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Test Report

Report Number:

F201871E1

Equipment under Test (EUT):

DTI901

Applicant:

ifm electronic gmbh

Manufacturer:

ifm electronic gmbh

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

References

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

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

[3] **RSS-247 Issue 2 (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) Amendment 1** General Requirements for Compliance of Radio Apparatus

Test Result

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

Test engineer:	Thomas KÜHN		05.02.2021
	Name	Signature	Date
Authorized reviewer:	Bernd STEINER		05.02.2021
	Name	Signature	Date

This test report is only valid in its original 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

Name:	ifm electronic gmbh
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Name for contact purposes:	Mr. Tobias GLÜCKLER
Phone:	+49 75 42 94 60 – 11 48
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eMail Address:	tobias.glueckler@ifm.com
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 Deutsche Akkreditierungsstelle GmbH (DAkkS) in compliance with DIN EN ISO/IEC 17025 under Reg. No. D-PL-17186-01-05 and D-PL-17186-01-06, FCC Test Firm Designation Number DE0004, FCC Test Firm Registration Number 469623, CAB Identifier DE0003 and ISED# 3469A.

1.4 EUT (Equipment Under Test)

Test object: *	RFID UHF compact unit
Model name (PMN): *	DTI901 (TR11)
HVIN: *	DTI901
FCC ID: *	UN6-DTRUHFA02
IC: *	6799A-DTRUHFA02
Serial number: *	None (prototype)
PCB identifier: *	80287387 11265215_00 (RF PCB), 11306319 B01 / 80292792 (main PCB), 11237985 / 80284036 FCC V2.0 (antenna PCB 1), 11265205 / 80287300 (LED PCB), 11277680 / 80289838 (antenna PCB 2)
Software version / FVIN: *	V1.012 / N/A
Lowest internal frequency: *	10 MHz

* declared by the applicant.

Note: PHOENIX TESTLAB GmbH does not take samples. The sample used for tests is provided exclusively by the applicant.

1.5 Technical data of equipment

Channel 0	RX:	902.750 MHz	TX:	902.750 MHz
Channel 24	RX:	914.750 MHz	TX:	914.750 MHz
Channel 49	RX:	927.250 MHz	TX:	927.250 MHz

Rated RF output power: *	25.2 dBm EIRP					
Antenna type: *	Integral only					
Antenna gain: *	2.5 dBic					
Antenna connector: *	None					
Adaptive frequency agility: *	No					
Modulation: *	FHSS (PR-ASK)					
Supply voltage: *	U_{nom}=	24.0 V_{DC}	U_{min}=	19.2 V_{DC}	U_{max}=	28.8 V_{DC}
Temperature range: *	-20 °C to +60 °C					
Ancillary equipment used for test:	Laptop PC type Siemens Fujitsu lifebook (supplied by the laboratory) with Software DteWebApp.exe (supplied by the applicant), IO-Link Master AL1300 (supplied by the applicant), PHOENIX CONTACT MINI-PS-100-240AC/24/DC/1.3 (supplied by the laboratory)					

* declared by the applicant.

The following external I/O cables were used:

Identification	Connector		Length *
	EUT	Ancillary	
IO-Link and power supply	5 pole M12 plug	5 pole M12 plug	5 m
-	-	-	-
-	-	-	-
-	-	-	-

*: Length during the test if no other specified.

1.6 Dates

Date of receipt of test sample:	08.12.2020
Start of test:	11.12.2020
End of test:	14.12.2020

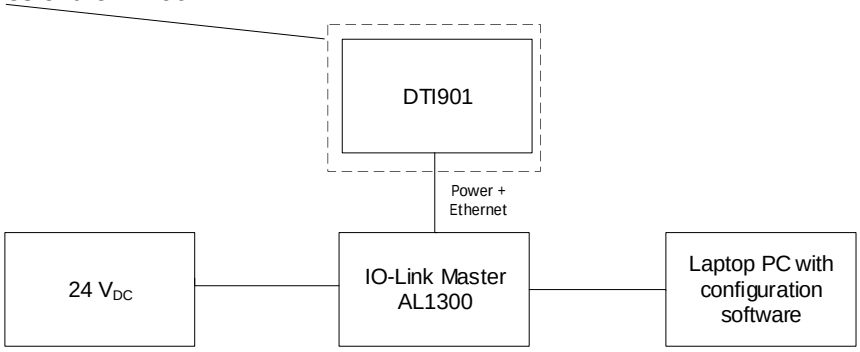
2 Operational states

The tested sample was unmodified and could be configured via Ethernet and the IO-Link Master AL1300 with the help of a laptop PC with a configuration software (UHF Test Application DTEWebAPP.exe), where the operation channel could be selected and hopping could be enabled / disabled.

All radiated measurements were carried out with a connection of the EUT to an external 24 V_{DC} power supply via the IO-Link Master AL1300.

Because the housing of the EUT is glued and the EUT has no external antenna connector, no conducted measurements could be carried out. All measurements were carried radiated while the EUT is connected to the IO-Link Master AL1300 and the laptop PC. The IO-Link Master AL1300 was positioned in the false floor of the (semi) anechoic chamber during the tests. For the connection between the IO-Link Master AL1300 and the PC outside the chamber a fibreoptic converter was used.

Physical boundaries of the DTI901



The following test modes were used during the tests:

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

3 Additional information

During the tests the EUT was not labelled.

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.
99 % bandwidth	General	-	6.7 [4]	Passed	8 et seq.
Carrier frequency separation	General	15.247 (a) (1) (i)	5.1 (c) [3]	Passed	9 et seq.
Number of hopping channels	902.0 – 928.0	15.247 (a) (1) (i)	5.1 (c) [3]	Passed	12 et seq.
Dwell time	902.0 – 928.0	15.247 (a) (1) (i)	5.1 (c) [3]	Passed	14 et seq.
Maximum peak output power	902.0 – 928.0	15.247 (b) (2)	5.4 (a) [3]	Passed	16 et seq.
Radiated emissions (transmitter)	1 - 10,000	15.247 (d) 15.205 (a) 15.209 (a)	5.5 [3] 8.9 [4]	Passed	17 et seq.
Conducted emissions on supply line	0.15 - 30	15.207 (a)	8.8 [4]	Passed	28 et seq.
Antenna requirement	-	15.203 [2]	6.8 [4]	Passed *	-

*: The DTI901 has an internal antenna only and as declared by the applicant it is intended for professional installation. So, the requirement is regarded as fulfilled.

5 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 disenabled, the transmitter shall work with its maximum data rate.

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

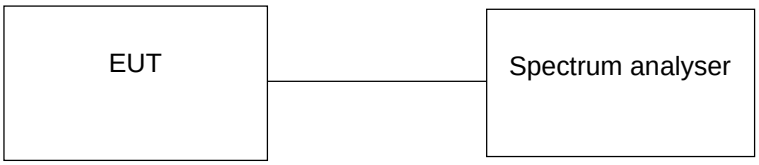
- Span: App. 2 to 5 times the 20 dB bandwidth, centred on the actual hopping channel.
- Resolution bandwidth: 1 % to 5 % of the 20 dB bandwidth.
- Video bandwidth: three times the resolution bandwidth.
- Set the reference level of the instrument either above the measured peak conducted output power level 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	22 °C	Relative humidity	20 %

Measured radiated inside semi anechoic chamber, hopping disabled.

Channel number	Nominal channel frequency [MHz]	20 dB bandwidth [kHz]
0	902.750	39.260
24	914.750	39.410
49	927.250	43.760
Measurement uncertainty		+0.66 dB / -0.72 dB

Remark: The plots of these measurements are presented in annex A of this test report.

Test equipment used (see chapter 6):

6 – 11, 13, 15 – 17, 33, 34

5.1.3 Test results (99 % bandwidth)

Ambient temperature	22 °C	Relative humidity	20 %

Measured radiated inside semi anechoic chamber, hopping disabled.

Channel number	Nominal channel frequency [MHz]	99 % bandwidth [kHz]
0	902.750	53.460
24	914.750	55.221
49	927.250	77.783
Measurement uncertainty		+0.66 dB / -0.72 dB

Remark: The plots of these measurements are presented in annex A of this test report.

Test equipment used (see chapter 6):

6 – 11, 13, 15 – 17, 33, 34

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 ≥ 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	20 %

Measured radiated inside semi anechoic chamber, hopping enabled.

Channel number	Nominal channel frequency [MHz]	Channel separation [kHz]	Minimum limit [kHz]	Test result
0	902.750	499.500	39.260	Passed
24	914.750	499.500	33.410	Passed
49	927.250			
Measurement uncertainty		<10^{-7}		

Remark: The plots of these measurements are presented in annex A of this test report.

Test equipment used (see chapter 6):

6 – 11, 13, 15 – 17, 33, 34

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: ≥ 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	20 %

Measured radiated inside semi anechoic chamber, hopping enabled.

Number of hopping channels	Limit	Test result
50	At least 50	Passed

Remark: The plot of this measurement is presented in annex A of this test report.

Test equipment used (see chapter 6):

6 – 11, 13, 15 – 17, 33, 34

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 ≤ channel spacing and where possible Resolution bandwidth should be set >> 1 / *T*, where *T* is the expected dwell time per channel.
- Video bandwidth: ≥ 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:

(Number of hops in the period specified in the requirements) =
(number of hops on spectrum analyzer) × (period specified in the requirements / analyzer sweep time)

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	22 °C	Relative humidity	20 %

Measured radiated inside semi anechoic chamber, hopping enabled.

Channel number	Nominal channel frequency [MHz]	t_{pulse} [ms]	Number of pulses	Dwell time [ms]	Limit [ms]	Test result
24	914.750	43.800	2	87.6	400.000	Passed
Measurement uncertainty				$<10^{-7}$		

Remark: The plots of this measurement are presented in annex A of this test report.

Test equipment used (see chapter 6):

6 – 11, 13, 15 – 17, 33, 34

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 5.6.2.3 (final measurement (30 MHz to 1 GHz)) of this test report with the exception that a peak detector was used. According to clause 11.12.2.2 e) [1] with this the field strength value the radiated peak power of the EUT was calculated. With the antenna gain of the EUTs antenna the conducted peak power was calculated.

5.5.2 Test results (maximum peak output power)

Ambient temperature	22 °C	Relative humidity	20 %

Result measured with the peak detector:

Frequency [MHz]	Peak [dBµV/m]	Meas. Time [ms]	Bandwidth [kHz]	Height [cm]	Pol.	Azimuth [deg]	Elevat. [deg]	Corr. [dB]
902.750	120.2	1000	120	130	Vert.	0	0	32.1
914.750	121.4	1000	120	126	Vert.	5	0	32.5
927.250	119.2	1000	120	106	Hor.	15	0	32.9
Measurement uncertainty				±5.1 dB				

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

Calculated peak radiated output power [dBm (EIRP)] = (field strength [dBµV/m] + 20 log(measuring distance [m]) -104.8

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

Maximum peak output power [dBm] = Calculated peak radiated output power [dBm] – antenna gain [dB]

Frequency	Field strength	Peak radiated power, EIRP		Antenna gain	Maximum peak conducted output power		Limit [W]	Test result
[MHz]	[dBµV/m]	[dBm]	[W]	[dBi]	[dBm]	[W]		
902.750	120.2	24.9	0.309	-0.5	25.4	0.347	1.0	Passed
914.750	121.4	26.1	0.407	-0.5	26.6	0.457	1.0	Passed
927.250	119.2	23.9	0.245	-0.5	24.4	0.275	1.0	Passed

Test equipment used (see chapter 6):

6 – 13, 15 – 17, 33, 34

5.6 Radiated emissions

5.6.1 Method of measurement (radiated emissions)

The radiated emission measurement is subdivided into different stages.

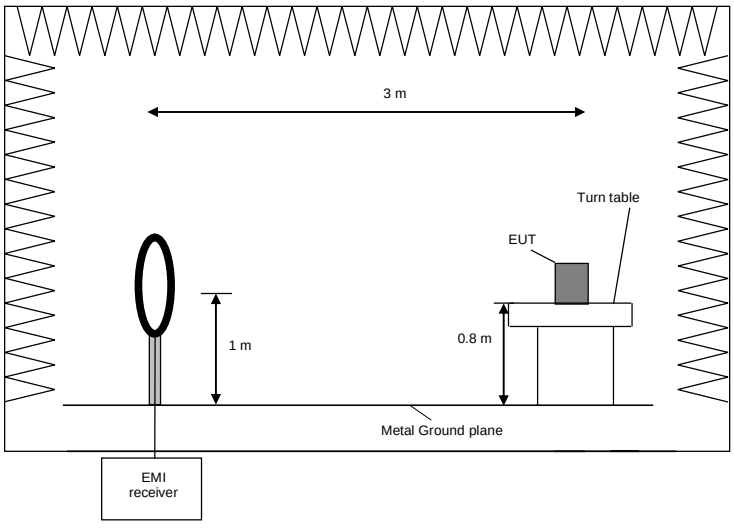
- A preliminary measurement carried out inside a semi anechoic chamber with reflecting ground plane with a fixed antenna height in the frequency range 9 kHz to 30 MHz.
- A final measurement carried out on an outdoor test side without reflecting ground plane and a fixed antenna height in the frequency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

The frequency range 10 MHz 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 find the maximum emissions.

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

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



Preliminary measurement procedure:

Prescans were performed in the frequency range 10 MHz 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.
7. Rotate the measuring antenna and repeat steps 1) to 5).

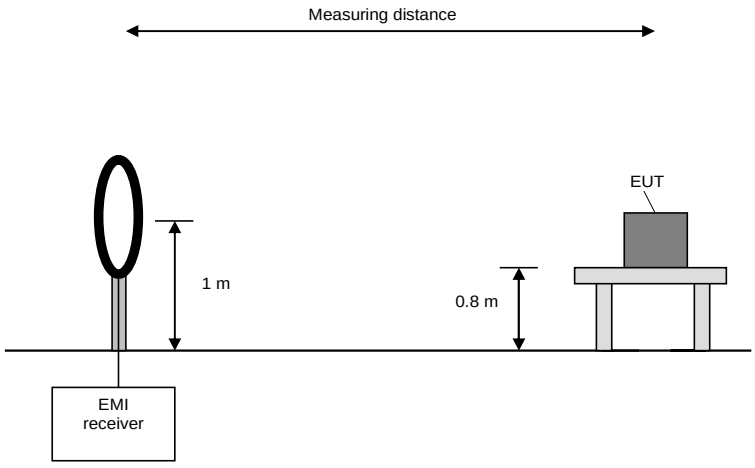
Final measurement (9 kHz to 30 MHz):

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 whichever is appropriate. In the case where larger measuring distances were required the results will be extrapolated based on the values measured on the closer distances according to [2]. The final measurement will be performed with a EMI Receiver set to Quasi Peak.

On the during the preliminary measurement detected frequencies 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 (only if the EUT is a module or is used in a handheld application).

Preliminary and final measurement (30 MHz to 1 GHz)

The EUT is measured in the frequency range from 30 MHz to 1 GHz inside a semi anechoic chamber with a metal ground plane, which has been validated to the requirements of [1]. It is placed on a non-conducting table with a height of 80 cm at a distance of 3 meters from the receiving antenna. Both polarizations (vertical and horizontal) have been evaluated and the turn table has been turned to 360° to maximize the emissions. The receiving antenna is raised from 1 to 4 m.

Procedure preliminary measurement:

The following procedure is used:

1. Set the measurement antenna to 1 m height.
2. Monitor the frequency range at vertical polarization and a EUT azimuth of 0 °.
3. Rotate the EUT by 360° to maximize the detected signals in two axes.
4. Repeat 1) to 2) with the horizontal polarization of the measuring antenna.
5. Increase the height of the antenna for 0.5 m and repeat steps 2 – 4 until the final height of 4 m is reached (30 MHz to 1 GHz only).
6. Repeat steps 1) to 4) with the other orthogonal axes of the EUT (only if the EUT is a module or is used in a handheld application).
7. The highest values for each frequency will be saved by the software, including the antenna height, measurement antenna polarization and turntable azimuth for that value.

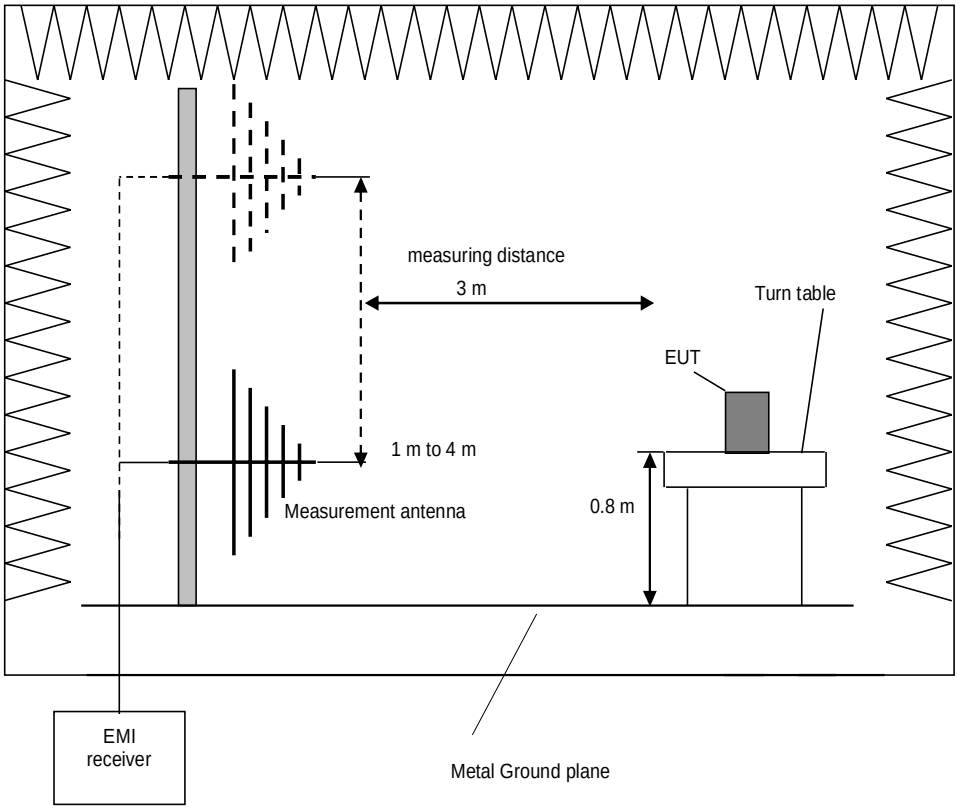
Procedure final measurement:

The following procedure is used:

1. Select the highest frequency peaks to the limit for the final measurement.
2. The software will determine the exact peak frequencies by doing a partial scan with reduced RBW with +/- 10 times the RBW of the pre-scan of the selected peaks.
3. If the EUT is portable or ceiling mounted, find the worst case EUT position (x, y, z) for the final test.
4. The worst measurement antenna height is found by the measurement software by varying the measurement antenna height by +/- 0.5 m from the value obtained in the preliminary measurement, and to monitor the emission level.
5. The worst azimuth turntable position is found by varying the turntable azimuth by +/- 25° from the value obtained in the preliminary measurement, and to monitor the emission level.
6. The final measurement is performed at the worst-case antenna height and the worst-case turntable azimuth
7. Steps 2 – 6 will be repeated for each frequency peak selected in step 1.

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

Frequency range	Resolution bandwidth
30 MHz to 1 GHz	100 kHz



Test setup for measurements below 1 GHz

Preliminary and final measurement (1 GHz to 40 GHz)

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

Procedure preliminary measurement:

The frequency range will be divided into different sub ranges depending of the frequency range of the used horn antenna. The measurement will be performed in horizontal and vertical polarisation of the measuring antenna and while rotating the EUT in its vertical axis in the range of 0 ° to 360 °. This measurement is repeated after raising the EUT in 30 ° steps according 6.6.5.4 in [1].

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

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

Prescans were performed in the frequency range 1 to 40 GHz.

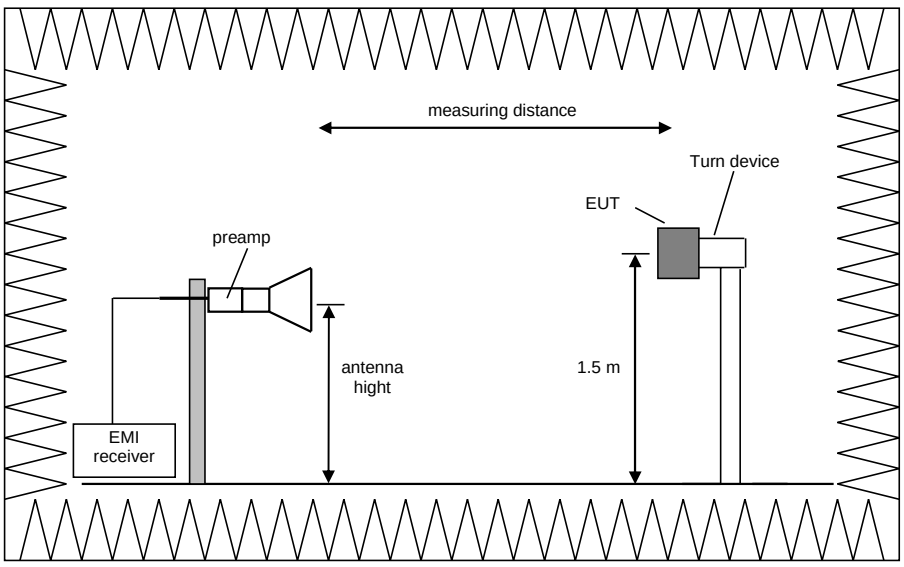
The following procedure will be used:

1. Monitor the frequency range at horizontal polarisation and a EUT azimuth of 0 ° with peak or RMS detector of the spectrum analyser (depending of the noise floor and the applicable limit).
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.

Procedure final measurement:

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

8. Set the turntable and the turn device to obtain the worst-case emission for the first frequency identified in the preliminary measurements.
9. Set the measurement antenna polarisation to the orientation with the highest emission for the first frequency identified in the preliminary measurements.
10. Set the spectrum analyser to EMI mode with peak and CISPR average detector activated.
11. Rotate the turntable from 0° to 360° to find the EUT angle that produces the highest emissions.
12. Note the highest displayed peak and average values
13. Repeat the steps 1) to 5) for each frequency detected during the preliminary measurements.
14. Replace the EUT by a substitution antenna, which is fed by a signal generator.
15. Carry out a substitution for each frequency detected during the steps 5) to 6).
16. Calculate the EIRP values with the help of the final measurement and the substitution results.



Test setup for measurements from 1 GHz to 40 GHz

5.6.2 Test results (radiated emissions)

5.6.2.1 Preliminary radiated emission measurement (1 MHz to 10 GHz)

Ambient temperature	22 °C	Relative humidity	20 %

Position of EUT: The EUT was set-up on the non-conducting table at a height of 0.8 m (below 1 GHz) and on the positioning device at a hight of 1.5 m (above 1 GHz). The distance between EUT and antenna was 3 m.

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

Test record: All results are shown in the following. The plots of this measurements are presented in annex A of this test report, they are showing the maximum of all orthogonal directions.

Supply voltage: During all measurements the EUT was supplied 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)

The following frequencies were found inside the restricted bands during the preliminary radiated emission test in the frequency range 30 MHz to 10 GHz:

- 1200.004 MHz, 1350.004 MHz, 1499.970 MHz and 2708.250 MHz.

The following frequencies were found outside the restricted bands during the preliminary radiated emission test in the frequency range 30 MHz to 10 GHz:

- 31.488 MHz, 570.255 MHz, 575.000MHz, 750.000 MHz, 902.750 MHz, 904.375 MHz, 912.000 MHz and 921.170 MHz

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

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

No significant frequencies above the noise floor of the system (max. 40.4 dBµV/m / -11.1 dBµA/m (measured with peak detector) at 3 m distance) were found during the preliminary radiated emission test in the frequency range 1 MHz to 30 MHz, so no final measurements were carried out on the outdoor test site.

The following frequencies were found inside the restricted bands during the preliminary radiated emission test in the frequency range 30 MHz to 10 GHz:

- 1200.169 MHz, 1349.990 MHz and 2744.250 MHz.

The following frequencies were found outside the restricted bands during the preliminary radiated emission test in the frequency range 30 MHz to 10 GHz:

- 32.815 MHz, 146.080 MHz, 750.000 MHz, 850.000 MHz, 900.345 MHz, 900.690 MHz, 906.185 MHz, 911.990 MHz, 914.750 MHz, 916.375 MHz, 936.000 MHz, 943.725 MHz, 1275.163 MHz and 1299.995 MHz.

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

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

The following frequencies were found inside the restricted bands during the preliminary radiated emission test in the frequency range 30 MHz to 10 GHz:

- 1199.990 MHz, 1349.989 MHz, 2781.750 MHz, 3709.000 MHz and 5439.415 MHz.

The following frequencies were found outside the restricted bands during the preliminary radiated emission test in the frequency range 30MHz to 10 GHz:

- 30.465 MHz, 146.095 MHz, 750.000 MHz, 912.000 MHz, 927.250 MHz and 936.000 MHz.

These frequencies have to be measured in a final measurement. The result is presented in the following.

Test equipment used (refer chapter 6):

6 – 31, 33, 34

5.6.2.2 Final radiated emission measurement (1 MHz to 30 MHz)

No significant frequencies above the noise floor of the system (max. 40.4 dBµV/m / -11.1 dBµA/m (measured with peak detector) at 3 m distance) were found during the preliminary radiated emission test in the frequency range 1 MHz to 30 MHz, so no final measurements were carried out on the outdoor test site.

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

Ambient temperature	22 °C	Relative humidity	20 %

Position of EUT: The EUT was set-up on the non-conducting table at 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 B of this test report.

Test record: All results are shown in the following. The plots of this measurements are presented in annex A of this test report.

Supply voltage: During all measurements the EUT was supplied 24.0 V_{DC} by an external power supply.

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

Result [dBµV/m] = reading [dBµV] + cable loss [dB] + antenna factor [dB/m] + 6 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.

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

Transmitter operates at the lower end of the assigned frequency band [operation mode 1]												
Frequency [MHz]	QuasiPeak [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Meas. Time [ms]	RBW [kHz]	Height [cm]	Pol.	Azimuth [deg]	Position	Corr. [dB]	Restr. Band	Test result
31.480	16.5	100.1	83.6	1000	120	235	Vert.	79	2	27.9	No	Passed
570.255	18.5	100.1	81.6	1000	120	210	Vert.	123	2	28.2	No	Passed
575.000	18.5	100.1	81.6	1000	120	211	Hor.	60	1	28.1	No	Passed
750.000	25.6	100.1	74.5	1000	120	231	Hor.	290	2	30.7	No	Passed
902.750	120.1	Carrier	-	1000	120	130	Vert.	0	1	32.1	No	Passed
904.375	25.7	100.1	74.4	1000	120	302	Hor.	-3	1	32.2	No	Passed
912.000	30.5	100.1	69.6	1000	120	291	Hor.	-15	1	32.4	No	Passed
921.170	23.6	100.1	76.5	1000	120	172	Vert.	63	2	32.7	No	Passed
Transmitter operates at the lower end of the assigned frequency band [operation mode 2]												
Frequency [MHz]	QuasiPeak [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Meas. Time [ms]	RBW [kHz]	Height [cm]	Pol.	Azimuth [deg]	Position	Corr. [dB]	Restr. Band	Test result
32.815	14.7	101.3	86.6	1000	120	283	Vert.	272	1	27.3	No	Passed
146.080	10.5	101.3	90.8	1000	120	132	Hor.	181	2	18.6	No	Passed
750.000	28.2	101.3	73.1	1000	120	254	Hor.	293	2	30.7	No	Passed
850.000	24.2	101.3	77.1	1000	120	230	Hor.	285	2	32.0	No	Passed
900.345	22.4	101.3	78.9	1000	120	392	Hor.	145	2	32.1	No	Passed
900.690	22.5	101.3	78.8	1000	120	396	Hor.	176	2	32.1	No	Passed
906.185	22.5	101.3	78.8	1000	120	406	Hor.	110	2	32.2	No	Passed
911.990	30.7	101.3	70.6	1000	120	134	Hor.	290	2	32.4	No	Passed
914.750	121.3	Carrier	-	1000	120	126	Vert.	5	1	32.5	No	Passed
916.375	30.0	101.3	71.3	1000	120	288	Hor.	-4	1	32.5	No	Passed
936.000	27.8	101.3	73.5	1000	120	301	Hor.	30	1	33.4	No	Passed
943.725	24.2	101.3	77.1	1000	120	259	Vert.	311	2	33.7	No	Passed
Transmitter operates at the lower end of the assigned frequency band [operation mode 3]												
Frequency [MHz]	QuasiPeak [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Meas. Time [ms]	RBW [kHz]	Height [cm]	Pol.	Azimuth [deg]	Position	Corr. [dB]	Restr. Band	Test result
30.465	17.9	99.1	81.2	1000	120	179	Hor.	269	1	28.3	No	Passed
146.095	11.4	99.1	87.7	1000	120	217	Vert.	118	1	18.6	No	Passed
750.000	25.1	99.1	74.0	1000	120	152	Vert.	305	1	30.7	No	Passed
912.000	30.5	99.1	68.6	1000	120	102	Hor.	13	2	32.4	No	Passed
927.250	119.1	Carrier	-	1000	120	106	Hor.	15	1	32.9	No	Passed
936.000	28.3	99.1	70.8	1000	120	294	Hor.	20	1	33.4	No	Passed
Measurement uncertainty				±5.1 dB								

Test equipment used (see chapter 6):

6 – 13, 15 – 17, 33, 34

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

Ambient temperature	22 °C	Relative humidity	31 %

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 B of this test report.

Test record: All results are shown in the following.

Supply voltage: During all measurements the EUT was supplied 24.0 V_{DC} by an external power supply.

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

Results measured with the peak detector:

Transmitter operates at the lower end of the assigned frequency band (operation mode 1)									
Frequency [MHz]	Peak result [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Pol.	Azimuth [deg]	Elevation [deg]	Corr. [dB]	Restr. Band	Test result
1200.004	25.6	74.0	48.4	Hor.	245	90	-15.1	Yes	Passed
1350.004	26.9	74.0	47.1	Vert.	310	0	-15.0	Yes	Passed
1499.970	28.1	74.0	45.9	Vert.	225	0	-14.9	Yes	Passed
2708.250	34.0	74.0	40.0	Hor.	330	0	-11.2	Yes	Passed
Transmitter operates at the middle of the assigned frequency band (operation mode 2)									
Frequency [MHz]	Peak result [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Pol.	Azimuth [deg]	Elevation [deg]	Corr. [dB]	Restr. Band	Test result
1200.169	25.3	74.0	48.7	Vert.	227.0	60.0	-15.1	Yes	Passed
1275.163	25.7	101.3	75.6	Vert.	198.0	60.0	-15.1	No	Passed
1299.995	27.8	101.3	73.8	Vert.	216.0	90.0	-14.9	No	Passed
1349.990	28.1	74.0	45.9	Vert.	230.0	30.0	-15.0	Yes	Passed
2744.250	32.4	74.0	41.6	Hor.	342.0	0.0	-11.4	Yes	Passed
Transmitter operates at the upper end of the assigned frequency band [operation mode 3]									
Frequency [MHz]	Peak result [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Pol.	Azimuth [deg]	Elevation [deg]	Corr. [dB]	Restr. Band	Test result
1199.990	26.1	74.0	47.9	Vert.	226	120	-15.1	Yes	Passed
1349.989	27.8	74.0	46.2	Vert.	206	150	-15.0	Yes	Passed
2781.750	31.2	74.0	42.8	Vert.	359	0	-11.2	Yes	Passed
3709.000	31.1	74.0	42.9	Vert.	322	0	-7.1	Yes	Passed
5439.415	32.0	74.0	42.0	Vert.	95	60	-2.5	Yes	Passed
Measurement uncertainty				±5.1 dB					

Results measured with the average detector:

Transmitter operates at the lower end of the assigned frequency band (operation mode 1)									
Frequency [MHz]	Average result [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Pol.	Azimuth [deg]	Elevation [deg]	Corr. [dB]	Restr. Band	Test result
1200.004	14.1	54.0	39.9	Hor.	245	90	-15.1	Yes	Passed
1350.004	17.7	54.0	36.3	Ver.	310	0	-15.0	Yes	Passed
1499.970	18.1	54.0	35.9	Vert.	225	0	-14.9	Yes	Passed
2708.250	29.3	54.0	24.7	Hor.	330	0	-11.2	Yes	Passed
Transmitter operates at the lower end of the assigned frequency band (operation mode 1)									
Frequency [MHz]	Average result [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Pol.	Azimuth [deg]	Elevation [deg]	Corr. [dB]	Restr. Band	Test result
1200.169	13.1	54.0	40.9	Vert.	227	60	-15.1	Yes	Passed
1275.163	12.9	101.3	88.4	Vert.	198	60	-15.1	No	Passed
1299.995	19.8	101.3	81.5	Vert.	216	90	-14.9	No	Passed
1349.990	20.0	54.0	34.0	Vert.	230	30	-15.0	Yes	Passed
2744.250	27.5	54.0	26.5	Hor.	342	0	-11.4	Yes	Passed
Transmitter operates at the lower end of the assigned frequency band (operation mode 1)									
Frequency [MHz]	Average result [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Pol.	Azimuth [deg]	Elevation [deg]	Corr. [dB]	Restr. Band	Test result
1199.990	15.0	54.0	39.0	Vert.	226	120	-15.1	Yes	Passed
1349.989	19.3	54.0	34.7	Vert.	206	150	-15.0	Yes	Passed
2781.750	24.9	54.0	29.1	Vert.	359	0	-11.2	Yes	Passed
3709.000	22.5	54.0	31.5	Vert.	322	0	-7.1	Yes	Passed
5439.415	19.7	54.0	34.3	Vert.	95	60	-2.5	Yes	Passed
Measurement uncertainty				±5.1 dB					

Test equipment used (see chapter 6):

18 – 30, 33, 34

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

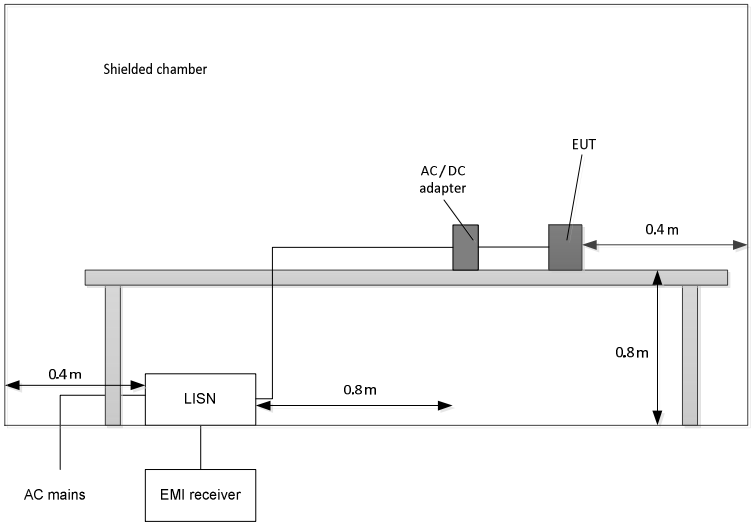
5.7.1 Method of measurement

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. In case of DC powered equipment, which is not exclusively powered by a battery, it will be connected to the LISN via a suitable AC/DC adaptor. 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 all lines of the AC mains network, grounded and floated. 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

Test setup for measurement with the EUT supplied with DC via an AC/DC adaptor:



5.7.2 Test results (conducted emissions on AC power supply lines)

Ambient temperature	21 °C	Relative humidity	32 %

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 B of this test report.

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

Supply voltage: During this test the EUT was supplied 24.0 V_{DC} by an AC/DC adaptor type MINI-PS-100-240AC/24/DC/1.3, which was connected to an AC mains network with 120 V_{AC} / 60 Hz.

The curves in the diagram in annex A 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 ♦, the average measured points with ▼.

Frequency [MHz]	QuasiPeak [dBµV]	Average [dBµV]	Limit [dBµV]	Margin [dB]	Meas. Time [ms]	Bandwidth [kHz]	Line	PE	Corr. [dB]	Test result
0.160800	55.7	---	65.4	9.7	5000	9	N	GND	9.8	Passed
0.160800	---	45.2	55.4	10.2	5000	9	L1	FLO	9.8	Passed
0.441600	38.7	---	57.0	18.3	5000	9	N	GND	9.9	Passed
0.442500	---	37.4	47.0	9.6	5000	9	L1	FLO	9.9	Passed
17.497500	48.7	---	60.0	11.3	5000	9	L1	GND	10.9	Passed
18.299400	---	46.9	50.0	3.1	5000	9	L1	GND	10.9	Passed
18.983400	49.5	---	60.0	10.5	5000	9	N	GND	10.9	Passed
Measurement uncertainty			±2.8 dB							

Test equipment used (refer clause 6):

1 – 5, 34, 35

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	100292	481182	12.02.2020	02.2022
3	LISN	NSLK8128	Schwarzbeck	8128161	480138	11.02.2020	02.2022
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	Semi anechoic chamber M276	SAC5-2	Albatross Projects	C62128-A540-A138-10-0006	483227	Calibration not necessary	
7	RF Switch Matrix	OSP220	Rohde & Schwarz	-	482976	Calibration not necessary	
8	Turntable	TT3.0-3t	Maturo	825/2612/.01	483224	Calibration not necessary	
9	Controller	NCD	Maturo	474/2612.01	483226	Calibration not necessary	
10	Positioner	TG1.5-10kg	Maturo	110/2648.01	483042	Calibration not necessary	
11	Antenna support	BAM 4.5-P-10kg	Maturo	222/2612.01	483225	Calibration not necessary	
12	System software EMC32 M276	EMC32	Rohde & Schwarz	100970	482972	Calibration not necessary	
13	Ultralog Antenna	CBL6111D	Chase	25761	480894	09.10.2020	10.2023
14	Loop antenna	HFH2-Z2	Rohde & Schwarz	100417	481912	05.02.2020	02.2021
15	EMI Test receiver ESW	ESW44	Rohde & Schwarz	101828	482979	12.04.2019	04.2021
16	Cable C417	Sucoflex 118	Huber+Suhner	500654/118	-	Calibration not necessary	
17	6 dB attenuator	R412706000	Radiall	9833	410082	Calibration not necessary	
18	Fully anechoic chamber M20	-	Albatross Projects	B83107-E2439-T232	480303	Calibration not necessary	
19	Spectrum analyser	FSW43	Rohde & Schwarz	100586 & 100926	481720	04.03.2020	03.2022
20	Measuring receiver	ESW44	Rohde & Schwarz	101635	482467	18.02.2020	02.2022
21	Controller	MCU	Maturo	MCU/043/971107	480832	Calibration not necessary	
22	Turntable	DS420HE	Deisel	420/620/80	480315	Calibration not necessary	
23	Antenna support	AS615P	Deisel	615/310	480187	Calibration not necessary	
24	Horn antenna	3115	EMCO	9609-4918	480183	05.02.2018	02.2021
25	RF-cable No. 36	Sucoflex 106B	Suhner	0587/6B	480865	Calibration not necessary	
26	RF-cable No. 3	Sucoflex 106B	Suhner	0563/6B	480670	Calibration not necessary	
27	RF-cable No. 40	Sucoflex 106B	Suhner	0708/6B	481330	Calibration not necessary	
28	Preamplifier	JS3-00101200-23-5A	Miteq	681851	480337	Calibration not necessary	
29	Turn device	TDF 1.5- 10Kg	Maturo	15920215	482034	Calibration not necessary	
30	High Pass Filter	WHKX12-935-1000-15000-40ST	Wainwright	12	482908	Calibration not necessary	
31	Tuneable Notch Filter	WRCA800/900-0.2/40-6EEK	Wainwright Instruments GmbH	15	480414	Calibration not necessary	

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal. due
32	20 dB attenuator	WA8 / 18-20-34	Weinschel	-	481450	Calibration not necessary	
33	DC power supply	HM8142	Hameg	142981P 03955	480719	Calibration not necessary	
34	Digital multimeter	971A	Hewlett Packard	JP39009358	480721	16.01.2020	01.2021
35	AC source	AC6803A	Keysight	JPVJ002509	482350	Calibration not necessary	

7 Test site validation

Test equipment	PM. No.	Frequency range	Type of validation	According to	Val. Date	Val Due
Semi anechoic chamber M276	483227	30 – 1000 MHz	NSA	ANSI C63.4-2014	19.09.2019	18.09.2021
Fully anechoic chamber M20	480303	1 -18 GHz	SVSWR	CISPR 16-1-4 Amd. 1	13.07.2018	12.07.2021
Shielded chamber M4	480088	9 kHz – 30 MHz	GND-Plane	ANSI C63.4-2014	12.05.2020	05.2022

8 Report history

Report Number	Date	Comment
F201871E1	05.02.2021	Document created
-	-	-
-	-	-
-	-	-

9 List of annexes

Annex A	Measurement plots	13 pages
Annex B	Test set-up photos	11 pages