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Test Report

Report Number:

F152117E1

Equipment under Test (EUT):

**UHF RFID read/write device
IUH-F192-V1-FR2-02**

Applicant:

Pepperl + Fuchs, Inc.

Manufacturer:

Pepperl+Fuchs 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 (July 2014)** Radio Frequency Devices
- [3] **RSS-247 Issue 1 (May 2015)** Licence-exempt Radio Apparatus (All Frequency Bands): Category I Equipment
- [4] **RSS-Gen Issue 4 (November 2014)** General Requirements for Compliance of Radio Apparatus
- [5] **DA 00-705 (March 30, 2000)** Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems

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 <small>Name</small>	 <small>Signature</small>	11 th August 2015 <small>Date</small>
Authorized reviewer:	Bernd STEINER <small>Name</small>	 <small>Signature</small>	11 th August 2015 <small>Date</small>

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

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1 Identification

1.1 Applicant

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Applicant represented during the test by the following person:	-

1.2 Manufacturer

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Manufacturer represented during the test by the following person:	-

1.3 Test laboratory

The tests were carried out at: **PHOENIX TESTLAB GmbH**
Königswinkel 10
32825 Blomberg
Germany

accredited by DGA Deutsche Gesellschaft Akkreditierungsstelle GmbH (DAkkS) in compliance with DIN EN ISO/IEC 17025 under Reg. No. D-PL-17186-01-02, FCC Test site registration number 90877 and Industry Canada Test site registration IC3469A-1.

1.4 EUT (Equipment Under Test)

Test object: *	UHF RFID read/write device
Modelname / HVIN: *	IUH-F192-V1-FR2-02
FCC ID:*	IREIUH-F192-V1
IC: *	7037A-IUHF192V1
Serial number: *	256083
PCB identifier: *	05-6970A, 05-7008A, 05-6909A
Hardware version: *	May 2015
Software version: *	18-32765, 11.06.2015
Lowest internal frequency	16 MHz

1.5 Technical data of equipment

Channel 1	RX:	902.75 MHz	TX:	902.75 MHz
Channel 25	RX:	914.75 MHz	TX:	914.75 MHz
Channel 50	RX:	927.25 MHz	TX:	927.25 MHz

Rated RF output power: *	36 dBm (e.i.r.p.)				
Antenna type: *	Internal only				
Antenna gain: *	7 dBi				
Antenna connector: *	None				
Adaptive frequency agility: *	No				
Modulation: *	OOK (FHSS)				
Supply Voltage: *	U _{nom} =	24.0 V DC	U _{min} =	20.0 V DC	U _{max} = 30.0 V DC
Temperature range: *	-25 °C to +70 °C (operating temperature range)				
Ancillary used for test:	A switchbox type IC-KP2-2HRX-2V1 was used to connect the EUT to the power supply. Furthermore an AC / DC adaptor type MINI-PS-100-240AC/24DC/2 was used for conducted emission measurement on AC mains.				

* declared by the applicant.

The following external I/O cables were used:

Identification	Connector		Length *
	EUT	Ancillary	
Power / RS485	4-pin M12-connector	-	2.0 m
-	-	-	-

*: Length during the test if no other specified.

1.6 Dates

Date of receipt of test sample:	30 th April 2015
Start of test:	12 th May 2015
End of test:	2 nd June 2015

2 Operational states

All tests were carried out with an unmodified sample with integral antenna.

During the all tests the IUH-F192-V1-FR2-02 was powered by an external 24.0 V DC power supply. During the emission measurement on the AC supply line the EUT was powered by an AC / DC adaptor type MINI-PS-100-240AC/24DC/2.

The operation mode could be chosen with the help of a laptop computer with a test-software, communicates with the EUT via the RS485/RS232 line of the IC-KP2-2HRX-2V1.

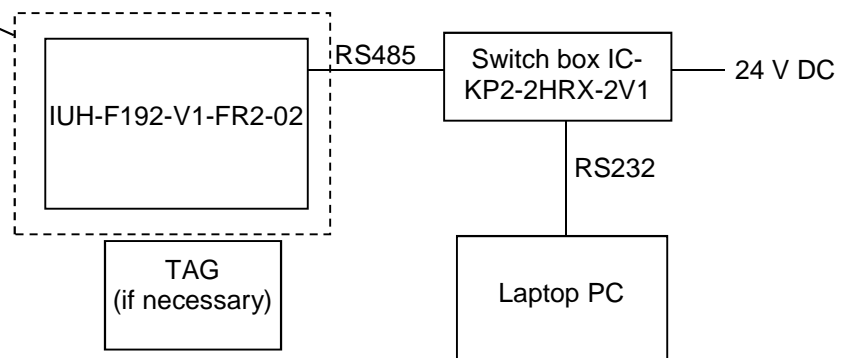
All measurements were carried out with the output power set to the maximum value (4000 mW).

Because the EUT has no antenna connector and also no internal connector at the antenna input, the output power of the EUT was measured as e.r.p. value instead of the measuring the conducted peak output power. Measurements of the 20 dB bandwidth (clause 5.1), carrier frequency separation (clause 5.2), the number of hopping channels (clause 5.3) and dwell time (clause 5.4) were carried out on an internal rf-connector.

The following test modes were adjusted during the tests:

Test items	Operation	Operation mode
20 dB bandwidth	Transmit with normal modulation on channel 1, 25 or 50	1, 2, 3
Carrier frequency separation	Transmit with normal modulation on channel 1, 25 or 50	1, 2, 3
Number of hopping channels	Transmit with normal modulation, hopping on all channels	4
Dwell time	Transmit with normal modulation on channel 1, 25 or 50	1, 2, 3
Maximum peak output power	Transmit with normal modulation on channel 1, 25 or 50	1, 2, 3
Radiated emissions (transmitter)	Transmit with normal modulation on channel 1, 25 or 50	1, 2, 3
Conducted emissions on supply line	Transmit with normal modulation, hopping on all channels	4

Physical boundary of the EUT



3 Additional information

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

4 Overview

Application	Frequency range [MHz]	FCC 47 CFR Part 15 section [2]	RSS 247, Issue 1 [3] or RSS-Gen, Issue 4 [4]	Status	Refer page
20 dB bandwidth	General	15.247 (a) (1) (i)	5.1 (1) [3]	Passed	8 et seq.
Carrier frequency separation	General	15.247 (a) (1) (i)	5.1 (2) [3]	Passed	11 et seq.
Number of hopping channels	902.0 – 928.0	15.247 (a) (1) (i)	5.1 (3) [3]	Passed	14 et seq.
Dwell time	902.0 – 928.0	15.247 (a) (1) (i)	5.1 (3) [3]	Passed	16 et seq.
Maximum peak output power	902.0 – 928.0	15.247 (b) (2)	5.4 (1) [3]	Passed	18 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	20 et seq.
Conducted emissions on supply line	0.15 - 30	15.207 (a)	8.8 [4]	Passed	41 et seq.
Radiated emissions (receiver)	30 - 5,000	15.109 (a)	6.1 [4]	N. a. *	-
Antenna requirement	-	15.203 [2]	-	Passed**	-

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

** : Integrated antenna only, requirement fulfilled.

5 Test results

5.1 20 dB bandwidth

5.1.1 Method of measurement (20 dB 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.

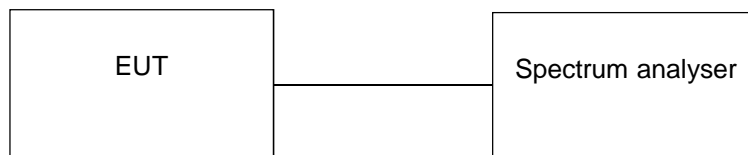
The following spectrum analyser settings according to [5] shall be used:

- Span: App. 2 to 3 times the 20 dB bandwidth, centred on the actual hopping channel.
- Resolution bandwidth: $\geq 1\%$ of the 20 dB bandwidth.
- Video bandwidth: \geq 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 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.

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

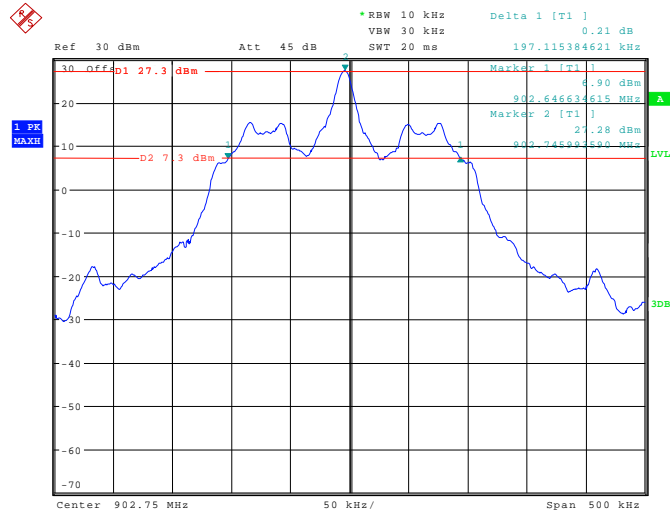
Test set-up:



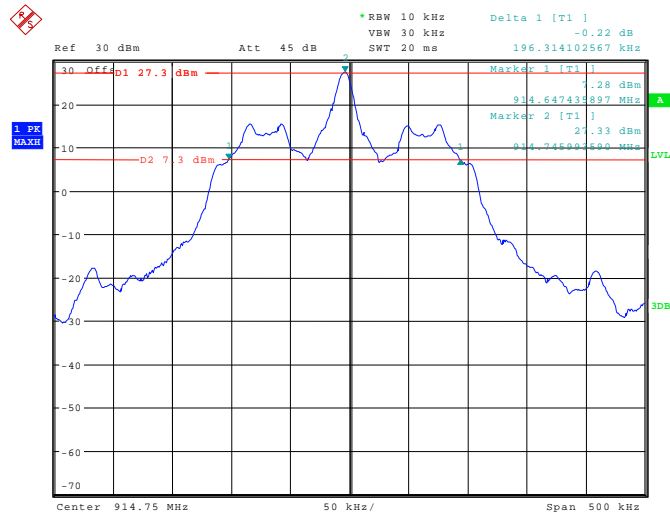
5.1.2 Test results (20 dB bandwidth)

Ambient temperature	22 °C	Relative humidity	39 %
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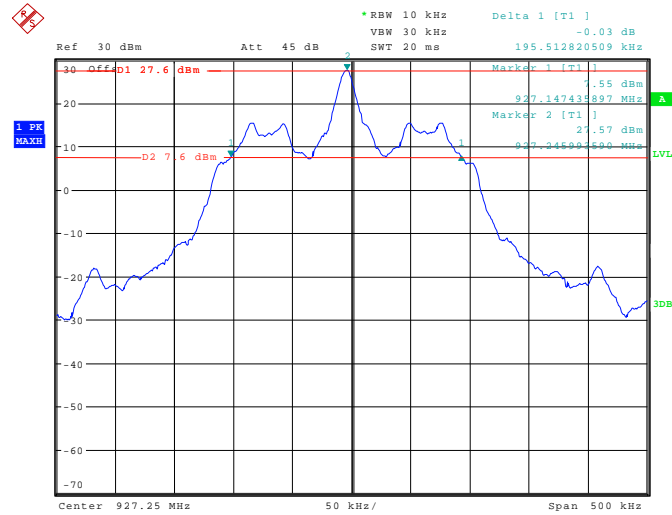
152117_15.wmf: 20 dB bandwidth at the lower end of the assigned frequency band:



152117_16.wmf: 20 dB bandwidth at the middle of the assigned frequency band:



152117_17.wmf: 20 dB bandwidth at the upper end of the assigned frequency band:



Channel number	Channel frequency [MHz]	20 dB bandwidth [kHz]
20 dB bandwidth		
1	902.750	197.115
25	914.750	196.314
50	927.250	195.513
Measurement uncertainty		+0.66 dB / -0.72 dB

TEST EQUIPMENT USED FOR THE TEST:

30, 54, 84

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.

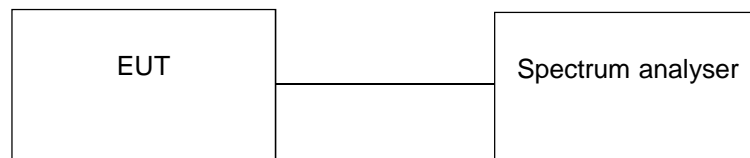
The following spectrum analyser settings according to [5] shall be used:

- Span: Wide enough to capture the peaks of two adjacent channels.
- Resolution bandwidth: $\geq 1\%$ of the span.
- Video bandwidth: \geq the 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.

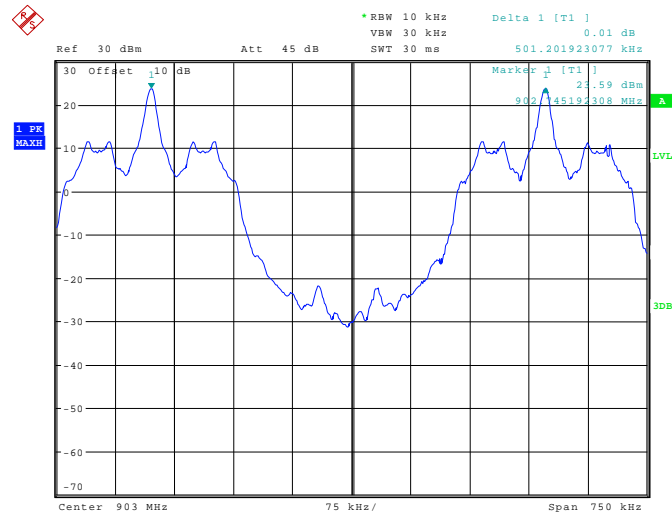
Test set-up:



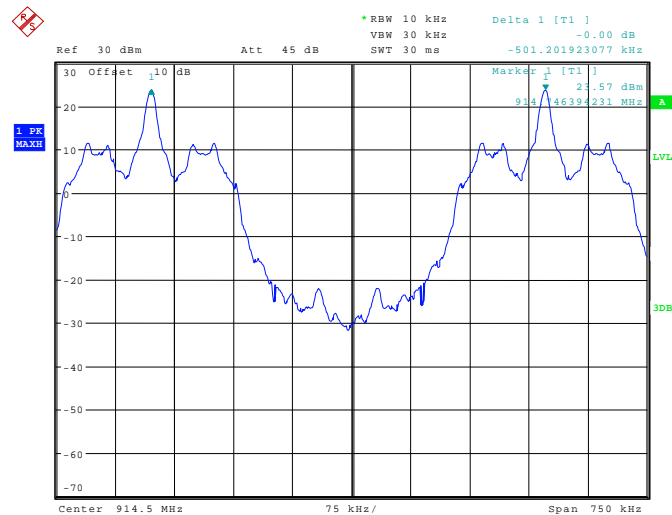
5.2.2 Test results (carrier frequency separation)

Ambient temperature	22 °C	Relative humidity	39 %
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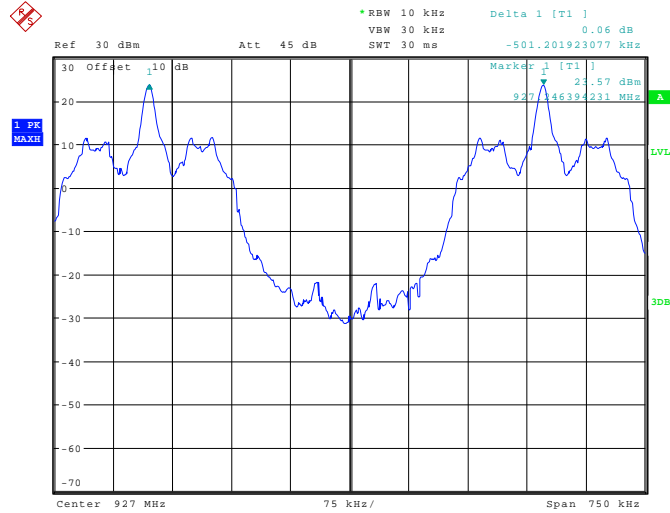
152117_18.wmf: Channel separation at the lower end of the assigned frequency band:



152117_19.wmf: Channel separation at the middle of the assigned frequency band:



152117_20.wmf: Channel separation at the upper end of the assigned frequency band:



Channel number	Channel frequency [MHz]	Channel separation [kHz]	Minimum limit [kHz]
1	902.750	501.202	197.115 (the 20 dB bandwidth)
25	914.750	501.202	196.314 (the 20 dB bandwidth)
50	927.250	501.202	195.513 (the 20 dB bandwidth)
Measurement uncertainty			$<10^{-7}$

Test:

Passed

TEST EQUIPMENT USED FOR THE TEST:

30, 54, 84

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 [5] shall be used:

- Span: Equal to the assigned frequency band.
- Resolution bandwidth: $\geq 1\%$ of the span.
- Video bandwidth: \geq 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.

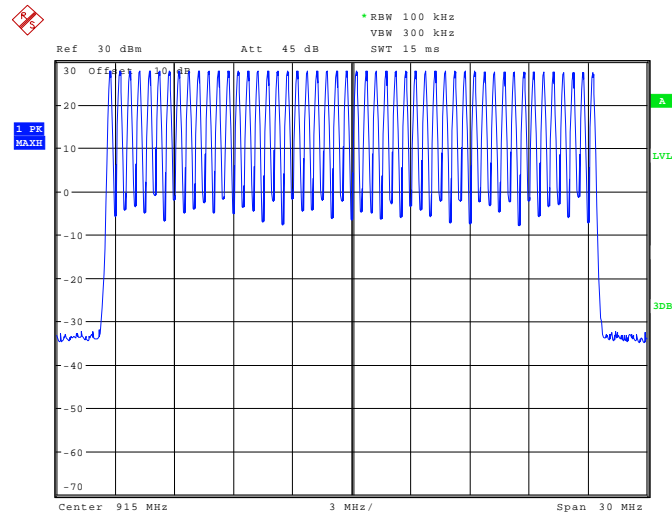
Test set-up:



5.3.2 Test results (number of hopping frequencies)

Ambient temperature	22 °C	Relative humidity	39 %
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152117 14.wmf: Number of hopping channels:



Number of hopping channels	Limit
Operation mode 4	
50	At least 50

Test: Passed

Test equipment used (see chapter 6):

30, 54, 84

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 [5] shall be used:

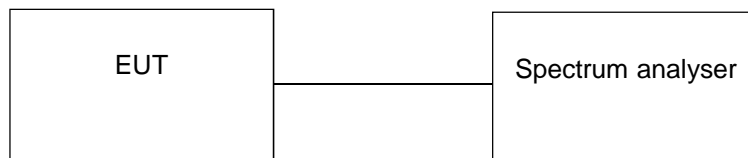
- Span: Zero, centred on a hopping channel.
- Resolution bandwidth: 1 MHz.
- Video bandwidth: \geq the resolution bandwidth.
- Sweep: As necessary to capture the entire dwell time per hopping channel.
- Detector function: peak.
- Trace mode: Max hold.

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.

If the EUT is possible to operate with different mode of operation (data rates, modulation formats etc.) the test will be repeated with every different operation mode of the EUT.

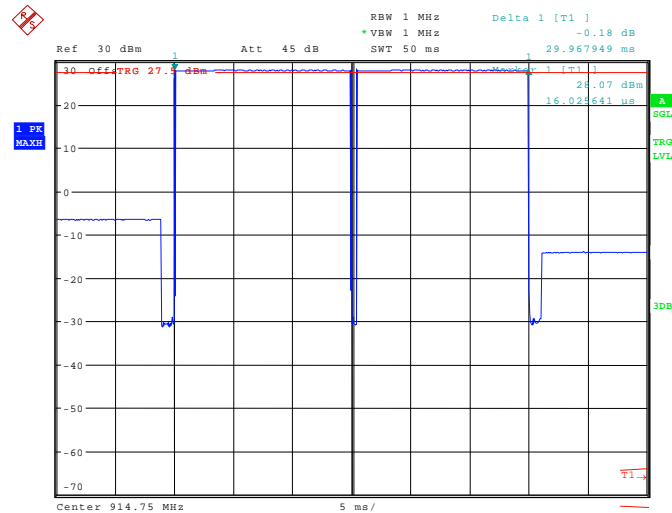
Test set-up:



5.4.2 Test results (dwell time)

Ambient temperature	22 °C	Relative humidity	39 %
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152117_24.wmf: Dwell time at the middle of the assigned frequency band:



The dwell time is calculated with the following formula:

$$\text{Dwell time} = t_{\text{pulse}} \times n_{\text{hops}} / \text{number of hopping channels} \times 20 \text{ s}$$

Where:

t_{pulse} is the measured pulse time (pls. refer the plots of the spectrum analyser above) [s],
 n_{hops} is the number of hops per second in the actual operating mode of the transmitter [1/s].

The hopping rate of the system is 33.3 hops per second and the system uses 50 channels.

Channel number	Channel frequency [MHz]	t_{pulse} [ms]	Dwell time [ms]	Limit [ms]
25	914.750	29.968	399.573	400
Measurement uncertainty			<10 ⁻⁷	

Test: Passed

Test equipment used (see chapter 6):

30, 54, 84

5.5 Maximum peak output power

5.5.1 Method of measurement (maximum peak output power)

Because the EUT has no antenna connector, which presents the power delivered to the antenna, the peak value of the field strength was measured. The method of measurement is described under clause 5.6.1 (final measurement (30 MHz to 1 GHz)) of this test report with the exception that a peak detector was used. According to [1] with this the field strength value the radiated power of the EUT was calculated. After subtraction of the antenna gain, which was declared by the manufacturer the maximum peak output power was calculated. The used formulas are listed below.

5.5.2 Test results (maximum peak output power)

Ambient temperature	22 °C	Relative humidity	36 %
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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 with 24 V DC by an external power supply.

Test results: The test results were calculated with the following formula:

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

Radiated field strength at 3 m OATS (peak)									
Frequency MHz	Result dB μ V/m	Limit dB μ V/m	Margin dB	Readings dB μ V	Antenna factor dB/m	Cable loss dB	Height cm	Azimuth deg	Pol.
902.750	133.0	Carrier	-	107.1	22.5	3.4	104	1	Vert.
914.750	133.0	Carrier	-	106.8	22.8	3.4	101	3	Vert.
927.250	132.3	Carrier	-	105.5	23.4	3.4	100	1	Vert.
Measurement uncertainty				+2.2 dB / -3.6 dB					

The maximum peak output power was calculated with the following formula:

$$\text{Calculated maximum peak output power [W]} = (\text{field strength [V/m]} * \text{measuring distance [m]})^2 / 30$$

This maximum peak output power was converted in dBm and the antenna gain was subtracted to get the conducted maximum peak output power value.

Frequency MHz	Field strength		Radiated peak power		Antenna gain	Conducted peak output power	Limit
	dB μ V/m	V/m	W	dBm	dBi	dBm	dBm
902.750	133.0	4.46	3.63	35.6	7.0	28.6	29.0
914.750	133.0	4.46	3.63	35.6	7.0	28.6	29.0
927.250	132.3	4.11	3.09	34.9	7.0	27.9	29.0

Test: Passed

Test equipment used (see chapter 6):

14 – 20, 54, 84

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 site 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 site with reflecting ground plane and various antenna height in the frequency range 30 MHz to 1 GHz.
- A preliminary measurement carried out in a fully anechoic chamber with a variable antenna distance and height in the frequency range 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.

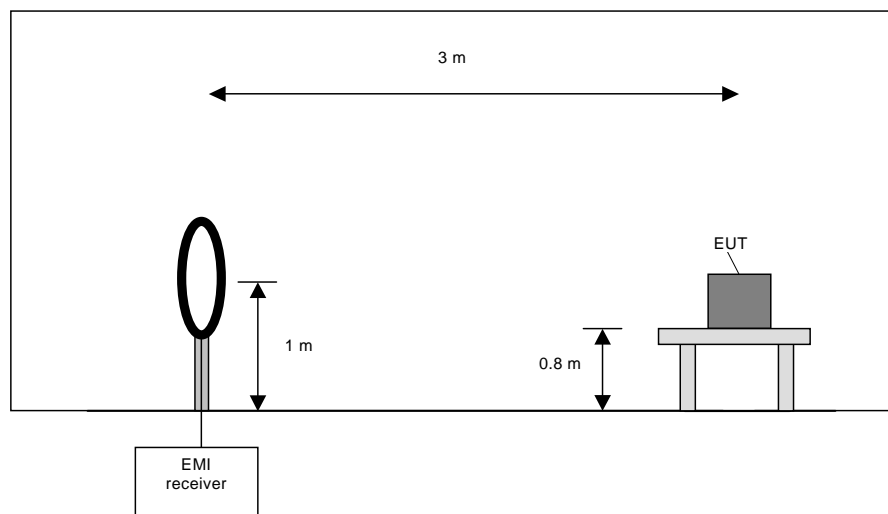
Preliminary measurement (9 kHz to 30 MHz):

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).

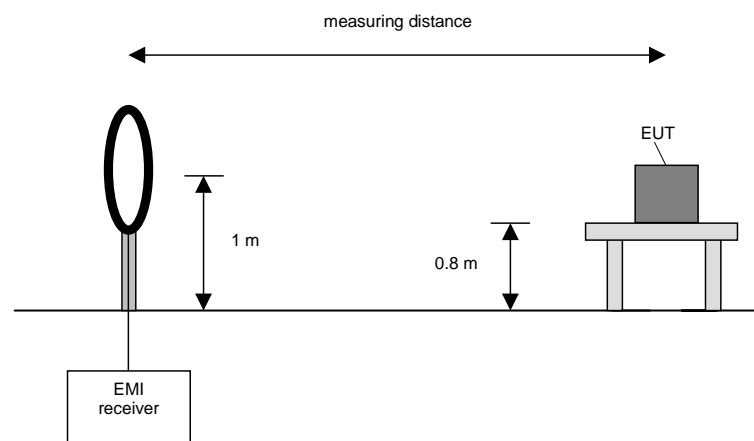
Final measurement (9 kHz to 30 MHz):

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).

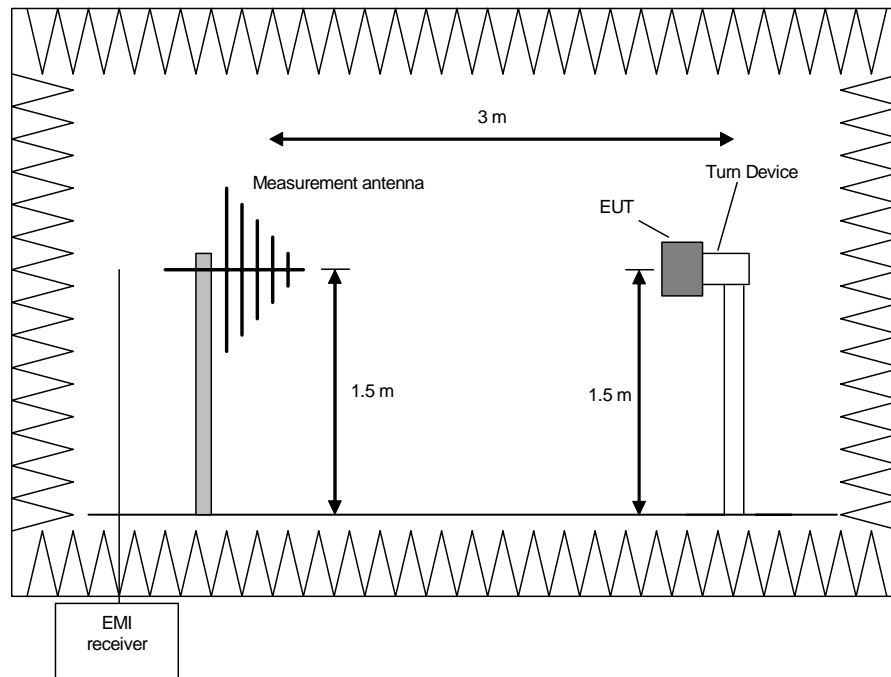
Preliminary measurement (30 MHz to 1 GHz)

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:

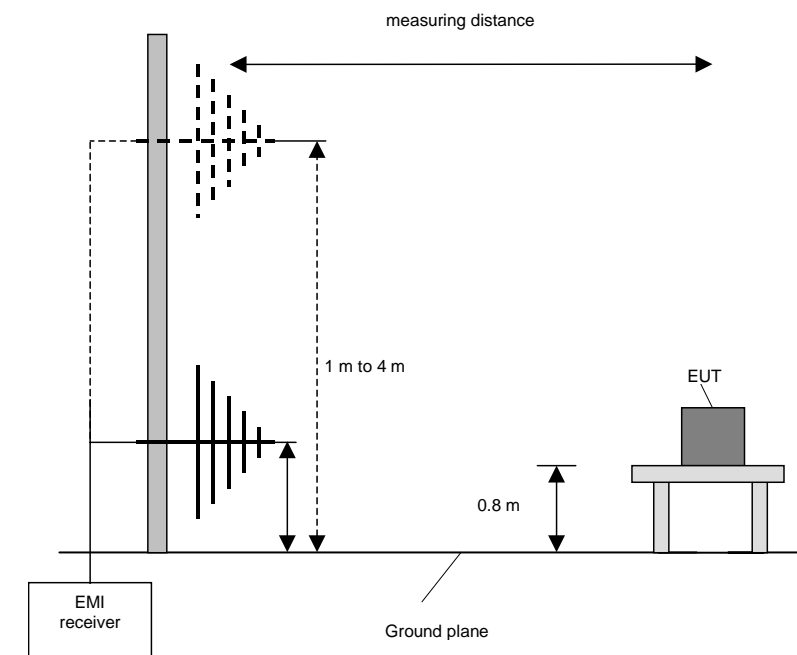
1. Monitor the frequency range at horizontal polarisation and a EUT azimuth of 0 °.
2. Manipulate the system cables within the range to produce the maximum level of emission.
3. Rotate the EUT by 360 ° to maximize the detected signals.
4. Repeat 1) to 3) with the vertical polarisation of the measuring 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)

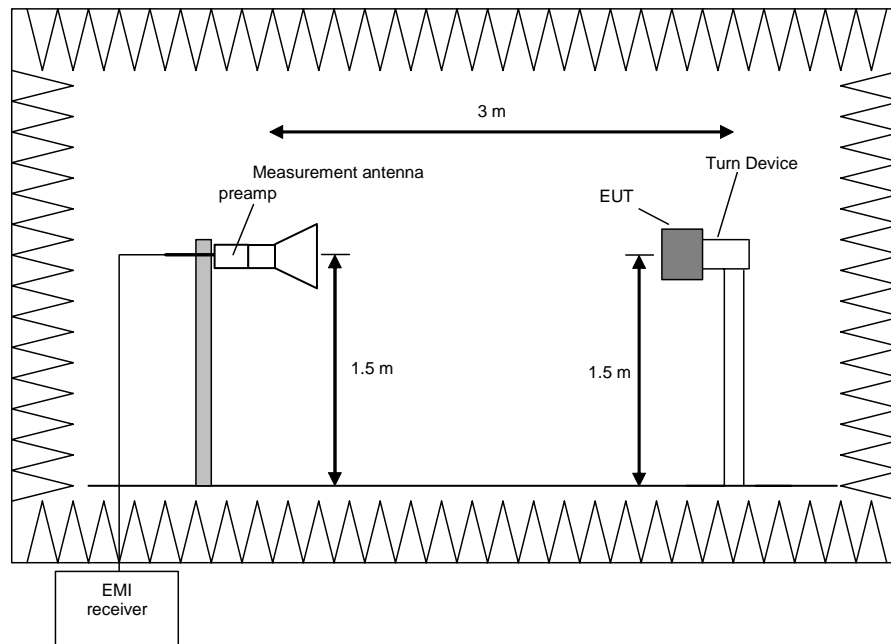
This measurement will be performed in a fully anechoic chamber. Table top devices will set up on a non-conducting turn device on the height of 1.5 m. The set-up of the Equipment under test will be in accordance to [1].

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:

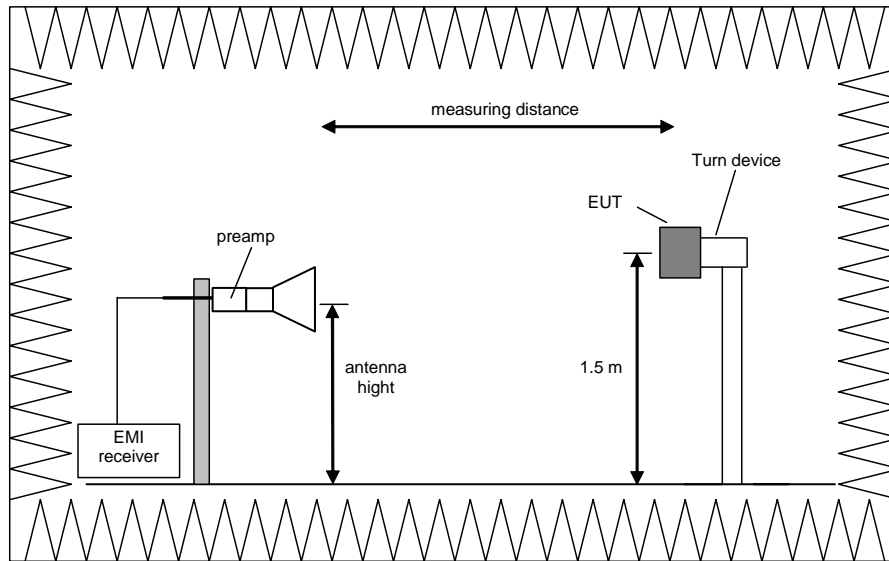
1. Monitor the frequency range at horizontal polarisation and a EUT azimuth of 0 °.
2. Rotate the EUT by 360° to maximize the detected signals.
3. Repeat 1) to 2) with the vertical polarisation of the measuring antenna.
4. Make a hardcopy of the spectrum.
5. Repeat 1) to 4) with the EUT raised by an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

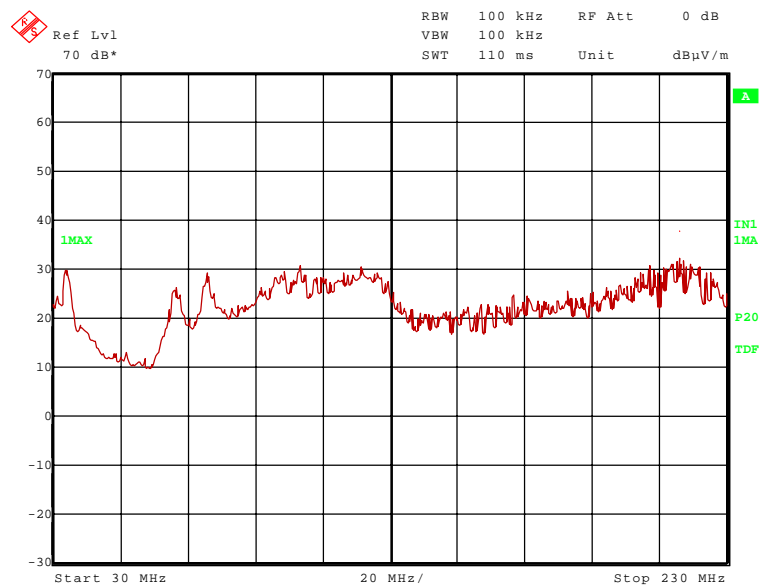
5.6.2.1 Preliminary radiated emission measurement

Ambient temperature	22 °C	Relative humidity	39 %
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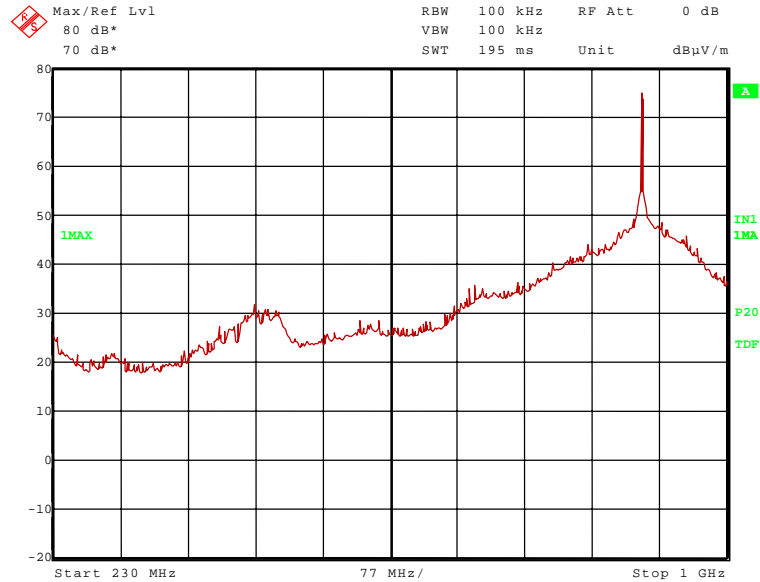
Position of EUT:	The EUT was set-up on a non-conducting table of a height of 0.8 m. The distance between EUT and antenna was 3 m.
Cable guide:	For detail information of test set-up and the cable guide refer to the pictures in annex A of this test report.
Test record:	All results are shown in the following.
Supply voltage:	During all measurements the EUT was supplied with 24 V DC by an external power supply.
Frequency range:	The preliminary measurement was carried out in the frequency range 1 MHz to 10 GHz according to [2].
Remark:	As pre-tests have shown, the emissions in the frequency range 1 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)

152117_7.wmf: Spurious emissions from 30 MHz to 230 MHz (operation mode 1):



152117_8.wmf: Spurious emissions from 230 MHz to 1 GHz (operation mode 1, carrier notched):



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

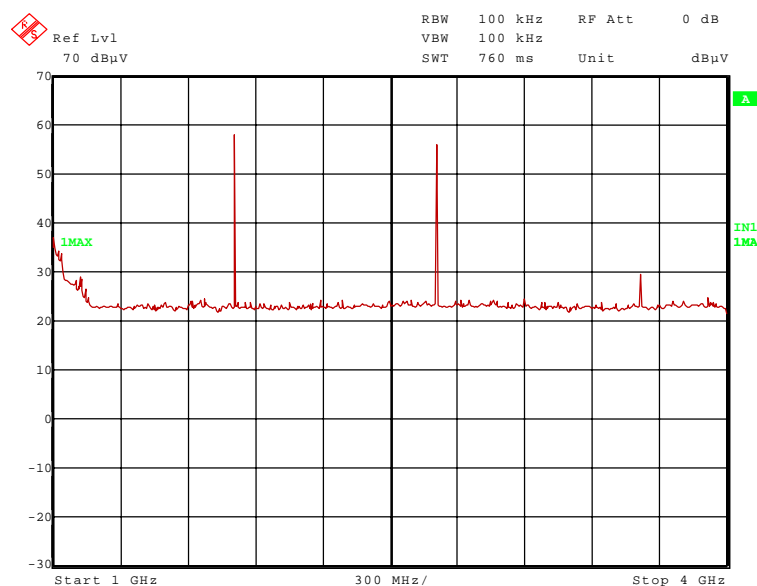
- 33.830 MHz, 65.170 MHz, 76.127 MHz, 104.012 MHz, 208.202 MHz, 212.020 MHz, 463.841 MHz, 711.420 MHz and 902.750 MHz.

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

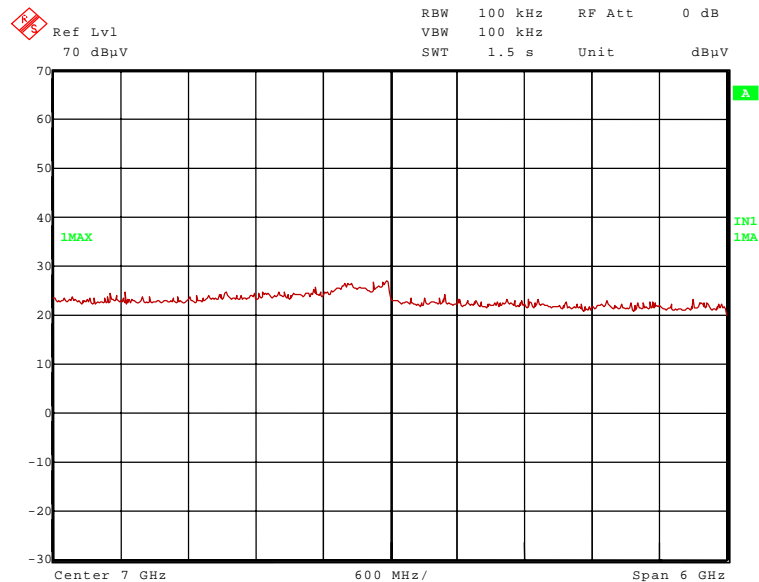
- 965.556 MHz.

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

152117_1.wmf: Spurious emissions from 1 GHz to 4 GHz (operation mode 1):



152117_6.wmf: Spurious emissions from 4 GHz to 10 GHz (operation mode 1):



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

- 2.70825 GHz and 3.61100 GHz.

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

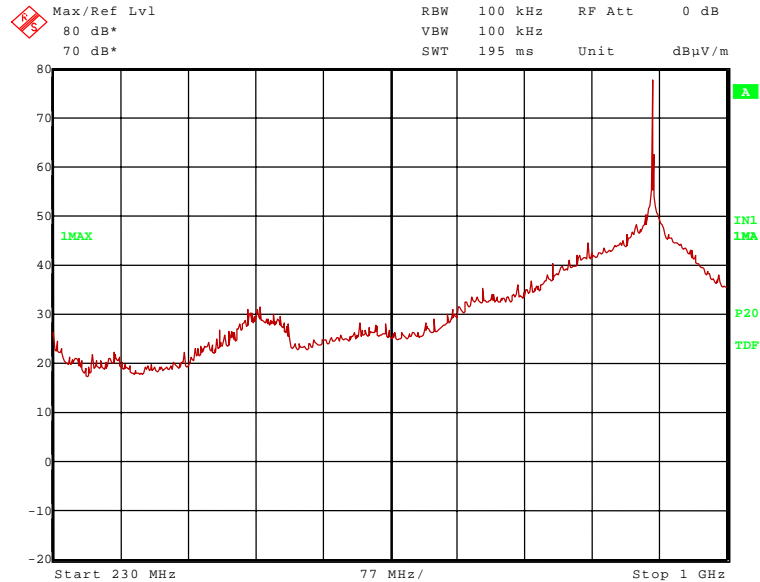
- 1.8055 GHz.

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

Test equipment used (see chapter 6):

29, 31 - 36, 43 - 45, 49, 54, 55, 73, 75, 83, 84

152117_9.wmf: Spurious emissions from 230 MHz to 1 GHz (operation mode 2, carrier notched):



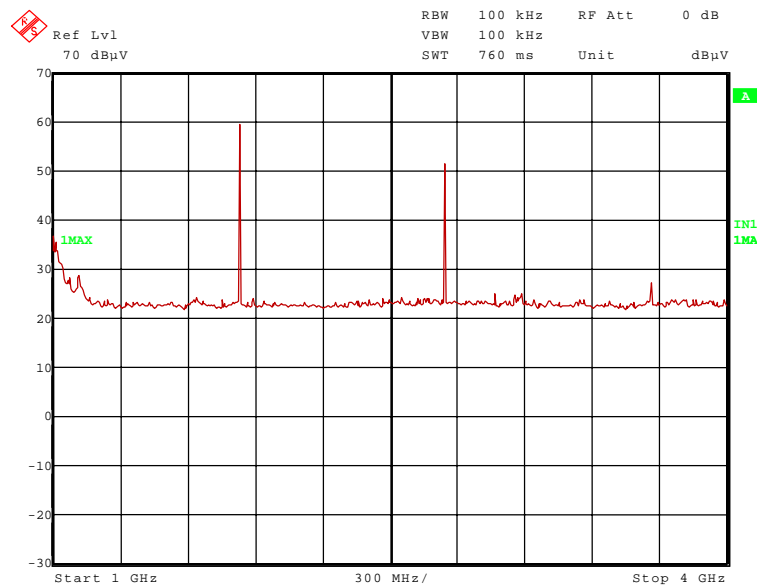
The following frequencies were found outside the restricted bands during the preliminary radiated emission test:

- 33.830 MHz, 65.170 MHz, 76.127 MHz, 104.012 MHz, 208.202 MHz, 212.020 MHz, 463.841 MHz, 720.068 MHz, 840.055 MHz, and 914.750 MHz.

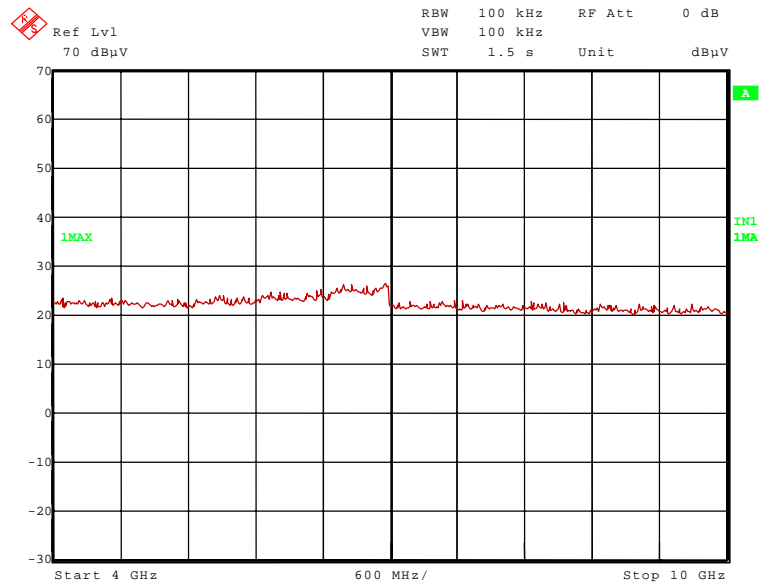
No frequencies were found inside the restricted bands during the preliminary radiated emission test:

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

152117_2.wmf: Spurious emissions from 1 GHz to 4 GHz (operation mode 2):



152117_5.wmf: Spurious emissions from 4 GHz to 10 GHz (operation mode 2):



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

- 2.74425 GHz and 3.65900 GHz.

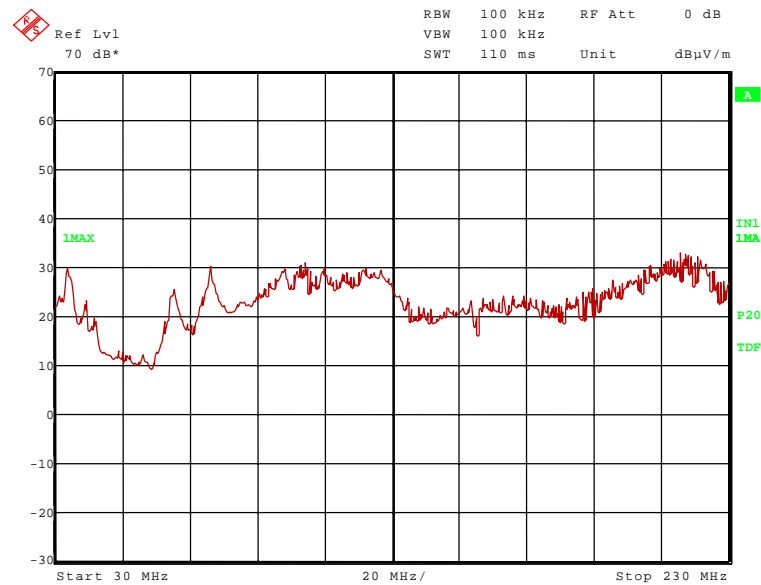
The following frequency was found outside the restricted bands during the preliminary radiated emission test:

- 1.8295 GHz.

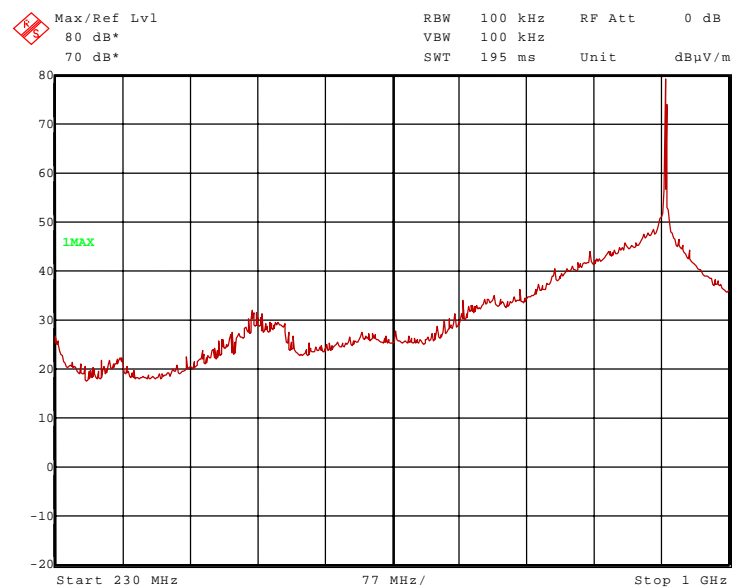
These frequencies have to be measured in a final measurement. The results were presented in the following.

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

152117_12.wmf: Spurious emissions from 30 MHz to 230 MHz (operation mode 3):



152117_11.wmf: Spurious emissions from 230 MHz to 1 GHz (operation mode 3, carrier notched):



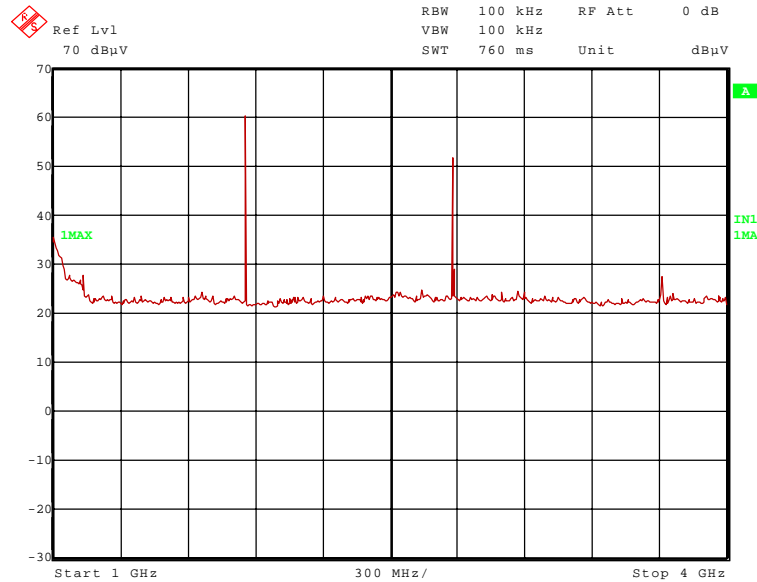
The following frequencies were found outside the restricted bands during the preliminary radiated emission test:

- 33.830 MHz, 65.170 MHz, 76.127 MHz, 104.012 MHz, 208.202 MHz, 212.020 MHz, 463.841 MHz, 730.500 MHz, 839.988 MHz and 927.250 MHz.

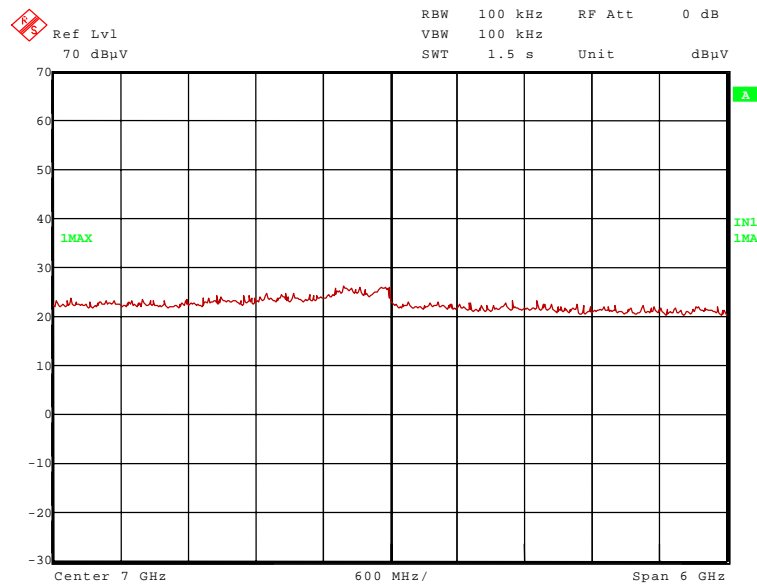
No frequencies were found inside the restricted bands during the preliminary radiated emission test:

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

152117_3.wmf: Spurious emissions from 1 GHz to 4 GHz (operation mode 3):



152117_4.wmf: Spurious emissions from 4 GHz to 10 GHz (operation mode 3):



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

- 2.78175 GHz and 3.70900 GHz.

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

- 1.8545 GHz.

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 (30 MHz to 1 GHz)

Ambient temperature	22 °C	Relative humidity	34 %
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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 with 24 V DC by an external power supply.

Test results: The test results were calculated with the following formula:

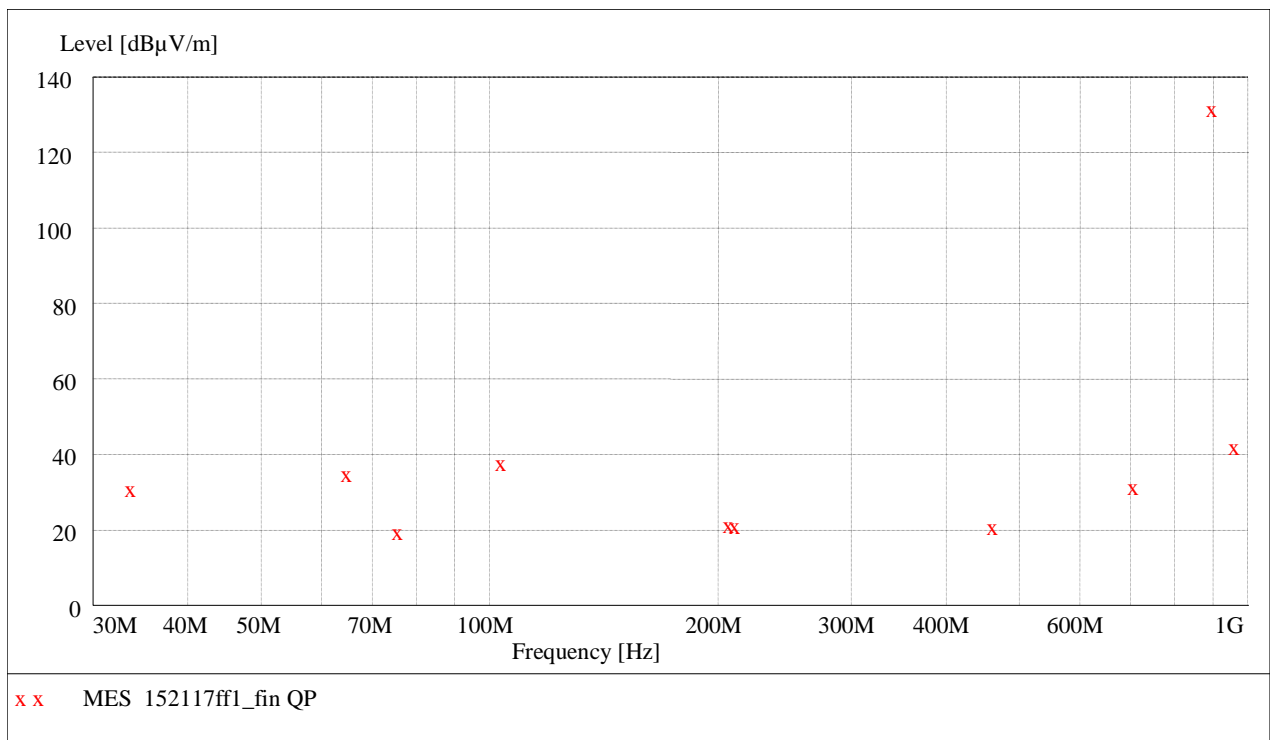
$$\text{Result [dB}\mu\text{V/m]} = \text{reading [dB}\mu\text{V]} + \text{cable loss [dB]} + \text{antenna factor [dB/m]}$$

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.

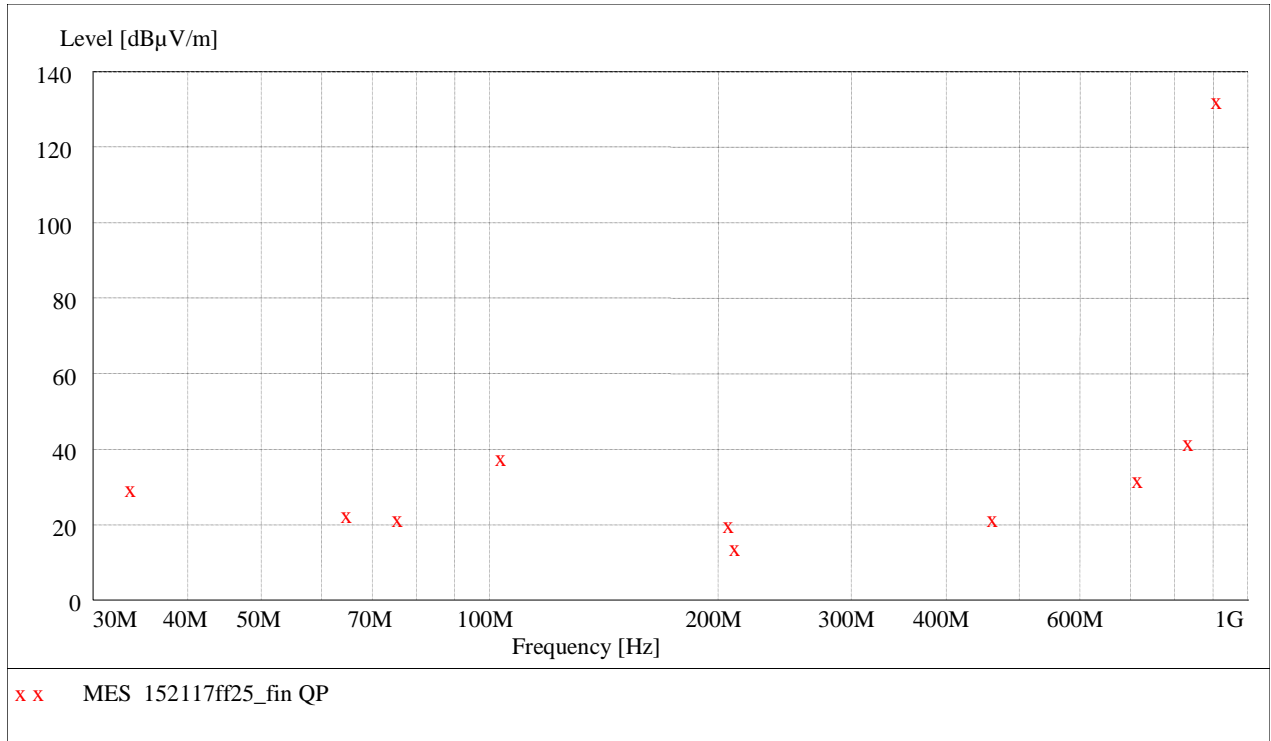
The measurement time with the quasi-peak measuring detector is 1 second.

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



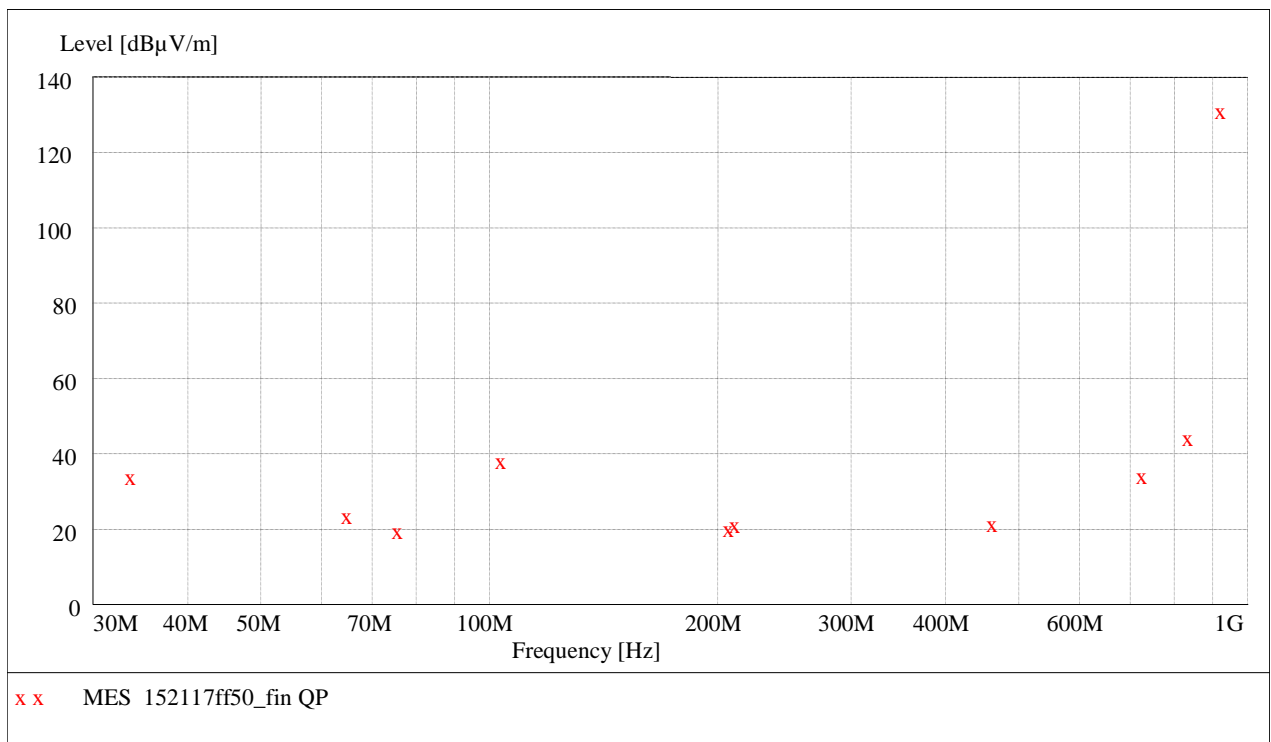
Data record name: 152117ff1

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



Data record name: 152117ff25

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



Data record name: 135012ffh

Result measured with the quasi-peak detector:
(These values were marked in the diagrams by an x)

Transmitter operates on the lower end of the assigned frequency band (operation mode 1)									
Spurious emissions outside restricted bands									
Frequency	Result	Limit	Margin	Readings	Antenna factor	Cable loss	Height	Azimuth	Pol.
MHz	dB μ V/m	dB μ V/m	dB	dB μ V	dB/m	dB	cm	deg	
33.830	31.8	112.4	80.6	13.2	18.0	0.6	110	271	Vert.
65.170	35.7	112.4	76.7	28.7	6.1	0.9	161	136	Vert.
76.127	20.3	112.4	92.1	11.9	7.5	0.9	169	152	Vert.
104.012	38.5	112.4	73.9	26.1	11.3	1.1	389	359	Hor.
208.202	22.2	112.4	90.2	11.4	9.3	1.5	100	101	Hor.
212.020	21.9	112.4	90.5	11.0	9.3	1.6	100	295	Hor.
463.841	21.7	112.4	90.7	2.6	16.7	2.4	144	256	Hor.
711.420	32.1	112.4	80.3	8.5	20.6	3.0	153	322	Hor.
902.750	132.4	Carrier	-	106.5	22.5	3.4	104	1	Vert.
Spurious emissions inside restricted bands									
Frequency	Result	Limit	Margin	Readings	Antenna factor	Cable loss	Height	Azimuth	Pol.
MHz	dB μ V/m	dB μ V/m	dB	dB μ V	dB/m	dB	cm	deg	
965.556	43.0	54.0	11.0	15.7	23.8	3.5	160	359	Hor.

Transmitter operates on the middle of the assigned frequency band (operation mode 2)									
Spurious emissions outside restricted bands									
Frequency	Result	Limit	Margin	Readings	Antenna factor	Cable loss	Height	Azimuth	Pol.
MHz	dB μ V/m	dB μ V/m	dB	dB μ V	dB/m	dB	cm	deg	
33.830	30.3	113.0	82.7	11.7	18.0	0.6	252	226	Vert.
65.170	23.6	113.0	89.4	16.6	6.1	0.9	225	242	Vert.
76.172	22.3	113.0	90.7	13.9	7.5	0.9	243	271	Vert.
104.012	38.6	113.0	74.4	26.2	11.3	1.1	381	70	Hor.
208.202	20.9	113.0	92.1	10.1	9.3	1.5	106	98	Hor.
212.020	14.6	113.0	98.4	3.7	9.3	1.6	132	315	Vert.
463.841	22.2	113.0	90.8	3.1	16.7	2.4	143	265	Hor.
720.068	32.7	113.0	80.3	8.6	21.1	3.0	149	330	Hor.
840.055	42.5	113.0	70.5	16.6	22.7	3.2	187	359	Hor.
914.750	133.0	Carrier	-	106.8	22.8	3.4	101	3	Vert.

Transmitter operates on the upper end of the assigned frequency band (operation mode 3)									
Spurious emissions outside restricted bands									
Frequency	Result	Limit	Margin	Readings	Antenna factor	Cable loss	Height	Azimuth	Pol.
MHz	dB μ V/m	dB μ V/m	dB	dB μ V	dB/m	dB	cm	deg	
33.830	34.7	112.0	77.3	16.1	18.0	0.6	100	90	Vert.
65.170	24.4	112.0	87.6	17.4	6.1	0.9	275	22	Vert.
76.127	20.4	112.0	91.6	12.0	7.5	0.9	165	217	Vert.
104.012	38.8	112.0	73.2	26.4	11.3	1.1	400	225	Hor.
208.202	21.0	112.0	91.0	10.2	9.3	1.5	100	106	Hor.
212.020	22.0	112.0	90.0	11.1	9.3	1.6	100	108	Hor.
463.841	22.4	112.0	89.6	3.3	16.7	2.4	143	263	Hor.
730.500	35.1	112.0	76.9	10.5	21.5	3.1	153	324	Hor.
839.988	44.9	112.0	67.1	19.0	22.7	3.2	184	357	Hor.
927.250	132.0	Carrier	-	105.2	23.4	3.4	100	1	Vert.
Measurement uncertainty				+2.2 dB / -3.6 dB					

Test: Passed

Test equipment used (see chapter 6):

14 – 20, 54, 84

5.6.2.3 Final radiated emission measurement (1 GHz to 10 GHz)

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. 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 with 24 V DC by an external power supply.
- Resolution bandwidth: For all measurements a resolution bandwidth of 1 MHz was used.
- Test results: The test results were calculated with the following formula:

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

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

Result measured with the peak detector:

Frequency GHz	Result dB μ V/m	Limit dB μ V/m	Margin dB	Readings dB μ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	Restr. Band
1.80550	63.4	112.4	49.0	60.3	26.5	25.9	2.5	150	Vert.	No
2.70825	57.4	74.0	16.6	51.5	28.7	26.1	3.2	150	Vert.	Yes
3.61100	42.6	74.0	31.4	33.4	31.3	25.9	3.7	150	Vert.	Yes
Measurement uncertainty							+2.2 dB / -3.6 dB			

Result measured with the average detector:

Frequency GHz	Result dB μ V/m	Limit dB μ V/m	Margin dB	Readings dB μ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	Restr. Band
1.80550	57.7	112.4	54.7	54.6	26.5	25.9	2.5	150	Vert.	No
2.70825	48.4	54.0	5.6	42.5	28.7	26.1	3.2	150	Vert.	Yes
3.61100	30.6	54.0	23.4	21.4	31.3	25.9	3.7	150	Vert.	Yes
Measurement uncertainty							+2.2 dB / -3.6 dB			

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

Result measured with the peak detector:

Frequency GHz	Result dB μ V/m	Limit dB μ V/m	Margin dB	Readings dB μ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	Restr. Band
1.82950	63.9	113.0	49.1	60.7	26.7	26.1	2.6	150	Vert.	No
2.74425	58.7	74.0	15.3	52.1	28.9	25.6	3.3	150	Vert.	Yes
3.65900	41.9	74.0	32.1	32.0	31.5	25.4	3.8	150	Vert.	Yes
Measurement uncertainty							+2.2 dB / -3.6 dB			

Result measured with the average detector:

Frequency GHz	Result dB μ V/m	Limit dB μ V/m	Margin dB	Readings dB μ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	Restr. Band
1.82950	58.9	113.0	54.1	55.7	26.7	26.1	2.6	150	Vert.	No
2.74425	52.9	54.0	1.1	46.3	28.9	25.6	3.3	150	Vert.	Yes
3.65900	31.3	54.0	22.7	21.4	31.5	25.4	3.8	150	Vert.	Yes
Measurement uncertainty							+2.2 dB / -3.6 dB			

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

Result measured with the peak detector:

Frequency GHz	Result dB μ V/m	Limit dB μ V/m	Margin dB	Readings dB μ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	Restr. Band
1.85450	66.6	112.0	45.4	62.7	27.0	25.7	2.6	150	Vert.	No
2.78175	57.0	74.0	17.0	50.7	29.0	26.1	3.4	150	Vert.	Yes
3.70900	44.2	74.0	29.8	34.3	31.8	25.7	3.8	150	Vert.	Yes
Measurement uncertainty							+2.2 dB / -3.6 dB			

Result measured with the average detector:

Frequency GHz	Result dB μ V/m	Limit dB μ V/m	Margin dB	Readings dB μ V	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	Restr. Band
1.85450	61.3	112.0	50.7	57.4	27.0	25.7	2.6	150	Vert.	No
2.78175	51.9	54.0	2.1	45.6	29.0	26.1	3.4	150	Vert.	Yes
3.70900	33.9	54.0	20.1	24.0	31.8	25.7	3.8	150	Vert.	Yes
Measurement uncertainty							+2.2 dB / -3.6 dB			

Test: Passed

Test equipment used (see chapter 6):

29, 31 - 34, 36, 44, 45, 49, 54, 73, 75, 84

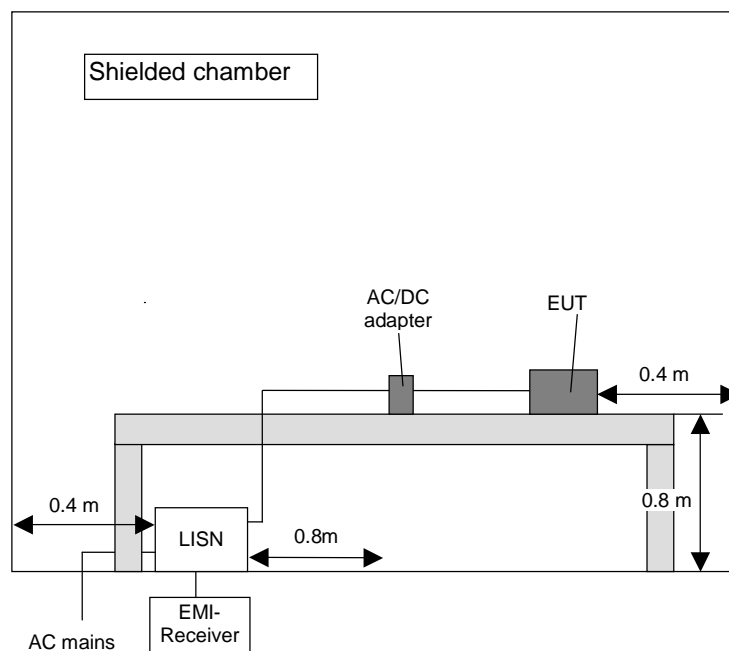
5.7 Conducted emissions on power supply lines (150 kHz to 30 MHz)

5.7.1 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 appropriate 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



5.7.2 Test results (conducted emissions on power supply lines)

Ambient temperature	22 °C	Relative humidity	33 %
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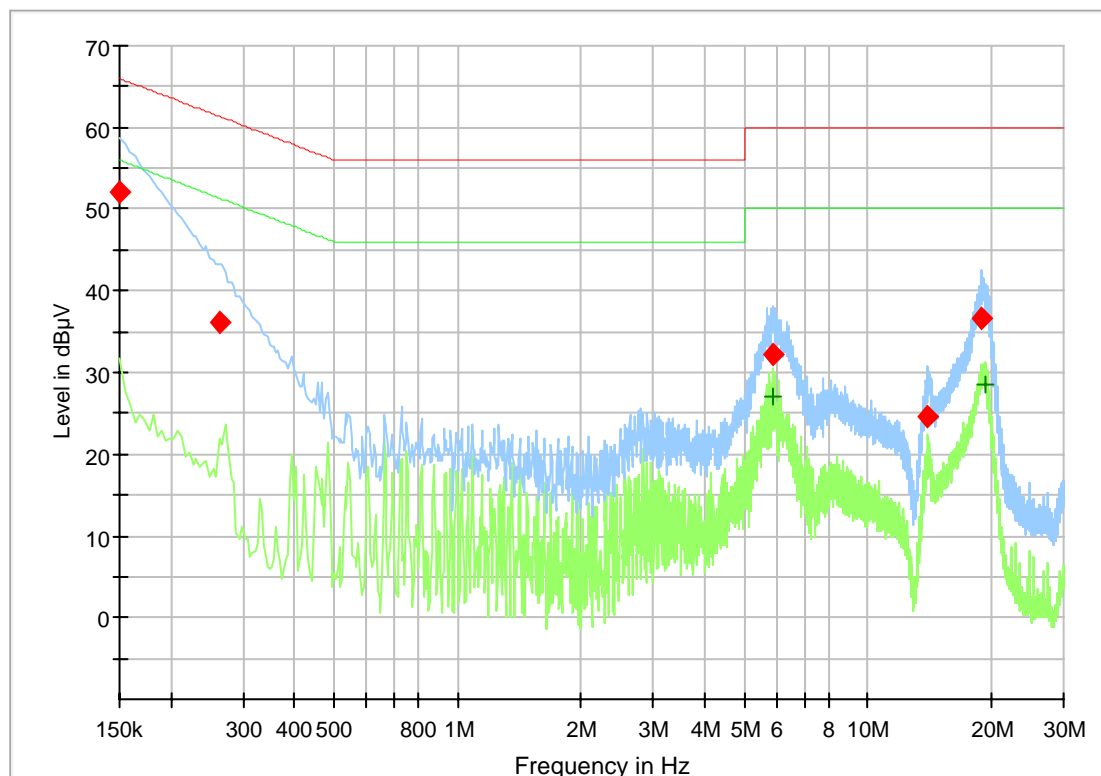
Position of EUT: The EUT was set-up on a non-conducting table of a height of 0.8 m.

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: All results are shown in the following.

Supply voltage: During this test the EUT was powered with 24 V_{DC} by the Mini-PS-100-240AC/24DC/2, which was itself 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 **◆** and the average measured points by **+**.



— Preview Result 2-AVG — Preview Result 1-PK+ — FCC 15.207 V QP
— FCC 15.207 V AV **◆** Final_Result QPK **+** Final_Result AVG

Data record name: 152117con

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

Frequency (MHz)	QuasiPeak (dB μ V)	Average (dB μ V)	Limit (dB μ V)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	PE	Transducer (dB)
0.150000	52.2	---	66.0	13.8	5000.0	9.000	N	GND	10.0
0.262500	36.1	---	61.4	25.3	5000.0	9.000	N	GND	10.0
5.845200	32.3	---	60.0	27.7	5000.0	9.000	L1	FLO	10.6
5.857800	---	27.2	50.0	22.8	5000.0	9.000	L1	GND	10.6
13.905600	24.6	---	60.0	35.4	5000.0	9.000	N	GND	11.4
18.902400	36.5	---	60.0	23.5	5000.0	9.000	L1	GND	12.0
19.396500	---	28.5	50.0	21.5	5000.0	9.000	L1	GND	12.0
Measurement uncertainty			+6.7 dB / -6.0 dB						

Test: Passed

Test equipment used (see chapter 6):

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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	Weekly verification (system cal.)	
2	EMI Receiver	ESIB 26	Rohde & Schwarz	1088.7490	481182	03/21/2014	03/2016
3	LISN	NSLK8128	Schwarzbeck	8128161	480138	02/27/2015	02/2016
4	Transient Filter Limiter	CFL 9206A	Teseq GmbH	38268	481982	Weekly verification (system cal.)	
6	EMI Software	EMC 32	Rohde & Schwarz	100061	481022	-	-
14	Open area test site	-	Phoenix Test-Lab	-	480085	Weekly verification (system cal.)	
15	Measuring receiver	ESIB7	Rohde & Schwarz	100304	480521	03/06/2015	03/2017
16	Controller	HD100	Deisel	100/670	480139	-	-
17	Turntable	DS420HE	Deisel	420/620/80	480087	-	-
18	Antenna support	AS615P	Deisel	615/310	480086	-	-
19	Antenna	CBL6111 D	Chase	25761	480894	09/18/2014	09/2017
20	EMI Software	ES-K1	Rohde & Schwarz	-	480111	-	-
29	Fully anechoic chamber M20	-	Albatross Projects	B83107-E2439-T232	480303	Weekly verification (system cal.)	
30	Spectrum analyser	FSU	Rohde & Schwarz	200125	480956	03/09/2015	03/2016
31	Measuring receiver	ESI 40	Rohde & Schwarz	100064	480355	03/02/2015	03/2016
32	Controller	MCU	Maturo	MCU/043/971107	480832	-	-
33	Turntable	DS420HE	Deisel	420/620/80	480315	-	-
34	Antenna support	AS615P	Deisel	615/310	480187	-	-
35	Antenna	CBL6112 B	Chase	2688	480328	04/14/2014	04/2017
36	Antenna	3115 B	EMCO	9609-4922	480184	09/18/2014	09/2017
43	RF-cable No. 36	Sucoflex 106B	Suhner	0587/6B	480865	Weekly verification (system cal.)	
44	RF-cable No. 3	Sucoflex 106B	Suhner	0563/6B	480670	Weekly verification (system cal.)	
45	RF-cable No. 40	Sucoflex 106B	Suhner	0708/6B	481330	Weekly verification (system cal.)	
49	Preamplifier	JS3-00101200-23-5A	Miteq	681851	480337	Six month verification (system cal.)	
54	Power supply	TOE 8752	Toellner	31566	480010	-	-
55	Loop antenna	HFH2-Z2	Rohde & Schwarz	100417	481912	09/22/2014	09/2015
73	High Pass Filter	WHJS1000C 11/60EF	Wainwright Instruments GmbH	1	480413	Weekly verification (system cal.)	
75	High Pass Filter	WHKX4.0/18 G-8SS	Wainwright Instruments GmbH	1	480587	Weekly verification (system cal.)	
83	Tuneable Notch Filter	WRCA800/90 0-0.2/40-6EEK	Wainwright Instruments GmbH	15	480414	Weekly verification (system cal.)	
84	Multimeter	971A	Hewlett Packard	JP39009365	480722	03/13/2014	03/2016

