

**Test Report acc. to FCC Title 47 CFR Part 15
relating to
Feig Electronic GmbH
ID ISC.MRMU102-A**

**Title 47 – Telecommunication
Part 15 - Radio Frequency Devices
Subpart C – Intentional Radiators
Measurement Procedure:
ANSI C63.4-2014
ANSI C63.10-2013**



Deutsche
Akkreditierungsstelle
D-PL-12053-01-03

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RELEVANT STANDARD	
Title	47 - Telecommunication
Part	15 - Radio Frequency Devices
Subpart	Subpart C – Intentional Radiators - Section 15.247
Measurement procedure	ANSI C63.4-2014 & ANSI C63.10-2013

EQUIPMENT UNDER TEST (EUT)	
Equipment category	RFID Reader
Trade name	Feig Electronic
Type designation	ID ISC.MRMU102-A
Serial no.	7693060
Variants	ID ISC.MRMU102-A ID ISC.MRU102-A ID ISC.MRU102-USB ID ISC.MRU102-PoE ID ISC.MRU102-PoE-LED

Test result summary

Test report Clause	FCC section	Requirements headline	Test result		
8.1	§15.203	Antenna requirement	Pass	~~Fail~~	~~N.t.*~~
8.2	§15.207 (a)	AC power line conducted limits	Pass	~~Fail~~	~~N.t.*~~
8.3	§15.205, §15.209, §15.247 (d)	Restricted bands of operation	Pass	~~Fail~~	~~N.t.*~~
8.4	§15.205, §15.209, §15.247 (d)	Radiated emission limits, general requirements	Pass	~~Fail~~	~~N.t.*~~
8.5	§15.247 (a) (1)	Bandwidth	Pass	~~Fail~~	~~N.t.*~~
8.6	§15.247 (a) (1)	Carrier frequency separation	Pass	~~Fail~~	~~N.t.*~~
8.7	§15.247 (a) (1)	Number of hopping channels	Pass	~~Fail~~	~~N.t.*~~
8.8	§15.247 (a) (1)	Average time of occupancy	Pass	~~Fail~~	~~N.t.*~~
8.9	§15.247 (b) (2)	Peak output power	Pass	~~Fail~~	~~N.t.*~~
8.10	§15.247 (d)	Out of band emissions	Pass	~~Fail~~	~~N.t.*~~
8.11	§1.1310 §2.1091	Radio frequency hazard	Pass	~~Fail~~	~~N.t.*~~

* Not tested

As far as in this report statements on conformity are made, decision rules according to DIN EN ISO/IEC 17025:2018, 7.8.6 have been applied. If the report does not state otherwise, procedure 1 according to IEC Guide 115 ed.1.0 2007 (uncertainty of measurement calculated) has been applied on measurement and test procedures which are the base of this report.

The equipment passed all the conducted tests	Yes	~~No~~
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Signature	 Digital unterschrieben von Shrestha Anup Datum: 2021.06.30 11:42:06 +02'00'	 Digital unterschrieben von Trepper Ralf Datum: 2021.06.30 11:42:49 +02'00'
Name	Mr. Anup Shrestha	Mr. Ralf Trepper
Designation	RF Test Engineer	Deputy Laboratory Manager
Date of issue	2021-06-24	2021-06-24

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1. Table of contents

Revision	Date of issue	Creator	Content of change
00	24.06.21	AS	Initial release
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Table 0-1: Table of contents

Note: If the document has been changed by revision number, all previous documents are no longer valid and must be destroyed.

2. Introduction

This test report **is not an expert opinion** and consists of:

- Test result summary
- List of contents
- Introduction and further information
- Performance assessment
- Detailed test information

All pages have been numbered consecutively and bear the TÜV NORD Hochfrequenztechnik GmbH & Co. KG logo, the test report number, the date, the test specification in its current version as well as the type designation of the EUT. The total numbers of pages in this report is **64**.

The tests were carried out in a representative assembly and in accordance with the test methods and/or requirements stated in:

FCC Title 47 CFR Part 15 Subpart C Section 15.247, ANSI C63.4-2014 & ANSI C63.10-2013

The sample of the product was received on:

- 2021-06-04

The tests were carried out in the following period of time:

- 2021-06-07 - 2021-06-23

3. Testing laboratory

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Accredited by:

DAkkS Deutsche Akkreditierungsstelle GmbH
DAkkS accreditation number: D-PL-12053-01-03

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For issuing this report the following product documentation was used:

Description	Date	Identifications
External photographs of the Equipment Under Test (EUT)	2021-06-24	Annex no. 1
Internal photographs of the Equipment Under Test (EUT)	2021-06-24	Annex no. 2
Channel occupancy / bandwidth	2021-06-24	Annex no. 3
Label sample	2021-06-24	Annex no. 4
Functional description / User Manual	2021-06-24	Annex no. 5
Test setup photos	2021-06-24	Annex no. 6
Block diagram	2021-06-24	Annex no. 7
Operational description	2021-06-24	Annex no. 8
Schematics	2021-06-24	Annex no. 9
Parts list	2021-06-24	Annex no. 10
Test Results	2021-06-24	Annex no. 11

6. Conclusions, observations and comments

The test report will be filed at TÜV NORD Hochfrequenztechnik GmbH & Co. KG for a period of 10 years following the issue of this report. It may only be reproduced or published in full. Reproduction or publication of extracts from the report requires the prior written approval of TÜV NORD Hochfrequenztechnik GmbH & Co. KG.

The results of the tests as stated in this report are exclusively applicable to the EUT as identified in this report. TÜV NORD Hochfrequenztechnik GmbH & Co. KG cannot be held liable for properties of the EUT that have not been observed during these tests.

TÜV NORD Hochfrequenztechnik GmbH & Co. KG assumes the sample to comply with the requirements of FCC Title 47 CFR Part 15 for the respective test sector, if the test results turn out positive.

Comments:

There are three SMA antenna connectors (ANT1, ANT2 and ANT3) on the PCB board of the EUT which can be connected up to three external UHF antennas to achieve long reader range. The output power from all the three SMA antenna connectors are same. For our test, we have used ANT1 and other two antenna connectors were terminated with 50 ohm terminators.

All RFID Readers ID ISC.MRMU102-A, ID ISC.MRU102-A, ID ISC.MRU102-USB, ID ISC.MRU102-PoE, ID ISC.MRU102-PoE LED, have identical internal antenna and identical RF connectors. All Versions use the same printed circuit board.

7. Operational description

7.1 EUT details

The EUT is a small, compact and with internal antenna RFID reader operating at UHF (902 MHz – 928 MHz) in a frequency hopping mode. The EUT is available in three device variants with Ethernet, USB or RS232. The EUT has three SMA antenna connectors such that it can be connected up to three external UHF antennas to achieve long reader ranges. The RFID reader has an output power level of 500 mW. The RFID reader can be supplied with 12.0 – 24.0V DC via a separate power supply or via Power over Ethernet (type PoE).

7.2 EUT configuration

The EUT is powered up as soon as it is connected to 12.0V DC voltage (nominal) or via PoE. With the test software “CPRStart” on a controller PC, the EUT could be configured at different power levels, frequencies and hopping modes. The test was performed at maximum output power with continuous transmission mode at lower, upper and middle frequencies as well as at frequency hopping modes.

The following configurations were set during the test:

Output power: +27 dBm

Frequency hopping in the band: 902 MHz – 928 MHz

Channel spacing: 500 kHz

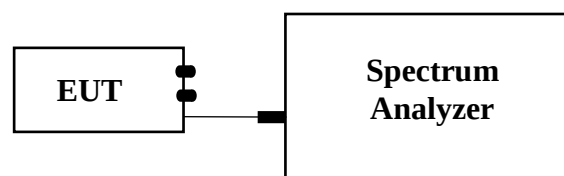
Single frequency operation at: 902.75 MHz, 914.75 MHz, 927.25 MHz

Changes in the modulation: none

7.3 EUT measurement description

Conducted measurements at antenna port

Among three SMA Antenna connectors, ANT1 of the the EUT was connected to the spectrum analyser via a RF cable as shown in the test setup block diagram. ANT2 and ANT3 were terminated with 50 Ohm terminators. The reading of the spectrum analyser was corrected with a RF cable loss, Blocking capacitor and a 20 dB Attenuator.



Radiated measurements

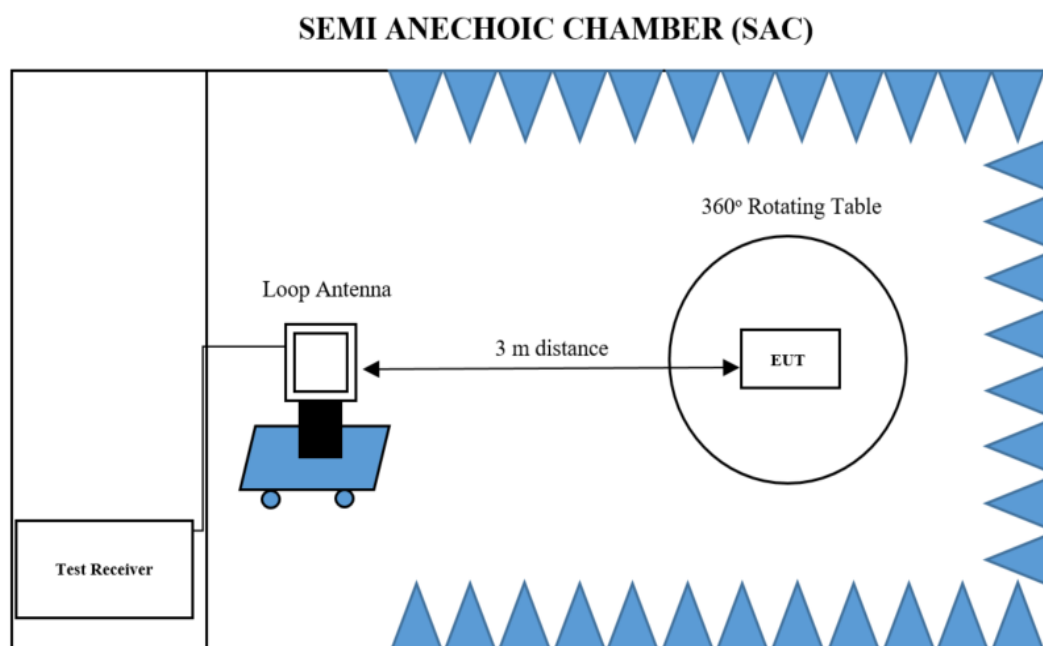
The EUT was tested in a typical fashion. During preliminary emission tests, the EUT was operated in the continuous measuring mode for worst-case emission mode investigation. Therefore, the final qualification testing was completed with the EUT operated in continuous measuring mode. All tests were performed in a semi-anechoic chamber (SAC) with the EUT's typical voltage: 12.0V DC.

In order to establish the maximum radiation, firstly, there have been viewed all orthogonal adjustments of the test samples, secondly the test sample have been rotated at all adjustments around the own axis between 0° and 360°, and thirdly, the antenna polarization between horizontal and vertical had been varied.

Radiated measurements from 9 kHz – 30 MHz, 30MHz – 1 GHz and above 1 GHz were performed using a small loop antenna, Linear polarized Logarithmic Periodic Broadband Antenna and stacked Logarithmic-Periodic Broadband Antenna for linear polarized respectively with a measuring distance of 3 m inside SAC.

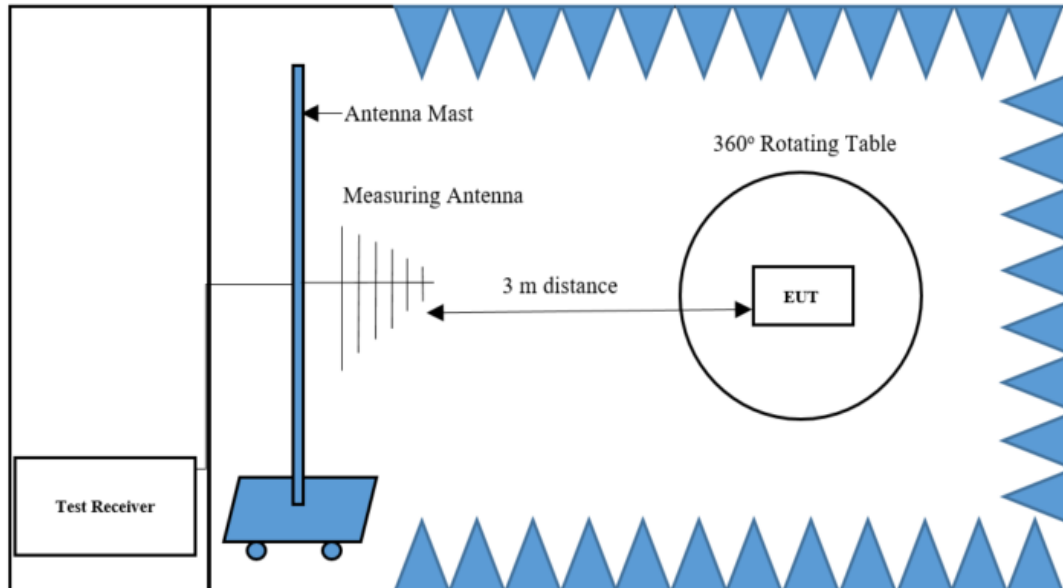
Radiated measurements above 1 GHz is made by placing loose-laid RF absorber material on the ground plane. Additionally, radiated emission measurements above 1 GHz are made using calibrated linearly polarized antennas, which may have a smaller beam width (main lobe) than do the antennas used for frequencies below 1 GHz. The measurement antenna away from each area of the EUT determined to be a source of emissions at the specified measurement distance, while keeping the measurement antenna aimed at the source of emissions at each frequency of significant emissions, with polarization oriented for maximum response. The measurement antenna may have to be higher or lower than the EUT, depending on the radiation pattern of the emission and staying aimed at the emission source for receiving the maximum signal.

Radiated measurements setup (9 kHz – 30 MHz)



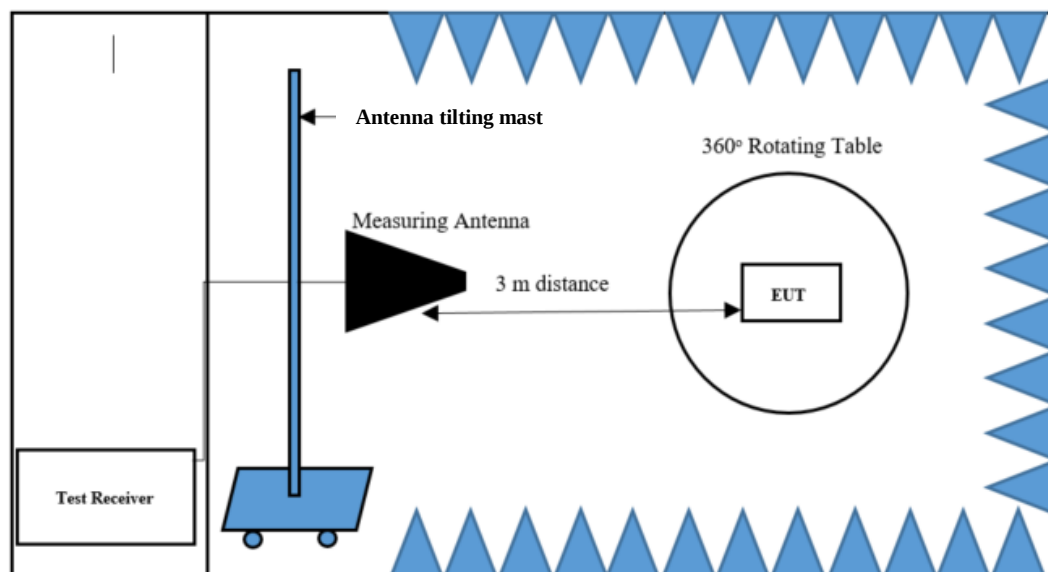
Radiated measurements setup (30 MHz – 1 GHz)

SEMI ANECHOIC CHAMBER (SAC)



Radiated measurements setup above 1 GHz

SEMI ANECHOIC CHAMBER (SAC)

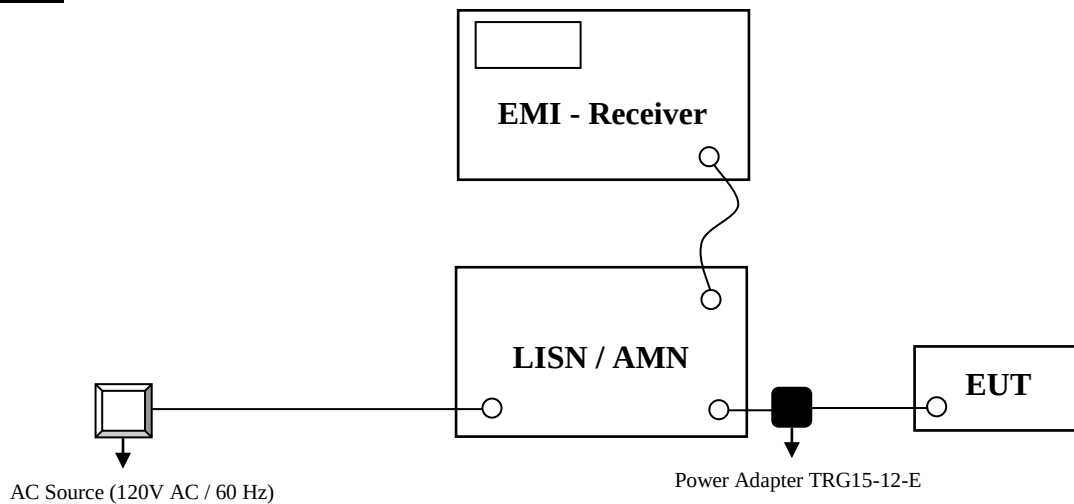


AC Powerline Conducted measurements

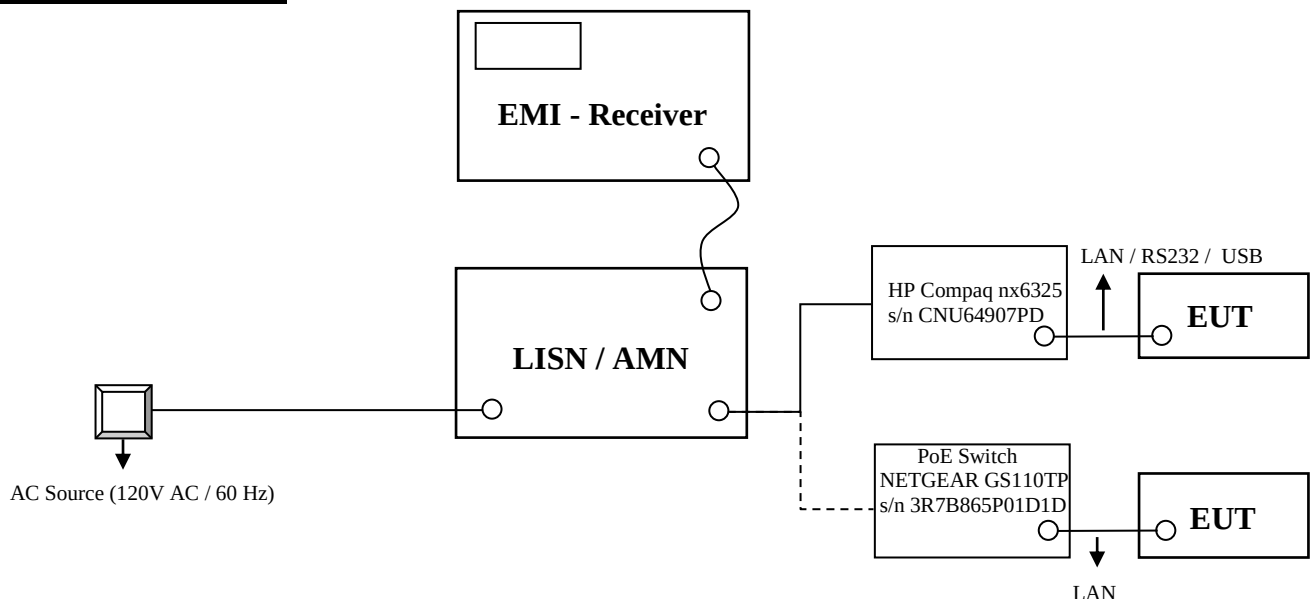
AC powerline conducted measurements were performed on four available RFID reader types (ID ISC.MRU102-A, ID ISC.MRU102-USB, ID ISC.MRU102-PoE and ID ISC.MRU102-PoE-LED) connected via serial, USB, LAN and AC ports to the artificial mains network. The measurements was also performed on the EUT MRU102 without outer casing. It has been tested in four steps:

1. Test laptop with inactive EUT
2. Test laptop with active EUT connected via serial and USB ports to the artificial mains network
3. Only with active EUT connected via PoE (LAN-port) to the artificial mains network
4. Test laptop with active EUT (without outer casing) connected via USB and serial ports to the artificial mains network

AC Port



RS232 / LAN / USB Port



8.1 Antenna requirement

8.1.1 Regulation

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to carrier current devices or to devices operated under the provisions of §15.211, §15.213, §15.217, §15.219, or §15.221. Further, this requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with §15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this part are not exceeded.

8.1.2 Result

Antenna Type	Antenna description	Frequency	Gain
Integrated	Integrated internal circular polarized antenna	902.0 – 928.0 MHz	-7.0 dBic
ID ISC.ANT.U170/170	External UHF RFID circular polarized antenna	902.0 – 928.0 MHz	4.0 dBic
ID ISC.ANT.U270/270	External UHF RFID circular polarized antenna	902.0 – 928.0 MHz	9.0 dBic
ID ISC.ANT.U600/270	External UHF RFID circular polarized antenna	902.0 – 928.0 MHz	11.0 dBic
ID ISC.ANT.U290/290	External UHF RFID circular polarized antenna	902.0 – 928.0 MHz	9.0 dBic
ID ISC.ANT.U580/290	External UHF RFID circular polarized antenna	902.0 – 928.0 MHz	11.0 dBic

The equipment passed the conducted tests	Yes	~~No~~	~~Not~~ *
Test setup photos / test results are attached	Yes	~~No~~	Annex no.: 2

8.2 Conducted limits

8.2.1 Regulation

§15.207 (a) Except as shown in paragraphs (b) and (c) of this section, for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 μ H/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

Conducted Limits		
Frequency of Emission	Quasi-Peak (QP)	Average (AV)
MHz	dB μ V	dB μ V
0.15 - 0.5	66 to 56*	56 to 46*
0.5 - 5	56	46
5 - 30	60	50
*Decreases with the logarithm of the frequency		

(b) The limit shown in paragraph (a) of this section shall not apply to carrier current systems operating as intentional radiators on frequencies below 30 MHz. In lieu thereof, these carrier current systems shall be subject to the following standards:

- 1) For carrier current system containing their fundamental emission within the frequency band 535–1705 kHz and intended to be received using a standard AM broadcast receiver: no limit on conducted emissions.
- (2) For all other carrier current systems: 1000 μ V within the frequency band 535–1705 kHz, as measured using a 50 μ H/50 ohms LISN.
- (3) Carrier current systems operating below 30 MHz are also subject to the radiated emission limits in §15.205, §15.209, §15.221, §15.223, or §15.227, as appropriate.

(c) Measurements to demonstrate compliance with the conducted limits are not required for devices which only employ battery power for operation and which do not operate from the AC power lines or contain provisions for operation while connected to the AC power lines. Devices that include, or make provisions for, the use of battery chargers which permit operating while charging, AC adapters or battery eliminators or that connect to the AC power lines indirectly, obtaining their power through another device which is connected to the AC power lines, shall be tested to demonstrate compliance with the conducted limits.

8.2.2 Test procedures

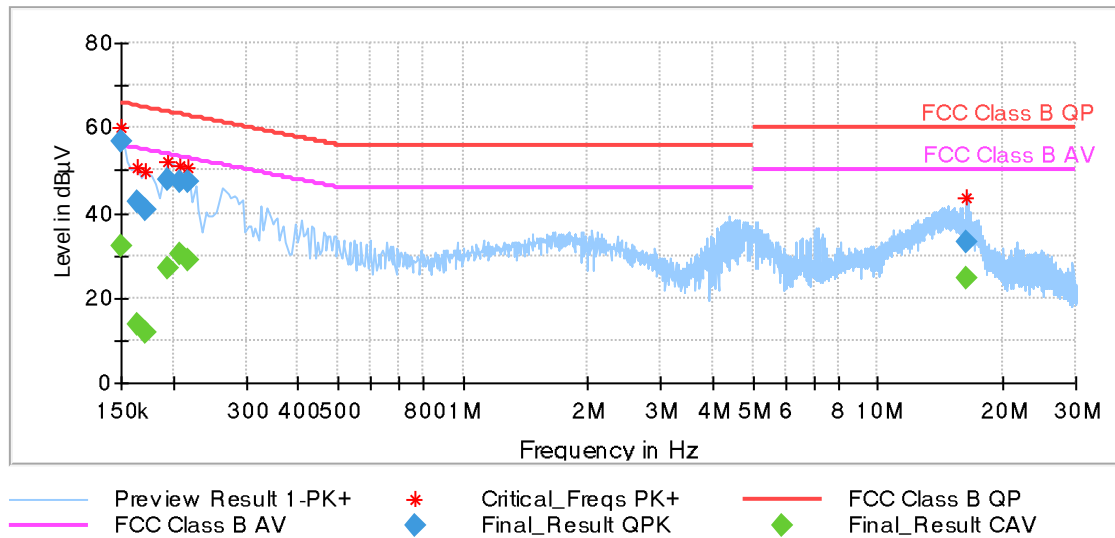
The EUT and the additional equipment (if required) are connected to the main power through a line impedance stabilization network (LISN). The LISN must be appropriate to ANSI C63.4-2014 Section 7.

Additional equipment must also be connected to a second LISN with the same specifications described in the above section (if required).

8.2.3 Result

– **Test laptop with inactive EUT (ID ISC.MRMU102-A):**

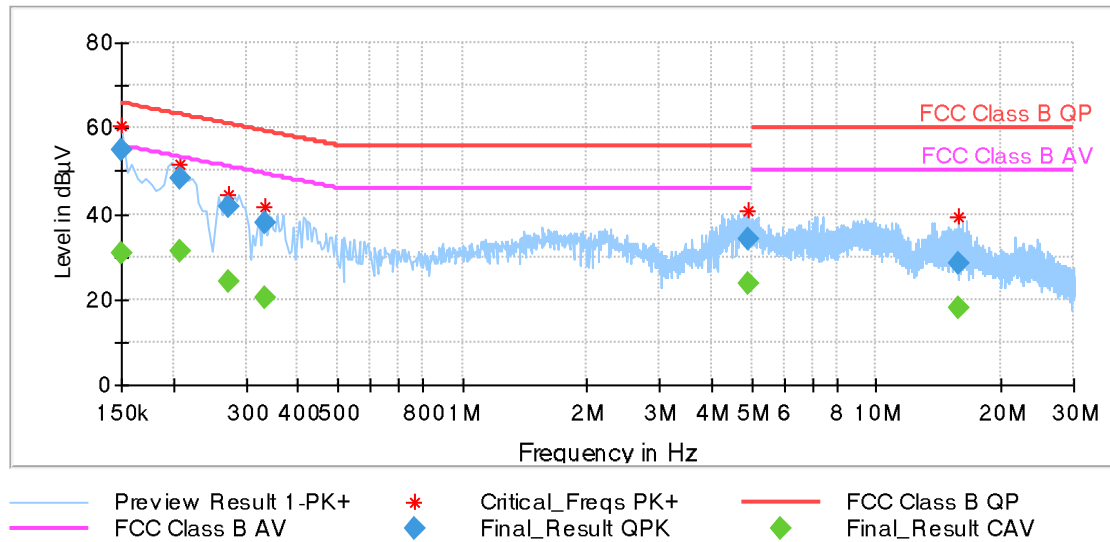
Full Spectrum



Frequency (MHz)	QuasiPeak (dBuV)	CAverage (dBuV)	Limit (dBuV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	PE	Corr. (dB)
0.150000	56.73	---	66.00	9.27	1000.0	9.000	N	GND	20.1
0.150000	---	32.41	56.00	23.59	1000.0	9.000	N	GND	20.1
0.163500	---	13.64	55.28	41.64	1000.0	9.000	N	GND	20.1
0.163500	42.68	---	65.28	22.60	1000.0	9.000	N	GND	20.1
0.172500	---	11.80	54.84	43.04	1000.0	9.000	N	GND	20.1
0.172500	40.75	---	64.84	24.09	1000.0	9.000	N	GND	20.1
0.195000	47.89	---	63.82	15.93	1000.0	9.000	L1	GND	20.1
0.195000	---	26.99	53.82	26.83	1000.0	9.000	L1	GND	20.1
0.208500	---	30.11	53.27	23.15	1000.0	9.000	L1	GND	20.1
0.208500	47.44	---	63.27	15.83	1000.0	9.000	L1	GND	20.1
0.217500	47.25	---	62.91	15.66	1000.0	9.000	N	GND	20.1
0.217500	---	28.74	52.91	24.17	1000.0	9.000	N	GND	20.1
16.422000	32.99	---	60.00	27.01	1000.0	9.000	L1	GND	21.0
16.422000	---	24.59	50.00	25.41	1000.0	9.000	L1	GND	21.0

- **Test laptop with active EUT (ID ISC.MRU102-A) - RS232 port:**

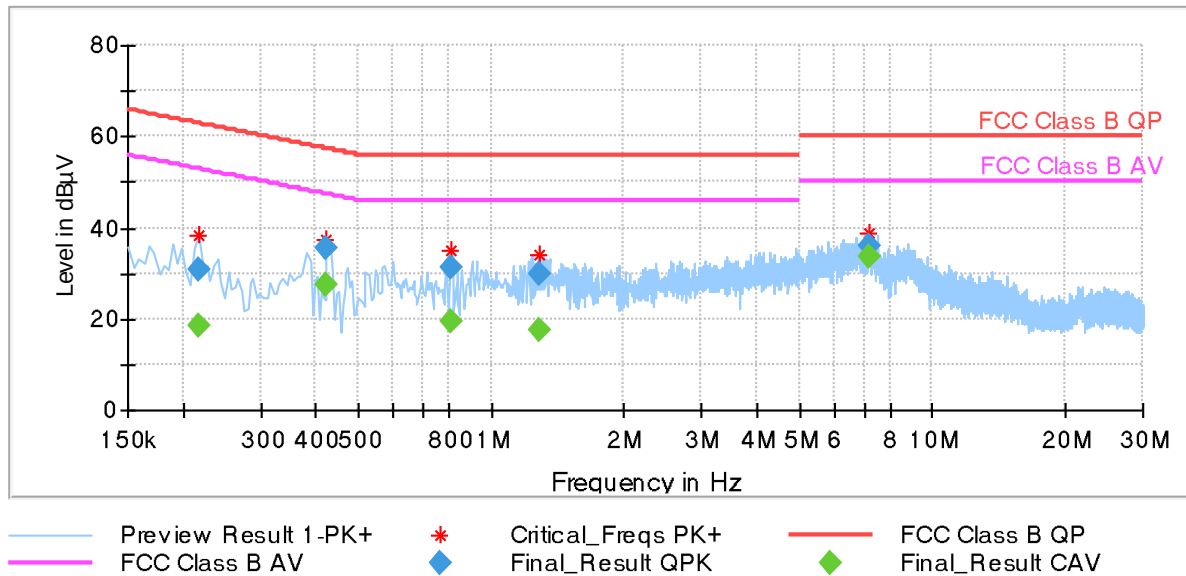
Full Spectrum



Frequency (MHz)	QuasiPeak (dBμV)	CAverage (dBμV)	Limit (dBμV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	PE	Corr. (dB)
0.150	55.14	---	66.00	10.86	1000.0	9.0	N	GND	20.1
0.150	---	30.96	56.00	25.04	1000.0	9.0	N	GND	20.1
0.2085	48.19	---	63.27	15.07	1000.0	9.0	N	GND	20.1
0.2085	---	31.12	53.27	22.14	1000.0	9.0	N	GND	20.1
0.2715	41.76	---	61.07	19.31	1000.0	9.0	N	GND	20.1
0.2715	---	24.04	51.07	27.03	1000.0	9.0	N	GND	20.1
0.3345	37.96	---	59.34	21.38	1000.0	9.0	N	GND	20.1
0.3345	---	20.54	49.34	28.80	1000.0	9.0	N	GND	20.3
4.9155	---	23.80	46.00	22.20	1000.0	9.0	L1	GND	20.3
4.9155	34.02	---	56.00	21.98	1000.0	9.0	L1	GND	21.0
15.7875	---	17.87	50.00	32.13	1000.0	9.0	L1	GND	21.0
15.7875	28.19	---	60.00	31.81	1000.0	9.0	L1	GND	20.1

- **Test with ext. power adapter (TRG1512-E) with active EUT (ID ISC.MRU102-A) - AC port:**

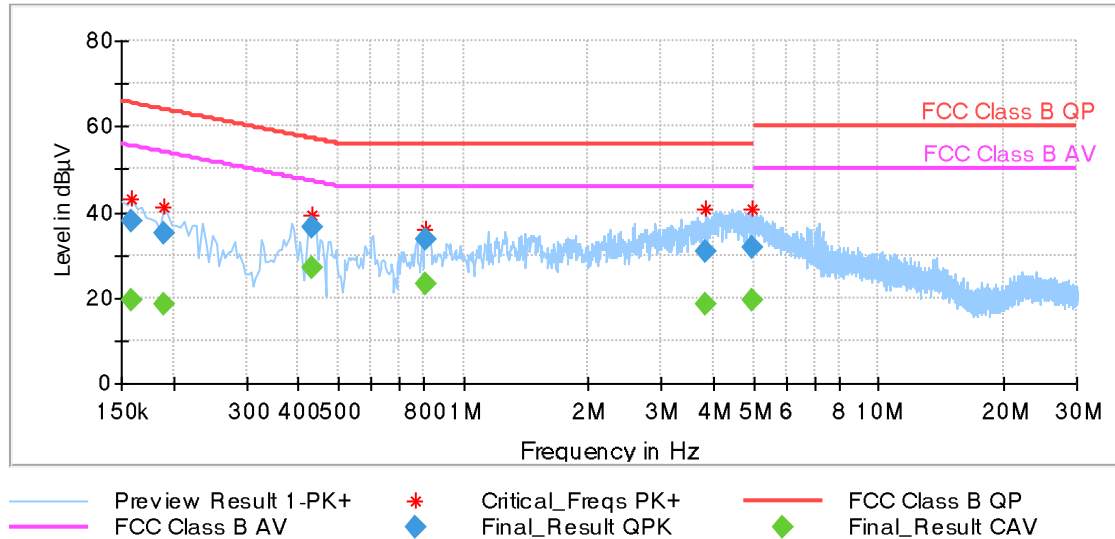
Full Spectrum



Frequency (MHz)	QuasiPeak (dBµV)	CAverage (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	PE	Corr. (dB)
0.217500	---	18.37	52.91	34.54	1000.0	9.0	N	GND	20.1
0.217500	30.80	---	62.91	32.11	1000.0	9.0	N	GND	20.1
0.424500	---	27.24	47.36	20.12	1000.0	9.0	N	GND	20.1
0.424500	35.52	---	57.36	21.83	1000.0	9.0	N	GND	20.1
0.811500	---	19.64	46.00	26.36	1000.0	9.0	L1	GND	20.1
0.811500	31.38	---	56.00	24.62	1000.0	9.0	L1	GND	20.1
1.288500	29.77	---	56.00	26.23	1000.0	9.0	L1	GND	20.1
1.288500	---	17.72	46.00	28.28	1000.0	9.0	L1	GND	20.1
7.215000	35.90	---	60.00	24.10	1000.0	9.0	L1	GND	20.4
7.215000	---	33.39	50.00	16.61	1000.0	9.0	L1	GND	20.4

– Test laptop with active EUT (MRU102-USB) - AC port:

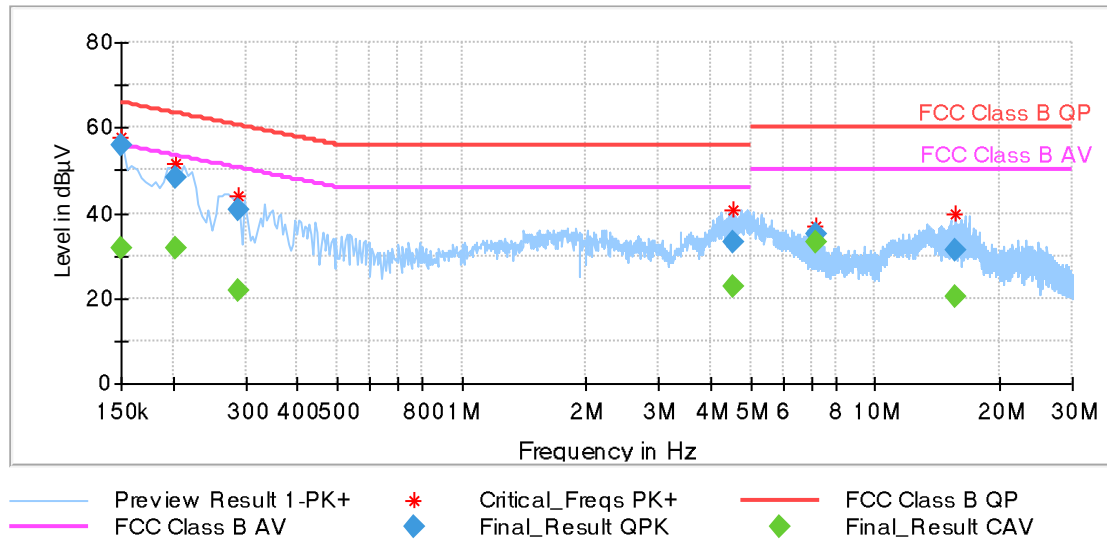
Full Spectrum



Frequency (MHz)	QuasiPeak (dBµV)	CAverage (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	PE	Corr. (dB)
0.159000	38.01	---	65.52	27.51	1000.0	9.0	N	GND	20.1
0.159000	---	19.47	55.52	36.05	1000.0	9.0	N	GND	20.1
0.190500	35.07	---	64.02	28.95	1000.0	9.0	N	GND	20.1
0.190500	---	18.62	54.02	35.39	1000.0	9.0	N	GND	20.1
0.433500	36.54	---	57.19	20.65	1000.0	9.0	L1	GND	20.1
0.433500	---	26.91	47.19	20.28	1000.0	9.0	L1	GND	20.1
0.811500	33.41	---	56.00	22.59	1000.0	9.0	L1	GND	20.1
0.811500	---	23.16	46.00	22.84	1000.0	9.0	L1	GND	20.1
3.817500	---	18.59	46.00	27.41	1000.0	9.0	N	GND	20.2
3.817500	30.66	---	56.00	25.34	1000.0	9.0	N	GND	20.2
4.983000	---	19.55	46.00	26.45	1000.0	9.0	N	GND	20.2
4.983000	31.83	---	56.00	24.17	1000.0	9.0	N	GND	20.2

– Test laptop with active EUT (MRU102-USB) - USB port:

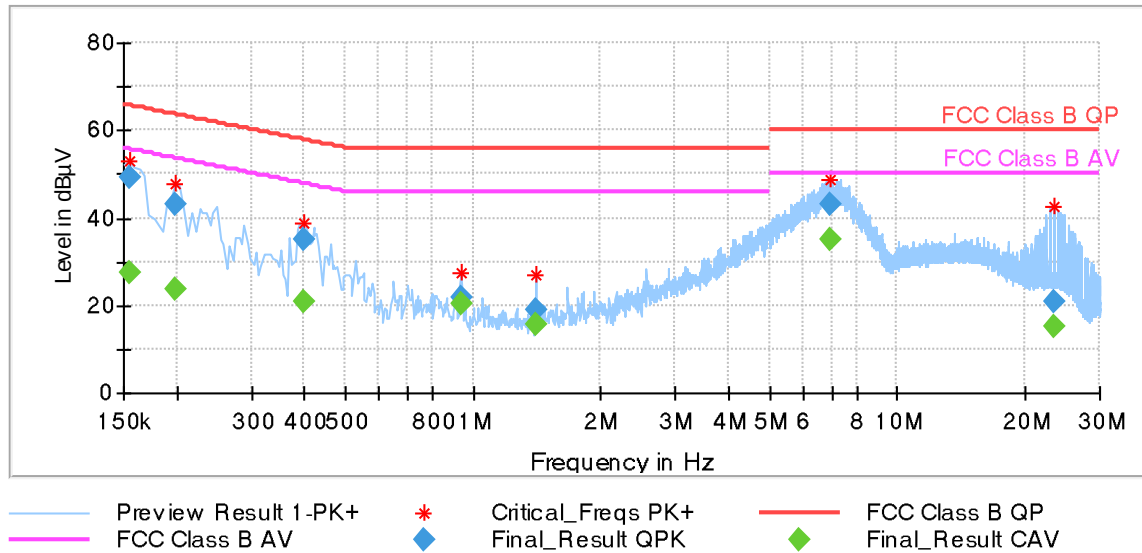
Full Spectrum



Frequency (MHz)	QuasiPeak (dBµV)	CAverage (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	PE	Corr. (dB)
0.150000	---	31.86	56.00	24.14	1000.0	9.0	L1	GND	20.1
0.150000	55.91	---	66.00	10.09	1000.0	9.0	L1	GND	20.1
0.204000	48.47	---	63.45	14.97	1000.0	9.0	N	GND	20.1
0.204000	---	31.55	53.45	21.90	1000.0	9.0	N	GND	20.1
0.289500	40.89	---	60.54	19.65	1000.0	9.0	N	GND	20.1
0.289500	---	21.99	50.54	28.55	1000.0	9.0	N	GND	20.1
4.510500	32.92	---	56.00	23.08	1000.0	9.0	L1	GND	20.3
4.510500	---	22.81	46.00	23.19	1000.0	9.0	L1	GND	20.3
7.210500	---	32.93	50.00	17.07	1000.0	9.0	N	GND	20.4
7.210500	34.90	---	60.00	25.10	1000.0	9.0	N	GND	20.4
15.612000	31.30	---	60.00	28.70	1000.0	9.0	L1	GND	21.0
15.612000	---	20.48	50.00	29.52	1000.0	9.0	L1	GND	21.0

– **With active EUT (MRU102-PoE) - LAN port:**

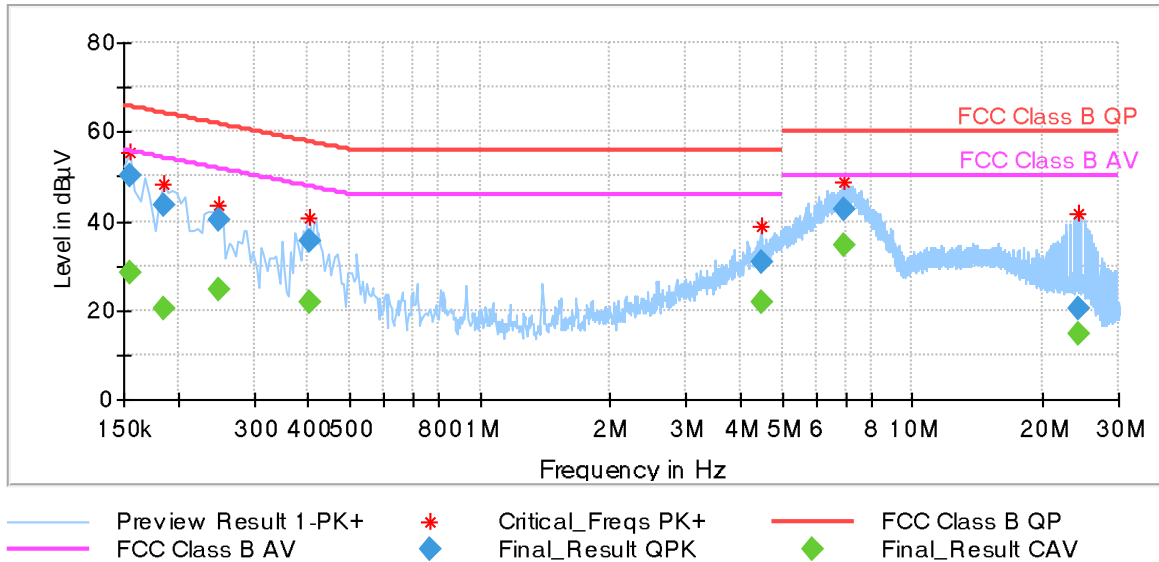
Full Spectrum



Frequency (MHz)	QuasiPeak (dBμV)	CAverage (dBμV)	Limit (dBμV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	PE	Corr. (dB)
0.154500	---	27.26	55.75	28.49	1000.0	9.0	L1	GND	20.1
0.154500	49.37	---	65.75	16.39	1000.0	9.0	L1	GND	20.1
0.199500	---	23.82	53.63	29.81	1000.0	9.0	N	GND	20.1
0.199500	43.08	---	63.63	20.56	1000.0	9.0	N	GND	20.1
0.397500	---	20.95	47.91	26.96	1000.0	9.0	L1	GND	20.1
0.397500	34.80	---	57.91	23.10	1000.0	9.0	L1	GND	20.1
0.937500	21.73	---	56.00	34.27	1000.0	9.0	L1	GND	20.1
0.937500	---	20.26	46.00	25.74	1000.0	9.0	L1	GND	20.1
1.405500	18.70	---	56.00	37.30	1000.0	9.0	L1	GND	20.1
1.405500	---	15.60	46.00	30.40	1000.0	9.0	L1	GND	20.1
6.981000	---	35.24	50.00	14.76	1000.0	9.0	N	GND	20.4
6.981000	43.15	---	60.00	16.85	1000.0	9.0	N	GND	20.4
23.442000	---	14.95	50.00	35.05	1000.0	9.0	N	GND	21.3
23.442000	20.66	---	60.00	39.34	1000.0	9.0	N	GND	21.3

– **With active EUT (MRU102-PoE-LED) - LAN port:**

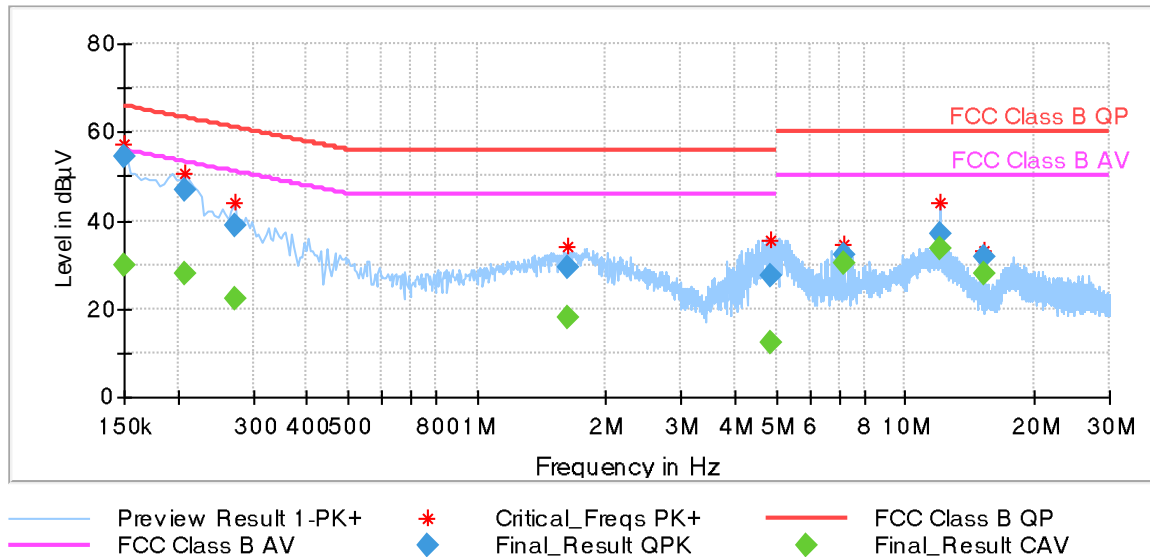
Full Spectrum



Frequency (MHz)	QuasiPeak (dBμV)	CAverage (dBμV)	Limit (dBμV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	PE	Corr. (dB)
0.154500	---	28.31	55.75	27.44	1000.0	9.0	N	GND	20.1
0.154500	50.13	---	65.75	15.63	1000.0	9.0	N	GND	20.1
0.186000	---	20.47	54.21	33.75	1000.0	9.0	N	GND	20.1
0.186000	43.70	---	64.21	20.51	1000.0	9.0	N	GND	20.1
0.249000	40.19	---	61.79	21.60	1000.0	9.0	L1	GND	20.1
0.249000	---	24.85	51.79	26.94	1000.0	9.0	L1	GND	20.1
0.402000	35.55	---	57.81	22.26	1000.0	9.0	L1	GND	20.1
0.402000	---	21.56	47.81	26.25	1000.0	9.0	L1	GND	20.1
4.461000	30.77	---	56.00	25.23	1000.0	9.0	L1	GND	20.3
4.461000	---	21.58	46.00	24.42	1000.0	9.0	L1	GND	20.3
6.967500	42.73	---	60.00	17.27	1000.0	9.0	N	GND	20.4
6.967500	---	34.78	50.00	15.22	1000.0	9.0	N	GND	20.4
24.121500	20.51	---	60.00	39.49	1000.0	9.0	N	GND	21.3
24.121500	---	14.60	50.00	35.40	1000.0	9.0	N	GND	21.3

– Test laptop with active EUT (MRMU102-without outer casing) - USB port:

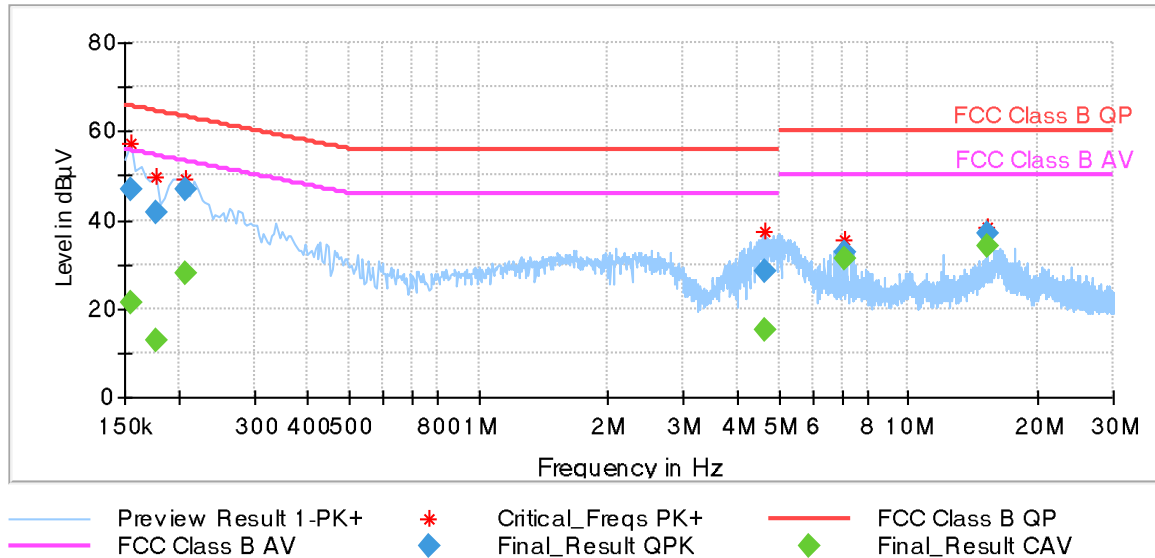
Full Spectrum



Frequency (MHz)	QuasiPeak (dBµV)	CAverage (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	PE	Corr. (dB)
0.150000	54.31	---	66.00	11.69	1000.0	9.0	N	GND	20.1
0.150000	---	30.03	56.00	25.97	1000.0	9.0	N	GND	20.1
0.208500	47.00	---	63.27	16.27	1000.0	9.0	L1	GND	20.1
0.208500	---	28.06	53.27	25.20	1000.0	9.0	L1	GND	20.1
0.271500	---	22.25	51.07	28.82	1000.0	9.0	L1	GND	20.1
0.271500	38.93	---	61.07	22.15	1000.0	9.0	L1	GND	20.1
1.626000	29.46	---	56.00	26.54	1000.0	9.0	L1	GND	20.1
1.626000	---	18.02	46.00	27.98	1000.0	9.0	L1	GND	20.1
4.866000	---	12.49	46.00	33.51	1000.0	9.0	L1	GND	20.3
4.866000	27.63	---	56.00	28.37	1000.0	9.0	L1	GND	20.3
7.224000	32.15	---	60.00	27.85	1000.0	9.0	N	GND	20.4
7.224000	---	30.10	50.00	19.90	1000.0	9.0	N	GND	20.4
12.003000	36.78	---	60.00	23.22	1000.0	9.0	L1	GND	20.8
12.003000	---	33.72	50.00	16.28	1000.0	9.0	L1	GND	20.8
15.342000	31.76	---	60.00	28.24	1000.0	9.0	L1	GND	21.0
15.342000	---	27.80	50.00	22.20	1000.0	9.0	L1	GND	21.0

- Test laptop with active EUT (MRMU102-without outer casing) – RS232 port:

Full Spectrum



Frequency (MHz)	QuasiPeak (dBμV)	CAverage (dBμV)	Limit (dBμV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	PE	Corr. (dB)
0.154500	46.67	---	65.75	19.08	1000.0	9.0	N	GND	20.1
0.154500	---	21.37	55.75	34.38	1000.0	9.0	N	GND	20.1
0.177000	---	12.66	54.63	41.97	1000.0	9.0	N	GND	20.1
0.177000	41.83	---	64.63	22.79	1000.0	9.0	N	GND	20.1
0.208500	46.96	---	63.27	16.31	1000.0	9.0	L1	GND	20.1
0.208500	---	27.90	53.27	25.36	1000.0	9.0	L1	GND	20.2
4.641000	---	14.96	46.00	31.04	1000.0	9.0	N	GND	20.2
4.641000	28.31	---	56.00	27.69	1000.0	9.0	N	GND	20.4
7.116000	---	31.39	50.00	18.61	1000.0	9.0	N	GND	20.4
7.116000	32.71	---	60.00	27.29	1000.0	9.0	N	GND	21.0
15.342000	---	34.30	50.00	15.70	1000.0	9.0	N	GND	21.0
15.342000	37.09	---	60.00	22.91	1000.0	9.0	N	GND	20.1

Test cables used	KISN2
Test equipment used	272, 551, 665

The equipment passed the conducted tests	Yes	No	Not*
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Test setup photos / test results are attached	Yes	No	Annex no.: 6
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8.3 Restricted bands of operation

8.3.1 Regulation

§15.205 (a) Except as shown in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

Restricted bands of operation			
Frequency Band MHz	Frequency Band MHz	Frequency Band MHz	Frequency Band GHz
0.090-0.110	16.42-16.423	399.9-410	4.5-5.15
¹ 0.495-0.505	16.69475-16.69525	608-614	5.35-5.46
2.1735-2.1905	16.80425-16.80475	960-1240	7.25-7.75
4.125-4.128	25.5-25.67	1300-1427	8.025-8.5
4.17725-4.17775	37.5-38.25	1435-1626.5	9.0-9.2
4.20725-4.20775	73-74.6	1645.5-1646.5	9.3-9.5
6.215-6.218	74.8-75.2	1660-1710	10.6-12.7
6.26775-6.26825	108-121.94	1718.8-1722.2	13.25-13.4
6.31175-6.31225	123-138	2200-2300	14.47-14.5
8.291-8.294	149.9-150.05	2310-2390	15.35-16.2
8.362-8.366	156.52475-156.52525	2483.5-2500	17.7-21.4
8.37625-8.38675	156.7-156.9	2690-2900	22.01-23.12
8.41425-8.41475	162.0125-167.17	3260-3267	23.6-24.0
12.29-12.293	167.72-173.2	3332-3339	31.2-31.8
12.51975-12.52025	240-285	3345.8-3358	36.43-36.5
12.57675-12.57725	322-335.4	3600-4400	(²)
13.36-13.41	---	---	---
¹ Until February 1, 1999, this restricted band shall be 0.490-0.510 MHz.			
² Above 38.6			

(b) Except as provided in paragraphs (d) and (e) of this section, the field strength of emissions appearing within these frequency bands shall not exceed the limits shown in §15.209. At frequencies equal to or less than 1000 MHz, compliance with the limits in §15.209 shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1000 MHz, compliance with the emission limits in §15.209 shall be demonstrated based on the average value of the measured emissions. The provisions in §15.35 apply to these measurements.

(c) Except as provided in paragraphs (d) and (e) of this section, regardless of the field strength limits specified elsewhere in this subpart, the provisions of this section apply to emissions from any intentional radiator.

(d) The following devices are exempt from the requirements of this section:

(1) Swept frequency field disturbance sensors operating between 1.705 and 37 MHz provided their emissions only sweep through the bands listed in paragraph (a) of this section, the sweep is never stopped with the fundamental emission within the bands listed in paragraph (a) of this section, and the fundamental emission is outside of the bands listed in paragraph (a) of this section more than 99% of the time the device is actively transmitting, without compensation for duty cycle.

(2) Transmitters used to detect buried electronic markers at 101.4 kHz which are employed by telephone companies.

(3) Cable locating equipment operated pursuant to §15.213.

(4) Any equipment operated under the provisions of §15.253, 15.255, and 15.256 in the frequency band 75-85 GHz, or §15.257 of this part.

(5) Biomedical telemetry devices operating under the provisions of §15.242 of this part are not subject to the restricted band 608-614 MHz but are subject to compliance within the other restricted bands.

(6) Transmitters operating under the provisions of subparts D or F of this part.

(7) Devices operated pursuant to §15.225 are exempt from complying with this section for the 13.36-13.41 MHz band only.

(8) Devices operated in the 24.075-24.175 GHz band under §15.245 are exempt from complying with the requirements of this section for the 48.15-48.35 GHz and 72.225-72.525 GHz bands only, and shall not exceed the limits specified in §15.245(b).

(9) Devices operated in the 24.0-24.25 GHz band under §15.249 are exempt from complying with the requirements of this section for the 48.0-48.5 GHz and 72.0-72.75 GHz bands only, and shall not exceed the limits specified in §15.249(a).

(10) White space devices operating under subpart H of this part are exempt from complying with the requirements of this section for the 608-614 MHz band.

(e) Harmonic emissions appearing in the restricted bands above 17.7 GHz from field disturbance sensors operating under the provisions of §15.245 shall not exceed the limits specified in §15.245(b).

8.3.2 Result

Test Cables used	K60, K101, K119
Test equipment used	23, 406, 445a, 660, 665, 451, 452

The equipment passed the conducted tests	Yes**	No	Not [§]
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Test setup photos / test results are attached	Yes	No	Annex no.: 6, 11
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**All emissions that falls under the restricted bands of operations are included in clause 8.4 and are maked [blue](#).

8.4 Radiated emission limits, general requirements

8.4.1 Regulation

- (a) Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Intentional radiator- radiated emission limits		
Frequency	Field Strength	Measurement distance
MHz	$\mu\text{V} / \text{m}$	m
0.009-0.490	$2400/\text{F}(\text{kHz})$	300
0.490-1.705	$24000/\text{F}(\text{kHz})$	30
1.705-30.0	30	30
30-88	100**	3
88-216	150**	3
216-960	200**	3
above 960	500	3
Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this section shall not be located in the frequency bands 54-72 MHz, 76-88 MHz, 174-216 MHz or 470-806 MHz. However, operation within these frequency bands is permitted under other sections of this part, e.g., §§15.231 and 15.241.		

- (b) In the emission table above, the tighter limit applies at the band edges.

(c) The level of any unwanted emissions from an intentional radiator operating under these general provisions shall not exceed the level of the fundamental emission. For intentional radiators which operate under the provisions of other sections within this part and which are required to reduce their unwanted emissions to the limits specified in this table, the limits in this table are based on the frequency of the unwanted emission and not the fundamental frequency. However, the level of any unwanted emissions shall not exceed the level of the fundamental frequency.

(d) The emission limits shown in the above table are based on measurements employing a CISPR quasi-peak detector except for the frequency bands 9-90 kHz, 110-490 kHz and above 1000 MHz. Radiated emission limits in these three bands are based on measurements employing an average detector.

(e) The provisions in §§15.31, 15.33, and 15.35 for measuring emissions at distances other than the distances specified in the above table, determining the frequency range over which radiated emissions are to be measured, and limiting peak emissions apply to all devices operated under this part.

(f) In accordance with §15.33(a), in some cases the emissions from an intentional radiator must be measured to beyond the tenth harmonic of the highest fundamental frequency designed to be emitted by the intentional radiator because of the incorporation of a digital device. If measurements above the tenth harmonic are so required, the radiated emissions above the tenth harmonic shall comply with the general radiated emission limits applicable to the incorporated digital device, as shown in §15.109 and as based on the frequency of the emission being measured, or, except for emissions contained in the restricted frequency bands shown in §15.205, the limit on spurious emissions specified for the intentional radiator, whichever is the higher limit. Emissions which must be measured above the tenth harmonic of the highest fundamental frequency designed to be emitted by the intentional radiator and which fall within the restricted bands shall comply with the general radiated emission limits in §15.109 that are applicable to the incorporated digital device.

(g) Perimeter protection systems may operate in the 54-72 MHz and 76-88 MHz bands under the provisions of this section. The use of such perimeter protection systems is limited to industrial, business and commercial applications.

8.4.2 Test procedure

The EUT and this peripheral (when additional equipment exists) are placed on a turn table which is 0.8 m above the ground. The turn table would be allowed to rotate 360° to determine the position of the maximum emission level. The test distance between the EUT and the receiving antenna are 3m. To find the maximum emission, the polarization of the receiving antenna is changed in horizontal and vertical polarization; the position of the EUT was changed in different orthogonal determinations.

ANSI C63.4-2014 Section 8 “Radiated Emissions Testing”

Measurement procedures for electric field radiated emissions from 9kHz - 1 GHz & 1 GHz - 40 GHz are covered in Clause 8 of ANSI C63.4-2014. The ANSI C63.4-2014 measurement procedure consists of both an exploratory test and a final measurement. The exploratory test is critical to determine the frequency of all significant emissions. For each mode of operation required to be tested, the frequency spectrum is monitored. Variations in antenna height, antenna orientation, antenna polarization, EUT azimuth, and cable or wire placement is explored to produce the emission that has the highest amplitude relative to the limit.

The final measurements are made based on the findings in the exploratory testing. When making exploratory and final measurements it is necessary to maximize the measured radiated emission. Sub clause 8.3.2 of ANSI C63.4-2014 states that the measurement is to be made “while keeping the antenna in the ‘cone of radiation’ from that area and pointed at the area both in azimuth and elevation, with polarization oriented for maximum response.” We consider the “cone of radiation” to be the 3 dB beam width of the measurement antenna.

While the “bore-sighting” technique is not explicitly mentioned in ANSI C63.4-2014, it is a useful technique for measurements using a directional antenna, such as a double-ridged waveguide antenna. Several precautions must be observed, including: knowledge of the beam width of the antenna and the resulting illumination area relative to the size of the EUT, estimation for source of the emission and general location within larger EUTs, measuring system sensitivity, etc.

ANSI C63.4-2014 requires that the measurement antenna is kept pointed at the source of the emission both in azimuth and elevation, with the polarization of the antenna oriented for maximum response. That means that if the directional radiation pattern of the EUT results in a maximum emission at an upwards angle from the EUT, when a directional antenna is used to make the measurement it will be necessary for it to be pointed towards the source of the emission within the EUT. This can be done by either pointing the antenna at an angle towards the source of the emission, or by rotating the EUT, in both height and polarization, to maximize the measured emission. The emission must be kept within the illumination area of the 3 dB beamwidth of the antenna so that the maximum emission from the EUT is measured.

Radiated emissions test characteristics	
Test distance	3 m*
Test instrumentation resolution bandwidth	9 kHz (Below 30 MHz)
	120 kHz (30 MHz - 1,000 MHz)
	1 MHz (Above 1000 MHz)
Receive antenna scan height	1 m - 4 m
Receive antenna polarization	Vertical/horizontal

* According to Section 15.31 (f) (1): At frequencies at or above 30 MHz, measurements may be performed at a distance other than what is specified provided: measurements are not made in the near field except where it can be shown that near field measurements are appropriate due to the characteristics of the device; and it can be demonstrated that the signal levels needed to be measured at the distance employed can be detected by the

EUT: ID ISC.MRMU102-A FCC ID: PJMMRU102A FCC Title 47 CFR Part 15 Date of issue: 2021-06-24

measurement equipment. Measurements shall not be performed at a distance greater than 30 meters unless it can be further demonstrated that measurements at a distance of 30 meters or less are impractical. When performing measurements at a distance other than that specified, the results shall be extrapolated to the specified distance using an extrapolation factor of 20 dB/decade (inverse linear-distance for field strength measurements; inverse-linear-distance-squared for power density measurements).

8.4.3 Calculation of the field strength

The field strength is calculated by the following calculation:

Corrected Level = Receiver Level + Correction Factor (without the use of a pre-amplifier)

Corrected Level = Receiver Level + Correction Factor – Pre-amplifier (with the use of a pre-amplifier)

Receiver Level : Receiver reading without correction factors

Correction Factor : Antenna factor + cable loss

For example:

The receiver reading is 32.7 dB μ V. The antenna factor for the measured frequency is +2.5 dB (1/m) and the cable factor for the measured frequency is 0.71 dB, giving a field strength of 35.91dB μ V/m.

The 35.91 dB μ V/m value can be mathematically converted to its corresponding level in μ V/m.

Level in μ V/m = Common Antilogarithm (35.91/20) = 62.44

For test distance other than what is specified, but fulfilling the requirements of Section 15.31 (f) (1) the field strength is calculated by adding additionally an extrapolation factor of 20 dB/decade (inverse linear distance for field strength measurements).

8.4.4 Result

Radiated Emissions from EUT (ID ISC.MRMU102-A)

Lower Channel @ 902.75 MHz

Transmitter Spurious Radiation below 30 MHz, (Section 15.205, 15.209)							
Frequency (MHz)	QuasiPeak (dBμV/m)	Average (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Bandwidth (kHz)	Pol V / H	Azimuth (deg)
0.009 - 30	**	**	---	---	---	---	---
**No emissions detected							
Measurement uncertainty: Conducted ± 1 dB / ERP ± 4 dB							

Middle Channel @ 914.75 MHz

Transmitter Spurious Radiation below 30 MHz, (Section 15.205, 15.209)							
Frequency (MHz)	QuasiPeak (dBμV/m)	Average (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Bandwidth (kHz)	Pol V / H	Azimuth (deg)
0.009 - 30	**	**	---	---	---	---	---
**No emissions detected							
Measurement uncertainty: Conducted ± 1 dB / ERP ± 4 dB							

Higher Channel @ 927.25 MHz

Transmitter Spurious Radiation below 30 MHz, (Section 15.205, 15.209)							
Frequency (MHz)	QuasiPeak (dBμV/m)	Average (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Bandwidth (kHz)	Pol V / H	Azimuth (deg)
0.009 - 30	**	**	---	---	---	---	---
**No emissions detected							
Measurement uncertainty: Conducted ± 1 dB / ERP ± 4 dB							

Test cables used	K60, K101, K119
Test equipment used	23, 665, 660

The equipment passed the conducted tests	Yes	No	~~Not~~ *
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Test setup photos / test results are attached	Yes	No	Annex no.: 6, 11
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Lower Channel @ 902.75 MHz

Transmitter Spurious Radiation (30 MHz – 1 GHz), (Section 15.205, 15.209)							
Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol V / H	Azimuth (deg)
240.01	18.94	46.0	27.1	120.0	104.0	H	128.0
360.00	25.82	46.0	20.2	120.0	100.0	H	333.0
Measurement uncertainty: Conducted ± 1 dB / ERP ± 4 dB							

Blue marked: restricted bands

Middle Channel @ 914.75 MHz

Transmitter Spurious Radiation (30 MHz – 1 GHz), (Section 15.205, 15.209)							
Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol V / H	Azimuth (deg)
30 - 1000	**	---	---	---	---	---	---
**No emissions detected							
Measurement uncertainty: Conducted ± 1 dB / ERP ± 4 dB							

Blue marked: restricted bands

Higher Channel @ 927.25 MHz

Transmitter Spurious Radiation (30 MHz – 1 GHz), (Section 15.205, 15.209)							
Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol V / H	Azimuth (deg)
30 - 1000	**	---	---	---	---	---	---
**No emissions detected							
Measurement uncertainty: Conducted ± 1 dB / ERP ± 4 dB							

Blue marked: restricted bands

Test cables used	K60, K101, K119
Test equipment used	406, 660, 665

The equipment passed the conducted tests	Yes	No	~~Not~~ *
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Test setup photos / test results are attached	Yes	No	Annex no.: 6, 11
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Lower Channel @ 902.75 MHz

Transmitter Spurious Radiation (1 GHz – 10 GHz), (Section 15.205, 15.209)								
Frequency (MHz)	Average (dBμV/m)	MaxPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol V / H	Azimuth (deg)
1805.375*	55.51	---	---	---	1000.0	116.0	H	224.0
1805.375*	---	63.05	---	---	1000.0	116.0	H	224.0
2708.125	53.61	---	54.00	0.39	1000.0	164.0	H	204.0
2708.125	---	61.93	74.00	12.07	1000.0	164.0	H	204.0
3610.875	---	53.16	74.00	20.84	1000.0	247.0	V	57.0
3610.875	43.93	---	54.00	10.07	1000.0	247.0	V	57.0
4513.625	47.37	---	54.00	6.63	1000.0	165.0	H	113.0
4513.625	---	56.20	74.00	17.80	1000.0	165.0	H	113.0
5416.375	---	54.83	74.00	19.17	1000.0	104.0	V	119.0
5416.375	44.70	---	54.00	9.30	1000.0	104.0	V	119.0
6319.125	---	55.93	74.00	18.07	1000.0	199.0	H	91.0
6319.125	46.18	---	54.00	7.82	1000.0	199.0	H	91.0
7221.875	42.10	---	54.00	11.90	1000.0	190.0	H	124.0
7221.875	---	54.32	74.00	19.68	1000.0	190.0	H	124.0
Measurement uncertainty: Conducted ± 1 dB / ERP ± 4 dB								
* This frequency is not listed in the restricted bands of operation (section FCC 15.205), therefore does not require to follow the limits according to section FCC 15.209!								

Blue marked: restricted bands

Middle Channel @ 914.75 MHz

Transmitter Spurious Radiation (1 GHz – 10 GHz) , (Section 15.205, 15.209)								
Frequency (MHz)	Average (dBμV/m)	MaxPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol V / H	Azimuth (deg)
1829.375*	56.63	---	---	---	1000.0	135.0	H	149.0
1829.375*	---	64.34	---	---	1000.0	135.0	H	149.0
2744.125	52.17	---	54.00	1.83	1000.0	204.0	H	206.0
2744.125	---	60.33	74.00	13.67	1000.0	204.0	H	206.0
3658.875	---	58.97	74.00	15.03	1000.0	104.0	V	191.0
3658.875	49.98	---	54.00	4.02	1000.0	104.0	V	191.0
4573.625	---	56.45	74.00	17.55	1000.0	218.0	H	118.0
4573.625	46.22	---	54.00	7.78	1000.0	218.0	H	118.0
5488.375	43.95	---	54.00	10.05	1000.0	111.0	V	131.0
5488.375	---	54.60	74.00	19.40	1000.0	111.0	V	131.0
6403.125	---	60.28	74.00	13.72	1000.0	193.0	H	103.0
6403.125	48.87	---	54.00	5.13	1000.0	193.0	H	103.0
7317.875	40.98	---	54.00	13.02	1000.0	185.0	H	123.0
7317.875	---	53.19	74.00	20.81	1000.0	185.0	H	123.0
Measurement uncertainty: Conducted ± 1 dB / ERP ± 4 dB								
* This frequency is not listed in the restricted bands of operation (section FCC 15.205), therefore does not require to follow the limits according to section FCC 15.209!								

Blue marked: restricted bands

Higher Channel @ 902.75 MHz

Transmitter Spurious Radiation (1 GHz – 10 GHz), (Section 15.205, 15.209)								
Frequency (MHz)	Average (dBμV/m)	MaxPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol V / H	Azimuth (deg)
1854.375*	57.00	---	---	---	1000.0	160.0	H	142.0
1854.375*	---	65.01	---	---	1000.0	160.0	H	142.0
2781.625	---	59.06	74.00	14.94	1000.0	100.0	H	242.0
2781.625	50.20	---	54.00	3.80	1000.0	100.0	H	242.0
3708.875	50.24	---	54.00	3.76	1000.0	100.0	V	142.0
3708.875	---	59.11	74.00	14.89	1000.0	100.0	V	142.0
4636.125	---	53.08	74.00	20.92	1000.0	200.0	H	142.0
4636.125	43.19	---	54.00	10.81	1000.0	200.0	H	142.0
5563.375	43.58	---	54.00	10.42	1000.0	130.0	H	226.0
5563.375	---	54.18	74.00	19.82	1000.0	130.0	H	226.0
6490.625	51.41	---	54.00	2.59	1000.0	208.0	H	98.0
6490.625	---	61.63	74.00	12.37	1000.0	208.0	H	98.0
Measurement uncertainty: Conducted ± 1 dB / ERP ± 4 dB								
* This frequency is not listed in the restricted bands of operation (section FCC 15.205), therefore does not require to follow the limits according to section FCC 15.209!								

Blue marked: restricted bands

Test cables used	K60, K101, K119		
Test equipment used	445a, 660, 665		
The equipment passed the conducted tests	Yes	No	Not*
Test setup photos / test results are attached	Yes	No	Annex no.: 6, 11

Radiated Emissions from EUT (MRU102-PoE-LED)

Lower Channel @ 902.75 MHz

Transmitter Spurious Radiation below 30 MHz, (Section 15.205, 15.209)							
Frequency (MHz)	QuasiPeak (dBμV/m)	Average (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Bandwidth (kHz)	Pol V / H	Azimuth (deg)
0.116590	---	37.8	106.3	68.6	0.2	H	14.0
24.971250	54.8	---	69.5	14.7	9.0	V	265.0
Measurement uncertainty: Conducted ± 1 dB / ERP ± 4 dB							

Blue marked: restricted bands

Middle Channel @ 914.75 MHz

Transmitter Spurious Radiation below 30 MHz, (Section 15.205, 15.209)							
Frequency (MHz)	QuasiPeak (dBμV/m)	Average (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Bandwidth (kHz)	Pol V / H	Azimuth (deg)
24.954250	53.9	---	69.5	15.6	9.0	V	242.0
**No emissions detected							
Measurement uncertainty: Conducted ± 1 dB / ERP ± 4 dB							

Blue marked: restricted bands

Higher Channel @ 927.25 MHz

Transmitter Spurious Radiation below 30 MHz, (Section 15.205, 15.209)							
Frequency (MHz)	QuasiPeak (dBμV/m)	Average (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Bandwidth (kHz)	Pol V / H	Azimuth (deg)
24.489750	54.2	---	69.5	15.3	9.0	V	286.0
**No emissions detected							
Measurement uncertainty: Conducted ± 1 dB / ERP ± 4 dB							

Blue marked: restricted bands

Test cables used	K60, K101, K119
Test equipment used	23, 665, 660

The equipment passed the conducted tests	Yes	No	N.t.*
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Test setup photos / test results are attached	Yes	No	Annex no.: 6, 11
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Lower Channel @ 902.75 MHz

Transmitter Spurious Radiation (30 MHz – 1 GHz), (Section 15.205, 15.209)							
Frequency (MHz)	Average (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol V / H	Azimuth (deg)
34.52	30.5	40.0	10.5	120.0	100.0	V	159.0
57.99*	40.5	---	---	120.0	100.0	V	4.0
66.25	38.2	40.0	1.8	120.0	100.0	V	180.0
124.98	36.2	43.5	7.3	120.0	100.0	V	206.0
225.00	39.1	46.0	5.9	120.0	100.0	V	85.0
275.01	37.6	46.0	8.4	120.0	100.0	V	298.0
324.99	42.9	46.0	3.1	120.0	100.0	H	107.0
399.99	36.9	46.0	9.1	120.0	100.0	H	92.0
500.01	36.6	46.0	9.4	120.0	104.0	V	79.0
750.00	40.0	46.0	6.0	120.0	100.0	H	187.0
Measurement uncertainty: Conducted ± 1 dB / ERP ± 4 dB							
* This frequency is not listed in the restricted bands of operation (section FCC 15.205), therefore does not require to follow the limits according to section FCC 15.209!							

Blue marked: restricted bands

Middle Channel @ 914.75 MHz

Transmitter Spurious Radiation (30 MHz – 1 GHz), (Section 15.205, 15.209)							
Frequency (MHz)	Average (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol V / H	Azimuth (deg)
34.98	32.4	40.0	7.6	120.0	100.0	V	5.0
57.52*	40.5	---	---	120.0	100.0	V	25.0
64.41	38.2	40.0	1.8	120.0	100.0	V	-25.0
124.98	27.3	43.5	16.2	120.0	104.0	V	196.0
225.00	40.5	46.0	5.5	120.0	100.0	V	105.0
324.99	44.0	46.0	2.0	120.0	100.0	H	121.0
399.99	36.4	46.0	9.6	120.0	100.0	H	78.0
750.00	39.9	46.0	5.1	120.0	100.0	H	187.0
Measurement uncertainty: Conducted ± 1 dB / ERP ± 4 dB							
* This frequency is not listed in the restricted bands of operation (section FCC 15.205), therefore does not require to follow the limits according to section FCC 15.209!							

Blue marked: restricted band

Higher Channel @ 927.25 MHz

Transmitter Spurious Radiation (30 MHz – 1 GHz), (Section 15.205, 15.209)							
Frequency (MHz)	Average (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol V / H	Azimuth (deg)
35.45	31.8	40.0	9.2	120.0	100.0	V	239.0
58.00*	40.1	---	---	120.0	100.0	V	-25.0
64.91	38.5	40.0	1.5	120.0	100.0	V	-39.0
124.98	33.9	43.5	9.1	120.0	100.0	V	193.0
225.00	42.5	46.0	3.5	120.0	100.0	V	109.0
275.01	41.8	46.0	5.2	120.0	100.0	V	325.0
425.01	34.6	46.0	11.4	120.0	100.0	V	129.0
800.01	38.7	46.0	7.3	120.0	100.0	H	187.0
Measurement uncertainty: Conducted ± 1 dB / ERP ± 4 dB							
* This frequency is not listed in the restricted bands of operation (section FCC 15.205), therefore does not require to follow the limits according to section FCC 15.209!							

Blue marked: restricted bands

Lower Channel @ 902.75 MHz

Transmitter Spurious Radiation (1 GHz – 10 GHz), (Section 15.205, 15.209)								
Frequency (MHz)	Average (dBμV/m)	MaxPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol V / H	Azimuth (deg)
1805.375	50.60	---	54.00	3.40	1000.0	192.0	H	204.0
1805.375	---	63.32	74.00	10.68	1000.0	192.0	H	204.0
2019.375	34.36	---	54.00	19.64	1000.0	160.0	H	12.0
2019.375	---	47.28	74.00	26.72	1000.0	160.0	H	12.0
2708.125	46.97	---	54.00	7.03	1000.0	100.0	V	161.0
2708.125	---	59.17	74.00	14.83	1000.0	100.0	V	161.0
3610.875	---	56.66	74.00	17.34	1000.0	192.0	H	258.0
3610.875	43.62	---	54.00	10.38	1000.0	192.0	H	258.0
4513.625	39.14	---	54.00	14.86	1000.0	149.0	H	209.0
4513.625	---	52.05	74.00	21.95	1000.0	149.0	H	209.0
5416.375	---	52.68	74.00	21.32	1000.0	117.0	V	232.0
5416.375	39.50	---	54.00	14.50	1000.0	117.0	V	232.0
6319.125	41.41	---	54.00	12.59	1000.0	138.0	H	236.0
6319.125	---	54.16	74.00	19.84	1000.0	138.0	H	236.0
7222.125	38.56	---	54.00	15.44	1000.0	110.0	H	91.0
7222.125	---	51.55	74.00	22.45	1000.0	110.0	H	91.0
Measurement uncertainty: Conducted ± 1 dB / ERP ± 4 dB								

Blue marked: restricted bands

Middle Channel @ 914.75 MHz

Transmitter Spurious Radiation (1 GHz – 10 GHz), (Section 15.205, 15.209)								
Frequency (MHz)	Average (dBμV/m)	MaxPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol V / H	Azimuth (deg)
1829.375	49.08	---	54.00	4.92	1000.0	111.0	H	206.0
1829.375	---	61.84	74.00	12.16	1000.0	111.0	H	206.0
2019.375	---	47.56	74.00	26.44	1000.0	188.0	H	5.0
2019.375	33.19	---	54.00	20.81	1000.0	188.0	H	5.0
2744.125	45.24	---	54.00	8.76	1000.0	190.0	V	168.0
2744.125	---	57.90	74.00	16.10	1000.0	190.0	V	168.0
3658.875	---	58.87	74.00	15.13	1000.0	116.0	V	176.0
3658.875	45.95	---	54.00	8.05	1000.0	116.0	V	176.0
4573.625	---	51.39	74.00	22.61	1000.0	118.0	H	232.0
4573.625	38.37	---	54.00	15.63	1000.0	118.0	H	232.0
5488.375	---	54.01	74.00	19.99	1000.0	129.0	V	256.0
5488.375	40.43	---	54.00	13.57	1000.0	129.0	V	256.0
6403.125	---	55.05	74.00	18.95	1000.0	324.0	H	237.0
6403.125	41.23	---	54.00	12.77	1000.0	324.0	H	237.0
7317.875	---	51.90	74.00	22.10	1000.0	162.0	H	237.0
7317.875	38.29	---	54.00	15.71	1000.0	162.0	H	237.0
Measurement uncertainty: Conducted ± 1 dB / ERP ± 4 dB								

Blue marked: restricted bands

Higher Channel @ 927.25 MHz

Transmitter Spurious Radiation (1 GHz – 10 GHz), (Section 15.205, 15.209)								
Frequency (MHz)	Average (dBµV/m)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol V / H	Azimuth (deg)
1854.375	---	61.19	74.00	12.81	1000.0	167.0	H	138.0
1854.375	48.53	---	54.00	5.47	1000.0	167.0	H	138.0
2019.375	32.14	---	54.00	21.86	1000.0	194.0	V	157.0
2019.375	---	46.36	74.00	27.64	1000.0	194.0	V	157.0
2781.625	46.01	---	54.00	7.99	1000.0	162.0	V	167.0
2781.625	---	58.88	74.00	15.12	1000.0	162.0	V	167.0
3708.875	45.01	---	54.00	8.99	1000.0	116.0	V	191.0
3708.875	---	57.94	74.00	16.06	1000.0	116.0	V	191.0
4636.125	---	51.37	74.00	22.63	1000.0	176.0	V	164.0
4636.125	37.89	---	54.00	16.11	1000.0	176.0	V	164.0
5563.375	41.48	---	54.00	12.52	1000.0	217.0	H	251.0
5563.375	---	54.61	74.00	19.39	1000.0	217.0	H	251.0
6490.625	43.43	---	54.00	10.57	1000.0	137.0	H	239.0
6490.625	---	56.07	74.00	17.93	1000.0	137.0	H	239.0
7417.875	38.62	---	54.00	15.38	1000.0	201.0	H	235.0
7417.875	---	51.57	74.00	22.43	1000.0	201.0	H	235.0
Measurement uncertainty: Conducted ± 1 dB / ERP ± 4 dB								

Blue marked: restricted bands

Test cables used	K60, K101, K119
Test equipment used	445a, 660, 665, 406, 451, 452

The equipment passed the conducted tests	Yes	No	Not*
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Test setup photos / test results are attached	Yes	No	Annex no.: 6, 11
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8.5 Bandwidth

8.5.1 Regulation

Section 15.247 (a) Operation under the provisions of this Section is limited to frequency hopping and digitally modulated intentional radiators that comply with the following provisions:

(1) Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

(i) For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

(ii) Frequency hopping systems operating in the 5725-5850 MHz band shall use at least 75 hopping frequencies. The maximum 20 dB bandwidth of the hopping channel is 1 MHz. The average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 30 second period.

(iii) Frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

8.5.2 Result

Operating Frequency	Minimum Measured 20 dB Bandwidth
MHz	kHz
902.75	97.7
914.75	97.9
927.25	97.4

Operating Frequency	Maximum Measured 99 % Bandwidth
MHz	kHz
902.75	95.9
914.75	94.4
927.25	93.9

Test Cables used	K121
Test equipment used	356, 502, 226, 571, 594, 493

The equipment passed the conducted tests	Yes	~~No~~	~~N.t.~~ *
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Test setup photos / test results are attached	Yes	~~No~~	Annex no.: 3
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8.6 Carrier frequency separation

8.6.1 Regulation

Section 15.247 (a) Operation under the provisions of this Section is limited to frequency hopping and digitally modulated intentional radiators that comply with the following provisions:

(1) Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

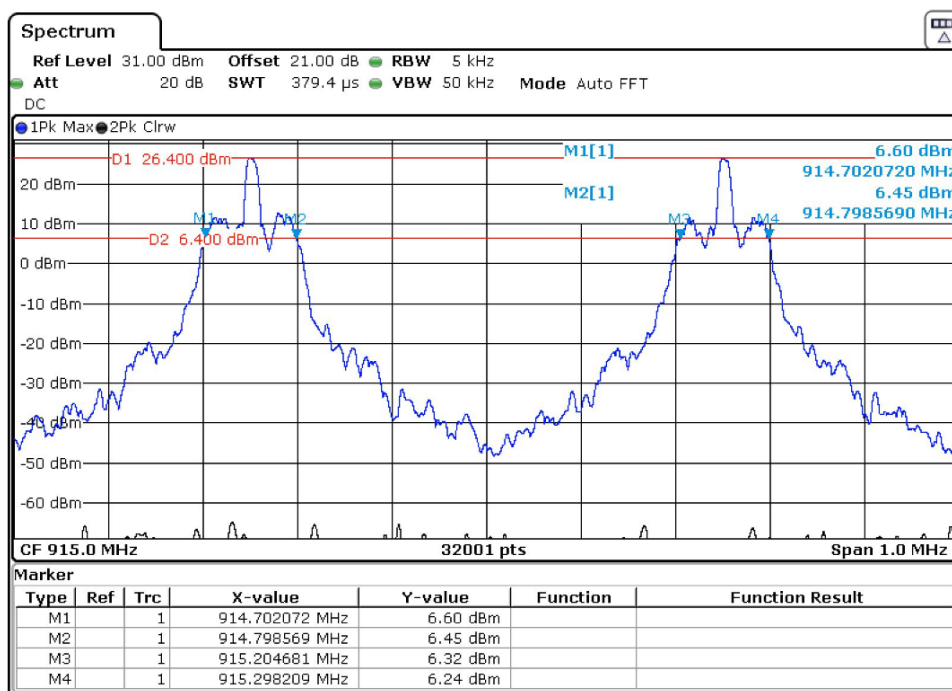
(i) For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

(ii) Frequency hopping systems operating in the 5725-5850 MHz band shall use at least 75 hopping frequencies. The maximum 20 dB bandwidth of the hopping channel is 1 MHz. The average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 30 second period.

(iii) Frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

8.6.2 Result

Plot of channel separation measurement



	20 dBc frequencies		Calculated centre frequencies	Calculated channel separation
	MHz		MHz	kHz
Operating Frequency 1	F1 _L	914.702072	F1	914.7503205
	F1 _H	914.798569		
Operating Frequency 2	F2 _L	915.204681	F2	915.251445
	F2 _H	915.298209		

$$F1 = F1_H - F1_L$$

$$F2 = F2_H - F2_L$$

$$\text{channel separation} = F2 - F1$$

Test Cables used	K121
Test equipment used	356, 502, 226, 571, 594, 493

The equipment passed the conducted tests	Yes	No	~~Not~~
Test setup photos / test results are attached	~~Yes~~	No	Annex no.:

8.7 Number of hopping channels

8.7.1 Regulation

Section 15.247 (a) Operation under the provisions of this Section is limited to frequency hopping and digitally modulated intentional radiators that comply with the following provisions:

(1) Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

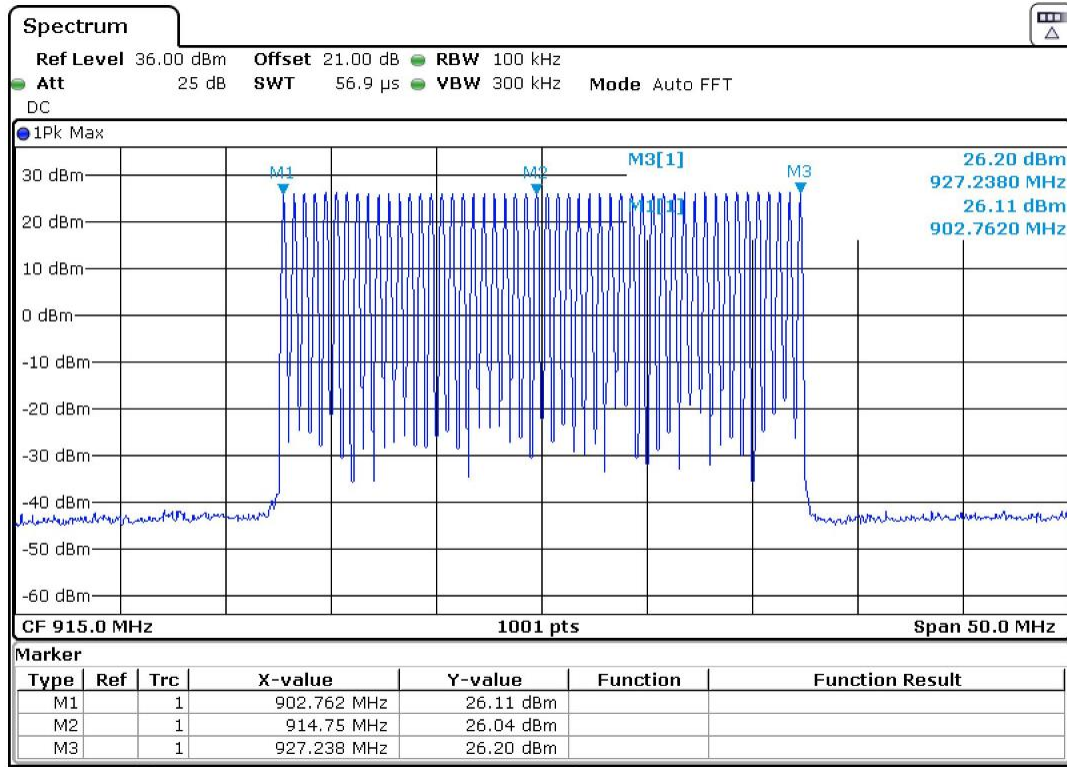
(i) For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

(ii) Frequency hopping systems operating in the 5725-5850 MHz band shall use at least 75 hopping frequencies. The maximum 20 dB bandwidth of the hopping channel is 1 MHz. The average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 30 second period.

(iii) Frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

8.7.2 Result

Plot of number of hopping channels



Operating Frequency Band	Number of hopping channels Measured	Number of hopping channels Limit
902 - 928	50	50

Test Cables used	K121
Test equipment used	356, 502, 226, 571, 594, 493

The equipment passed the conducted tests	Yes	No	~~No~~ *
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Test setup photos / test results are attached	~~Yes~~	No	Annex no.:
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8.8 Average time of occupancy

8.8.1 Regulation

Section 15.247 (a) Operation under the provisions of this Section is limited to frequency hopping and digitally modulated intentional radiators that comply with the following provisions:

(1) Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

(i) For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

(ii) Frequency hopping systems operating in the 5725-5850 MHz band shall use at least 75 hopping frequencies. The maximum 20 dB bandwidth of the hopping channel is 1 MHz. The average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 30 second period.

(iii) Frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

8.8.2 Result

Operating Frequency MHz	Duration of a single transmission ms	Number of transmissions	Average time of occupancy ms	Limit ms
F _{Low} 902.75	321	1	321	400
F _{Middle} 914.75	321	1	321	400
F _{High} 927.25	321	1	321	400

Test Cables used	K121
Test equipment used	356, 502, 226, 571, 594, 493

The equipment passed the conducted tests	Yes	~~No~~	~~Not~~ [§]
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Test setup photos / test results are attached	~~Yes~~	No	Annex no.:
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8.9 Peak output power

8.9.1 Regulation

Section 15.247 (b) The maximum peak conducted output power of the intentional radiator shall not exceed the following:

(1) For frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725-5850 MHz band: 1 watt. For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 watts.

(2) For frequency hopping systems operating in the 902-928 MHz band: 1 watt for systems employing at least 50 hopping channels; and, 0.25 watts for systems employing less than 50 hopping channels, but at least 25 hopping channels, as permitted under paragraph (a)(1)(i) of this section.

(3) For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the *maximum conducted output power* is the highest total transmit power occurring in any mode.

(4) The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

(c) Operation with directional antenna gains greater than 6 dBi.

(1) Fixed point-to-point operation:

(i) Systems operating in the 2400-2483.5 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi provided the maximum conducted output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi.

(ii) Systems operating in the 5725-5850 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi without any corresponding reduction in transmitter conducted output power.

(iii) Fixed, point-to-point operation, as used in paragraphs (c)(1)(i) and (c)(1)(ii) of this section, excludes the use of point-to-multipoint systems, omnidirectional applications, and multiple co-located intentional radiators transmitting the same information. The operator of the spread spectrum or digitally modulated intentional radiator or, if the equipment is professionally installed, the installer is responsible for ensuring that the system is used exclusively for fixed, point-to-point operations. The instruction manual furnished with the intentional radiator shall contain language in the installation instructions informing the operator and the installer of this responsibility.

(2) In addition to the provisions in paragraphs (b)(1), (b)(3), (b)(4) and (c)(1)(i) of this section, transmitters operating in the 2400-2483.5 MHz band that emit multiple directional beams, simultaneously or sequentially, for

the purpose of directing signals to individual receivers or to groups of receivers provided the emissions comply with the following:

(i) Different information must be transmitted to each receiver.

(ii) If the transmitter employs an antenna system that emits multiple directional beams but does not emit multiple directional beams simultaneously, the total output power conducted to the array or arrays that comprise the device, *i.e.*, the sum of the power supplied to all antennas, antenna elements, staves, etc. and summed across all carriers or frequency channels, shall not exceed the limit specified in paragraph (b)(1) or (b)(3) of this section, as applicable. However, the total conducted output power shall be reduced by 1 dB below the specified limits for each 3 dB that the directional gain of the antenna/antenna array exceeds 6 dBi. The directional antenna gain shall be computed as follows:

(A) The directional gain shall be calculated as the sum of $10 \log$ (number of array elements or staves) plus the directional gain of the element or stove having the highest gain.

(B) A lower value for the directional gain than that calculated in paragraph (c)(2)(ii)(A) of this section will be accepted if sufficient evidence is presented, e.g., due to shading of the array or coherence loss in the beamforming.

(iii) If a transmitter employs an antenna that operates simultaneously on multiple directional beams using the same or different frequency channels, the power supplied to each emission beam is subject to the power limit specified in paragraph (c)(2)(ii) of this section. If transmitted beams overlap, the power shall be reduced to ensure that their aggregate power does not exceed the limit specified in paragraph (c)(2)(ii) of this section. In addition, the aggregate power transmitted simultaneously on all beams shall not exceed the limit specified in paragraph (c)(2)(ii) of this section by more than 8 dB.

(iv) Transmitters that emit a single directional beam shall operate under the provisions of paragraph (c)(1) of this section.

8.9.2 Test procedure

The EUT and this peripheral (when additional equipment exists) are placed on a turn table which is 0.8 m above the ground. The turn table would be allowed to rotate 360° to determine the position of the maximum emission level. The test distance between the EUT and the receiving antenna are 3m. To find the maximum emission, the polarization of the receiving antenna is changed in horizontal and vertical polarization; the position of the EUT was changed in different orthogonal determinations.

ANSI C63.4-2014 Section 8 “Radiated Emissions Testing”

Measurement procedures for electric field radiated emissions from 9kHz - 1 GHz & 1 GHz - 40 GHz are covered in Clause 8 of ANSI C63.4-2014. The ANSI C63.4-2014 measurement procedure consists of both an exploratory test and a final measurement. The exploratory test is critical to determine the frequency of all significant emissions. For each mode of operation required to be tested, the frequency spectrum is monitored. Variations in antenna height, antenna orientation, antenna polarization, EUT azimuth, and cable or wire placement is explored to produce the emission that has the highest amplitude relative to the limit.

The final measurements are made based on the findings in the exploratory testing. When making exploratory and final measurements it is necessary to maximize the measured radiated emission. Sub clause 8.3.2 of ANSI C63.4-2014 states that the measurement is to be made “while keeping the antenna in the ‘cone of radiation’ from that area and pointed at the area both in azimuth and elevation, with polarization oriented for maximum response.” We consider the “cone of radiation” to be the 3 dB beam width of the measurement antenna.

While the “bore-sighting” technique is not explicitly mentioned in ANSI C63.4-2014, it is a useful technique for measurements using a directional antenna, such as a double-ridged waveguide antenna. Several precautions must be observed, including: knowledge of the beam width of the antenna and the resulting illumination area relative to the size of the EUT, estimation for source of the emission and general location within larger EUTs, measuring system sensitivity, etc.

ANSI C63.4-2014 requires that the measurement antenna is kept pointed at the source of the emission both in azimuth and elevation, with the polarization of the antenna oriented for maximum response. That means that if the directional radiation pattern of the EUT results in a maximum emission at an upwards angle from the EUT, when a directional antenna is used to make the measurement it will be necessary for it to be pointed towards the source of the emission within the EUT. This can be done by either pointing the antenna at an angle towards the source of the emission, or by rotating the EUT, in both height and polarization, to maximize the measured emission. The emission must be kept within the illumination area of the 3 dB beamwidth of the antenna so that the maximum emission from the EUT is measured.

Radiated emissions test characteristics	
Test distance	10m, 3 m*
Test instrumentation resolution bandwidth	9 kHz (Below 30 MHz)
	120 kHz (30 MHz - 1000 MHz)
	1 MHz (Above 1000 MHz)
Receive antenna scan height	1 m (Below 30 MHz)
	1 m - 4 m (30 MHz - 15000 MHz)
	1 m – 2.5 m (18000 MHz - 40000 MHz)
	1 m (Above 40000 MHz)
Receive antenna polarization	0° or 90° (Below 30 MHz)
	vertical/horizontal (Above 30 MHz)

*According to Section 15.31 (f) (1): At frequencies at or above 30 MHz, measurements may be performed at a distance other than what is specified provided: measurements are not made in the near field except where it can be shown that near field measurements are appropriate due to the characteristics of the device; and it can be demonstrated that the signal levels needed to be measured at the distance employed can be detected by the measurement equipment. When performing measurements at a distance other than that specified, the results shall be extrapolated to the specified distance using an extrapolation factor of 20dB/decade (inverse linear-distance for field strength measurements; inverse-linear-distance-squared for power density measurements).

8.9.3 Calculation of the peak power (radiated)

The field strength is calculated by the following calculation:

Corrected Level = Receiver Level + Correction Factor (without the use of a pre-amplifier)

Corrected Level = Receiver Level + Correction Factor – Pre-Amplifier (with the use of a pre-amplifier)

Receiver Level : Receiver reading without correction factors

Correction Factor : field attenuation + cable loss

For example:

The receiver reading is +1.0 dBm. The field attenuation for the measured frequency is +19.5 dB and the cable factor for the measured frequency is 2.1 dB, giving a power of +22.6 dBm.

The +22.6dBm value can be mathematically converted to its corresponding level in W.

$$+22.6 \text{ dBm} = 0.182 \text{ W} = 182 \text{ mW}$$

8.9.4 Result

Peak output power at antenna port (Section 15.247 (b)(2))							
f	Detct	BW*	Rx Level	CF	LC	Limit	Margin
MHz	Type	kHz	dBm	dB	dBm	dBm	dB
902.75	PK	100	---	---	26.5	30.0	3.5
914.75	PK	100	---	---	26.3	30.0	3.7
927.25	PK	100	---	---	26.6	30.0	3.4
Measurement uncertainty: ± 3 dB							
f: Frequency Detct : Detector type BW: Bandwidth Rx Level : Receiver level CF : Correction factor LC : Level corrected							

BW* = the measuring receiver bandwidth

Max. radiated peak output power e.i.r.p. Calculated (Section 15.247 (b)(2))								
Antenna Type	f	Rx Level	Antenna gain	e.i.r.p. LC (cable 2m)	e.i.r.p. LC (cable 6m)	e.i.r.p. Limit	Margin Cable 2m	Margin Cable 6m
Internal / External	(MHz)	dBm	dBi	dBm	dBm	dBm	dB	
Internal	902.75	26.5	-10	16.0	14.9	36*	21.1	20.0
	914.75	26.3	-10	15.8	14.7	36*	21.3	20.2
	927.25	26.6	-10	16.1	15.0	36*	19.9	21.0
ID ISC.ANT.U170/170	902.75	26.5	1	27.0	25.9	36*	9.0	10.1
	914.75	26.3	1	26.8	25.7	36*	9.2	10.3
	927.25	26.6	1	27.5	26.0	36*	8.5	10.0
ID ISC.ANT.U270/270	902.75	26.5	6	32.0	30.9	36*	4.0	5.1
	914.75	26.3	6	31.8	30.7	36*	4.2	5.3
	927.25	26.6	6	32.1	31.0	36*	3.9	5.0
ID ISC.ANT.U600/270	902.75	26.5	8	34.0	32.9	36*	2.0	3.1
	914.75	26.3	8	33.8	32.7	36*	2.2	3.3
	927.25	26.6	8	34.1	33.0	36*	1.9	3.0
ID ISC.ANT.U290/290	902.75	26.5	6	27.0	30.9	36*	4.0	5.1
	914.75	26.3	6	26.8	30.7	36*	4.2	5.3
	927.25	26.6	6	27.5	31.0	36*	3.9	5.0
ID ISC.ANT.U580/290	902.75	26.5	8	34.0	32.9	36*	2.0	3.1
	914.75	26.3	8	33.8	32.7	36*	2.2	3.3
	927.25	26.6	8	34.1	33.0	36*	1.9	3.0
Measurement uncertainty: ± 0.5 dB								
f: Frequency Rx Level : Receiver e.i.r.p. LC : Corrected e.i.r.p Level *e.i.r.p. Limit = 30 dBm + 6 dBi (antenna gain) = 4 Watt								
Max. Peak output power (radiated) = Noted receiver level + Antenna gain - Coax cable attenuation								
Coax cable attenuation (length - 2m) = 0.5 dB ; Coax cable attenuation (length - 6m) = 1.6 dB								

Test Cables used	K121
Test equipment used	356, 502, 226, 571, 594, 493

The equipment passed the conducted tests	Yes	No	Not [§]
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Test setup photos / test results are attached	Yes	No	Annex no.: 11
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8.10 Out of band emission

8.10.1 Regulation

Section 15.247 (d) In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

8.10.2 Calculation of the “Out of band emissions”

The field strength is calculated by the following calculation:

Corrected Level = Receiver Level + Correction Factor (without the use of a pre-amplifier)

Corrected Level = Receiver Level + Correction Factor – Pre-Amplifier (with the use of a pre-amplifier)

Receiver Level : Receiver reading without correction factors

Correction Factor : field attenuation + cable loss

For example:

The receiver reading in a 100 kHz bandwidth is -45.0 dBm. The field attenuation for the measured frequency is +10.5 dB and the cable factor for the measured frequency is 1.5 dB, giving a power of -33.0 dBm.

The measured peak power in a 100 kHz bandwidth is +3.6dBm. Therefore the Attenuation can be calculated as follows:

Attenuation = measured peak power – out of band emission receiver reading = +3.6 dBm – (-33.0 dBm) =36.6 dB

8.10.3 Test procedure

The EUT and this peripheral (when additional equipment exists) are placed on a turn table which is 0.8 m above the ground. The turn table would be allowed to rotate 360° to determine the position of the maximum emission level. The test distance between the EUT and the receiving antenna are 3m. To find the maximum emission, the polarization of the receiving antenna is changed in horizontal and vertical polarization; the position of the EUT was changed in different orthogonal determinations.

ANSI C63.4-2014 Section 8 “Radiated Emissions Testing”

Measurement procedures for electric field radiated emissions from 9kHz - 1 GHz & 1 GHz - 40 GHz are covered in Clause 8 of ANSI C63.4-2014. The ANSI C63.4-2014 measurement procedure consists of both an exploratory test and a final measurement. The exploratory test is critical to determine the frequency of all significant emissions. For each mode of operation required to be tested, the frequency spectrum is monitored. Variations in antenna height, antenna orientation, antenna polarization, EUT azimuth, and cable or wire placement is explored to produce the emission that has the highest amplitude relative to the limit.

The final measurements are made based on the findings in the exploratory testing. When making exploratory and final measurements it is necessary to maximize the measured radiated emission. Sub clause 8.3.2 of ANSI C63.4-2014 states that the measurement is to be made “while keeping the antenna in the ‘cone of radiation’ from that area and pointed at the area both in azimuth and elevation, with polarization oriented for maximum response.” We consider the “cone of radiation” to be the 3 dB beam width of the measurement antenna.

While the “bore-sighting” technique is not explicitly mentioned in ANSI C63.4-2014, it is a useful technique for measurements using a directional antenna, such as a double-ridged waveguide antenna. Several precautions must be observed, including: knowledge of the beam width of the antenna and the resulting illumination area relative to the size of the EUT, estimation for source of the emission and general location within larger EUTs, measuring system sensitivity, etc.

ANSI C63.4-2014 requires that the measurement antenna is kept pointed at the source of the emission both in azimuth and elevation, with the polarization of the antenna oriented for maximum response. That means that if the directional radiation pattern of the EUT results in a maximum emission at an upwards angle from the EUT, when a directional antenna is used to make the measurement it will be necessary for it to be pointed towards the source of the emission within the EUT. This can be done by either pointing the antenna at an angle towards the source of the emission, or by rotating the EUT, in both height and polarization, to maximize the measured emission. The emission must be kept within the illumination area of the 3 dB beamwidth of the antenna so that the maximum emission from the EUT is measured.

8.10.4 Result

- EUT (ID ISC.MRMU102-A)

Lower Channel @ 902.75 MHz

Spurious Emissions - conducted (Transmitter), (Section 15.247 (d))							
frequency	Detector	BW	Rx Level	CF	LC	Limit	Margin
MHz	Type	kHz	dBm	dB	dBm	dBm*	dB
119.4	PK	100	---	---	-54.8	6.19	61.0
392.1	PK	100	---	---	-51.5	6.19	57.7
1804.9	PK	100	---	---	-33.5	6.4	39.9
2707.0	PK	100	---	---	-39.9	6.4	46.3
6950.5	PK	100	---	---	-50.4	6.4	56.8
Measurement uncertainty: ± 3 dB							
* 20 dB below the carrier peak level							
** All other emissions lower than the noise level of the measuring equipment!							
BW: meas. receiver Bandwidth Rx Level : Receiver level CF : Correction factor LC : Level corrected							

Middle Channel @ 914.75 MHz

Spurious Emissions - conducted (Transmitter), (Section 15.247 (d))							
frequency	Detector	BW	Rx Level	CF	LC	Limit	Margin
MHz	Type	kHz	dBm	dB	dBm	dBm*	dB
130.4	PK	100	---	---	-55.4	6.35	61.8
377.1	PK	100	---	---	-51.9	6.35	58.3
1830.1	PK	100	---	---	-33.3	6.52	39.8
2744.8	PK	100	---	---	-38.8	6.52	45.3
Measurement uncertainty: ± 3 dB							
* 20 dB below the carrier peak level							
** All other emissions lower than the noise level of the measuring equipment!							
BW: meas. receiver Bandwidth Rx Level : Receiver level CF : Correction factor LC : Level corrected							

Higher Channel @ 927.25 MHz

Spurious Emissions - conducted (Transmitter)							
frequency	Detector	BW	Rx Level	CF	LC	Limit	Margin
MHz	Type	kHz	dBm	dB	dBm	dBm*	dB
142.4	PK	100	---	---	-54.8	6.56	61.4
363.1	PK	100	---	---	-52.0	6.56	58.6
1855.2	PK	100	---	---	-33.3	6.57	39.9
2782.5	PK	100	---	---	-38.4	6.57	45.0
6725.8	PK	100	---	---	-51.1	6.57	57.7
Measurement uncertainty: ± 3 dB							
* 20 dB below the carrier peak level							
** All other emissions lower than the noise level of the measuring equipment!							
BW: meas. receiver Bandwidth Rx Level : Receiver level CF : Correction factor LC : Level corrected							

Test cables used	K121
Test equipment used	356, 502, 226, 571, 594, 493

The equipment passed the conducted tests	Yes	No	~~Not~~ *
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Test setup photos / test results are attached	Yes	No	Annex no.: 6, 11
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8.11 Radio Frequency hazard

8.11.1 Regulation

Section 15.247 (i)

According to § 1.1307(b)(1), systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy levels in excess of the Commission's guidelines.

8.11.2 Result

MPE calculation method

These equations are generally accurate in the far field of an antenna but will over predict power density in the near field, where they could be used for making a “worst case” prediction.

$$S = PG/4\pi R^2$$

where S = power density (in appropriate units, e.g. mW/cm²)

P = power input to the antenna (in appropriate units e.g. mW)

G = power gain of the antenna in the direction of interest relative to the isotropic radiator

R = distance to the center of radiation of the antenna (appropriate units e.g. cm)

$$\text{OR, } S = \text{EIRP}/(4\pi R^2)$$

Where, EIRP = equivalent isotropically radiated power

MPE Calculations			
Operating Frequency	Calculated EIRP	Power density (S) @ 20 cm	
		Calculated	Limit
kHz / MHz	mW	mW/ cm ²	
Channel 1 : 902.75	2511.9	0.49	0.6
Channel 2 : 914.75	2398.8	0.47	0.6
Channel 3 : 927.25	2570.4	0.51	0.6

Limit:

0.60 mW/ cm² is the reference level for general public exposure according to the OET Bulletin 65, Edition 97-01 Table 1.

The equipment passed the conducted tests	Yes	No	N.t.*
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Test setup photos / test results are attached	Yes	No	Annex no.:
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9. Additional information to the test report

Remarks	Description
N.t. ¹	Not tested, because the antenna is part of the PCB
N.t. ²	Not tested, because the EUT is directly battery powered
N.t. ³	Not tested, because not applicable to the EUT
N.t. ⁴	Not tested, because not ordered

10. List of test equipment

State Jun. 23, 2021					
Marking	Manufacturer	SW/Type/Serial-No.	Last Cal./Val.	Next Cal./Val.	No.
1 Measuring Instruments					
Attenuator	Radiall	---	Nov 19	Nov 22	62
Attenuator 3dB	Suhner	6803/17	Nov 19	Nov 22	137
Attenuator 3dB / 18 GHz	Suhner	3dB/18GHz	Nov 19	Nov 22	299
Terminator	Texcan	---	Nov 19	Nov 22	304
Attenuator 6dB / 18 GHz	Suhner	6dB/18GHz	Nov 19	Nov 22	344
Attenuator 20dB / 20GHz	Parzich	40AH-20	Nov 19	Nov 22	354
Terminator	KDI	T173CS	Nov 19	Nov 22	490
Variable transformer	RFT	LS 002	---	---	154a
Variable transformer	Schunt+Ben	---	---	---	155
Power sensor	Marconi	6914	Sep 20	Sep 22	258
Power sensor	Marconi	6913	Aug 19	Aug 21	286
Power sensor	Rohde & Schwarz	NRP18SN	Nov 19	Nov 21	651
3-Path Diode Power Sensor 10 MHz to 8 GHz	Rohde & Schwarz	NRP8S	Oct 20	Oct 22	663
3-Path Diode Power Sensor 10 MHz to 18 GHz	Rohde & Schwarz	NRP18S-20	Oct 20	Oct 22	664
Coaxial Directional Coupler	Narda	3003-20	Jan 21	Jan 24	370/342
Coaxial directional coupler	Mini Circuits	ZFDC-20-5	Mar 20	Mar 22	434
Coaxial directional coupler	Narda+Suhner	---	Mar 20	Mar 23	472/492
Coaxial High Pass Filter	Mini circuits	NHP-700	Apr 21	Apr 24	435
Coaxial High Pass Filter	Mini circuits	NHP-200	Apr 21	Apr 24	405
Coaxial High Pass Filter	Mini circuits	NHP-25+	Apr 21	Apr 24	455
High Pass Filter	Mini circuits	VHF-3500+	Apr 21	Apr 24	451
High Pass Filter	Mini circuits	VHF-1200+	Apr 21	Apr 24	452
Bandpass Filter	Schomandl	BN86871	Nov 18	Nov 21	66
Bandpass Filter	Schomandl	BN68673	Nov 18	Nov 21	67
Low Pass Filter	Mini circuits	SLP550	Apr 21	Apr 24	273
Low Pass Filter	Mini circuits	SLP550	Apr 21	Apr 24	274
RF Current Probe 9 kHz – 30 MHz	Rohde & Schwarz	ESH2-Z1	Jun 18	Jun 21	42
Passive Test Probe – 9 kHz – 30 MHz	TÜV NORD	VDE 0876	Apr 21	Apr 24	45
Coaxial Fixed Attenuator DC – 1 GHz	Texscan	HPF50/10	Jul 20	Jul 23	60
8 Wire Impedance Stabilisation Network	Schwarzbeck	CAT5 8158	Nov 19	Nov 21	71a
T-Section - 50 W	Rohde & Schwarz	BN 42441/50	Aug 18	Aug 21	93
RF Current Injection Clamp 0.15 – 1GHz	Lüthi GmbH	EM 101	Nov 19	Nov 22	156
Absorbing Clamp MDS 30MHz – 1GHz	Lüthi GmbH	MDS-21	Nov 19	Nov 22	160
Insertion Unit	Rohde & Schwarz	URV5-Z4	Mai 19	Mai 22	162
Coaxial RF Termination - 0 – 1000 MHz	Telewave Inc.	TWL 35	Nov 18	Nov 21	164
Coaxial RF Termination - 0 – 1000 MHz	Telewave Inc.	TWL 60	Nov 18	Nov 21	165
Fixed Attenuator - DC – 1.5GHz	Bird	Mod/ 8343-060	Apr. 20	Apr. 23	177
Rotary Step Attenuator DC – 2 GHz	Texscan	TA – 50	Mar20	Mar 22	184
CDN up to 230 MHz	MEB	KEN-M 2 /M 3	Nov 19	Nov 21	264
Impulse limiter 10 dB	Rohde & Schwarz	ESH3 Z2	Mai 19	Mai 22	272
Fixed Attenuator - DC – 18 GHz 30 dB	MTS	---	Nov 20	Nov 23	275
Fixed Attenuator - DC – 18 GHz 30 dB	MTS	---	Mar 20	Mar 22	276
Passive Probe - 9 kHz – 30 MHz 2.5 kΩ	RFT	TK 121	Jun 20	Jun 23	302
Passive probe 1.5kΩ	Schwarzbeck	TK 9416	Oct 20	Oct 23	621
Termination Resistor 50 W	Radiall	404011	Nov 18	Nov 21	309
Branching device (4x) 50W	Rohde & Schwarz	892228/20	Sep 19	Sep 22	320
Dummy-Load - 2 – 18 GHz	Narda	MODEL 367NF	Nov 19	Nov 22	343

DC Block Adapter - 0.045 – 26.5 GHz	Hewlett-Packard	11742A	Apr 21	Apr 24	356
Insertion Unit 10V 9 kHz 1000 MHz	Rohde & Schwarz	URV 5-Z2	Mai 19	Mai 22	367
RF Probe 0.02 – 1000 MHz	Rohde & Schwarz	395.2680.02	Mai 19	Mai 22	368
150W attenuator	Weinschel	49-20-33	Oct 19	Oct 22	374
Fixed Coaxial Attenuator - DC – 18 GHz	Weinschel	23-6-34	Feb 20	Feb 23	375
Insertion Unit 9 kHz – 2000 MHz	Rohde & Schwarz	URY-Z2	Oct 19	Oct 22	416
Panoramic Adapter (Monitoring)	Schwarzbeck	PAN1550	---	---	429
DC-BLOCK - DC – 6.0 GHz 50 W	Mini Circuits	BLK-6-N+	Aug 18	Aug 21	462
Terminating resistor 50Ω SMA	---	---	Nov 19	Nov 22	493
Terminating resistor 50Ω SMA	---	SC 60-601-0000-31	Nov 19	Nov 22	497
Fixed Attenuator – 0 – 40 GHz	Anritsu	41KC-10	Nov 19	Nov 22	504
Fixed Attenuator – 0 – 40 GHz	Anritsu	41KC-10	Nov 19	Nov 22	505
Fixed Attenuator – 0 – 40 GHz	Anritsu	41KC-6	Nov 19	Nov 22	506
Fixed Attenuator – 0 – 40 GHz	Anritsu	41KC-3	Nov 19	Nov 22	507
Electric Dummy Load	RA-NAV Lab.	DA-75U	---	---	526
Power Splitter / Combiner	Mini Circuits	ZESC-2-11	Nov 19	Nov 22	527
3 Way Power Splitter / Combiner	Mini Circuits	ZFSC-3-1	Mar 20	Mar 23	529
3 Way Power Splitter / Combiner	Mini Circuits	ZFSC-3-1	Mar 20	Mar 23	530
RF-Attenuator - 6 dB	Haefely	---	Mar 20	Mar 23	540
RF-Attenuator - 1– 120 MHz 12 dB	Haefely	---	Mar 20	Mar 23	541
RF-Attenuator - 1– 120 MHz 39 dB	Haefely	---	Mar 20	Mar 23	542
LISN 9kHz – 30 MHz	Schwarzbeck	NNLA 8120	Aug 20	Aug 22	551
HV Probe P6013A	Tektronix	P6013A	Mai 19	Mai 22	559
VLISN 5μH	Schwarzbeck	8125-1944	Nov 19	Nov 21	585
VLISN 5μH	Schwarzbeck	8125-1945	Nov 19	Nov 21	586
20dB Attenuator, up to 18 GHz	Mini Circuit	BW-N20W5+	Nov 19	Nov 22	594
Step Attenuator - DC-18 GHz 0 to 11 dB	Hewlett-Packard	8494B	Nov 19	Nov 22	604
Analyser Reference System	Spitzenberger & Spies	ARS 16/1	Jan 20	Jan 22	606a/b/c
Capacitive Coupling Clamp 5 kV	Schlöder	SFT 415	Mai 20	Mai 23	608
RF Probes for 50 Ω Receivers	Schwarzbeck	TK 9416	---	---	612
Current probe TRMS	BEHA APROB	CHB35	Oct 19	Oct 22	652
Semi Anechoic Chamber	COMTEST	SAC-3m	Apr 21	Apr 23	660
Maturo Turntable	Maturo	TT2.0SI (SN: TT2.05SI/817 SW: 1.0.0.4473)	---	---	667
Maturo Antenna Mast	Maturo	TAM4.5-E-10kg (SN: 10011/216/2588.01)	---	---	668
Maturo Controller	Maturo	FCU3.0/009/2588.01 (SN: 10014/2019)	---	---	669
Current probe 20 Hz – 100 MHz	Rohde & Schwarz	EZ-17 (0816.2063.03)	Mar 20	Mar 23	670
Coupling Decoupling Network	AMETEK	CDN ST08A	Aug 20	Aug 23	762
BONN HF Switch Matrix DC – 8 GHz	BONN Elektronik	BAS 0080-3	---	---	682
External Directional Coupler	BONN Elektronik	BDC 1060-40/500	Dec 20	Dec 22	683
BI-Directional Coax. Coup. 50-1000 MHz	Narda	3020A	Jan 18	Jan 22	141
Vertical coupling plate	TÜV NORD HFT	---	---	---	265
Measuring table	TÜV NORD HFT	---	---	---	106
Data line coupling network	EM Test AG	CNV 504/ 508	---	---	285
2 Generators					
EFT/Burst Generator	Schlöder	SFT 1400	Mai 20	Mai 22	46a
Hybrid Generator	Schlöder	CWG1500	Nov 19	Nov 21	522
ESD Generator	Schlöder	SESD 216	Oct 19	Oct 21	653
Signal Generator	Rohde & Schwarz	SMB100A	Jul 20	Jul 22	571
RF Generator	Rohde & Schwarz	SGT100A	Apr 20	Apr 22	636

Signal Generator	Rohde & Schwarz	SMG	Jun 21	Jun 23	136
Signal Generator	Marconi	2042	Mai 20	Mai 22	6
Signal Generator	Marconi	2024	Mai 20	Mai 22	213
Puls Generator	EM Test	MPG 200	Cal. before use	Cal. before use	181
Surge Generator	H+H	MIG063 IN S-T	Apr 21	Apr 23	561

3. Antennas

Loop Ant. 9kHz-30MHz	Schwarzbeck	FMZB1516	Sep 19	Sep 21	23
Biconical Ant. 30-300 MHz	Schwarzbeck	VHA9103/BBA9106	Apr 20	Apr 22	80/616
Double Ridged Horn	Schwarzbeck	BBHA9120C	Oct 19	Oct 21	169
Double Ridged Horn	Schwarzbeck	BBHA 9120A	Apr 20	Apr 22	284
Tri-Log Broadband	Schwarzbeck	VULB9168	Mai 21	Mai 23	406
Broadband Horn 14-40 GHz	Schwarzbeck	BBHA9170	Nov 19	Nov 21	442
Log Per Antenna 0.7-20 GHz	Schwarzbeck	STLP9148	Mai 21	Mai 23	445a
Bilog Ant.	Schwarzbeck	CBL6111	Cal. before use	Cal. before use	167
Balun with biconical BBA9106 (TX)	Schwarzbeck [only for NSA]	VHBB9124	Nov 19	Nov 21	0796
Balun with biconical BBA9106 (RX)	Schwarzbeck [only for NSA]	VHBA9123	Nov 19	Nov 21	9758
Log periodic Ant (TX)	Schwarzbeck [only for NSA]	UHALP9108	Nov 19	Nov 21	9002
Log periodic Ant (RX)	Schwarzbeck [only for NSA]	UHALP9108	Nov 19	Nov 21	9003
Spectrum analyser Mixer 220 – 325 GHz	Radiometer Physics	SAM325	Aug 19	Aug 21	591
Dual Mode Potter Horn 220-325 GHz	Radiometer Physics	325-WR2	---	---	592
Dual Mode Potter Horn 75-110 GHz	Radiometer Physics	---	---	---	649
Gain Horn Antenna 50-75 GHz	Dorado	GH-15-20	---	---	511
Standard Gain Horn 1.7 – 2.6 GHz	Narda	645	---	---	514
W-band active Sextupler with input drive amplifier	Spacek Labs Inc.	AW-6XW-0	---	---	221a
60 to 65 GHz active frequency quadrupler	Spacek Labs Inc.	A625-4XW-0	---	---	222a
Harmonic Mixer 40-60 GHz	Rohde & Schwarz	FS-Z60	Jul 19	Jul 21	515
Gain Horn Antenna 40-60 GHz	Dorado	GH-19-20	---	---	518
Spectrum analyser Mixer 90-140 GHz	Radiometer Physics	SAM140	Aug 19	Aug 21	545
Dual Mode Potter Horn 90-140 GHz	Radiometer Physics	140-WR8	---	---	547
Spectrum analyser Mixer 140-220GHz	Radiometer Physics	SAM220	Aug 19	Aug 21	450
Dual Mode Potter Horn 140-220 GHz	Radiometer Physics	220-WR5.1	---	---	548
Harmonic Mixer 60-90 GHz	Rohde & Schwarz	FS-Z90	Jul 19	Jul 21	501
Dual Mode Potter Horn 60-90 GHz	Radiometer Physics	90-W12	---	---	549
Gain Horn 33-55 GHz	Dorado	---	---	---	383
Gain Horn 50-75 GHz	Dorado	---	---	---	384
Gain Horn 75-110 GHz	Dorado	---	---	---	385
Standard Gain Ant. 26.5-40 GHz	Maury Microwave	U211C	---	---	532/628
Waveguide Harmonic Mixer 50 – 75 GHz	Keysight	M1971V	Oct 19	Oct 21	763
Waveguide Harmonic Mixer 75 – 110 GHz	Keysight	M1971W	Oct 19	Oct 21	764
Stacked Log.-Per. Antenna 70 MHz – 10 GHz	Schwarzbeck	STLP 9129	---	---	662

4. Amplifier

RF-Power Amplifier 250 kHz – 150 MHz	ENI	3100LA	---	---	---
RF pre-amplifier 100kHz-1.3GHz	HP	8447E	Aug 20	Aug 22	166a
Mitteq amplifier 26.5-40 GHz	Mitteq	---	Mar 20	Mar 22	223a
RF pre-amplifier 1-18GHz	Narda	---	Mar 20	Mar 22	345
Mitteq Amplifier 18-26GHz	Mitteq	---	Apr 20	Apr 22	433
Microwave amplifier 12-18GHz	Schwarzbeck	BBV9719	Mar 20	Mar 22	443
Microwave amplifier 0.5-18GHz	Schwarzbeck	BBV9718	Apr 21	Apr 23	444
RF-Power Amplifier 10kHz-1000 MHz	Poetschke	8100 (Band 1) BHED (Band 2)	---	---	684

		BHED (Band 3)			
RF-Power Amplifier 800 MHz – 4,2 GHz	Amplifier Research	10S1G4	---	---	685
RF-Power Amplifier 4 GHz – 8 GHz	Amplifier Research	35S4G8A	---	---	686
5. Power supplies					
Programmable Power Supply	Fluke	PM 2813	---	---	28a
Power Supply	HP	---	---	---	125
Power Supply	Sorensen	LM 30-6	---	---	134a
Power Supply	HP	6034L	---	---	226
Regulated Power Supply	Farnell	AP60-50	---	---	408
Power Supply	EA	PSI 8080-40-DT	---	---	560
Power Supply	HP	6032A	---	---	644
6. Meters					
Microwave Frequency Counter	Hewlett-Packard	5351B	Nov 20	Nov 22	432
Temperature test cabinet	Heraeus Vötsch	VMT04/35	---	---	102a
Temperature test cabinet	Brabender	TTE 32/40 H	---	---	87
Digital-Hygro-Thermometer	Greisinger	GFTH95	Nov 19	Nov 21	57a
Volt & RF Power Meter	Rohde & Schwarz	URV35	Cal. before use	Cal. before use	161
Spectrum Analyzer - 9 kHz – 18 GHz	Rohde & Schwarz	FSL18	Jul 20	Jul 22	171a
Multimeter	Gossen Metrawatt	Metrahit pro	Nov 19	Nov 21	215a
Humidity/Temperature Measuring device	TESTO	Testo 625	Oct 19	Oct 21	259a
Volt & RF Power Meter	Rohde & Schwarz	URV35	Nov 19	Nov 21	271
Multimeter	Gossen Metrawatt	Metrahit 26S	Sep 20	Sep 22	313
Level and Power Meter - 9 kHz – 3 GHz	Rohde & Schwarz	URY	Mar 20	Mar 22	307
Temperature test device	Ahlhorn	Almemo 2390-5 PT100	Mar 20	Mar 23	401/402
Signal & Spectrum Analyser 10 Hz-30 GHz	Rohde & Schwarz	FSV-30	Jul 19	Jul 21	502
Digital-Vacuum-/Barometer	Greisinger	GDH12AN	Oct 19	Oct 21	558
Temperature test cabinet	Weiß Umwelttechnik	WKL 34/40	Aug 18	Aug 21	562
Digital Storage Oscilloscope	Tektronix	TDS 2012C	Oct 19	Oct 21	568
Miniature Flat, Zero-Biased Schottky Detector -0.1– 18 GHz	Narda	4503A-03	Val. bevor use	Val. bevor use	613
Digital-Vacuum-/Barometer	Greisinger	GDH-200-14	Oct 19	Oct 21	632
EMI Test receiver ESW26	Rohde & Schwarz	R&S ESW26 (SN: 101383/26 SW: R&S ESW1.61))	Nov 19	Nov 21	665
Signal analyser Keysight 50GHz	Keysight	UXA N9040B (SN: MY57213006 SW: A.24.58/2019.0702)	Nov 19	Nov 21	666
7. test/control software					
EMC32	Rohde & Schwarz	V10.60.20	---	---	---
Maturo mcApp	Maturo	SW: V3.4.9.4537 (19.04.04)	---	---	---
SPS EMC	Spitzenberger & Spies	SW: V4.1.3	---	---	---
EMV-Soft	Schlöder GmbH	SW: V11.95	---	---	---
ISMISO	EM Test AG	SW:V3.63	---	---	---

11. List of test cables

Internal Cable Number	Connector Type	Frequency Range (MHz)	Cable Length (m)	Manufacturer
3	N	0,5 - 8000	3	Cellflex
4	N	0,5 - 8000	3	Cellflex
4a	BNC	10 – 1500	0.50	Telemeter
14a	BNC	10 – 1000	1.00	Telemeter
17a	APC3.5	10 – 26500	2.13	Huber + Suhner
18a	APC3.5	10 – 26500	2.13	Huber + Suhner
22	BNC	10 – 1000	1.50	---
27	BNC	10 – 1000	1.00	Fabrica Milanese Cond.
40	BNC	---	0.50	Aircell
43	SMA	10 – 18000	0.50	Rosenberger
44	SMA	---	0.50	Huber + Suhner
45	SMA	10 – 18000	0.50	Huber + Suhner
48	SMA	---	0.50	Huber + Suhner
49	N	10 – 18000	1.00	Huber + Suhner
50	N	10 – 18000	1.00	Huber + Suhner
51	N	10 – 18000	1.00	Huber + Suhner
52	N	10 – 18000	1.00	Huber + Suhner
54	BNC	10 – 3500	1.00	Aircell
58	N	10 – 18000	2.00	Huber + Suhner
59	N	10 – 18000	1.00	Huber + Suhner
60	N	10 – 18000	2.00	Huber + Suhner
61	N	10 – 18000	1.00	Huber + Suhner
62	SMA	---	0.50	Huber + Suhner
63	SMA	10 – 18000	0.50	Huber + Suhner
64	SMA	10 – 18000	0.50	Huber + Suhner
65	APC3.5	10 – 26500	0.60	---
66	APC3.5	10 – 26500	0.60	---
67	APC3.5	10 – 26500	0.60	---
68	APC3.5	10 – 26500	0.60	---
72	BNC	---	0.40	---
73	BNC	---	0.40	---
76	SMA	10 – 30000	3.00	Gore
79	BNC/N	10 – 1000	5.00	---
80	SMA	---	0.25	Huber + Suhner
87	SMA	10 – 18000	0.15	Huber + Suhner
88	SMA	10 – 18000	0.15	Huber + Suhner
89	SMA	10 – 18000	0.15	Huber + Suhner
90	SMA	10 – 18000	0.15	Huber + Suhner
91	SMA	---	1.50	Huber + Suhner
94	BNC	---	1.10	---
95	BNC	---	0.80	---
96	BNC	---	0.80	---
100	N	10 – 26500	6.00	Rosenberg
101	N	10 – 18000	2.90	Huber + Suhner
102	SMA	10 – 18000	2.00	Huber + Suhner
111	BNC	10 – 1000	0.50	---
112	BNC	10 – 1000	0.50	---
114	SMA	10 – 18000	0.25	Huber + Suhner
116	SMA	10 – 18000	0.25	Huber + Suhner
119	N	10 – 20000	8.00	Jyebao
121	SMA	10 – 18000	1.50	Huber + Suhner
122	SMA	10 – 18000	2.00	Huber + Suhner
123	SMA	10 – 18000	2.00	Huber + Suhner

Internal Cable Number	Connector Type	Frequency Range (MHz)	Cable Length (m)	Manufacturer
145	SMA	10 – 26500	8.00	Huber + Suhner
147	APC3.5	10 – 40000	1.50	Jyebao
148	APC3.5	10 – 40000	3.00	Jyebao
151	SMA	10 – 18000	0.50	Rosenberger
152	SMA	10 – 18000	0.50	Rosenberger
154	BNC	10 – 1000	1.00	---
155	N/BNC	---	0.85	---
157	BNC	---	0.50	---
158	SMA	10 – 26500	2.00	Huber + Suhner
160	SMA	10 – 18000	0.40	Nortel Networks
161	SMA	10 – 18000	1.00	Huber + Suhner
162	APC35	10 – 26500	2.00	Huber + Suhner
163	APC3.5	10 – 26500	2.00	Huber + Suhner
164	APC3.5	10 – 26500	2.00	Huber + Suhner
165	APC2.9	10 – 26500	2.00	Huber + Suhner
166	APC3.5	10 – 40000	---	---
167	APC3.5	10 – 40000	1.00	Jyebao
168	APC3.5	10 – 40000	1.00	Jyebao
169	APC3.5	10 – 40000	1.00	Jyebao
170	APC3.5	10 – 40000	1.00	Jyebao
171	APC3.5	10 – 40000	1.00	Jyebao
172	SAM	---	0.90	Huber + Suhner
173	APC	10 – 26500	2.00	Huber + Suhner
174	APC	10 – 26500	---	Huber + Suhner
175	SMA	10 – 18000	0.40	Huber + Suhner
176	N-SMA	10 – 18000	0.50	Huber + Suhner
188	N	10 – 18000	5.00	Huber + Suhner
EMV 1	BNC	---	2.00	Henn
EMV 2	BNC	10 – 1000	2.00	Henn
EMV 4	BNC	---	9.70	Henn
EMV 5	BNC	---	3.80	Henn
EMV 6	BNC/N	10 – 1000	5.00	Lüthi
EMV 7	BNC	10 – 1000	1.50	Henn
EMV 8	BNC	10 – 1500	1.70	Henn
EMV 9	BNC	10 – 1000	1.70	Henn
EMV 11	BNC	---	5.20	Hasselt
EMV 12	BNC	10 – 1000	2.40	Hasselt
EMV 13	BNC	10 – 1000	4.10	Hasselt
EMV 14	BNC	10 – 1000	2.50	Hasselt
EMV 15	BNC	---	0.90	Henn
EMV 16	Fischer	---	2.00	---
EMV 18a	Fischer	---	1.00	---
EMV 19a	Fischer	---	1.50	---
KISN2	BNC	10 – 2000	4.80	---

End of test report