GFSK)

Frequency [MHz]	MaxPeak [dBµV/m]	Caverage [dBµV/m]	Limit [dBµV/m]	Margin (dB)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB)
2378.150	45.6	---	74.0	28.4	H	193	0	34.3
2378.150	---	34.0	54.0	20.0	H	193	0	34.3
Measurement uncertainty				+2.2 dB / -3.6 dB				

Transmitter operates at the upper end of the assigned frequency band (operation mode 3 GFSK)

Frequency [MHz]	MaxPeak [dBµV/m]	Caverage [dBµV/m]	Limit [dBµV/m]	Margin (dB)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB)
2484.900	52.3	---	74.0	21.7	V	240	60	34.6
2484.900	---	38.8	54.0	15.3	V	240	60	34.6
Measurement uncertainty				+2.2 dB / -3.6 dB				

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

7 – 12, 15, 16, 24, 25

5.6 Radiated emissions

5.6.1 Test method

The radiated emission measurement is subdivided into six 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 preliminary and final measurement carried out in a semi anechoic chamber with a varying antenna height in the frequency range 30 MHz to 1 GHz.
- A preliminary and final measurement carried out in a semi-anechoic chamber with with ground absorbers at a distance of 3 m to the EUT position in the frequency range 1 GHz to 25 GHz.

Preliminary and final measurement (9 kHz to 30 MHz):

The preliminary and final measurements were conducted in a semi-anechoic chamber with a metal ground plane. During the test the EUT will be rotated in the range of 0 ° to 360 °, the measuring antenna will be set to horizontal and vertical polarization and ground parallel position and the and the positioning for the maximum emissions for each frequency will be stored.

The frequency range 9 kHz to 30 MHz will be monitored with a spectrum analyser while the system and its cables will be manipulated to find out the configuration with the maximum emission levels if applicable.

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

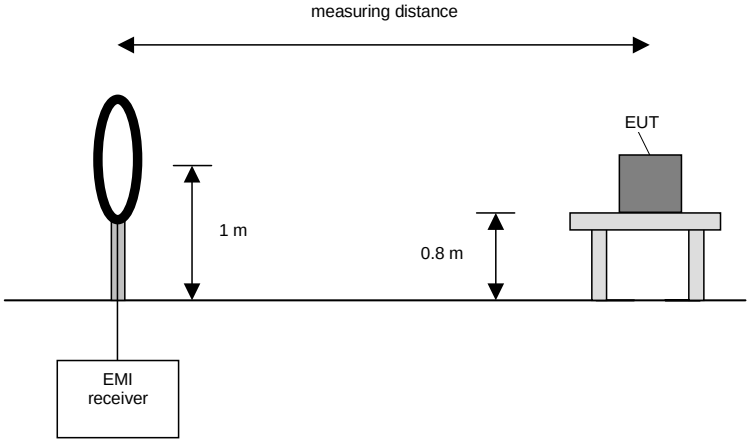
Frequency range	Resolution bandwidth
9 kHz to 150 kHz	200 Hz
150 kHz to 30 MHz	10 kHz

Preliminary measurement procedure:

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

The following procedure will be used:

1) Monitor the frequency range at horizontal polarisation and a EUT azimuth of 0 °.
2) Manipulate the system cables within the range to produce the maximum level of emission.
3) Rotate the EUT by 360 ° to maximize the detected signals.
4) Repeat steps 1) to 5) with the other orthogonal axes of the EUT (because of EUT is a module and might be used in a handheld equipment application).
5) Rotate the measuring antenna and repeat steps 1) to 5).
6) The test system stores the maximum values for each frequency for the final measurement.

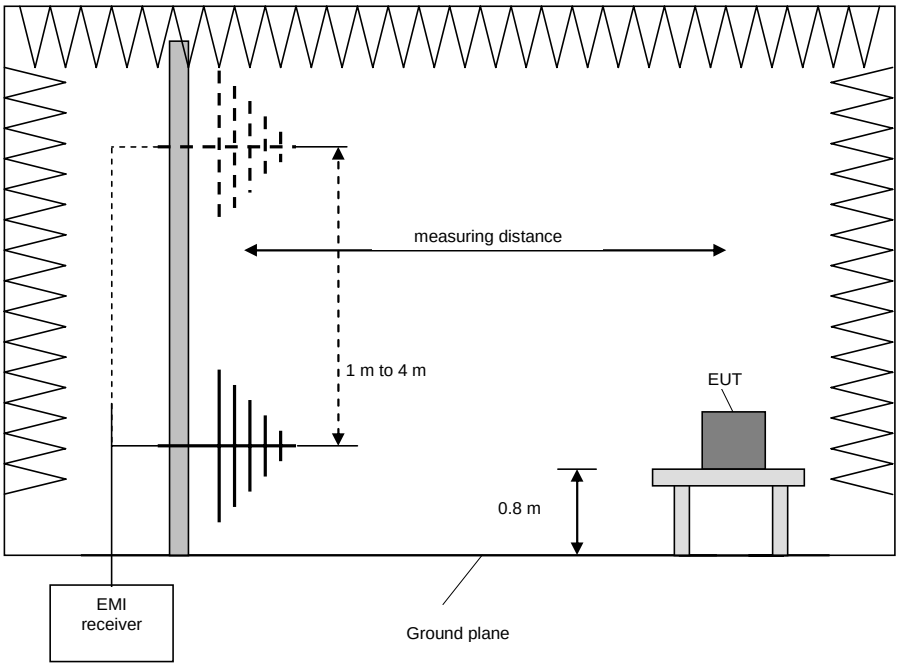


Preliminary and final measurement (30 MHz to 1 GHz)

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

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

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



Procedure preliminary measurement:

The following procedure is used:

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

Procedure final measurement:

The following procedure is used:

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

Preliminary and final measurement (1 GHz to 40 GHz)

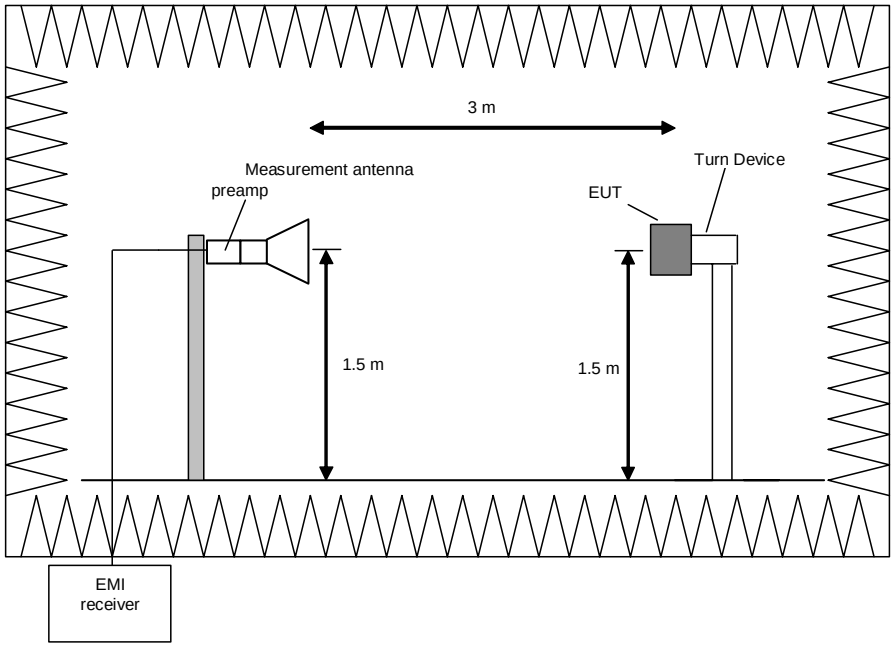
This measurement will be performed in a semi-anechoic chamber with floor absorbers. Table top devices will set up on a non-conducting turn device on the height of 1.5m. The set-up of the Equipment under test will be in accordance to [1].

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 analyser set to MAX Hold mode and a resolution bandwidth of 1 MHz. The measurement will be performed in horizontal and vertical polarisation 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	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 preliminary measurement:

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

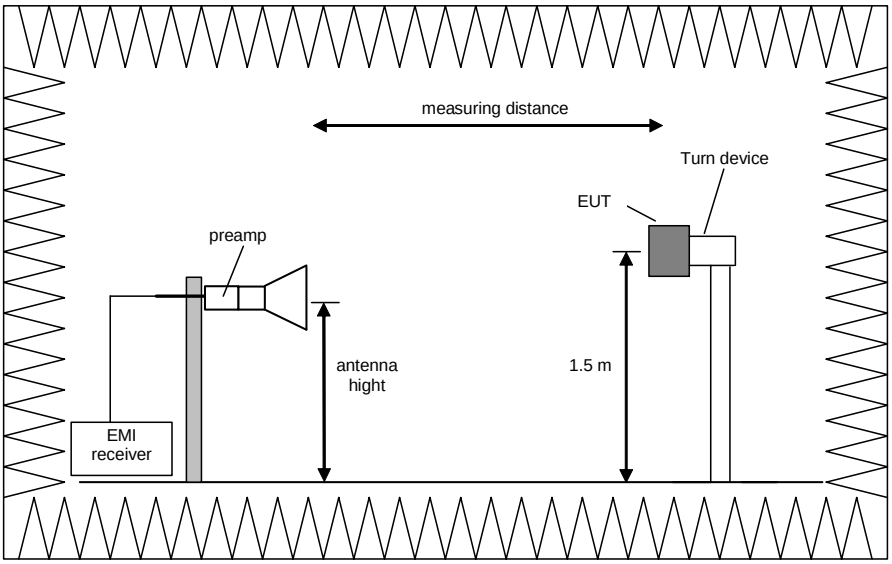
1. Monitor the frequency range at horizontal polarisation and a EUT azimuth of 0 °.
2. Rotate the EUT by 360° to maximize the detected signals.
3. Repeat 1) to 2) with the vertical polarisation of the measuring antenna.
4. Make a hardcopy of the spectrum.
5. Repeat 1) to 4) with the EUT raised by an 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. Measure the azimuth of the detected emissions with slower speed on the single to increase the accuracy and note the azimuth value.
8. The measurement antenna polarisation, 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 polarisation to the orientation with the highest emission for the first frequency identified in the preliminary measurements.
3) Set the spectrum analyser to EMI mode with peak and average detector activated.
4) Note the highest displayed peak and average values
5) Repeat the steps 1) to 5) for each frequency detected during the preliminary measurements.

5.6.2 Test results (radiated emissions) – Emissions with internal antenna from 9kHz – 26.5 GHz

5.6.2.1 Preliminary radiated emission measurement 9kHz – 26.5 GHz

Ambient temperature	22 °C	Relative humidity	59 %

Position of EUT: The EUT was set-up on an EUT turn device of a height of 1.5 m for f > 1 GHz and on a height of 0.8 m for f < 1 Ghz. The distance between EUT and antenna was 3 m.

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

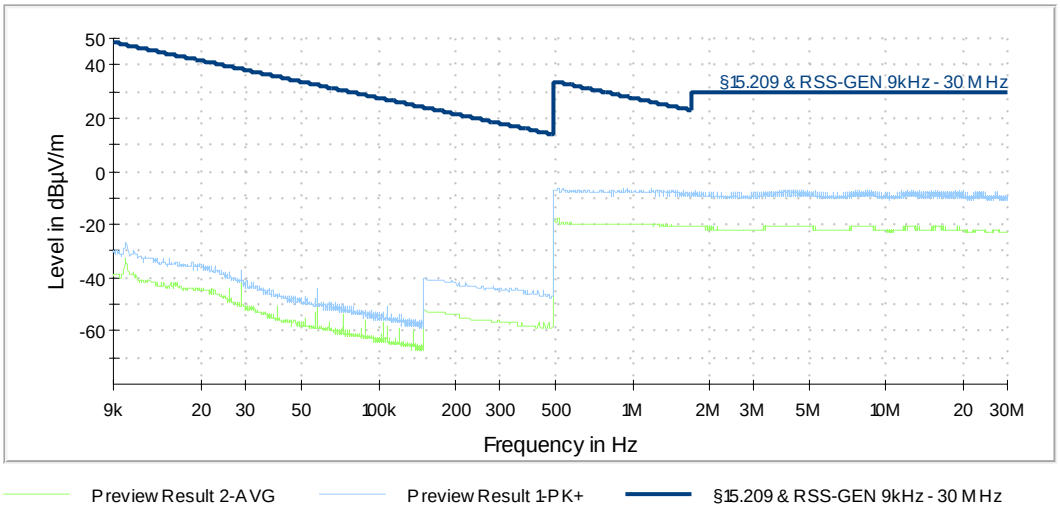
Test record: Only the plot of the worst case emission is submitted below. Since no emissions were found above 12 GHz, only an exemplary plot is submitted for each frequency range.

Remark: Since there were no differences in the spectrum for f < 1 GHz, only one representative plot is submitted below.

No emissions more than 20 dB to the limit were found in the preliminary measurement below 30 MHz, therefore no final measurement was performed in this frequency range.

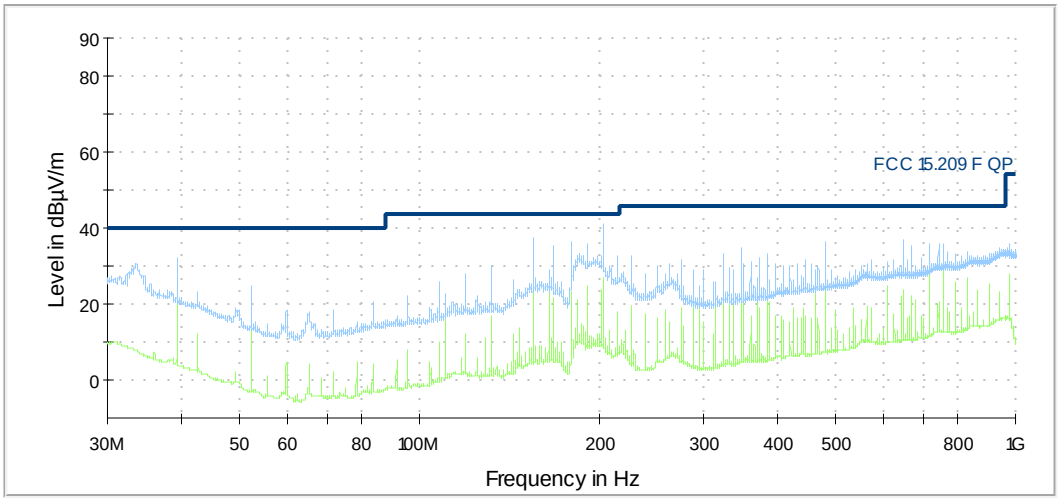
Plots of the worst case transmitter spurious emissions

Tx_ch0_9k-30M: Spurious emissions from 9 kHz to 30 MHz (operation mode 1):

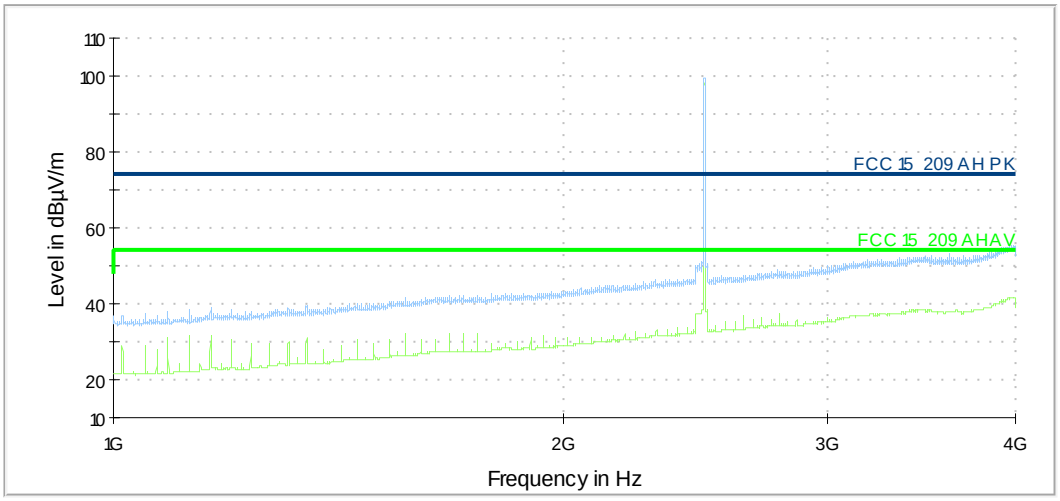


Remark: In the shown plot a distance correction factor was added to the measurement results to account for the different measuring distances according to standard (9 kHz to 490 kHz @ 300 m; 490 kHz to 30 MHz @ 30 m).

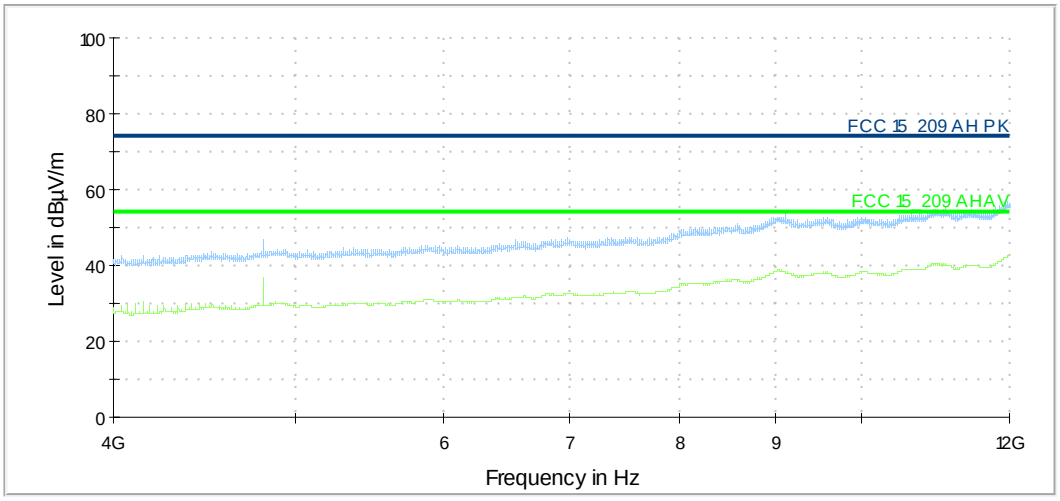
Tx_ch:_30M-1G Spurious emissions from 30 MHz to 1 GHz (operation mode 1):



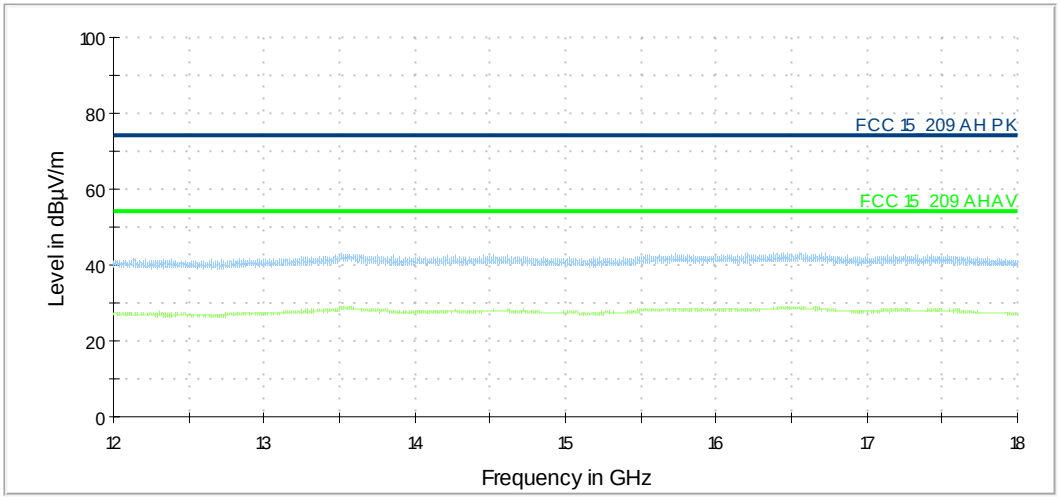
Tx_ch39_1-4G: Spurious emissions from 1 GHz to 4 GHz (operation mode 3)



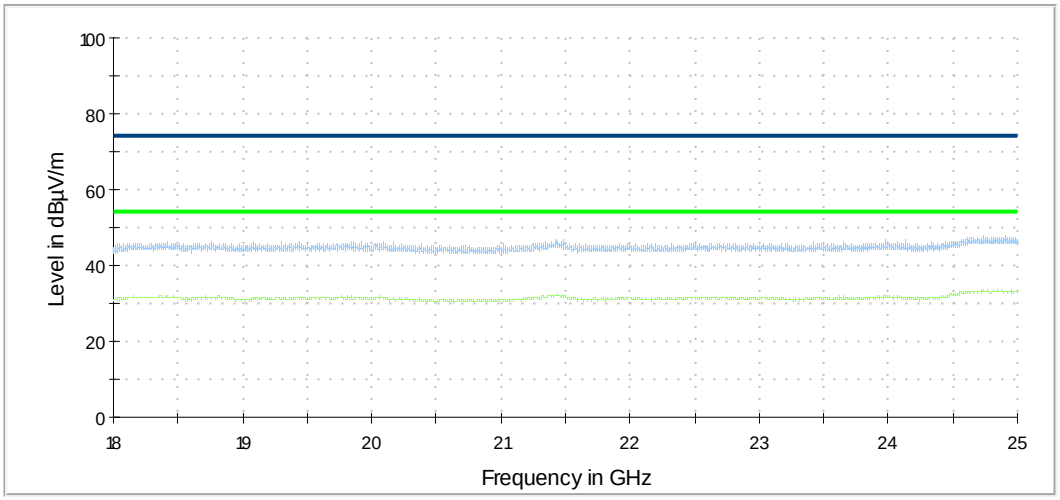
Tx_ch0_4-12G: Spurious emissions from 4 GHz to 12 GHz (operation mode 1):



Tx_ch0_12-18G: Spurious emissions from 12 GHz to 18 GHz (operation mode 1):



Tx_ch0_18-25G: Spurious emissions from 18 GHz to 25 GHz (operation mode 1):



5.6.2.2 Final radiated measurements

All TX modes (no difference detected when comparing channel / modulation)

Frequency [MHz]	QuasiPeak [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Meas. Time [ms]	Bandwidth [kHz]	Height [cm]	Pol	Azimuth [deg]	Corr. [dB]
39.300	27.2	40.0	12.8	1000.0	120.000	115	V	352	22.9
52.375	22.0	40.0	18.1	1000.0	120.000	281	V	167	15.3
155.725	34.3	43.5	9.2	1000.0	120.000	107	V	31	18.3
203.650	38.8	43.5	4.7	1000.0	120.000	146	H	266	16.4
479.250	33.5	46.0	12.5	1000.0	120.000	205	H	297	25.8
718.875	32.5	46.0	13.5	1000.0	120.000	102	H	216	29.8
Measurement uncertainty					+2.2 dB / -3.6 dB				

Transmitter operates at the lower end of the assigned frequency band (operation mode 1, GFSK)

Frequency [MHz]	MaxPeak [dBµV/m]	Caverage [dBµV/m]	Limit [dBµV/m]	Margin (dB)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB)
1124.300	39.3	---	74.0	34.8	V	359	60	26.0
1124.300	---	31.8	54.0	22.2	V	359	60	26.0
1887.200	42.7	---	74.0	31.3	H	75	90	31.4
1887.200	---	29.6	54.0	24.4	H	75	90	31.4
2402.200	---	98.4	Fund.	-	V	252	60	34.4
2402.200	99.4	---	Fund.	-	V	252	60	34.4
3990.950	---	42.7	54.0	11.3	H	291	90	40.3
3990.950	55.2	---	74.0	18.8	H	291	90	40.3
4803.500	---	35.6	54.0	18.4	H	317	120	8.7
4803.500	45.8	---	74.0	28.2	H	317	120	8.7
Measurement uncertainty				+2.2 dB / -3.6 dB				

Transmitter operates at the middle of the assigned frequency band (operation mode 2, GFSK)

Frequency [MHz]	MaxPeak [dBµV/m]	Caverage [dBµV/m]	Limit [dBµV/m]	Margin (dB)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB)
1124.450	39.4	---	74.0	34.6	V	2	30	26
1124.450	---	31.5	54.0	22.5	V	2	30	26
2439.750	100.2	---	Fund.	-	V	244	60	34.6
2439.750	---	98.9	Fund.	-	V	244	60	34.6
2783.150	49.2	---	74.0	24.8	H	195	90	36.7
2783.150	---	37.9	54.0	16.1	H	195	90	36.7
3994.550	55.1	---	74.0	18.9	V	37	0	40.3
3994.550	---	42.7	54.0	11.3	V	37	0	40.3
4879.550	---	33.2	54.0	20.8	H	343	90	9.2
4879.550	44.3	---	74.0	29.7	H	343	90	9.2
Measurement uncertainty				+2.2 dB / -3.6 dB				

Transmitter operates at the upper end of the assigned frequency band (operation mode 3, GFSK)

Frequency [MHz]	MaxPeak [dBµV/m]	Caverage [dBµV/m]	Limit [dBµV/m]	Margin (dB)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB)
1124.250	---	31.5	54.0	22.5	V	1	30	26
1124.250	39.2	---	74.0	34.8	V	1	30	26
2479.800	99.8	---	Fund.	-	V	241	60	34.6
2479.800	---	98.8	Fund.	-	V	241	60	34.6
2482.600	57.2	---	74.0	16.8	V	242	60	34.6
2482.600	---	43.6	54.0	10.4	V	242	60	34.6
2782.850	48.9	---	74.0	25.2	H	33	90	36.7
2782.850	---	36.0	54.0	18.0	H	33	90	36.7
3986.400	54.6	---	74.0	19.4	H	164	60	40.3
3986.400	---	42.6	54.0	11.4	H	164	60	40.3
4960.550	---	32.2	54.0	21.8	H	158	90	9.1
4960.550	43.9	---	74.0	30.1	H	158	90	9.1
Measurement uncertainty				+2.2 dB / -3.6 dB				

TEST EQUIPMENT USED FOR THE TEST:
7 – 22, 24, 25

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

Ambient temperature	20 °C	Relative humidity	52 %

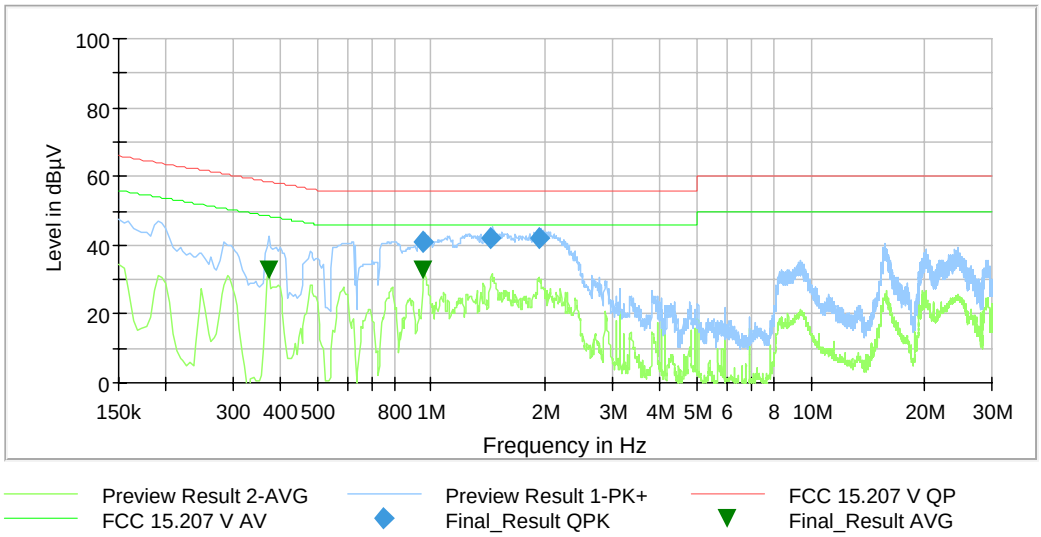
Position of EUT: For this test, the EUT was operated in normal mode. The EUT was inserted in a housing (Converter MFS400), which itself was connected to a remote sensor device (Optimass 6400).

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

Test record: All results are shown in the following.

Supply voltage: Measurement performed with US 120V/60Hz.

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	Transducer (dB)
0.373200	---	32.52	48.43	15.91	5000.0	9.000	L1	GND	9.9
0.952800	---	32.76	46.00	13.24	5000.0	9.000	L1	GND	9.9
0.952800	40.84	---	56.00	15.16	5000.0	9.000	L1	GND	9.9
1.439700	42.00	---	56.00	14.00	5000.0	9.000	L1	GND	9.9
1.929300	42.15	---	56.00	13.85	5000.0	9.000	L1	GND	10.0
Measurement uncertainty				+2.76 dB / -2.76 dB					

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:
1 – 6, 24, 25

6 Test equipment and ancillaries used for tests

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal. Due
1	Shielded chamber M4	-	Albatross Projects	B83117-C6439-T262	480662	Calibration not necessary	
2	EMI Receiver	ESIB 26	Rohde & Schwarz	1088.7490	481182	18.04.2019	04.2021
3	LISN	NSLK8128	Schwarzbeck	8128155	480058	09.04.2019	04.2021
4	Transient Filter Limiter	CFL 9206A	Teseq GmbH	38268	481982	12.02.2020	02.2022
5	EMI Software	EMC32	Rohde & Schwarz	100061	481022	Calibration not necessary	
6	Power supply AC	AC6803A AC	Keysight	JPVJ002509	482350	Calibration not necessary	
7	Positioner	TG1.5-10kg	Maturo	110/2648.01	483042	Calibration not necessary	
8	Semi anechoic chamber	M276	Albatross Projects	C62128-A540-A138-10-0006	483227	Calibration not necessary	
9	Antenna mast	BAM4.5-P-10kg	maturo	222/2612.01	483225	Calibration not necessary	
10	Turntable		Deisel	412/316	480087	Calibration not necessary	
11	Controller	HD100	Deisel	100/349	480139	Calibration not necessary	
12	Software	EMC32	Rohde & Schwarz	ID: 1300.7010.12-100970-Be	482972	Calibration not necessary	
13	Loop antenna	HFH2-Z2	Rohde & Schwarz	832609/014	480059	24.03.2020	03.2023
14	Antenne (Bilog)	CBL6111D	Schaffner	22921	480674	03.04.2018	04.2021
15	Log Per Antenne	HL050	Rohde & Schwarz	-	482977	13.08.2019	08.2022
16	EMI Testreceiver	ESW	Rohde & Schwarz	101828	482979	12.04.2019	04.2021
17	Low Noise Amplifier	LNA-30-00101800-25-10P	Narda-Miteq	2110917	482967	18.02.2020	02.2022
18	High-pass filter	WHKX4.0/18G-8SS	Wainwright Instruments	1	480587	Calibration not necessary	
19	Standard Gain Horn 11.9 GHz – 18 GHz	18240-20	Flann Microwave	483	480294	Calibration not necessary	
20	Standard Gain Horn 17.9 GHz – 26.7 GHz	20240-20	Flann Microwave	411	480297	Calibration not necessary	
21	Preamplifier	JS3-12001800-16-5A	Miteq	571667	480343	13.02.2020	02.2022
22	Preamplifier	JS3-18002600-20-5A	Miteq	658697	480342	13.02.2020	02.2022
23	Spectrum Analyser	FSU46	Rohde & Schwarz	200125	480956	24.03.2020	03.2022
24	Power Supply	HM8142	Hameg	142001P 04969	480720	Calibration not necessary	
25	Multimeter	971A	Hewlett Packard	JP39009358	480721	22.01.2020	02.2021

7 Test site Validation

Test equipment	PM. No.	Frequency range	Type of validation	According to	Val. Date	Val Due
Semi anechoic chamber M276	483227	30 – 1000 MHz	NSA	ANSI C63.4-2017	19.09.2019	18.09.2021
Semi anechoic chamber M276	483227	1 -18 GHz	SVSWR[*1]	CISPR 16-1-4 + Cor1:2010 + A1:2012 +A2:2017	19.09.2019	18.09.2021
Shielded chamber M4	480088	9 kHz – 30 MHz	GND-Plane	ANSI C63.4-2014	06.11.2018	05.11.2020

8 Report History

Report Number	Date	Comment
F200507E1	14.08.2020	Initial Test Report

9 List of Annexes

ANNEX A	TEST SETUP PHOTOS	9 pages
ANNEX B	EXTERNAL PHOTOS	2 pages
ANNEX C	INTERNAL PHOTOS	4 pages