

Test Report

Report Number:

F190760E1

Equipment under Test (EUT):

ZONESCAN 820 Alpha V2

Applicant:

Gutermann Technology GmbH

Manufacturer:

Gutermann Technology GmbH





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 (March 2019)** General Requirements for Compliance of Radio Apparatus

TEST RESULT

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

Test engineer:	Thomas KÜHN		28.08.2019
	Name	Signature	Date
Authorized reviewer:	Michael DINTER		28.08.2019
	Name	Signature	Date

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1 Identification

1.1 Applicant

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Applicant represented during the test by the following person:	Mr. Hermann WAIBEL, Mr. Stefan LANG

1.2 Manufacturer

Name:	Gutermann Technology GmbH
Address:	Gottlieb Daimler Straße 10 88214 Ravensburg
Country:	Germany
Name for contact purposes:	Mr. Hermann WAIBEL
Phone:	+49 751 35 90 16 - 83
Fax:	+49 751 35 90 16 - 99
eMail Address:	hermann.waibel@gutermann-water.com
Manufacturer represented during the test by the following person:	Mr. Hermann WAIBEL, Mr. Stefan LANG

1.3 Test laboratory

The tests were carried out at: **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 and D-PL-17186-01-05, FCC Test Firm Designation Number DE0004, FCC Test Firm Registration Number 469623, CAB Identifier DE0003 and ISED# 3469A.

1.4 EUT (Equipment Under Test)

Test object: *	Wireless transceiver for data collection
(PMN): *	ZONESCAN 820 Alpha V2
Modelname / HVIN: *	S-ALPHA-5-0-B3
FCC ID:*	ZSSZS820915AL3
IC: *	9789A-ZS820915AL3
Serial number: *	50274
PCB identifier: *	ZS820-40B, ZS820-41B and ZS-43A
Hardware version: *	B3
Software version: *	2.08
Lowest internal frequency: *	32.768 kHz

* declared by the applicant.

1.5 Technical data of equipment

Channel 0	RX:	904.000 MHz	TX:	904.000 MHz
Channel 24	RX:	911.200 MHz	TX:	911.200 MHz
Channel 49	RX:	918.700 MHz	TX:	918.700 MHz

Rated RF output power: *	16 dBm				
Antenna type: *	Integral or external				
Antenna gain: *	0 dBi (internal) up to 11 dBi (external)				
Antenna connector: *	Yes				
Adaptive frequency agility: *	No				
Modulation: *	FHSS (GFSK)				
Supply Voltage: *	U _{nom} =	3.3 V DC	U _{min} =	2.6 V DC	U _{max} = 3.6 V DC
Temperature range: *	-30 °C to +70 °C				
Ancillary used for test:	External power supply type eneracell CAT: NO. 273-316 for emission measurement on power supply lines (provided by the laboratory).				

* declared by the applicant.

The following external I/O cables were used:

Identification	Connector		Length *
	EUT	Ancillary	
DC power	3 pole M8 plug	-	2 m
External SRD-antenna	RP-TNC male	-	-
External SRD-antenna	RP-TNC male	-	-
External SRD-antenna	RP-TNC male	-	-

*: Length during the test if no other specified.

1.6 Dates

Date of receipt of test sample:	02.07.2019
Start of test:	02.07.2019
End of test:	04.07.2019

2 Operational states

The tested sample was unmodified and could be configured via the programming interface with the help of a laptop PC with a configuration software (LapView program SolarAlphaTest), which were both supplied by the applicant. After adjusting the operation mode, the connection between the programming interface and the Laptop PC was disconnected. The programming interface is intended to be used for testing purposes only if it is located below the shielding of the EUTs RF circuit.

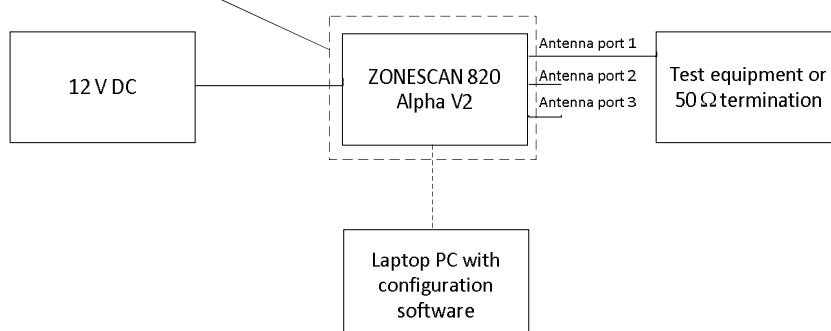
All radiated measurements were carried out with a connection to an external 12 V DC power supply (buffering the internal battery), because preliminary measurements has shown, that the use of an external power supply causes higher emissions than the use of the internal battery without any connection to an external power supply. Furthermore the EUT is intended to be used either with an external power supply or a solar panel.

The EUT uses either the internal antenna or one of the external antenna ports; no simultaneous transmission on more than one RF output port of the EUTs RF circuit is possible. The used antenna port was adjustable with the help of the configuration software, unused ports were terminated with 50 W.

The spurious emission measurements were carried out with the EUT configured operating either with its internal antenna or radiated with all on the external antenna ports terminated with 50 W. Conducted measurements were carried out at the external antenna port, which causes the highest RF output level (port 3); this port number was investigated during a preliminary measurement.

If not otherwise stated the radiated measurements were carried out in normal operation position of the EUT (connectors showing downwards), because of fixed mounting position.

Physical boundaries of the Equipment Under Test



The following test modes were adjusted during the tests:

Test items	Operation	Operation mode
20 dB bandwidth	Transmit with normal modulation on channel 0, 24 or 49	1, 2, 3
Carrier frequency separation	Transmit with normal modulation on channel 0, 24 or 49	1, 2, 3
Number of hopping channels	Transmit with normal modulation, hopping on all channels	4
Dwell time	Transmit with normal modulation on channel 0, 24 or 49	1, 2, 3
Maximum peak output power	Transmit with normal modulation on channel 0, 24 or 49	1, 2, 3
Radiated emissions (transmitter)	Transmit with normal modulation on channel 0, 24 or 49	1, 2, 3
Conducted emissions on supply line	Transmit with normal modulation, hopping on all channels	4

3 Additional information

During the tests the EUT was not labelled as required by FCC / IC.

The EUT contains also a GSM/UMTS/LTE transceiver and a GNSS receiver. Measurement results of these parts of the EUT are documented in separate test reports. As declared by the applicant, simultaneous transmission of GSM/UMTS/LTE part and frequency hopper part of the EUT is not possible.

4 Overview

Application	Frequency range [MHz]	FCC 47 CFR Part 15 section [2]	RSS 247 [3] or RSS-Gen [4]	Status	Refer page
20 dB bandwidth	General	15.247 (a) (1) (i)	5.1 (a) [3]	Passed	8 et seq.
Carrier frequency separation	General	15.247 (a) (1) (i)	5.1 (c) [3]	Passed	11 et seq.
Number of hopping channels	902.0 – 928.0	15.247 (a) (1) (i)	5.1 (c) [3]	Passed	16 et seq.
Dwell time	902.0 – 928.0	15.247 (a) (1) (i)	5.1 (c) [3]	Passed	18 et seq.
Maximum peak output power	902.0 – 928.0	15.247 (b) (2)	5.4 (a) [3]	Passed	21 et seq.
Radiated emissions (transmitter)	0.009 - 10,000	15.247 (d) 15.205 (a) 15.209 (a)	5.5 [3] 8.9 [4]	Passed	24 et seq.
Conducted emissions on supply line	0.15 - 30	15.207 (a)	8.8 [4]	Passed	61 et seq.
Antenna requirement	-	15.203 [2]	6.8 [4]	Passed *	-

*: The EUT has an internal antenna and reverse TMC antenna connectors and as declared by the applicant it is intended for professional installation. Furthermore the antenna specifications for the external antenna are defined in the user manual, so the requirement is regarded as fulfilled.

5 Test results

5.1 Bandwidth

5.1.1 Method of measurement (bandwidth)

The calibration of the spectrum analyser has to be checked with the help of a known signal from a signal generator. The EUT has to be connected to the spectrum analyser via a low loss cable. If the EUT is not equipped with an antenna connector, a temporary antenna connector has to be installed. The EUT has to be switched on and the hopping function has to be disabled, the transmitter shall work with its maximum data rate.

The following spectrum analyser settings according to [1] shall be used:

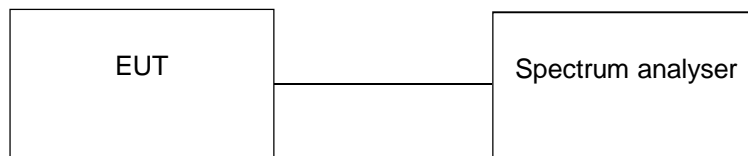
- Span: App. 2 to 5 times the 20 dB bandwidth, centred on the actual hopping channel.
- Resolution bandwidth: 1 % to 5 % of the 20 dB bandwidth.
- Video bandwidth: three times the resolution bandwidth.
- Set the reference level of the instrument either above the measured peak conducted output power level or 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.
- Sweep: Auto.
- Detector function: Peak.
- Trace mode: Max hold.

20 dB bandwidth: After trace stabilisation the marker shall be set on the signal peak. The first display line has to be set on this value. The second display line has to be set 20 dB below the first line (or the peak marker). The frequency lines shall be set on the intersection points between the second display line and the measured curve. Alternatively the 20 dB down function of the spectrum analyser could be used.

99% bandwidth: Use the 99% power bandwidth function of the instrument

The measurement will be performed at the upper, the lower end and the middle of the assigned frequency band.

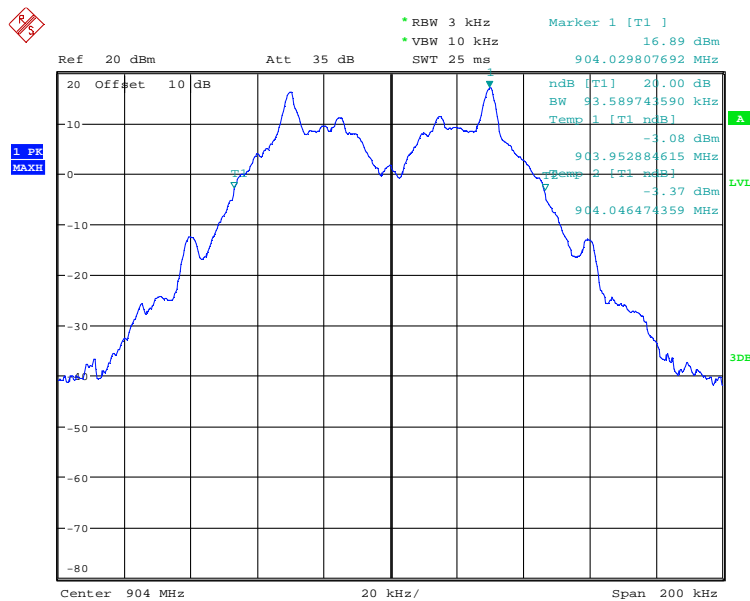
Test set-up:



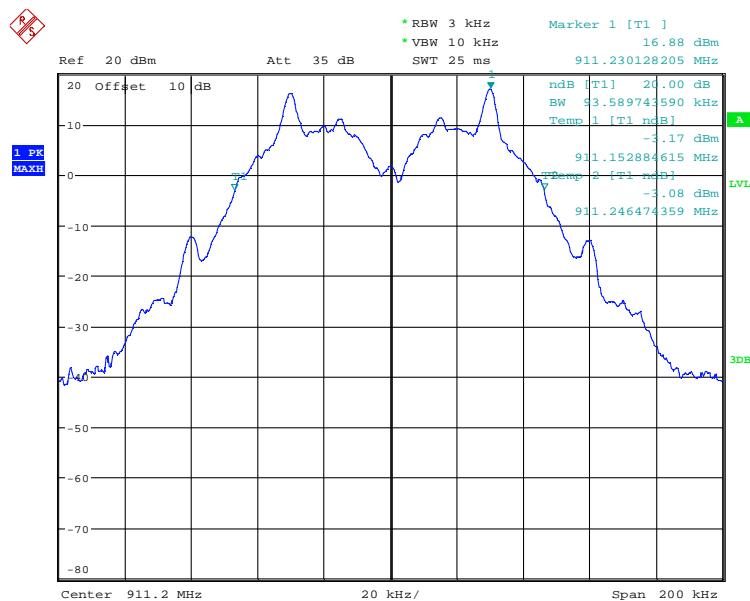
5.1.2 Test results (20 dB bandwidth)

Ambient temperature	23 °C	Relative humidity	39 %
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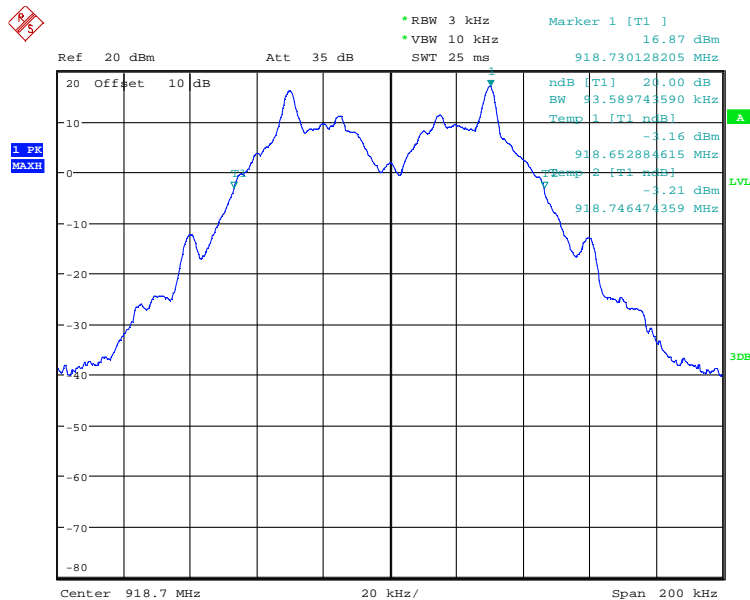
190760_20dB_0.wmf: 20 dB bandwidth at the lower end of the assigned frequency band:



190760_20dB_24.wmf: 20 dB bandwidth at the middle of the assigned frequency band:



190760_20dB_49.wmf: 20 dB bandwidth at the upper end of the assigned frequency band:



Channel number	Channel frequency [MHz]	20 dB bandwidth [kHz]
0	904.000	93.590
24	911.200	93.590
49	918.700	93.590
Measurement uncertainty		+0.66 dB / -0.72 dB

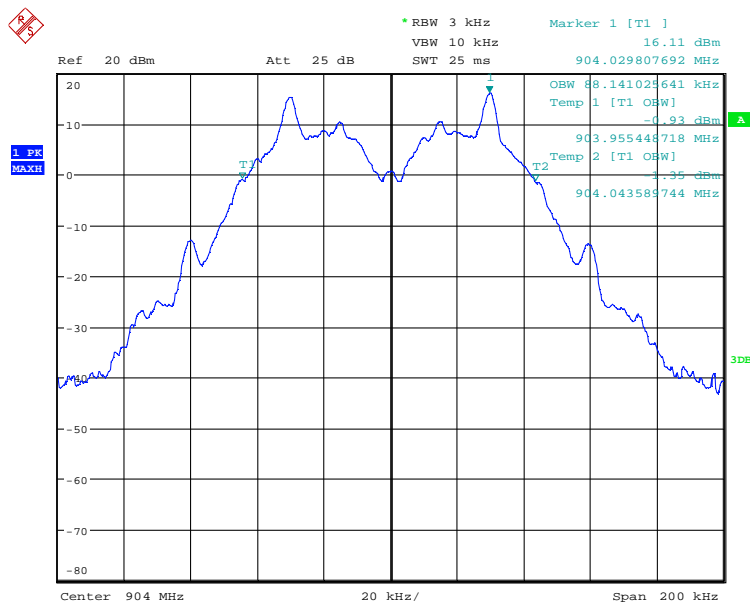
Test equipment used (see chapter 6):

15, 30

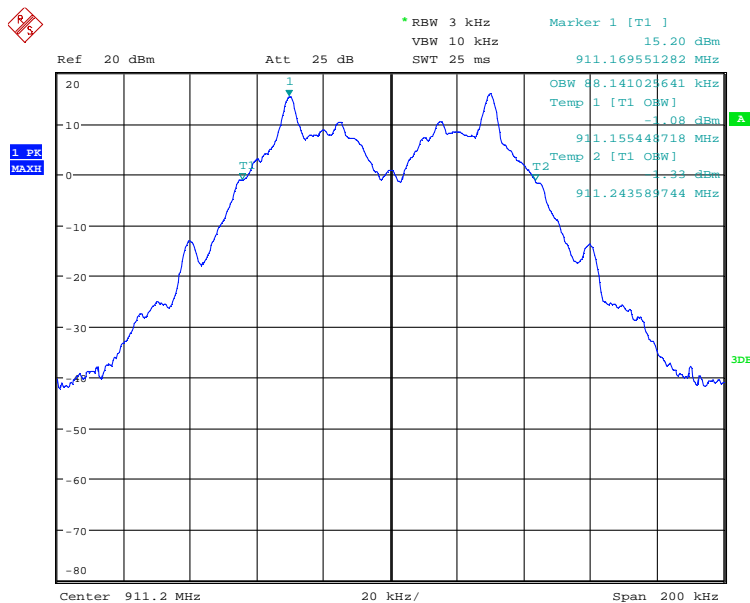
5.1.3 Test results (99 % bandwidth)

Ambient temperature	23 °C	Relative humidity	39 %
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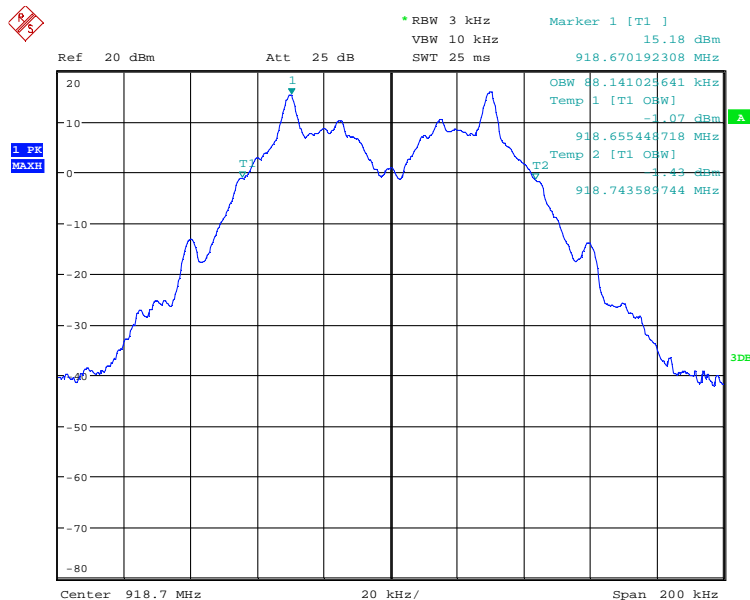
190760_99_0.wmf: 20 dB bandwidth at the lower end of the assigned frequency band:



190760_99_24.wmf: 20 dB bandwidth at the middle of the assigned frequency band:



190760_99_49.wmf: 20 dB bandwidth at the upper end of the assigned frequency band:



Channel number	Channel frequency [MHz]	99 % bandwidth [kHz]
0	904.000	88.141
24	911.200	88.141
49	918.700	88.141
Measurement uncertainty		+0.66 dB / -0.72 dB

Test equipment used (see chapter 6):

15, 30

5.2 Carrier frequency separation

5.2.1 Method of measurement (carrier frequency separation)

The calibration of the spectrum analyser has to be checked with the help of a known signal from a signal generator. The EUT has to be connected to the spectrum analyser via a low loss cable. If the EUT is not equipped with an antenna connector, a temporary antenna connector has to be installed. The EUT has to be switched on and the hopping function has to be enabled.

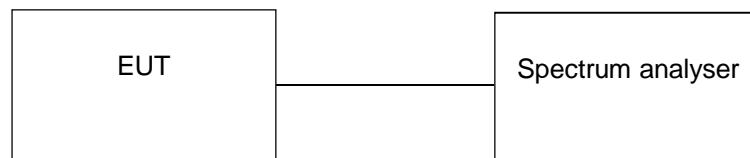
The following spectrum analyser settings according to [1] shall be used:

- Span: Wide enough to capture the peaks of two adjacent channels.
- Resolution bandwidth: Start with the Resolution bandwidth set to approximately 30% of the channel spacing; adjust as necessary to best identify the center of each individual channel.
- Video bandwidth \geq Resolution bandwidth.
- Sweep: Auto.
- Detector function: Peak.
- Trace mode: Max hold.

After trace stabilisation the marker and the delta marker function will be used to determine the separation between the peaks of two adjacent channel signals.

The measurement will be performed at the upper, the lower end and the middle of the assigned frequency band.

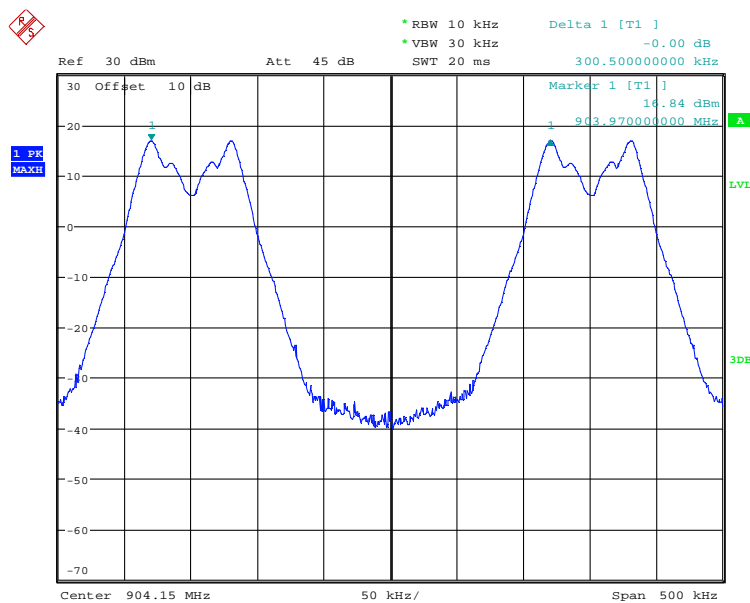
Test set-up:



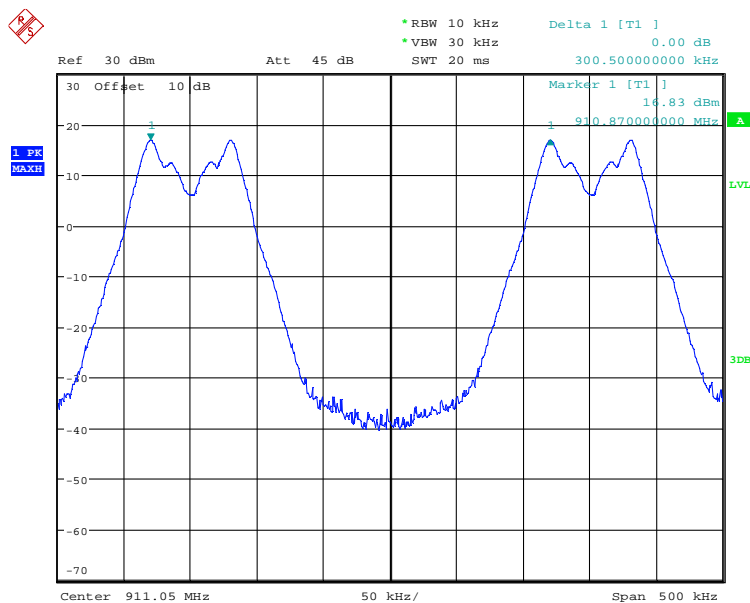
5.2.2 Test results (carrier frequency separation)

Ambient temperature	23 °C	Relative humidity	39 %
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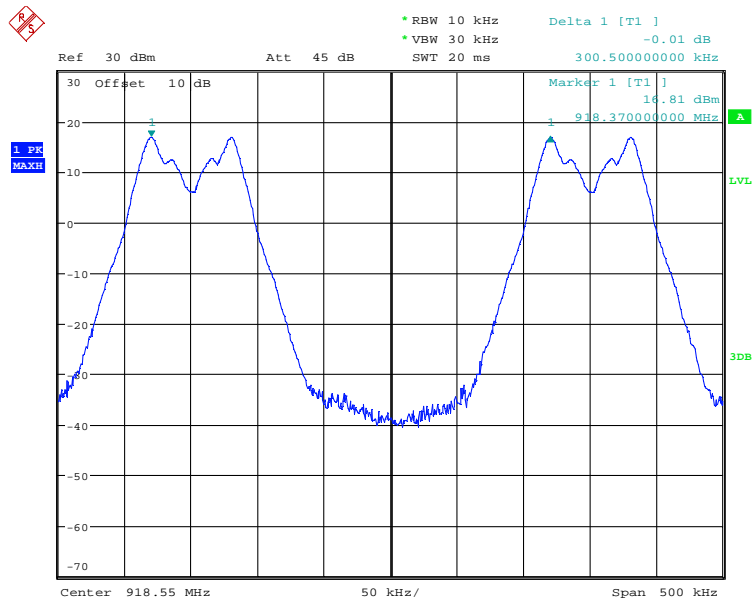
190760_CFS_0.wmf: Channel separation at the lower end of the assigned frequency band:



190760_CFS_24.wmf: Channel separation at the middle of the assigned frequency band:



190760_CFS_49.wmf: Channel separation at the upper end of the assigned frequency band:



Channel number	Channel frequency [MHz]	Channel separation [kHz]	Minimum limit [kHz]
0	904.000	300.500	93.590
24	911.200	300.500	93.590
49	918.700	300.500	93.590
Measurement uncertainty			$<10^{-7}$

Test: Passed

Test equipment used (see chapter 6):

15, 30

5.3 Number of hopping frequencies

5.3.1 Method of measurement (number of hopping frequencies)

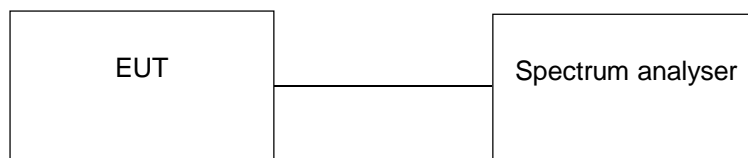
The calibration of the spectrum analyser has to be checked with the help of a known signal from a signal generator. The EUT has to be connected to the spectrum analyser via a low loss cable. If the EUT is not equipped with an antenna connector, a temporary antenna connector has to be installed. The EUT has to be switched on and the hopping function has to be enabled.

The following spectrum analyser settings according to [1] shall be used:

- Span: The frequency band of operation. Depending on the number of channels the device supports, it may be necessary to divide the frequency range of operation across multiple spans, to allow the individual channels to be clearly seen.
- Resolution bandwidth: To identify clearly the individual channels, set the Resolution bandwidth to less than 30% of the channel spacing or the 20 dB bandwidth, whichever is smaller.
- Video bandwidth: ³ the resolution bandwidth.
- Sweep: Auto.
- Detector function: Peak.
- Trace mode: Max hold.

After trace stabilisation the number of hopping channels could be counted. It might be possible to divide the span into some sub ranges in order to clearly show all hopping frequencies.

Test set-up:



5.4 Dwell time

5.4.1 Method of measurement (dwell time)

The calibration of the spectrum analyser has to be checked with the help of a known signal from a signal generator. The EUT has to be connected to the spectrum analyser via a low loss cable. If the EUT is not equipped with an antenna connector, a temporary antenna connector has to be installed. The EUT has to be switched on and the hopping function has to be enabled.

The following spectrum analyser settings according to [1] shall be used:

- Span: Zero, centred on a hopping channel.
- Resolution bandwidth shall be \leq channel spacing and where possible Resolution bandwidth should be set $\gg 1 / T$, where T is the expected dwell time per channel.
- Video bandwidth: ³ the resolution bandwidth.
- Sweep: As necessary to capture the entire dwell time per hopping channel; where possible use a video trigger and trigger delay so that the transmitted signal starts a little to the right of the start of the plot. The trigger level might need slight adjustment to prevent triggering when the system hops on an adjacent channel; a second plot might be needed with a longer sweep time to show two successive hops on a channel.
- Detector function: peak.
- Trace mode: Max hold.

The marker and delta marker function of the spectrum analyser will be used to determine the dwell time.

The measurement will be performed at the middle of the assigned frequency band.

Repeat the measurement using a longer sweep time to determine the number of hops over the period specified in the requirements. The sweep time shall be equal to, or less than, the period specified in the requirements. Determine the number of hops over the sweep time and calculate the total number of hops in the period specified in the requirements, using the following equation:

$$\begin{aligned} & \text{(Number of hops in the period specified in the requirements)} = \\ & \text{(number of hops on spectrum analyzer)} \times (\text{period specified in the requirements} / \text{analyzer sweep time}) \end{aligned}$$

The average time of occupancy is calculated from the transmit time per hop multiplied by the number of hops in the period specified in the requirements. If the number of hops in a specific time varies with different modes of operation (data rate, modulation format, number of hopping channels, etc.), then repeat this test for each variation.

The measured transmit time and time between hops shall be consistent with the values described in the operational description for the EUT.

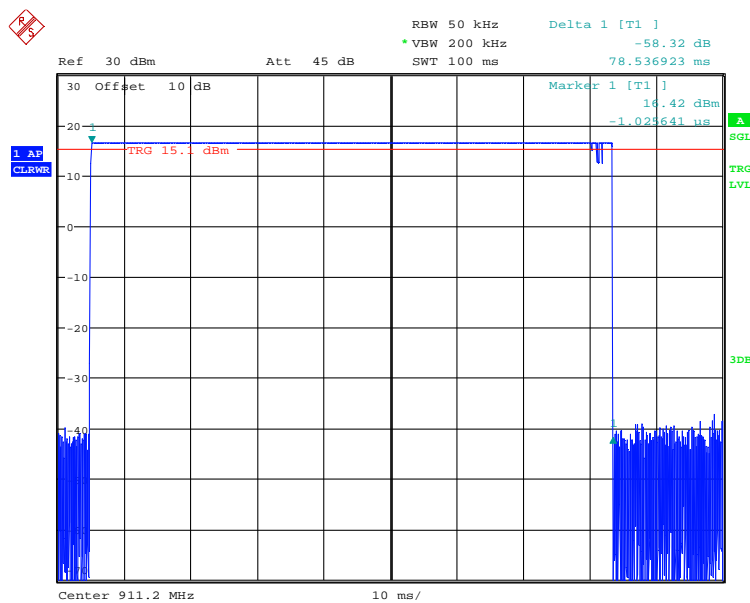
Test set-up:



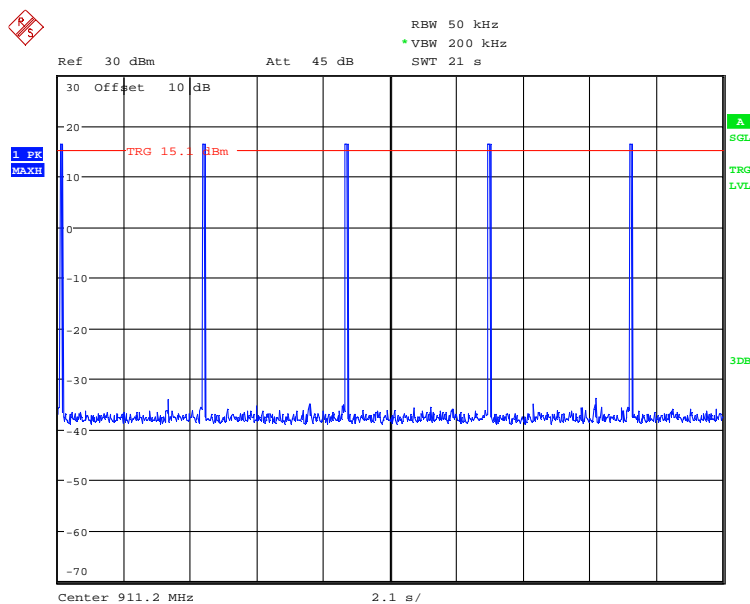
5.4.2 Test results (dwell time)

Ambient temperature	23 °C	Relative humidity	39 %
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190760_Dwell1_24.wmf: Dwell time at the middle of the assigned frequency band (single hop):



190760_Dwell2_24.wmf: Dwell time at the middle of the assigned frequency band (21 s sweep):



Channel number	Channel frequency [MHz]	t_{pulse} [ms]	Number of pulses	Dwell time [ms]	Limit [ms]
24	911.200	78.537	5	392.685	400.000
Measurement uncertainty				$<10^{-7}$	

Test: Passed

Test equipment used (see chapter 6):

15, 30

5.5 Maximum peak output power

5.5.1 Method of measurement (maximum peak output power)

The calibration of the spectrum analyser has to be checked with the help of a known signal from a signal generator. The EUT has to be connected to the spectrum analyser via a low loss cable. If the EUT is not equipped with an antenna connector, a temporary antenna connector has to be installed. The EUT has to be switched on and the hopping function has to be disabled.

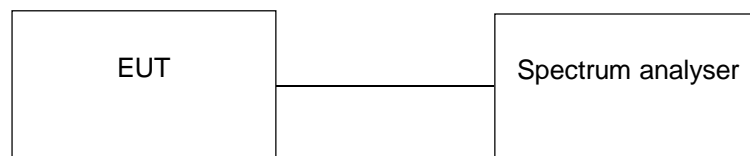
The following spectrum analyser settings according to [1] shall be used:

- Span: Approx. 5 times the 20 dB bandwidth, centred on a hopping channel.
- Resolution bandwidth: > the 20 dB bandwidth of the emission being measured.
- Video bandwidth: ³ the resolution bandwidth.
- Sweep: Auto.
- Detector function: peak.
- Trace mode: Max hold.

After trace stabilisation the marker shall be set on the signal peak. The indicated level is the peak output power, which has to be corrected with the value of the cable loss and an external attenuation (if necessary).

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

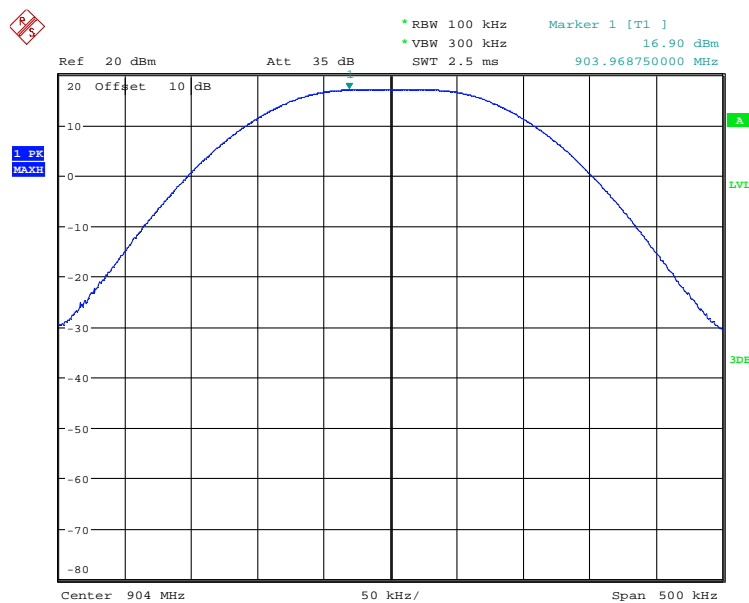
Test set-up:



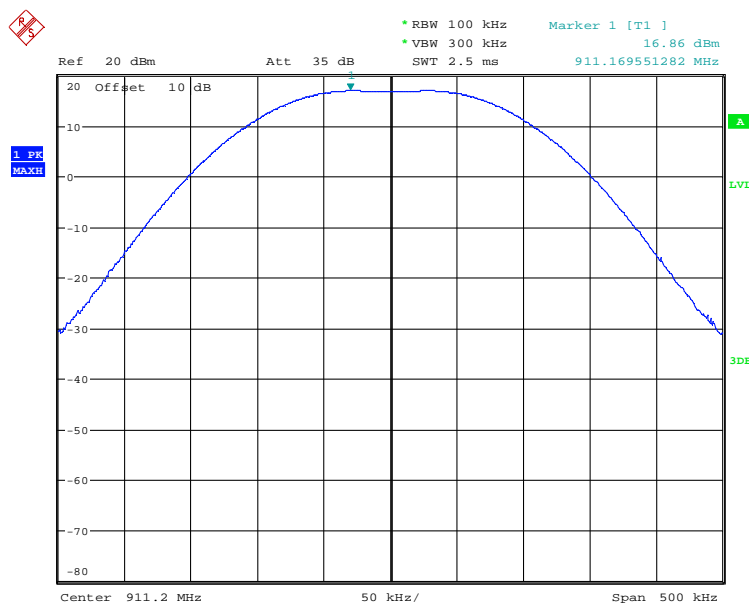
5.5.2 Test results (maximum peak output power)

Ambient temperature	23 °C	Relative humidity	39 %
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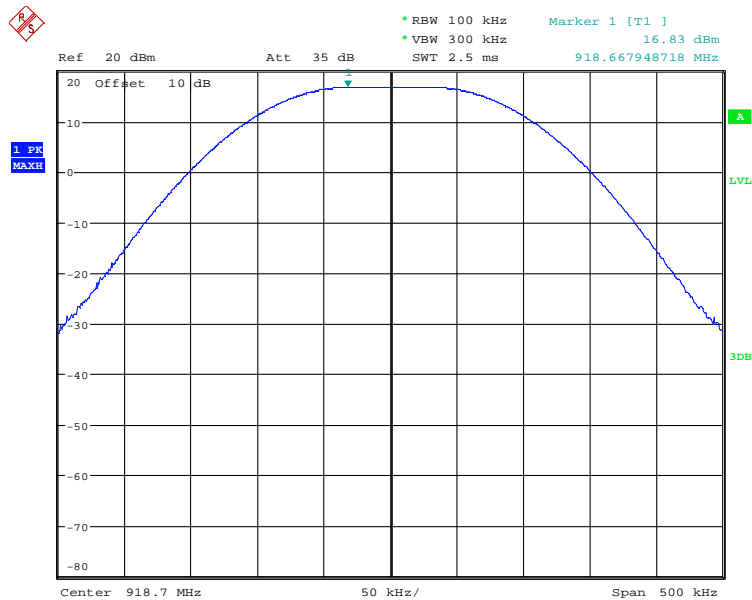
190760_PWR_0.wmf: Maximum peak output power at the lower end of the assigned frequency band:



190760_PWR_24.wmf: Maximum peak output power at the middle of the assigned frequency band:



190760_PWR_49.wmf: Maximum peak output power at the upper end of the assigned frequency band:



Operation mode	Channel number	Channel frequency [MHz]	Maximum peak output power [dBm]	Antenna gain [dBi]	Peak power limit [dBm]
1	0	904.000	16.9	11.0	25.0
2	24	911.200	16.9	11.0	25.0
3	49	918.700	16.8	11.0	25.0
Measurement uncertainty				+0.66 dB / -0.72 dB	

Test: Passed

Test equipment used (see chapter 6):

14, 30

5.6 Radiated emissions

5.6.1 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 heights 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 1 GHz to 25 / 40 GHz.
- A final measurement carried out in a fully anechoic chamber with a fixed antenna height in the frequency range 1 GHz to 40 GHz.

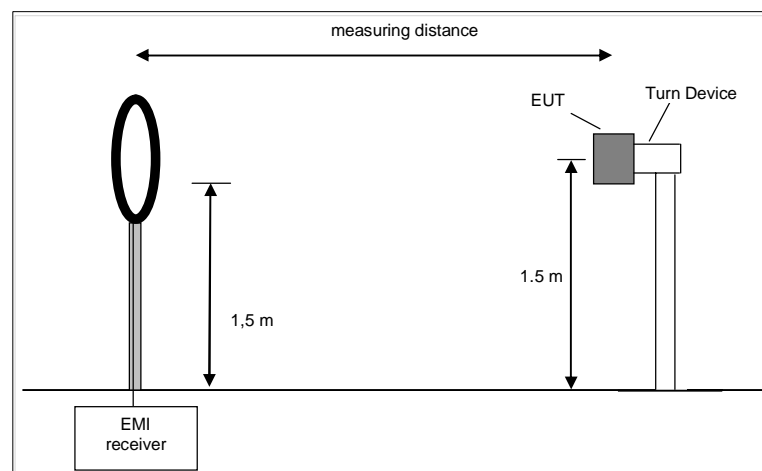
Preliminary measurement (9 kHz to 30 MHz):

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 support with a size of 1 m by 1.5 m and a height of 80 cm. Floor-standing devices will be placed directly on the turntable/ground plane. The 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 analyser 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 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:

Prescans were performed in the frequency range 9 kHz to 150 kHz and 150 kHz to 30 MHz.

The following procedure will be used:

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

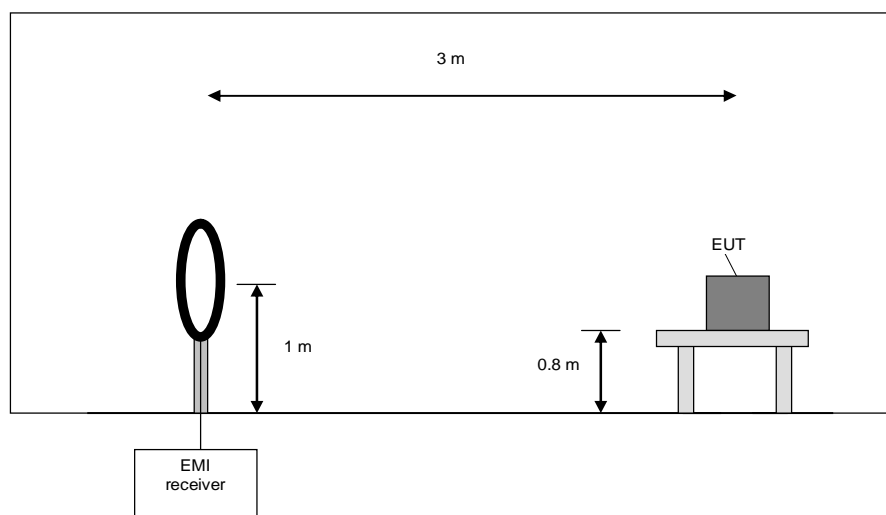
Final measurement (9 kHz to 30 MHz):

In the second stage a final measurement will be performed on an open area test site with no conducting ground plane in a measuring distances of 3 m, 10 m and 30 m. In the case where larger measuring distances are required the results will be extrapolated based on the values measured on the closer distances according to Section 15.31 (f) (2) [2]. The final measurement will be performed with 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).

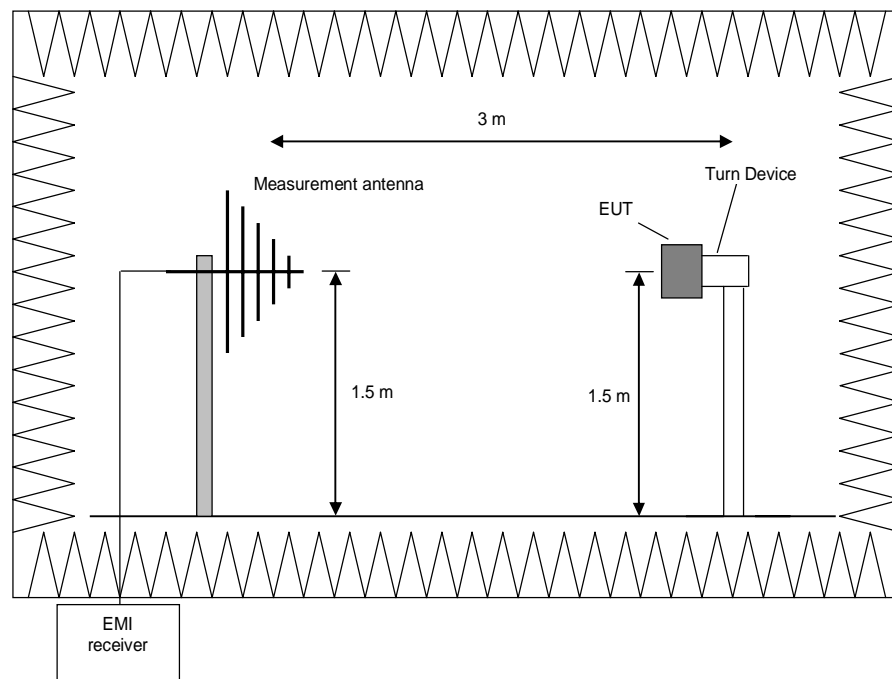
Preliminary measurement (30 MHz to 1 GHz)

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 1.5 m. 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 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 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
30 MHz to 230 MHz	100 kHz
230 MHz to 1 GHz	100 kHz



Procedure preliminary measurement:

Prescans were performed in the frequency range 30 MHz to 230 MHz and 230 MHz to 1 GHz.

The following procedure will be used:

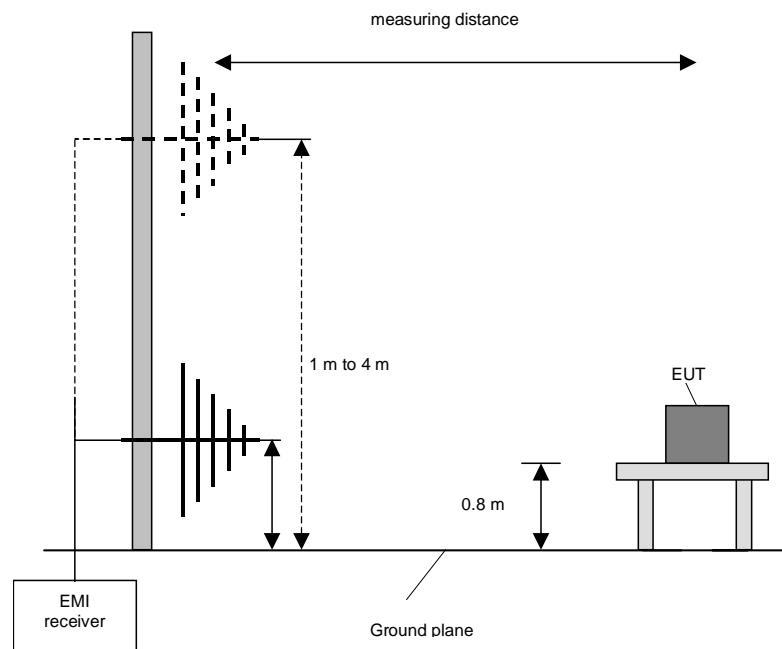
1. Monitor the frequency range at horizontal polarisation and a EUT azimuth of 0 °.
2. Manipulate the system cables within the range to produce the maximum level of emission.
3. Rotate the EUT by 360 ° to maximize the detected signals.
4. Repeat 1) to 3) with the vertical polarisation of the measuring antenna.
5. Make a hardcopy of the spectrum.
6. Repeat 1) to 5) with the EUT raised by an angle of 30 ° (60 °, 90 °, 120 ° and 150 °) 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 (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 polarisation 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)

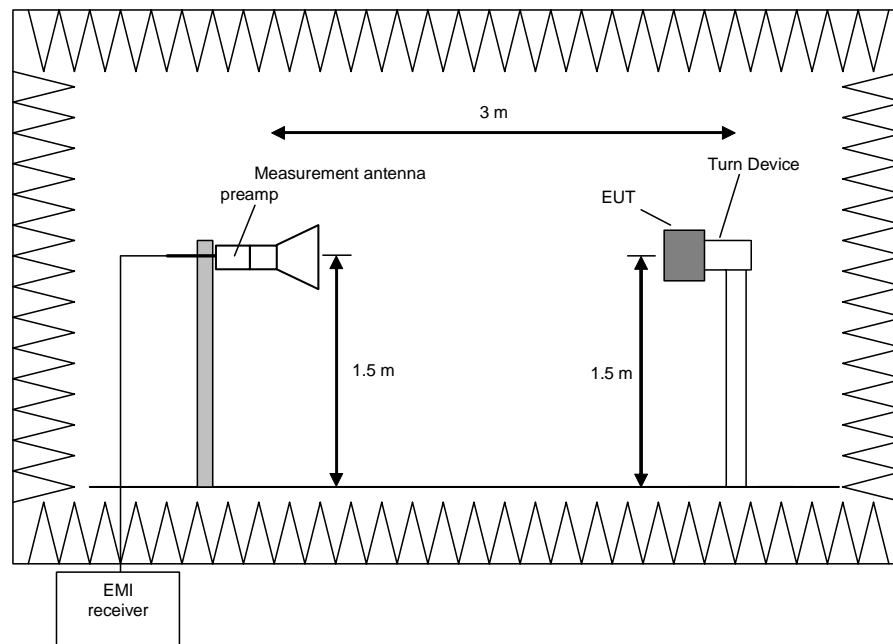
This measurement will be performed in a fully anechoic chamber. Table top devices will set up on a non-conducting turn device on the height of 1.5 m. The set-up of the Equipment under test will be in accordance to [1].

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 100 kHz. 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	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:

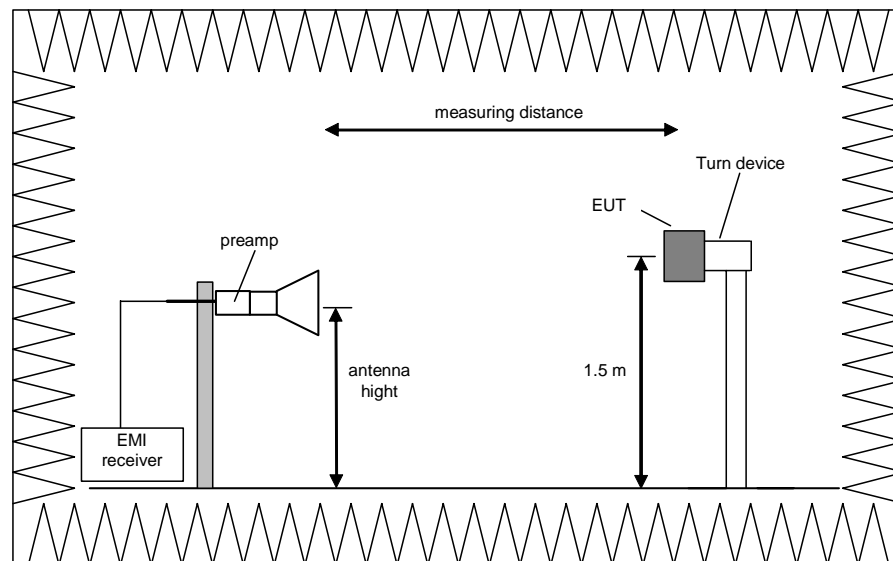
1. Monitor the frequency range at horizontal polarisation and a EUT azimuth of 0 °.
2. Rotate the EUT by 360° to maximize the detected signals.
3. Repeat 1) to 2) with the vertical polarisation of the measuring antenna.
4. Make a hardcopy of the spectrum.
5. Repeat 1) to 4) with the EUT raised by an 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. 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) Rotate the turntable from 0° to 360° to find the EUT angle 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.

5.6.2 Test results (radiated emissions)

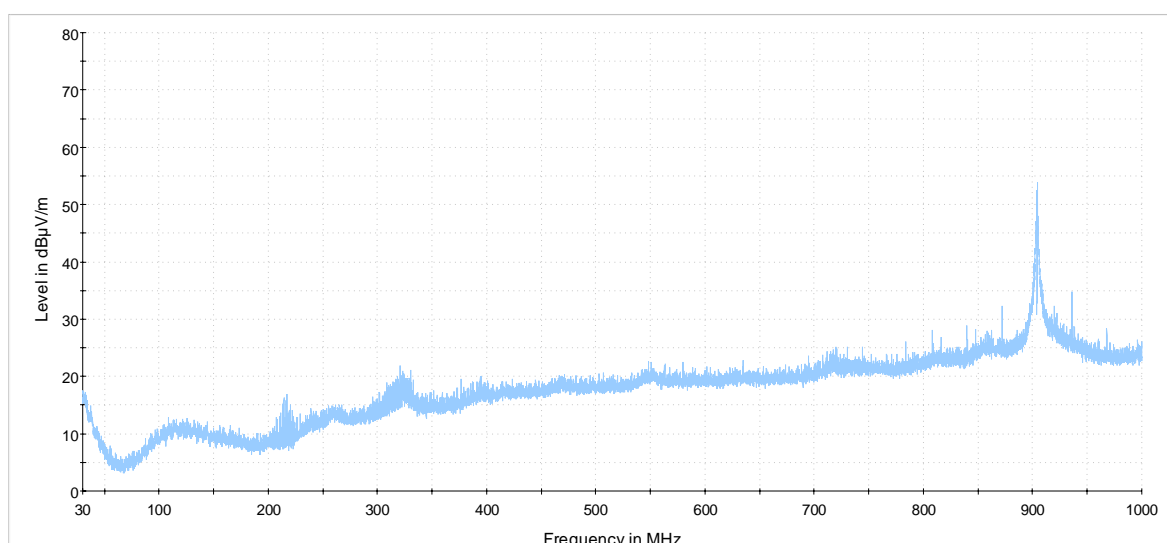
5.6.2.1 Preliminary radiated emission measurement with internal antenna

Ambient temperature	22 °C	Relative humidity	44 %
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Position of EUT:	The EUT was set-up on the positioner at 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 annex A of this test report.
Test record:	All results are shown in the following.
Supply voltage:	During all measurements the EUT was supplied 3.3 V DC by the internal battery.
Frequency range:	The preliminary measurement was carried out in the frequency range 9 kHz to 10 GHz according to [2].
Remark:	As pre-tests have shown, the emissions in the frequency range 9 kHz to 30 MHz are not depending on the transmitter operation mode. Therefore the emissions in this frequency range were measured only with the transmitter operates in operation mode 2.

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

190760 30M 1G 0 i: Spurious emissions from 30 MHz to 1 GHz (operation mode 1, carrier notched):



The following frequency was found inside the restricted bands during the preliminary radiated emission test.

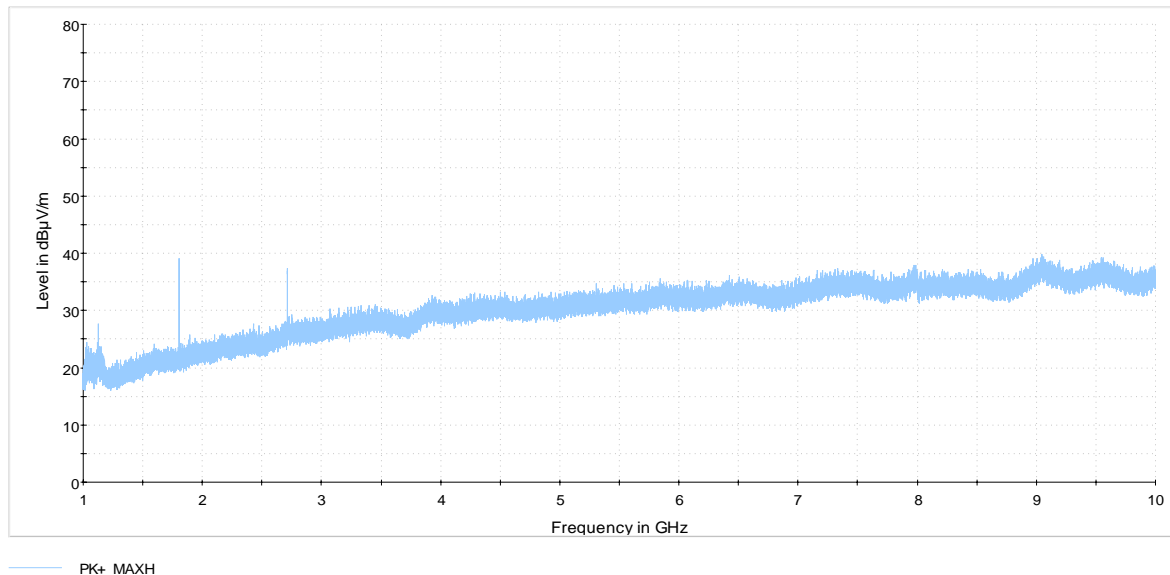
- 967.990 MHz.

The following frequencies were found outside the restricted bands during the preliminary radiated emission test:

- 30.291 MHz, 217.162 MHz, 320.370 MHz, 839.950 MHz, 872.009 MHz and 904.000 MHz.

These frequencies have to be measured on the open area test site. The result is presented in the following.

190760_1G_10G_0 i: Spurious emissions from 1 GHz to 10 GHz (operation mode 1):



The following frequency was found inside the restricted bands during the preliminary radiated emission test.

- 2712.000 MHz.

The following frequency was found outside the restricted bands during the preliminary radiated emission test:

- 1808.000 MHz.

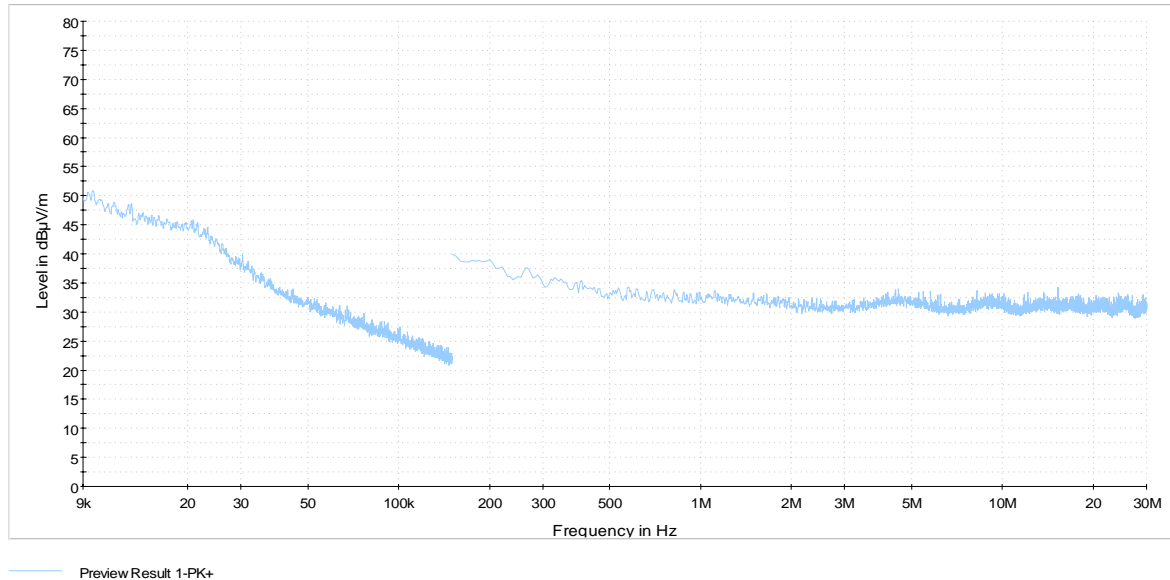
These frequencies have to be measured in a final measurement. The results were presented in the following.

Test equipment used (see chapter 6):

11, 13, 15 - 29

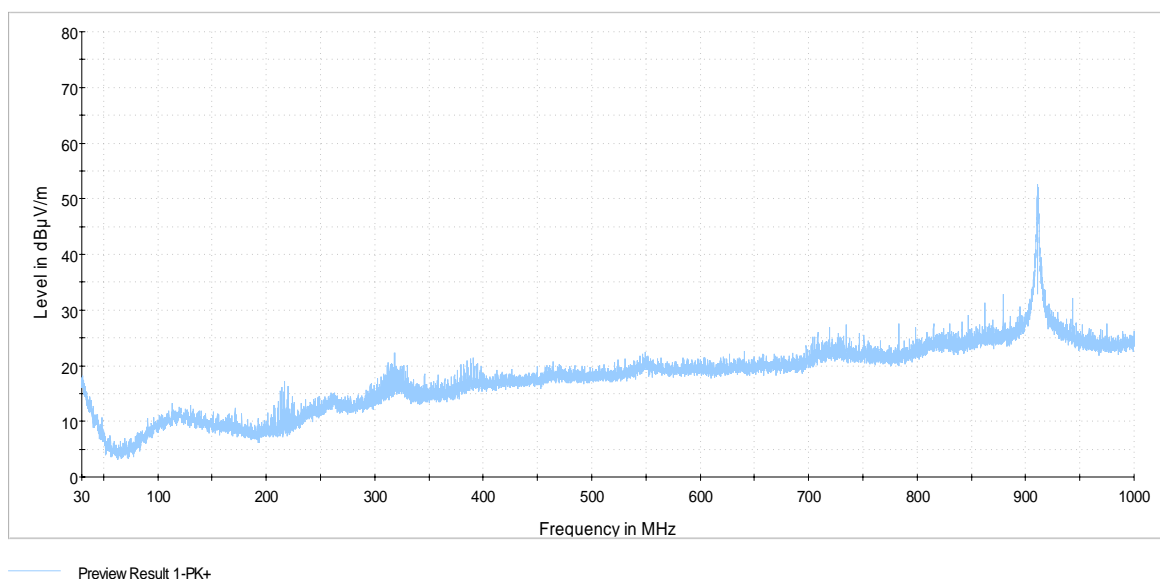
Transmitter operates on the middle of the assigned frequency band (operation mode 2)

190760 9k 30M 24 i: Spurious emissions from 9 kHz to 30 MHz (operation mode 2):



No significant frequencies above the noise floor of the system (max 50.5 dBµV/m (measured with peak detector) at 3 m distance) were found during the preliminary radiated emission test, so no measurements were carried out on the outdoor test site.

190760 30M 1G 24 i: Spurious emissions from 30 MHz to 1 GHz (operation mode 2, carrier notched):



The following frequency was found inside the restricted bands during the preliminary radiated emission test.

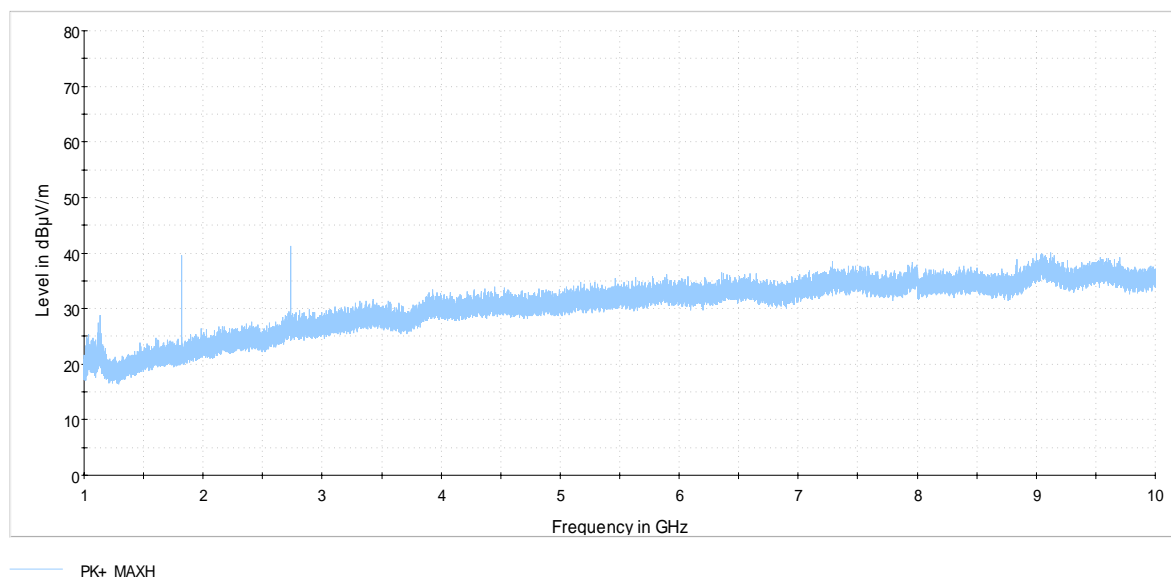
- 975.217 MHz.

The following frequencies were found outside the restricted bands during the preliminary radiated emission test:

- 30.631 MHz, 318.430 MHz, 734.366 MHz, 862.454 MHz, 879.235 MHz, 894.658 MHz, 911.200 MHz and 943.207 MHz.

These frequencies have to be measured on the open area test site. The result is presented in the following.

190760 1G 10G 24 i: Spurious emissions from 1 GHz to 10 GHz (operation mode 2):



The following frequency was found inside the restricted bands during the preliminary radiated emission test.

- 2733.300 MHz.

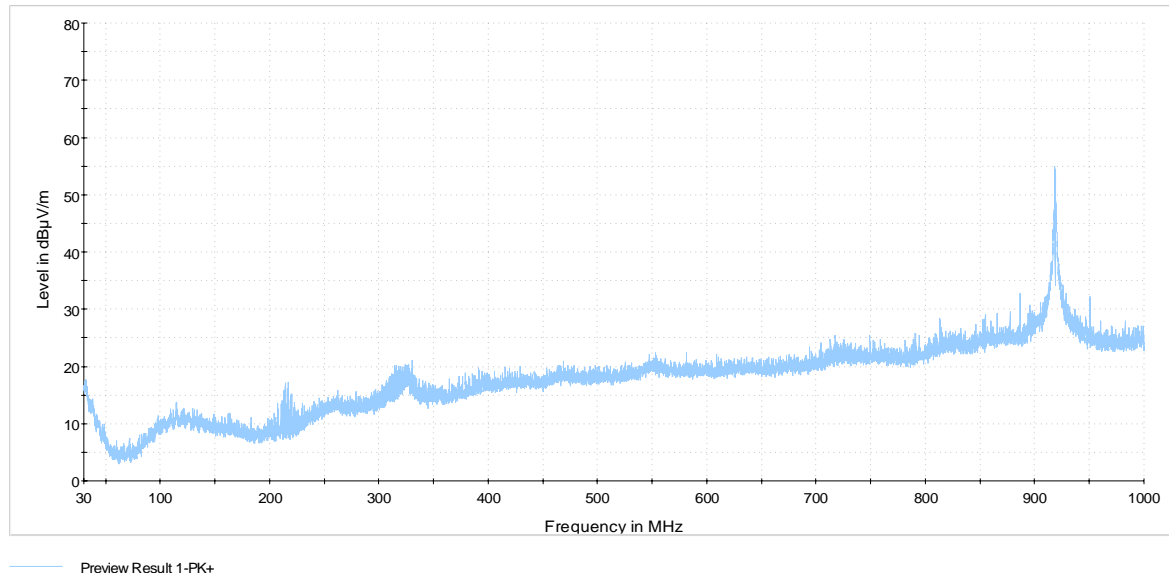
The following frequency was found outside the restricted bands during the preliminary radiated emission test:

- 1822.400 MHz.

These frequencies have to be measured in a final measurement. The results were presented in the following.

Transmitter operates on the upper end of the assigned frequency (operation mode 3)

190760 30M 1G 49 i: Spurious emissions from 30 MHz to 1 GHz (operation mode 3, carrier notched):



The following frequency was found inside the restricted bands during the preliminary radiated emission test.

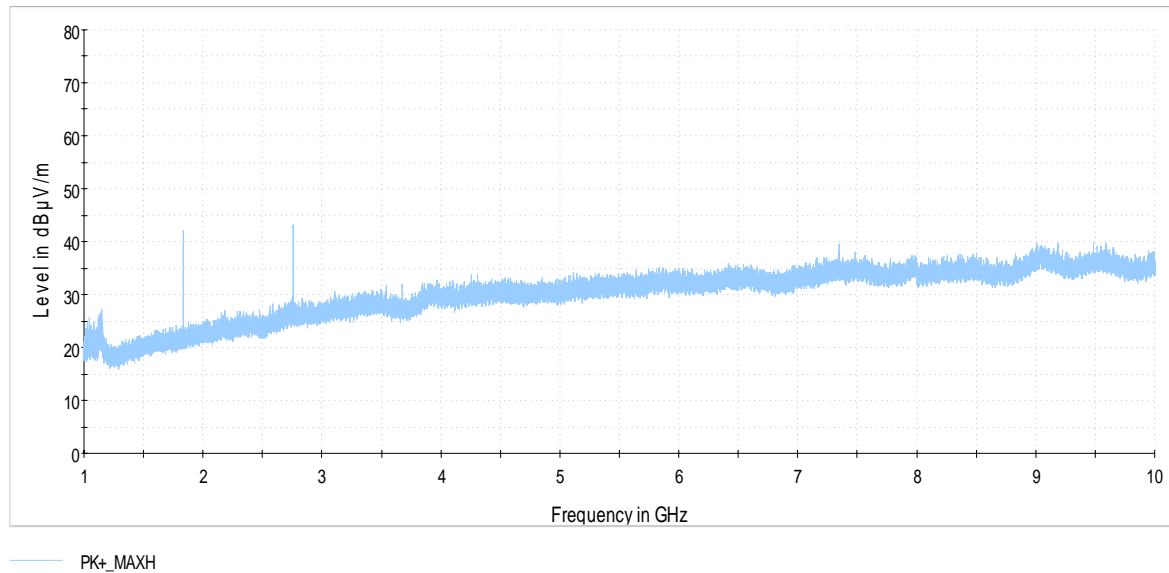
- 330.167 MHz.

The following frequencies were found outside the restricted bands during the preliminary radiated emission test:

- 31.989 MHz, 217.162 MHz, 886.704 MHz, 918.700 MHz, 950.676 MHz and 959.988 MHz.

These frequencies have to be measured on the open area test site. The result is presented in the following.

190760_1G_10G_49_i: Spurious emissions from 1 GHz to 10 GHz (operation mode 3):



The following frequencies were found inside the restricted bands during the preliminary radiated emission test.

- 2756.100 MHz and 7349.600 MHz.

The following frequency was found outside the restricted bands during the preliminary radiated emission test:

- 1837.400 MHz.

These frequencies have to be measured in a final measurement. The results were presented in the following.

5.6.2.2 Final radiated emission measurement (9 kHz to 30 MHz) with internal antenna

No significant frequencies above the noise floor of the system (max 50.5 dB μ V/m (measured with peak detector) at 3 m distance) were found during the preliminary radiated emission test, so no measurements were carried out on the outdoor test site.

5.6.2.3 Final radiated emission measurement (30 MHz to 1 GHz) with internal antenna

Ambient temperature	22 °C	Relative humidity	44 %
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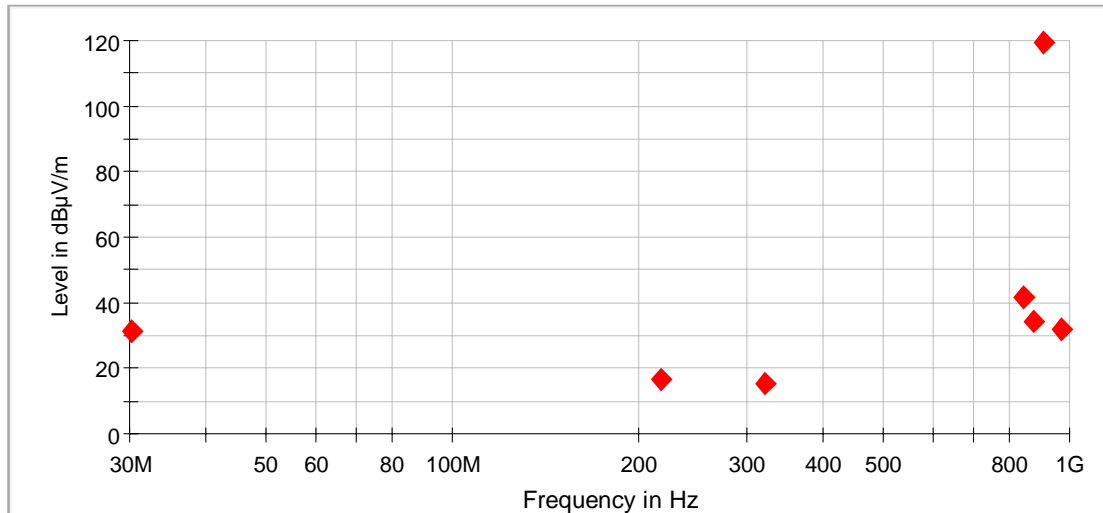
- Position of EUT: The EUT was set-up on a non-conducting table of a height of 0.8 m. The distance between EUT and antenna was 3 m.
- Cable guide: For detail information of test set-up and the cable guide refer to the pictures in annex A of this test report.
- Test record: All results are shown in the following.
- Supply voltage: During all measurements the EUT was supplied 3.6 V DC by the internal battery, which was buffered by an external power supply with 12 V DC.
- Test results: The test results were calculated with the following formula:

$$\text{Result [dB}\mu\text{V/m]} = \text{reading [dB}\mu\text{V]} + \text{cable loss [dB]} + \text{antenna factor [dB/m]} + 6 \text{ dB}$$

The measured points and the limit line in the following diagrams refer to the standard measurement of the emitted interference in compliance with the above-mentioned standard. The measured points marked with an x are the measured results of the standard final measurement on the open area test site. The results of the standard subsequent measurement on the open area test site are indicated in the table below. The limits as well as the measured results (levels) refer to the above mentioned standard while taking account of the specified requirements for a 3 m measuring distance.

The measurement time with the quasi-peak measuring detector is 1 second.

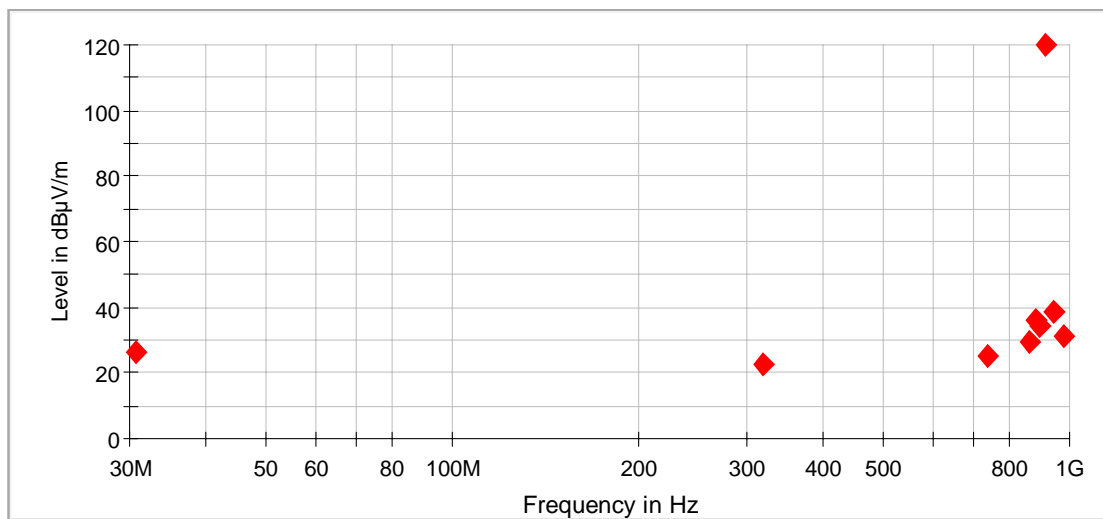
Transmitter operates on the lower end of the assigned frequency (operation mode 1)



◆ Final_Result QPK

Data record name: 190760_ff_0

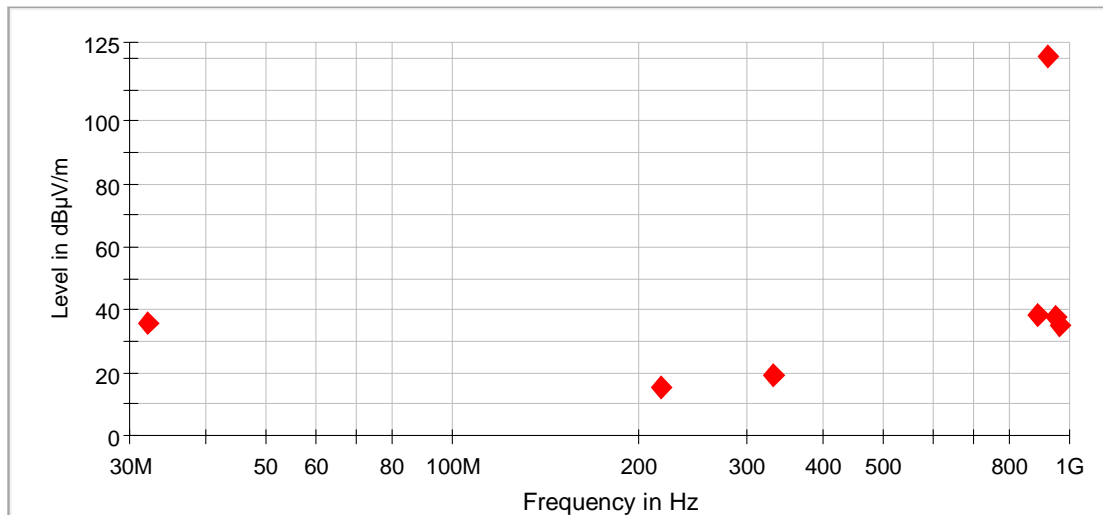
Transmitter operates on the middle of the assigned frequency (operation mode 2)



◆ Final_Result QPK

Data record name: 190760_ff_24

Transmitter operates on the upper end of the assigned frequency (operation mode 3)



◆ Final_Result QPK

Data record name: 190760_ff_49

Result measured with the quasi-peak detector:

(These values were marked in the diagrams by an ◆)

Transmitter operates on the lower end of the assigned frequency band (operation mode 1)										
Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol.	Azimuth (deg)	Corr. (dB)	Restr. Band
30.291	31.3	40.0	8.7	1000	120	122	Vert.	309.0	27.0	No
217.162	16.8	46.0	29.2	1000	120	150	Hor.	81.0	16.9	No
320.370	15.2	46.0	30.8	1000	120	119	Vert.	139.0	22.0	No
839.950	41.7	46.0	4.3	1000	120	210	Vert.	322.0	33.6	No
872.009	34.5	46.0	11.5	1000	120	113	Vert.	306.0	33.2	No
904.000	119.5	Carrier	-	1000	120	108	Vert.	354.0	33.7	No
967.990	31.8	54.0	22.2	1000	120	100	Vert.	328.0	35.7	Yes
Transmitter operates on the middle of the assigned frequency band (operation mode 2)										
Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol.	Azimuth (deg)	Corr. (dB)	Restr. Band
30.631	26.5	40.0	13.5	1000	120	373	Vert.	226	26.9	No
318.430	22.4	46.0	23.6	1000	120	102	Hor.	226	21.9	No
734.366	24.8	46.0	21.2	1000	120	253	Vert.	325	32.0	No
862.454	29.5	46.0	16.5	1000	120	187	Vert.	328	33.3	No
879.235	35.9	46.0	10.1	1000	120	113	Vert.	338	33.3	No
894.658	34.2	46.0	11.8	1000	120	106	Vert.	309	33.4	No
911.200	120.0	Carrier	-	1000	120	108	Vert.	344	34.0	No
943.207	38.6	46.0	7.4	1000	120	104	Vert.	326	35.6	No
975.217	31.2	54.0	22.8	1000	120	102	Vert.	337	35.6	Yes
Transmitter operates on the upper end of the assigned frequency band (operation mode 3)										
Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol.	Azimuth (deg)	Corr. (dB)	Restr. Band
31.989	35.8	40.0	4.2	1000	120	136	Vert.	319	26.3	No
217.162	15.4	46.0	30.6	1000	120	126	Hor.	46	16.9	No
330.167	19.1	46.0	26.9	1000	120	102	Hor.	46	22.3	Yes
886.704	38.3	46.0	7.7	1000	120	114	Vert.	337	33.4	No
918.700	120.5	Carrier	-	1000	120	110	Vert.	350	34.3	No
950.676	37.9	46.0	8.1	1000	120	108	Vert.	334	35.8	No
959.988	35.0	46.0	11.0	1000	120	103	Vert.	320	35.6	No
Measurement uncertainty				±4.8 dB						

Test: Passed

Test equipment used (see chapter 6):

6 - 11

5.6.2.4 Final radiated emission measurement (1 GHz to 10 GHz) with internal antenna

Ambient temperature	22 °C	Relative humidity	44 %
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Position of EUT: The EUT was set-up on the positioner at 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 annex A of this test report.

Test record: All results are shown in the following.

Supply voltage: During all measurements the EUT was supplied 3.3 V DC by the internal battery.

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

Transmitter operates at the lower end of the assigned frequency band (operation mode 2)

Result measured with the peak detector:

Frequency (MHz)	Result (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Polarisation	Azimuth (deg)	Elevation (deg)	Corr. (dB/m)	Restricted band
1808.000	42.4	99.5	57.1	Hor.	32.0	0.0	-13.0	No
2712.000	42.7	74.0	31.3	Vert.	303.0	0.0	-8.0	Yes
Measurement uncertainty					± 5.1 dB			

Result measured with the average detector:

Frequency (MHz)	Result (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Polarisation	Azimuth (deg)	Elevation (deg)	Corr. (dB/m)	Restricted band
1808.000	39.4	99.5	60.1	Hor.	32.0	0.0	-13.0	No
2712.000	37.0	54.0	17.0	Vert.	303.0	0.0	-8.0	Yes
Measurement uncertainty					± 5.1 dB			

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

Result measured with the peak detector:

Frequency (MHz)	Result (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Polarisation	Azimuth (deg)	Elevation (deg)	Corr. (dB/m)	Restricted band
1822.400	42.0	100.0	58.0	Hor.	62.0	0.0	-13.0	No
2733.300	44.6	74.0	29.4	Vert.V	299.0	0.0	-8.0	Yes
Measurement uncertainty					± 5.1 dB			

Result measured with the average detector:

Frequency (MHz)	Result (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Polarisation	Azimuth (deg)	Elevation (deg)	Corr. (dB/m)	Restricted band
1822.400	38.9	100.0	61.1	Hor.	62.0	0.0	-13.0	No
2733.300	40.0	54.0	14.0	Vert.	299.0	0.0	-8.0	Yes
Measurement uncertainty					± 5.1 dB			

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

Result measured with the peak detector:

Frequency (MHz)	Result (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Polarisation	Azimuth (deg)	Elevation (deg)	Corr. (dB/m)	Restricted band
1837.400	44.6	100.5	55.9	Hor.	66.0	30.0	-13.0	No
2756.100	46.8	74.0	27.2	Vert.	304.0	0.0	-8.0	Yes
7349.600	47.6	74.0	26.4	Vert.	0.0	0.0	5.0	Yes
Measurement uncertainty					± 5.1 dB			

Result measured with the average detector:

Frequency (MHz)	Result (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Polarisation	Azimuth (deg)	Elevation (deg)	Corr. (dB/m)	Restricted band
1837.400	42.4	100.5	58.1	Hor.	66.0	30.0	-13.0	No
2756.100	43.3	54.0	10.7	Vert.	304.0	0.0	-8.0	Yes
7349.600	37.4	54.0	16.6	Vert.	0.0	0.0	5.0	Yes
Measurement uncertainty					± 5.1 dB			

Test: Passed

Test equipment used (see chapter 6):

13, 15 – 18, 20 – 25, 27, 28

5.6.2.5 Preliminary radiated emission measurement with external antenna port terminated

Ambient temperature	22 °C	Relative humidity	44 %
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Position of EUT: The EUT was set-up on a non-conducting table of a height of 0.8 m and 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 annex A of this test report.

Test record: All results are shown in the following.

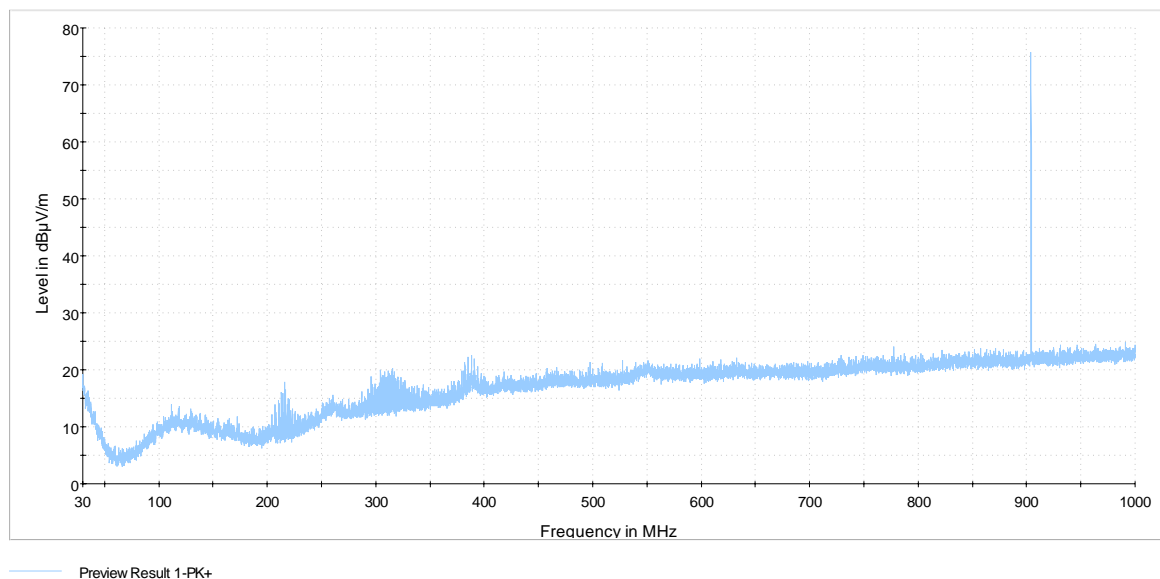
Supply voltage: During all measurements the EUT was supplied 3.6 V DC by the internal battery.

Frequency range: The preliminary measurement was carried out in the frequency range 9 kHz to 10 GHz according to [2].

Remark: As pre-tests have shown, the emissions in the frequency range 10 MHz to 30 MHz are not depending on the transmitter operation mode. Therefore the emissions in this frequency range were measured only with the transmitter operates in operation mode 2.

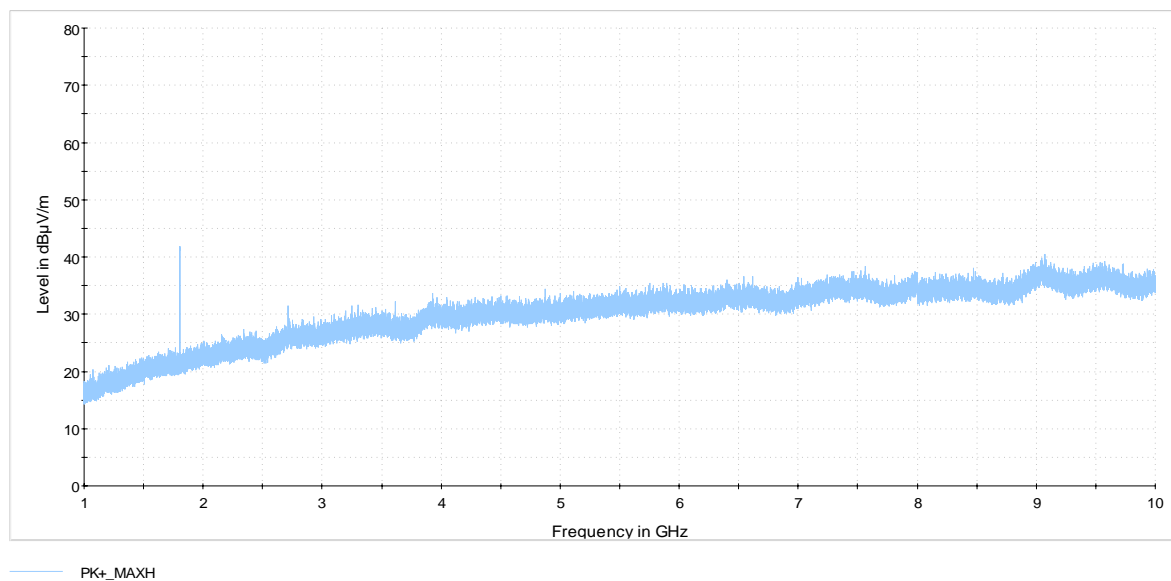
Transmitter operates at the lower end of the assigned frequency band (operation mode 1)

190760 30M 1G 0 t: Spurious emissions from 30 MHz to 1 GHz (operation mode 1):



No significant frequencies (except the wanted signal) above the noise floor of the system (max 24.9 dB μ V/m (measured with peak detector) at 3 m distance) were found during the preliminary radiated emission test, so no measurements were carried out on the open area test site.

190760 1G 10G 0 t: Spurious emissions from 1 GHz to 10 GHz (operation mode 1):



The following frequencies were found inside the restricted bands during the preliminary radiated emission test.

- 2712.000 MHz.

The following frequency was found outside the restricted bands during the preliminary radiated emission test:

- 1808.000 MHz.

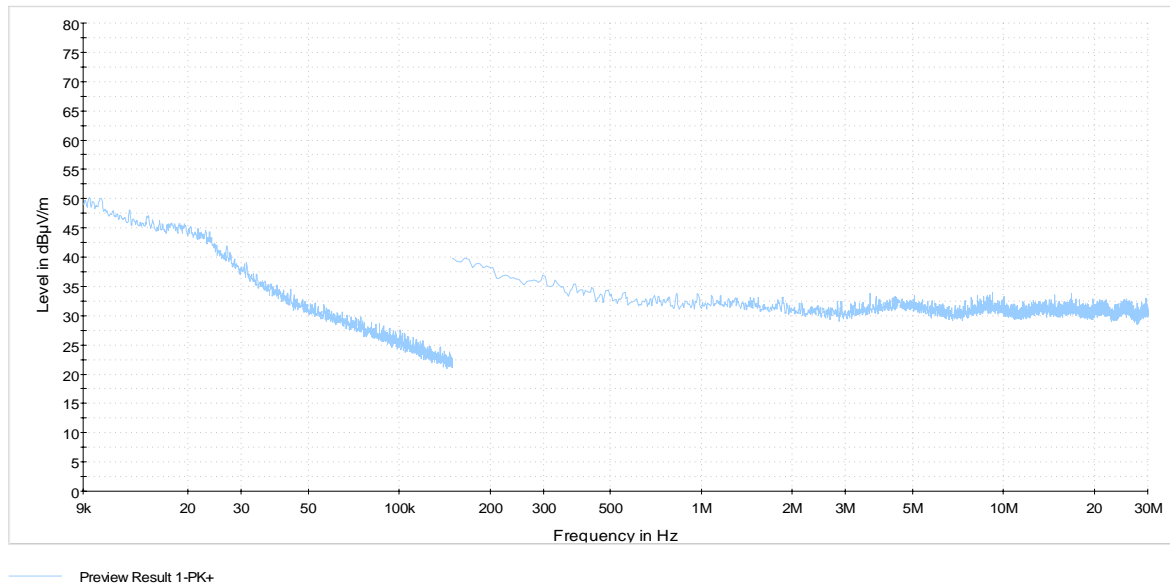
These frequencies have to be measured in a final measurement. The results were presented in the following.

Test equipment used (see chapter 6):

11, 13, 15 - 29

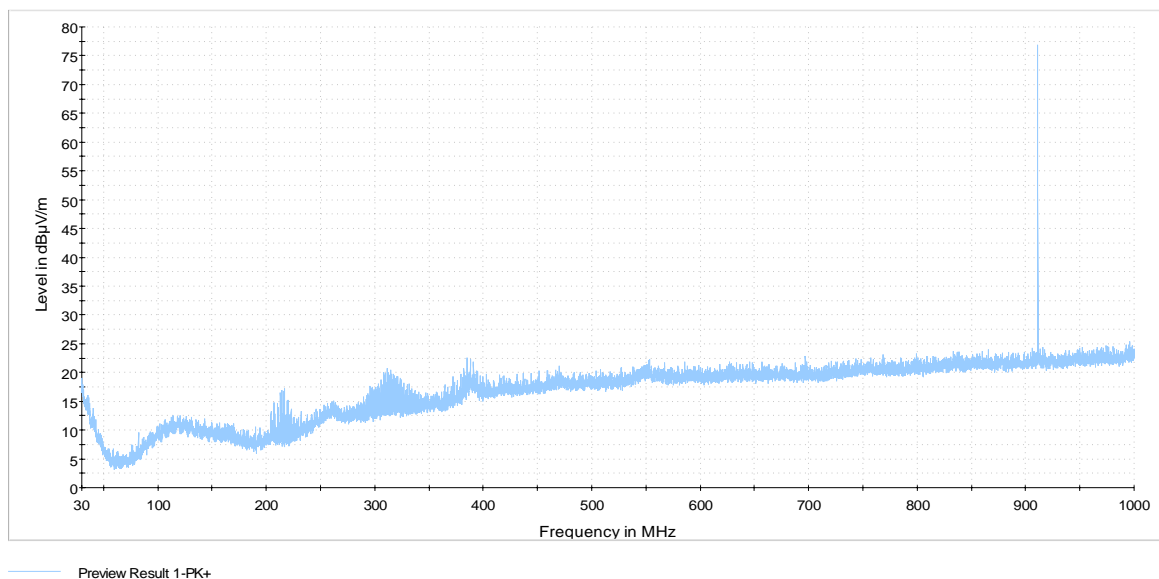
Transmitter operates on the middle of the assigned frequency band (operation mode 2)

190760 9k 30M-24 t: Spurious emissions from 9 kHz to 30MHz (operation mode 2):



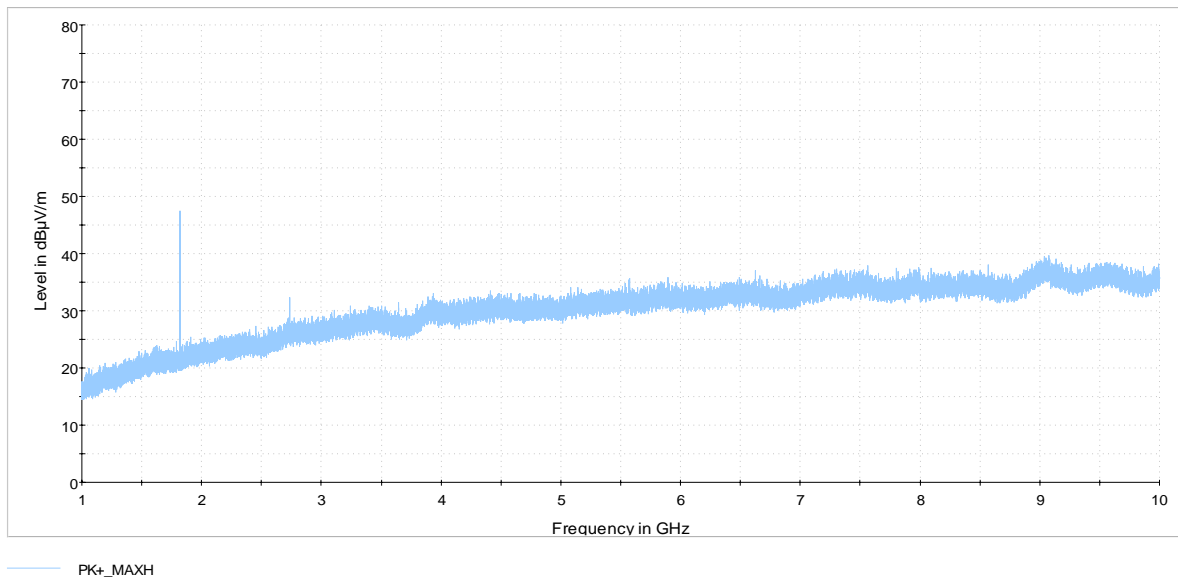
No significant frequencies above the noise floor of the system (max. 50 dBµV/m (measured with peak detector) at 3 m distance) were found during the preliminary radiated emission test, so no measurements were carried out on the outdoor test site.

190760 30M 1G 24 t: Spurious emissions from 30 MHz to 1 GHz (operation mode 2):



No significant frequencies (except the wanted signal) above the noise floor of the system (max 24.5 dB μ V/m (measured with peak detector) at 3 m distance) were found during the preliminary radiated emission test, so no measurements were carried out on the open area test site.

190760 1G 10G 24 t.wmf: Spurious emissions from 1 GHz to 10 GHz (operation mode 2):



The following frequencies were found inside the restricted bands during the preliminary radiated emission test.

- 2733.600 MHz.

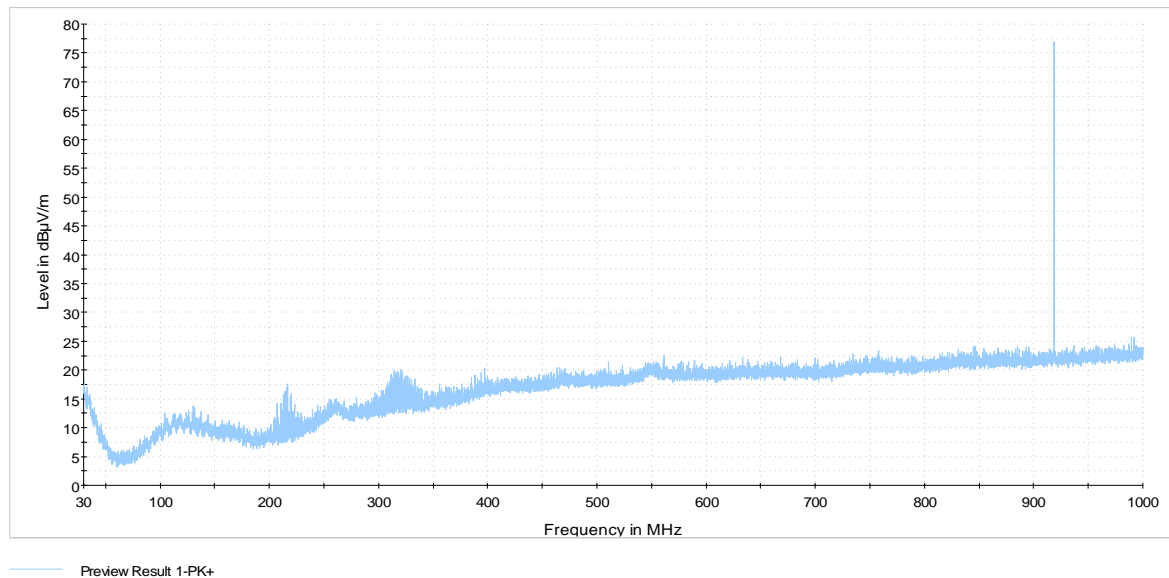
The following frequency was found outside the restricted bands during the preliminary radiated emission test:

- 1822.400 MHz.

These frequencies have to be measured in a final measurement. The results were presented in the following.

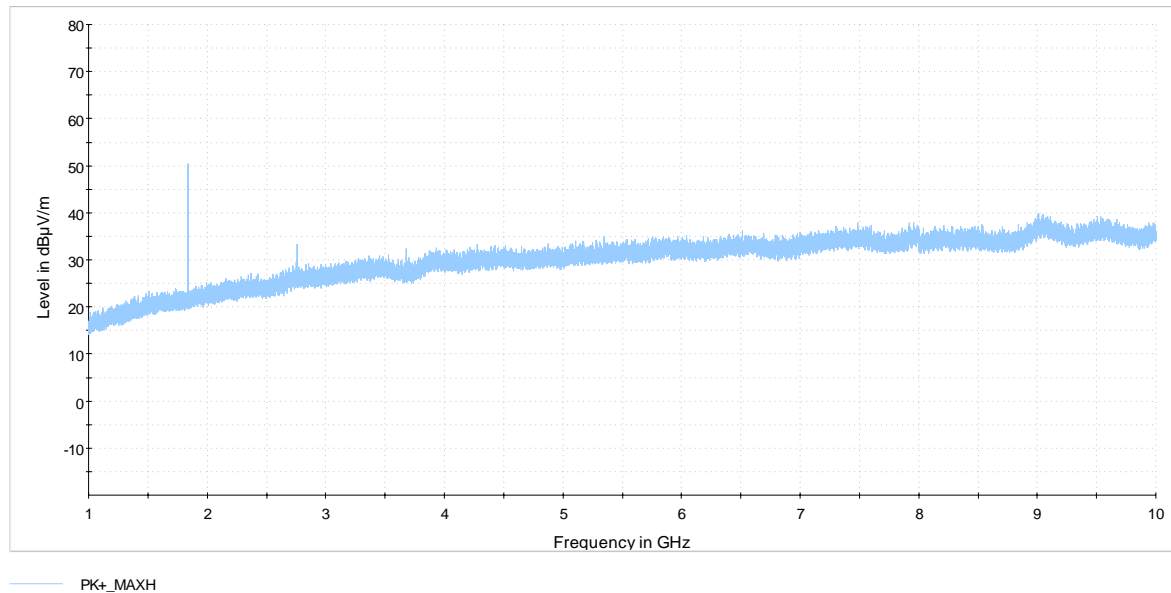
Transmitter operates on the upper end of the assigned frequency (operation mode 3)

190760_30M_1G_49_t: Spurious emissions from 30 MHz to 1 GHz (operation mode 3):



No significant frequencies (except the wanted signal) above the noise floor of the system (max 25.8 dBµV/m (measured with peak detector) at 3 m distance) were found during the preliminary radiated emission test, so no measurements were carried out on the open area test site.

190760_1G_10G_49_t: Spurious emissions from 1 GHz to 10 GHz (operation mode 3):



The following frequencies were found inside the restricted bands during the preliminary radiated emission test.

- 2756.100 MHz.

The following frequency was found outside the restricted bands during the preliminary radiated emission test:

- 1837.400 MHz.

These frequencies have to be measured in a final measurement. The results were presented in the following.

5.6.2.7 Final radiated emission measurement (9 kHz to 30 MHz) with external antenna port terminated

No significant frequencies above the noise floor of the system (max. 50 dB μ V/m (measured with peak detector) at 3 m distance) were found during the preliminary radiated emission test, so no measurements were carried out on the outdoor test site.

5.6.2.8 Final radiated emission measurement (30 MHz to 1 GHz) with external antenna port terminated

No significant frequencies (except the wanted signal) above the noise floor of the system (max 25.8 dB μ V/m (measured with peak detector) at 3 m distance) were found during the preliminary radiated emission test, so no measurements were carried out on the open area test site.

5.6.2.9 Final radiated emission measurement (1 GHz to 10 GHz) with internal antenna

Ambient temperature	22 °C	Relative humidity	44 %
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Position of EUT: The EUT was set-up on the positioner at 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 annex A of this test report.

Test record: All results are shown in the following.

Supply voltage: During all measurements the EUT was supplied 3.3 V DC by the internal battery.

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

Transmitter operates at the lower end of the assigned frequency band (operation mode 2)

Result measured with the peak detector:

Frequency (MHz)	Result (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Polarisation	Azimuth (deg)	Elevation (deg)	Corr. (dB/m)	Restricted band
1808.000	43.8	74.0	30.2	Hor.	65.0	30.0	-13.0	No
2712.000	38.9	74.0	35.1	Vert.	0.0	120.0	-8.3	Yes
Measurement uncertainty					± 5.1 dB			

Result measured with the average detector:

Frequency (MHz)	Result (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Polarisation	Azimuth (deg)	Elevation (deg)	Corr. (dB/m)	Restricted band
1808.000	41.2	54.0	12.8	Hor.	65.0	30.0	-13.0	No
2712.000	28.3	54.0	25.8	Vert.	0.0	120.0	-8.3	Yes
Measurement uncertainty					± 5.1 dB			

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

Result measured with the peak detector:

Frequency (MHz)	Result (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Polarisation	Azimuth (deg)	Elevation (deg)	Corr. (dB/m)	Restricted band
1822.400	49.1	74.0	24.9	Hor.	65.0	30.0	-13.0	No
2733.600	39.7	74.0	34.3	Vert.	0.0	90.0	-8.0	Yes
Measurement uncertainty					± 5.1 dB			

Result measured with the average detector:

Frequency (MHz)	Result (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Polarisation	Azimuth (deg)	Elevation (deg)	Corr. (dB/m)	Restricted band
1822.400	47.6	54.0	6.4	Hor.	65.0	30.0	-13.0	No
2733.600	30.0	54.0	24.0	Vert.	0.0	90.0	-8.0	30.0
Measurement uncertainty					± 5.1 dB			

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

Result measured with the peak detector:

Frequency (MHz)	Result (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Polarisation	Azimuth (deg)	Elevation (deg)	Corr. (dB/m)	Restricted band
1837.400	51.5	74.0	22.5	Hor.	73.0	30.0	-13.0	No
2756.100	41.0	74.0	33.0	Hor.	150.0	150.0	-8.0	Yes
Measurement uncertainty					± 5.1 dB			

Result measured with the average detector:

Frequency (MHz)	Result (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Polarisation	Azimuth (deg)	Elevation (deg)	Corr. (dB/m)	Restricted band
1837.400	50.6	54.0	3.4	Hor.	73.0	30.0	-13.0	No
2756.100	32.1	54.0	21.9	Hor.	150.0	150.0	-8.0	Yes
Measurement uncertainty					± 5.1 dB			

Test: Passed

Test equipment used (see chapter 6):

13, 15 – 18, 22 – 25, 27

5.7 Conducted emissions on antenna port

5.7.1 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 analyser. 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 ($D \geq 98\%$) cannot be achieved and the duty cycle is constant (duty cycle variations are less than $\pm 2\%$), 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 $\geq 3 \times$ RBW.
- Detector = power average (RMS).
- Ensure that the number of measurement points in the sweep to $\geq 2 \times$ (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 (only applicable if not transmit continuously).

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 \geq 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

5.7.1.1 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 dB μ V/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 this test report the procedure of summing of emissions as described in 14.3.2.2 in [1] was used.

To account for directional gain which might occur in case of N transmit antennas, the directional has to be calculated as

$$G_{Dir} = G_{Ant} + 10 \log(N) dBi ,$$

whereby N is the number of antennas.

This EUT has only one antenna port, therefore no calculation for multiple ports have to be performed.

5.7.2 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 5.7.2.1 and the emission level according to procedure 5.7.2.2. The procedures are based on chapter 11.11.2 and 11.11.3 in [1].

5.7.2.1 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 $\geq 3 \times$ 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.

5.7.2.2 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 $\geq 3 \times$ RBW.
- d) Detector = peak.
- e) Ensure that the number of measurement points \geq 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.

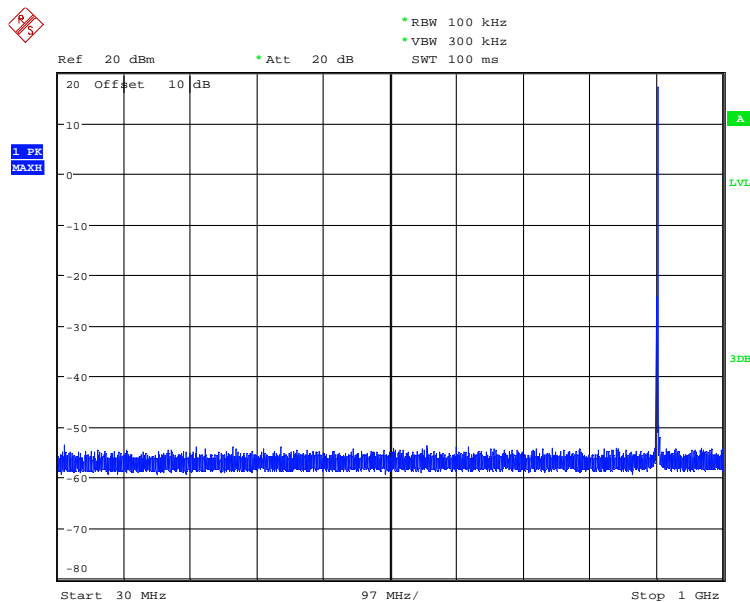
5.7.3 Test results (conducted emissions)

Ambient temperature	22 °C	Relative humidity	38 %
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Transmitter operates at the lower end of the assigned frequency band (operation mode 1)

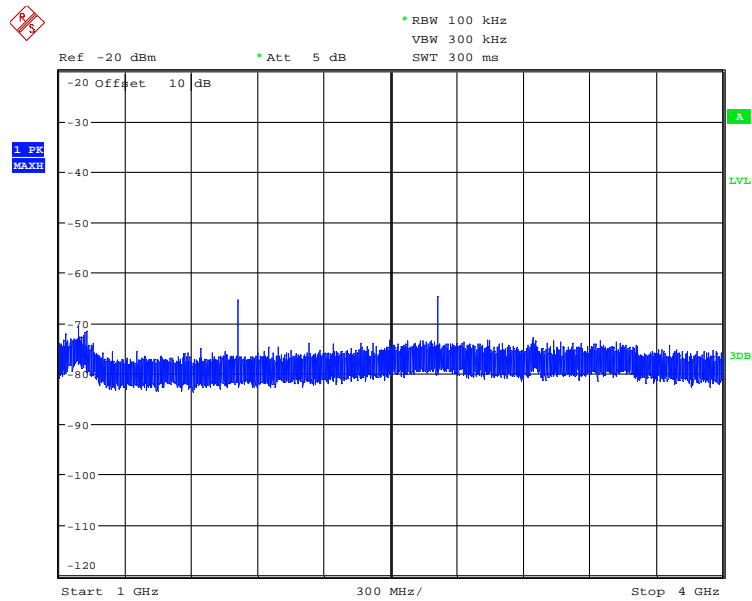
No significant emissions up to 20 dB to the limit were found in the frequency range below 30 MHz, therefore no results are submitted below.

190760_30M_1G_0_con.wmf: Conducted spurious emissions from 30 MHz to 1 GHz (operation mode 1):

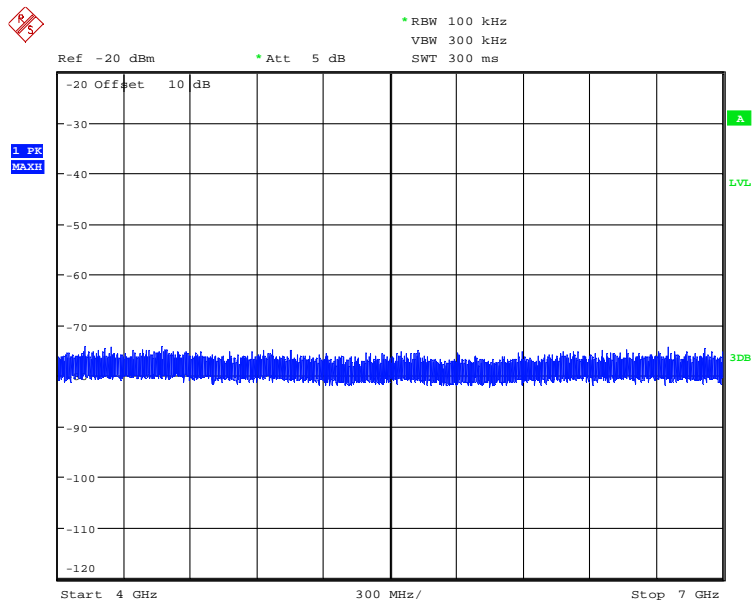


Remark: No emissions except the wanted signal were found in this frequency range.

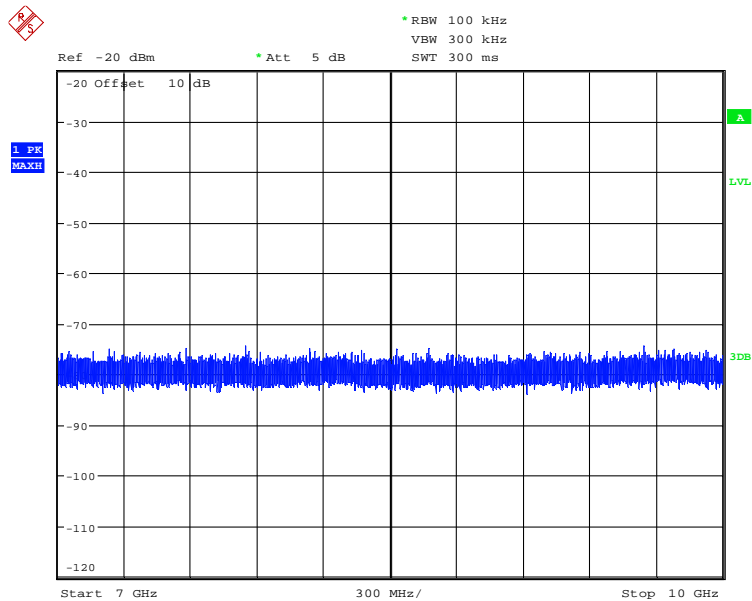
190760_1G_4G_0_con.wmf: Conducted spurious emissions from 1 GHz to 4 GHz (operation mode 1):



190760_4G_7G_0_con.wmf: Conducted spurious emissions from 4 GHz to 7 GHz (operation mode 1):



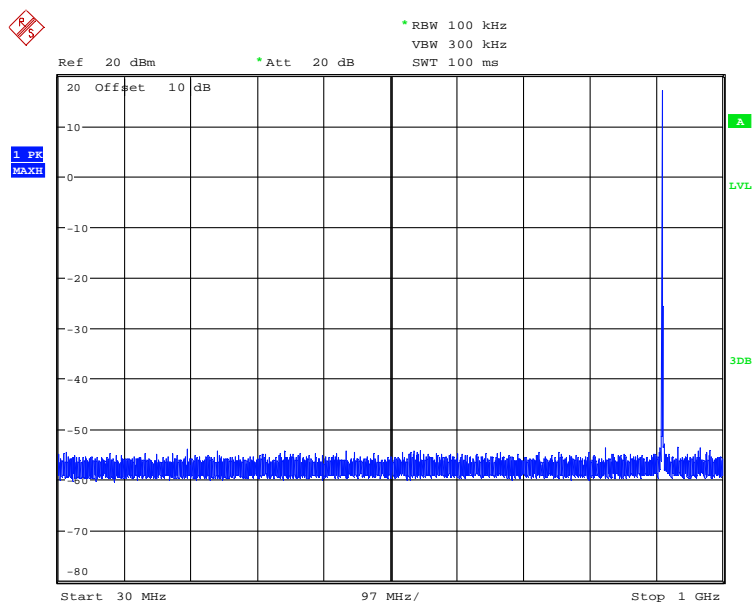
190760_7G_10G_0_con.wmf: Conducted spurious emissions from 7 GHz to 10 GHz (operation mode 1):



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

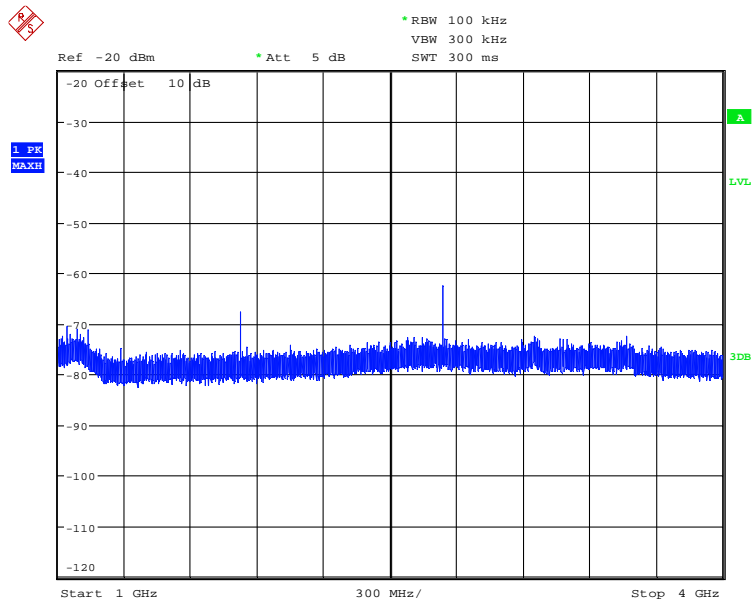
No significant emissions up to 20 dB to the limit were found in the frequency range below 30 MHz, therefore no results are submitted below.

190760_30M_1G_24_con.wmf: Conducted spurious emissions from 30 MHz to 1 GHz (operation mode 2):

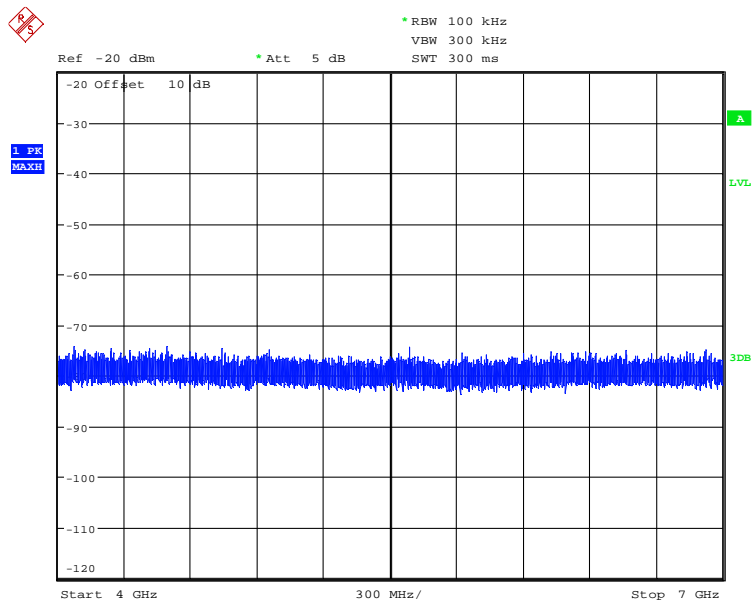


Remark: No emissions except the wanted signal were found in this frequency range.

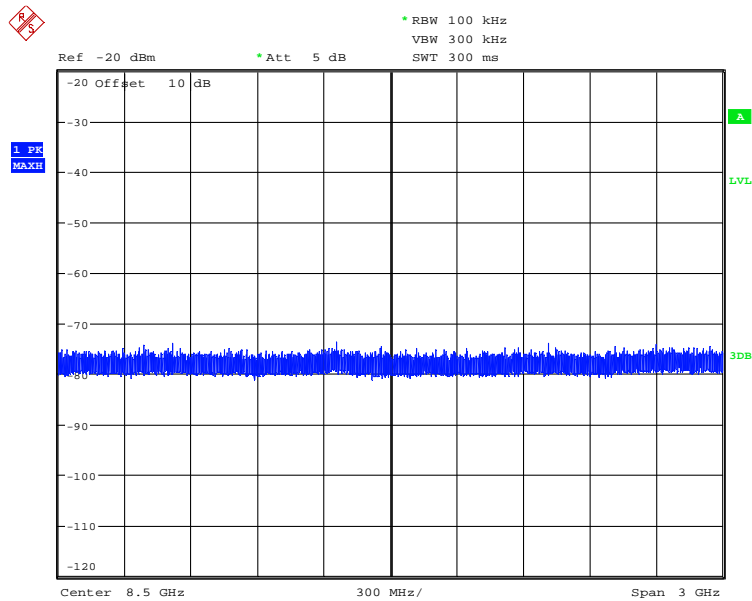
190760_1G_4G_24_con.wmf: Conducted spurious emissions from 1 GHz to 4 GHz (operation mode 2):



190760_4G_7G_24_con.wmf: Conducted spurious emissions from 4 GHz to 7 GHz (operation mode 2):



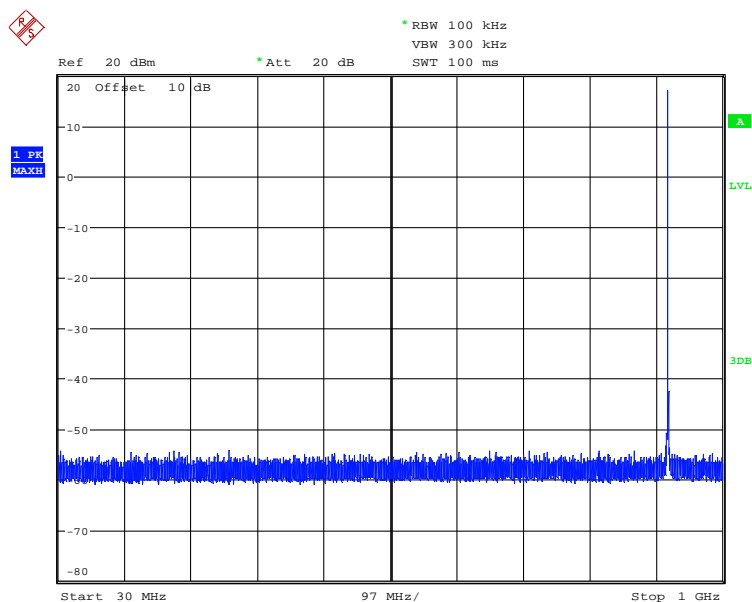
190760_7G_10G_49_con.wmf: Conducted spurious emissions from 7 GHz to 10 GHz (operation mode 2):



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

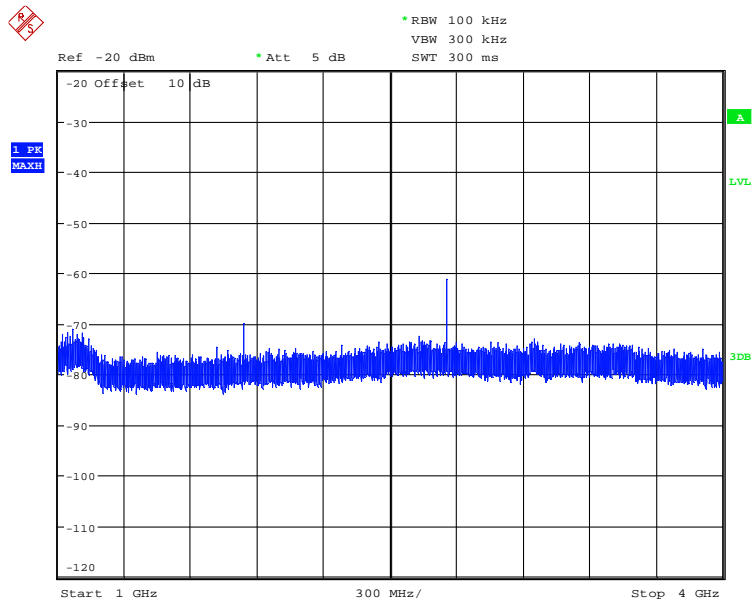
No significant emissions up to 20 dB to the limit were found in the frequency range below 30 MHz, therefore no results are submitted below.

190760_30M_1G_49_con.wmf: Conducted spurious emissions from 30 MHz to 1 GHz (operation mode 3):

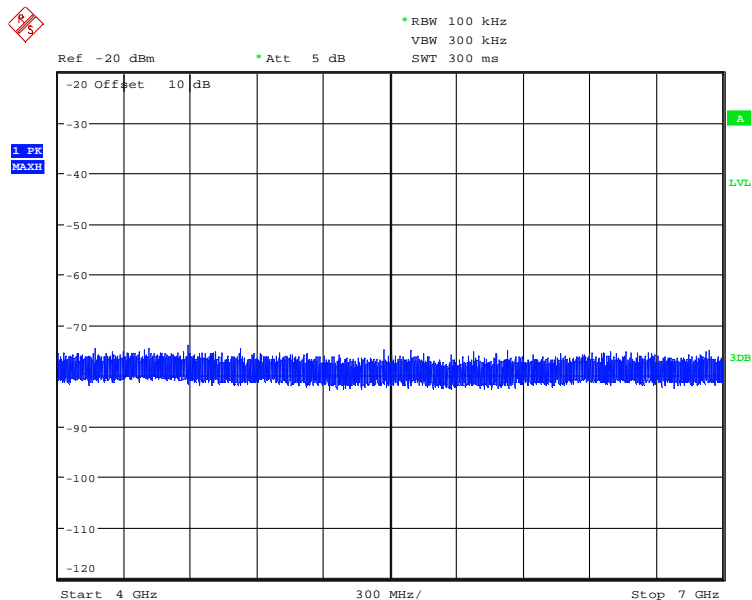


Remark: No emissions except the wanted signal were found in this frequency range.

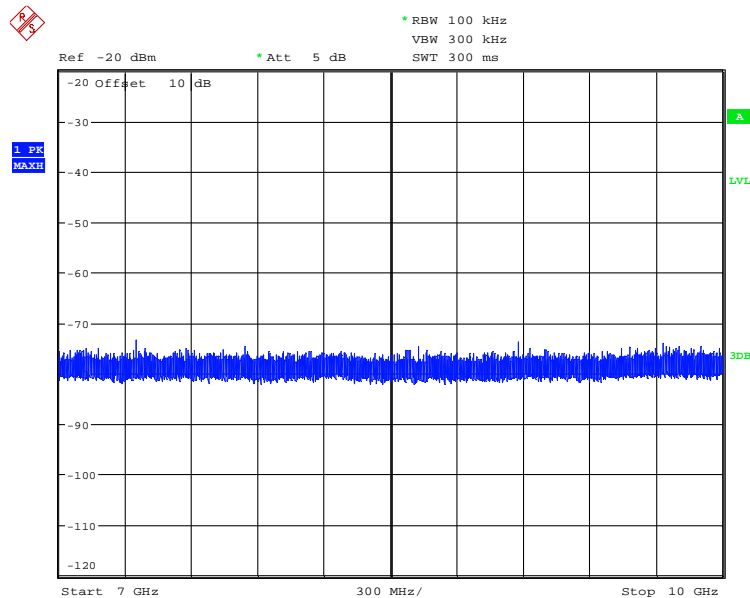
190760_1G_4G_49_con.wmf: Conducted spurious emissions from 1 GHz to 4 GHz (operation mode 3):



190760_4G_7G_49_con.wmf: Conducted spurious emissions from 4 GHz to 7 GHz (operation mode 3):



190760_7G_10G_49_con.wmf: Conducted spurious emissions from 7 GHz to 10 GHz (operation mode 3):



Spurious emissions (operation mode 1)									
Peak emission									
Operating channel	Frequency [MHz]	Reading [dBm]	Max. antenna gain [dBi]	Calculated EIRP [dBm]	Calculated field strength [dBμV/m]	Min. limit [dBμV/m]	Margin [dB]	Result	Restricted Band?
0 (904.000 MHz)	1808.000	-65.3	11.0	-54.3	41.0 *2	99.5 *1	58.5	Passed	No
	2712.00	-62.3	11.0	-51.3	44.0 *2	54.0 *1	10.0	Passed	Yes
Spurious emissions (operation mode 2)									
Peak emission									
Operating channel	Frequency [MHz]	Reading [dBm]	Max. antenna gain [dBi]	Calculated EIRP [dBm]	Calculated field strength [dBμV/m]	Min. limit [dBμV/m]	Margin [dB]	Result	Restricted Band?
24 (911.200 MHz)	1822.400	-66.9	11.0	-55.9	39.4 *2	100.0 *1	60.6	Passed	No
	2733.600	-62.3	11.0	-51.3	44.0 *2	54.0 *1	10.0	Passed	Yes
Spurious emissions (operation mode 3)									
Peak emission									
Operating channel	Frequency [MHz]	Reading [dBm]	Max. antenna gain [dBi]	Calculated EIRP [dBm]	Calculated field strength [dBμV/m]	Min. limit [dBμV/m]	Margin [dB]	Result	Restricted Band?
49 (918.700 MHz)	1837.400	-69.5	11.0	-58.5	36.8 *2	100.5 *1	63.7	Passed	No
	2756.100	-61.0	11.0	-50.0	45.3 *2	54.0 *1	8.7	Passed	Yes
Measurement uncertainty				±2.1 dB					

*1: Limit (20 dBc) calculated with minimum antenna gain (0 dBi) from radiated measurement, refer clause 5.6.2.3

*2: Measured with peak detector only, because the peak value is already below the average limit

Test equipment used (see chapter 6):

15, 28 - 30

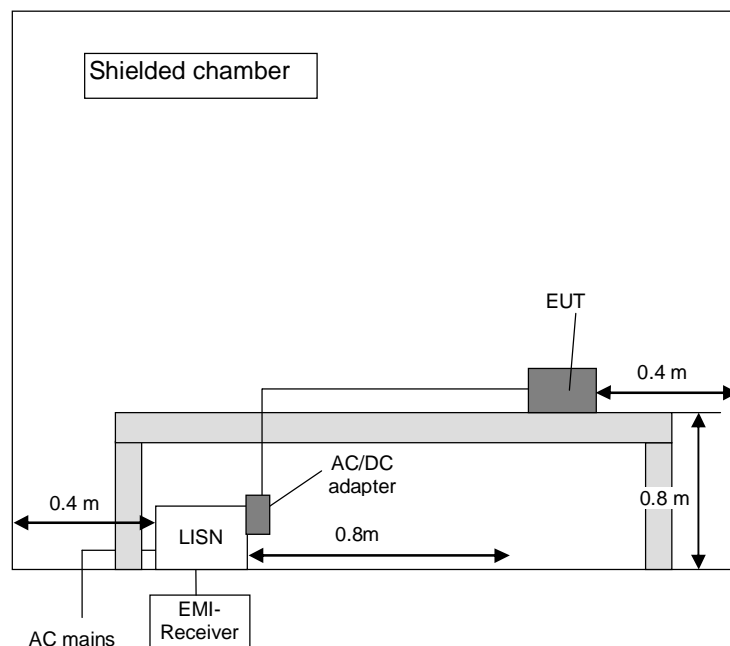
5.8 Conducted emissions on power supply lines (150 kHz to 30 MHz)

5.8.1 Method of measurement

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

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

Frequency range	Resolution bandwidth
150 kHz to 30 MHz	9 kHz



5.8.2 Test results (conducted emissions on power supply lines)

Ambient temperature	22 °C	Relative humidity	39 %
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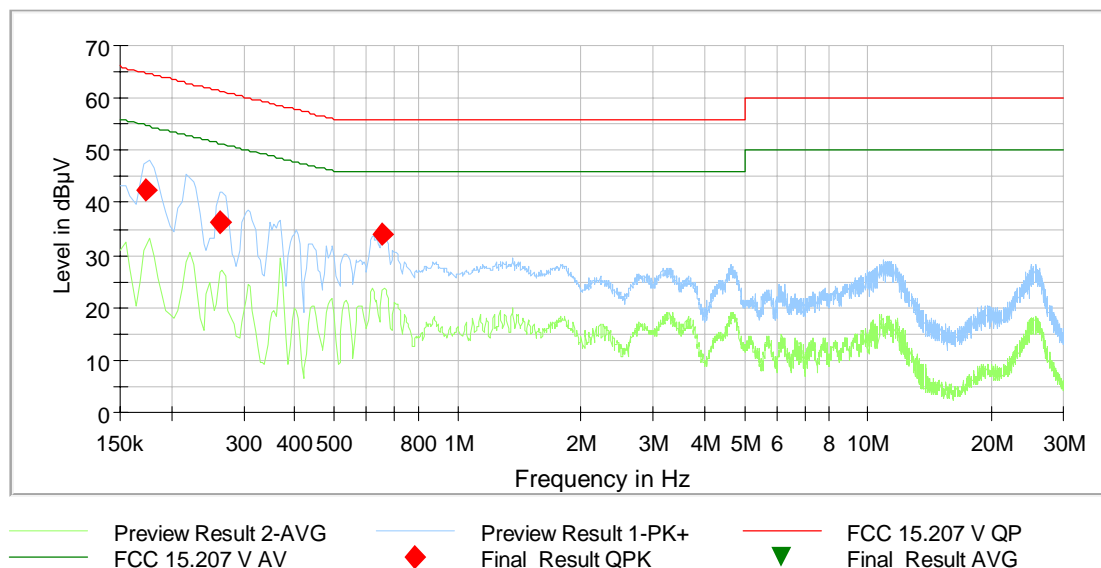
Position of EUT: The EUT was set-up on a non-conducting table of a height of 0.8 m.

Cable guide: The cables of the EUT were fixed on the non-conducting table. For further information of the cable guide refer to the pictures in annex A of this test report.

Test record: The test was carried out in operation mode 1 of the EUT (refer also clause 2 of this test report). All results are shown in the following.

Supply voltage: During this test the EUT was supplied 3.6 V_{DC} by the internal battery, which was buffered with 12 V_{DC} by an external power supply type enerCELL CAT: NO. 273-316 (provided by the laboratory), supplied with 120 V_{AC} / 60 Hz.

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 ◆.



Data record name: 190760_AC

Remark: The limits of FCC 15.207 are identical to [3]

Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	PE	Transducer (dB)
0.174300	42.3	---	64.8	22.5	5000	9.000	N	FLO	9.8
0.262500	36.3	---	61.4	25.1	5000	9.000	N	FLO	9.9
0.654000	34.0	---	56.0	22.0	5000	9.000	N	FLO	9.9
Measurement uncertainty			±2.8 dB						

Test: Passed

Test equipment used (see chapter 6):

1 - 5

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	-	Siemens	B83117-S1-X158-	480088	Calibration not necessary	
2	EMI Receiver	ESIB 26	Rohde & Schwarz	1088.7490	481182	28.02.2018	02.2020
3	LISN	NSLK8128	Schwarzbeck	8128161	480138	13.03.2018	03.2020
4	Transient Filter Limiter	CFL 9206A	Teseq GmbH	38268	481982	Calibration not necessary	
5	EMI Software	EMC 32	Rohde & Schwarz	100061	481022	Calibration not necessary	
6	Open area test site	-	Phoenix Test-Lab	-	480085	Calibration not necessary	
7	Controller	HD100	Deisel	100/670	480139	Calibration not necessary	
8	Turntable	DS420HE	Deisel	420/620/80	480087	Calibration not necessary	
9	Antenna support	AS615P	Deisel	615/310	480086	Calibration not necessary	
10	Antenna	CBL6111 D	Chase	25761	480894	19.10.2017	10.2020
11	EMI Software	EMC 32	Rohde & Schwarz	100061	481022	Calibration not necessary	
12	6 dB attenuator	R412706000	Radiall	9833	410082	Calibration not necessary	
13	Fully anechoic chamber M20	-	Albatross Projects	B83107-E2439-T232	480303	Calibration not necessary	
14	Spectrum analyser	FSU	Rohde & Schwarz	200125	480956	31.10.2018	10.2020
15	Measuring receiver	ESW44	Rohde & Schwarz	101635	482467	29.03.2018	03.2020
16	Controller	MCU	Maturo	MCU/043/971107	480832	Calibration not necessary	
17	Turntable	DS420HE	Deisel	420/620/80	480315	Calibration not necessary	
18	Antenna support	AS615P	Deisel	615/310	480187	Calibration not necessary	
19	Antenna	CBL6112 B	Chase	2688	480328	19.06.2017	06.2020
20	Antenna	HL50	Rohde & Schwarz	100438	481170	09.10.2017	10.2020
21	RF-cable No. 36	Sucoflex 106B	Suhner	0587/6B	480865	Calibration not necessary	
22	RF-cable No. 3	Sucoflex 106B	Suhner	0563/6B	480670	Calibration not necessary	
23	RF-cable No. 40	Sucoflex 106B	Suhner	0708/6B	481330	Calibration not necessary	
24	Preamplifier	JS3-00101200-23-5A	Miteq	681851	480337	Calibration not necessary	
25	Turn device	TDF 1.5- 10Kg	Maturo	15920215	482034	Calibration not necessary	
26	Loop antenna	HFH2-Z2	Rohde & Schwarz	100417	481912	10.01.2019	02.2020
27	High Pass Filter	WHJS1000C11/60EF	Wainwright Instruments GmbH	1	480413	Calibration not necessary	
28	High Pass Filter	WHKX4.0/18G-8SS	Wainwright Instruments GmbH	1	480587	Calibration not necessary	
29	Tuneable Notch Filter	WRCA800/900-0.2/40-6EEK	Wainwright Instruments GmbH	15	480414	Calibration not necessary	
30	10 dB attenuator	WA8 / 18-10-34	Weinschel	-	481449	Calibration not necessary	

7 Test site validation

Test equipment	PM. No.	Frequency range	Type of validation	According to	Val. Date	Val Due
Fully anechoic chamber M20	480303	30 – 1000 MHz	NSA	ANSI C63.4-2014	13.02.2018	12.02.2020
Fully anechoic chamber M20	480303	1 -18 GHz	SVSWR	CISPR 16-1-4 Amd. 1	13.07.2018	12.07.2020
Open area test site	480085	30 – 1000 MHz	NSA	ANSI C63.4-2014	25.10.2018	24.10.2020
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
F190760E1	28.08.2019	Document created
-	-	-
-	-	-
-	-	-

9 List of annexes

Annex A Test set-up photos

7 pages