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FCC Test report for parts 15.107, 15.109 and 15.207, 15.209, 15.247

Product name : iotspot LTE-M

Applicant : iottum B.V.

FCC ID : 2AYAIIEM02

Test report No. : 200101624 002 v1.00

Laboratory information

Accreditation

Telefication complies with the accreditation criteria for test laboratories as laid down in ISO/IEC 17025:2017. The accreditation covers the quality system of the laboratory as well as the specific activities as described in the authorized annex bearing the accreditation number L021 and is granted on 30 November 1990 by the Dutch Council For Accreditation (RvA: Raad voor Accreditatie).

Telefication is designated by the FCC as an Accredited Test Firm for compliance testing of equipment subject to Certification under Parts 15 & 18. The Designation number is: NL0001.

Telefication is a registered Conformity Assessment body (CAB) under the Japan-EC MRA (Agreement on Mutual Recognition between Japan and the European Community). The registration number is: 201.

Documentation

The test report must always be reproduced in full; reproduction of an excerpt only is subject to written approval of the testing laboratory. The documentation of the testing performed on the tested devices is archived for 10 years at Telefication Netherlands.

Testing Location

Test Site	Telefication BV
Test Site location	Edisonstraat 12a 6902 PK Zevenaar The Netherlands Tel. +31316583180 Fax. +31316583189
Test Site FCC	NL0001

Revision History

Version	Date	Remarks	By
v0.50	13-12-2020	First draft	RvB
v1.00	08-02-2021	Release version	RvB

Table of Contents

Summary of Test results

FCC	Description	Section in report	Verdict
15.247(d) 15.209 (a)/15.209	Radiated spurious emissions	3.1	Pass
15.205 (a)	Spurious emissions in the restricted bands	3.1	Pass
15.247 (a)	6 dB bandwidth	3.2	Pass
15.247 (b)	RF output power	3.3	Pass
15.247 (e)	Power spectral density	3.4	Pass
15.247 (d)	Band edge	3.5	Pass
15.207 (c)/15.107	Conducted spurious emissions on AC mains	3.6	Pass

1 General Description

1.1 Applicant

Client name:	iottum B.V.
Address	Veemarktkade 8, 5222 AE, 's-Hertogenbosch, The Netherlands.
Zip code:	5221 LC
E-mail:	marnix@iotspot.co
Contact name:	Mr. M. Lankhorst

1.2 Manufacturer

Manufacturer name:	iottum B.V.
Address:	Veemarktkade 8, 5222 AE, 's-Hertogenbosch, The Netherlands.
Zip code:	5221 LC
E-mail:	marnix@iotspot.co
Contact name:	Mr. M. Lankhorst

1.3 Tested Equipment Under Test (EUT)

Product name:	iotspot LTE-M
Brand name:	iotspot
Product type:	iotspot LTE-M is an on-premise, low-voltage powered device that transmits and receives GSM and Bluetooth signals, transmits passive NFC signals and emits LED light
Variant model(s):	--
Software version:	--
Hardware version:	--
Date of receipt:	27-01-2020
Tests started:	20-02-2020
Testing ended:	03-08-2020

1.4 Product specifications of Equipment under test

Tx Frequency:	BLE: 2400 – 2483.5 MHz
Rx frequency:	BLE: 2400 – 2483.5 MHz
Antenna type:	Chip Antenna
Antenna gain (dBi):	0.5
Type of modulation:	GFSK
Emission designator	1M02G1D

1.5 Environmental conditions

Test date	20-02-2020	29-07-2020	03-08-2020
Ambient temperature	22.4°C	22.1°C	24.8°C
Humidity	44.8%	36.4%	49.2%

1.6 Measurement standards

- ANSI C63.4:2014
- ANSI C63.10:2013

1.7 Applicable standards

According to the specifications of the manufacturer, the EUT must comply with the requirements of the following standards:

- FCC Part 15 Subpart C §15.207
- FCC Part 15 Subpart C §15.209
- FCC Part 15 Subpart C §15.247
- FCC Part 15 Subpart B §15.107
- FCC Part 15 Subpart B §15.109

1.8 Observation and remarks

The conducted spurious emissions were measured with the supplied AC to USB Adapter .

1.9 Conclusions

The sample of the product showed NO NON-COMPLIANCES to the specifications stated in paragraph 1.7 of this report.

The results of the test as stated in this report, are exclusively applicable to the product items as identified in this report. Telefication accepts no responsibility for any properties of product items in this test report, which are not supported by the tests as specified in paragraph 1.7 *"Applicable standards".*

All conducted tests are performed by:

Name : ing. R. van Barneveld

Review of test methods and report by:

Name : P. van Wanrooij, BASc

The above conclusions have been verified by the following signatory:

Date : 11-02-2021

Name : P. van Wanrooij

Function : Test Engineer

Signature :

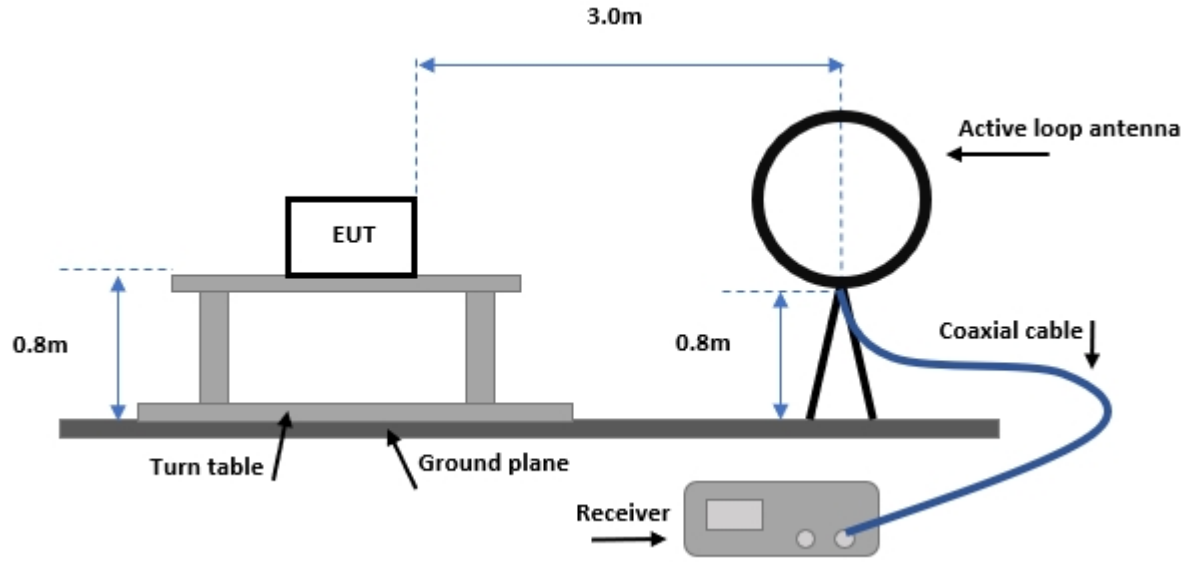
2 Test configuration of the Equipment Under Test

2.1 Test mode

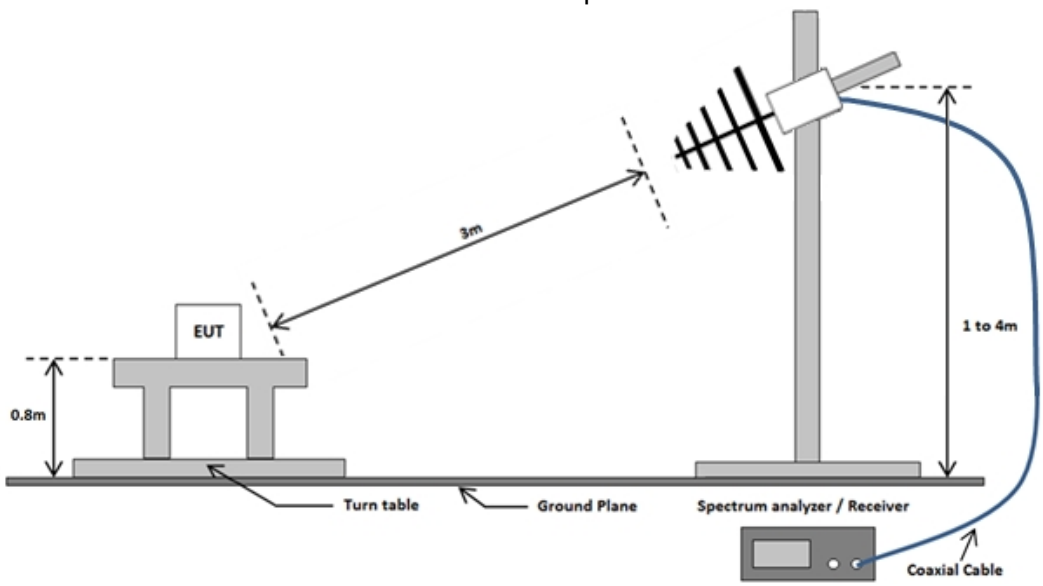
The applicant provided test mode firmware for the BLE radio, in which it was possible to configure the radio to transmit continuously.

2.2 Test setups

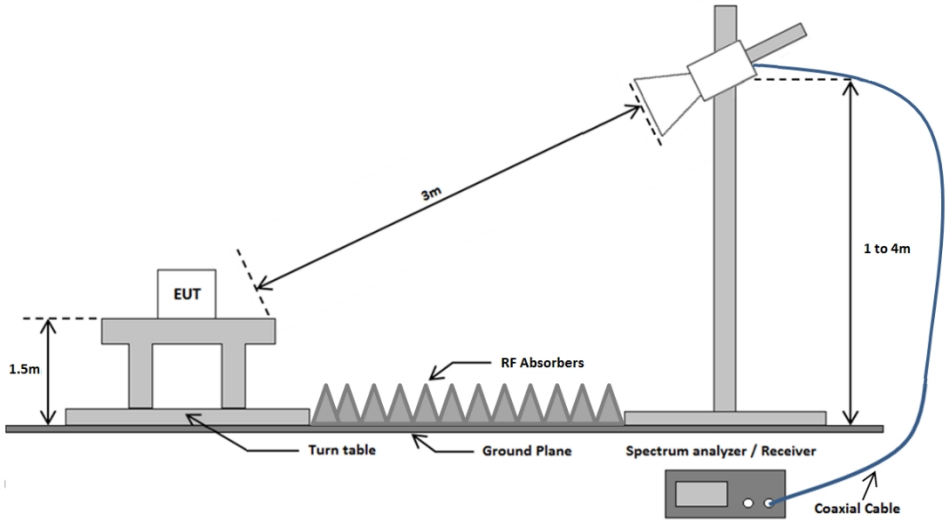
Radiated emissions test setup 9 kHz – 30 MHz



Radiated emissions test setup 30 MHz - 1 GHz

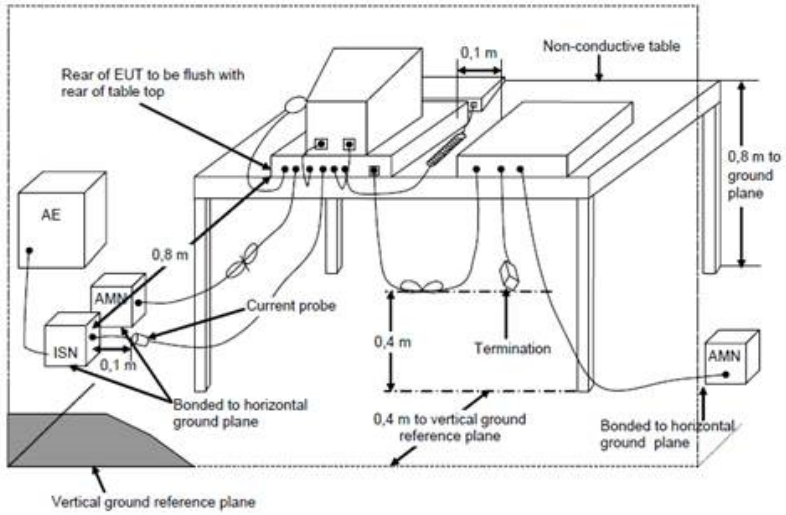


Radiated emissions test setup above 1 GHz



Conducted emissions test setup

Emissions test at AC mains



2.3 Equipment used in the test configuration

Description	Manufacturer	Model	ID	Used at Par.
Spectrum analyzer	Rohde & Schwarz	FSV40	TE 01269	3.2 – 3.5
Spectrum analyzer	Rohde & Schwarz	FSP40	TE 11125	3.1
Measurement receiver	Rohde & Schwarz	ESR7	TE 01220	3.1/ 3.6
Active loop antenna	EMCO	6502	TE11171	3.1
Biconilog antenna	Chase	CBL6112A	TE 00967	3.1
Horn antenna	EMCO	3115	TE 00531	3.1
Preamplifier	µComp Nordic	MCNA-40-0010800-25-10P	TE11175	3.1
Preamplifier	Miteq	JS4-18004000-33-8P	TE11131	3.1
Semi-Anechoic room	COMTEST	SAR	TE 00861	3.1

2.4 Sample calculations

All formulas for data conversions and conversion factors are reported in chapter 4 of this test report.

3 Test results

3.1 Radiated spurious emissions

3.1.1 Limit

Frequency (MHz)	Field strength (µV/m)	Field strength (dBµV/m)	Measurement distance(m)
0.009 – 0.490	2400/F(kHz)	20*{log[2400]-log[F(kHz)]}	300*
0.490 – 1.705	24000/F(kHz)	20*{log[24000]-log[F(kHz)]}	30*
1.705 – 13.11 14.01 – 30.0	30	29.5	30*
30 -88	100	40	3
88 - 216	150	43,5	3
216-960	200	46	3
Above 960	500	54	3

*Note: Limit lines in the plots corrected to 3m measurement distance according to the method described in ANSI C63.10-2013, clause 6.4

3.1.2 Measurement instruments

The measurement instruments are listed in chapter 2.3 of this report.

3.1.3 Test setup

The test setup is as shown in chapter 2.2 of this report.

3.1.4 Test procedure

9 kHz – 30 MHz: According to ANSI C63.4-2014, section 5.4.2 and 8.2.3
30 MHz to 26.5 GHz: According to ANSI C63.4-2014, section 8.3

9 kHz to 30 MHz: IRN 026 – Method 10
30 MHz to 1 GHz: IRN 026 – Method 1
1 GHz to 18 GHz: IRN 026 – Method 2
18 to 26.5 GHz: IRN 026 – Method 3

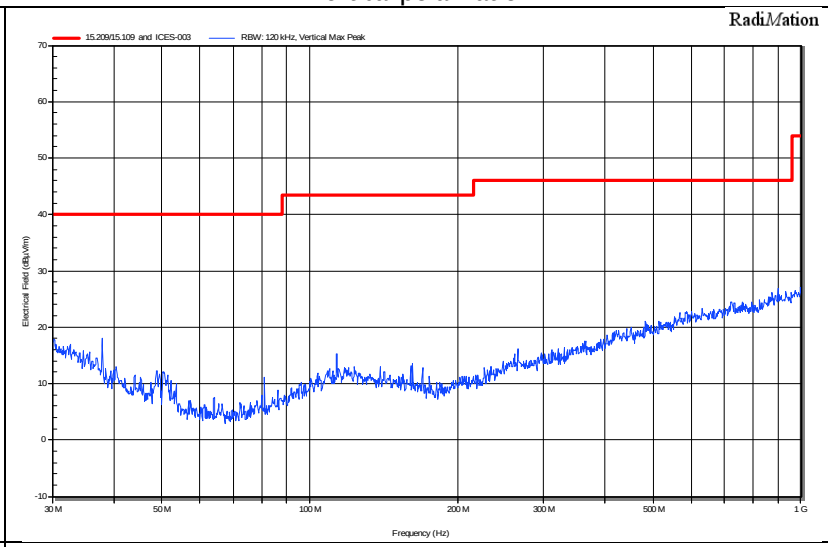
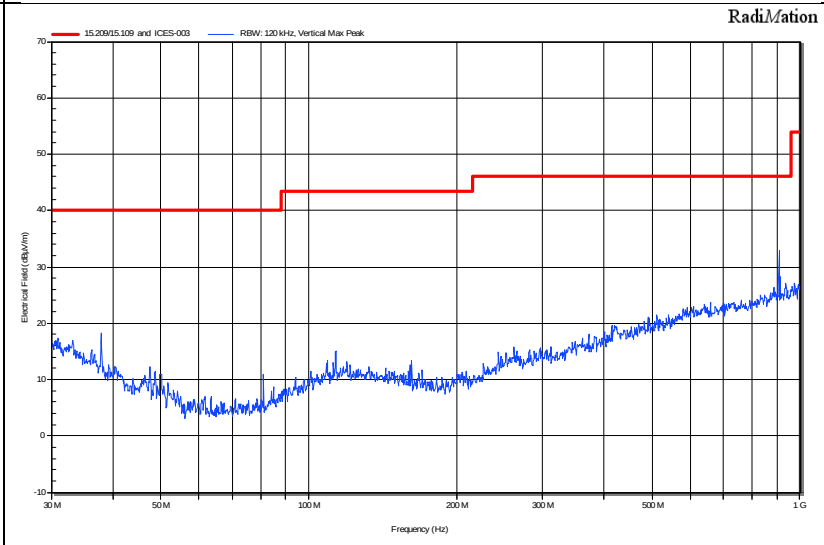
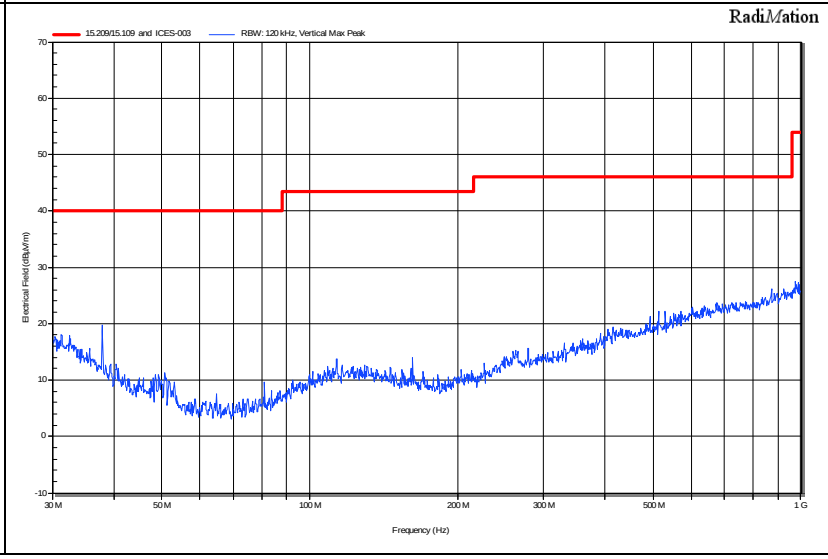
3.1.5 Measurement Uncertainty

Frequency range	Polarization	Uncertainty
9 kHz – 30 MHz	--	±1.6 dB
30 – 200 MHz	Horizontal	±4.5 dB
	Vertical	±5.4 dB
200 -1000 MHz	Horizontal	±3.6 dB
	Vertical	±4.6 dB
1 – 18 GHz	Horizontal	±5.7 dB
	Vertical	±5.7 dB
18 – 26.5 GHz	Horizontal	±4.9 dB
	Vertical	±4.9 dB

3.1.6 Plots of the Radiated Spurious Emissions Measurement

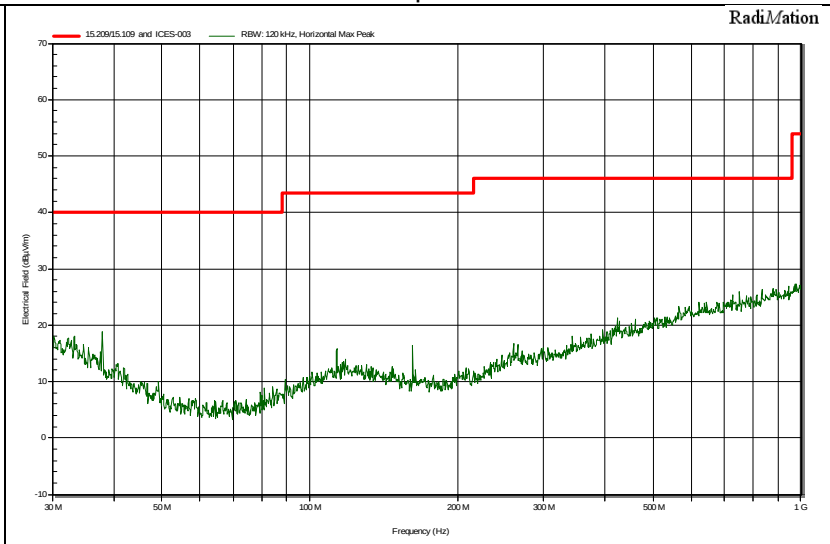
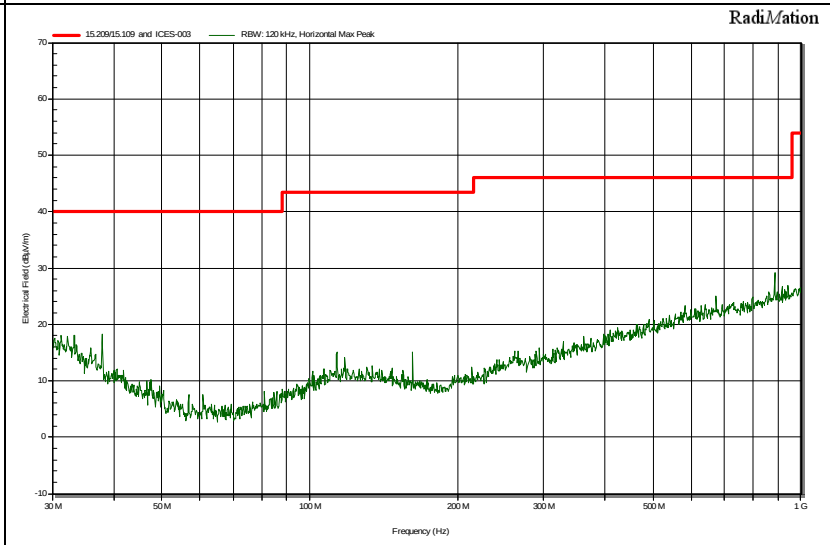
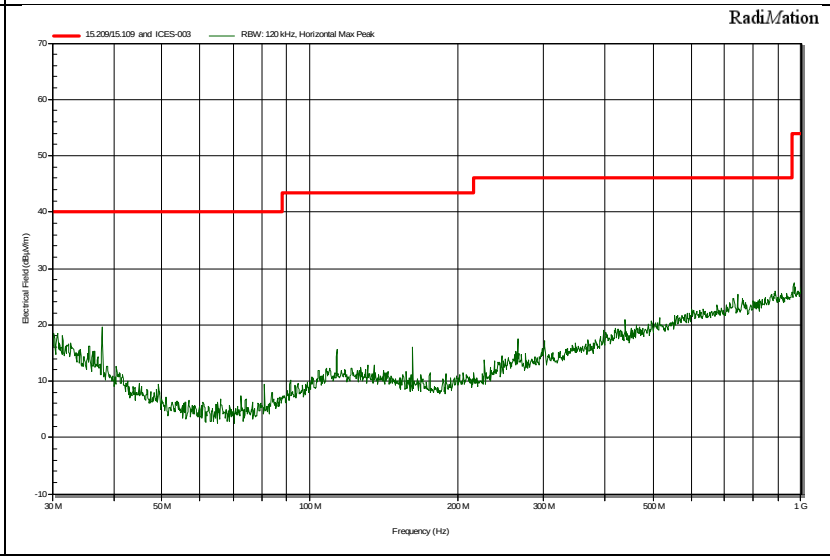
30 MHz to 1 GHz

Vertical polarization

Low ch	
Mid ch	
High ch	

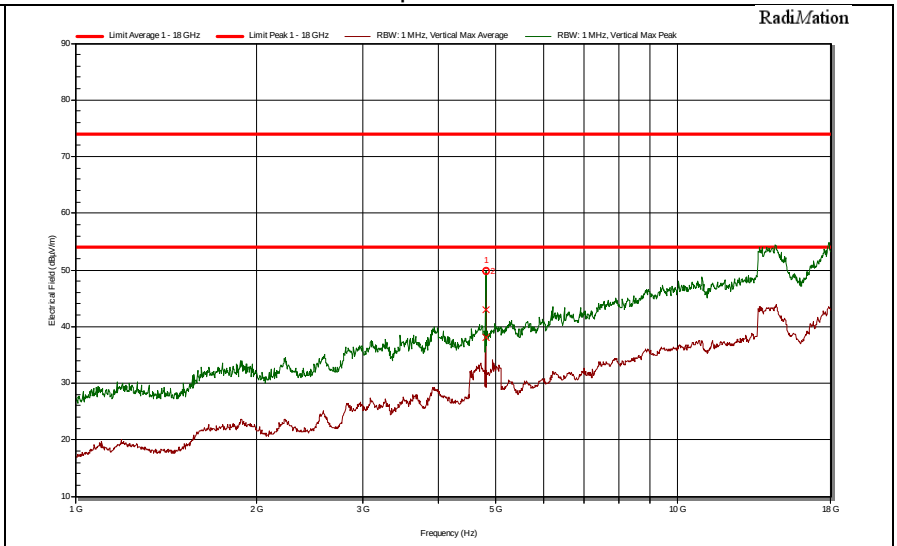
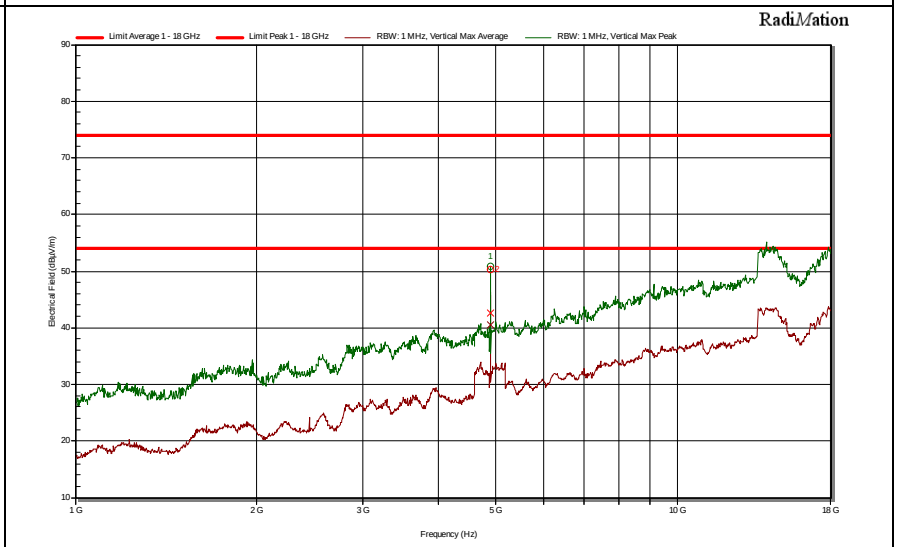
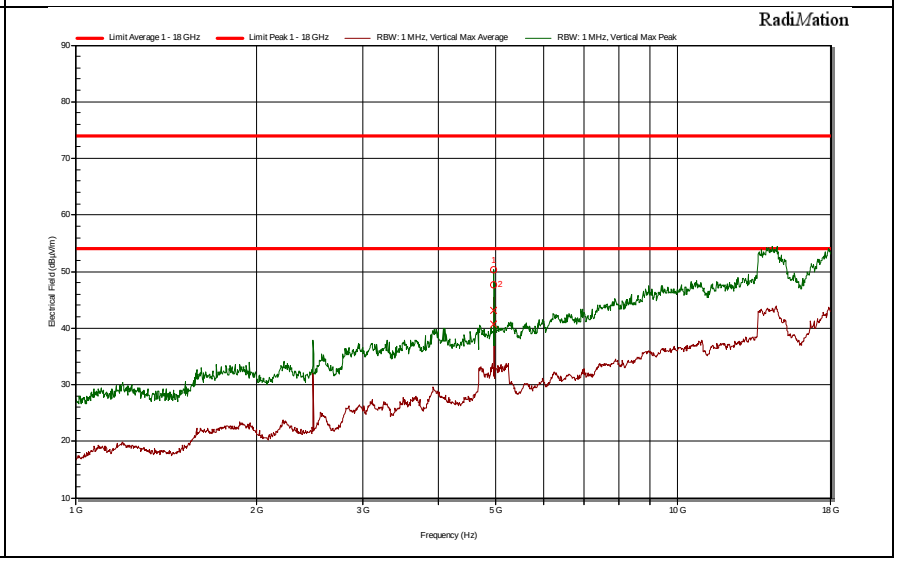
30 MHz to 1 GHz

Horizontal polarization

Low ch	
Mid ch	
High ch	

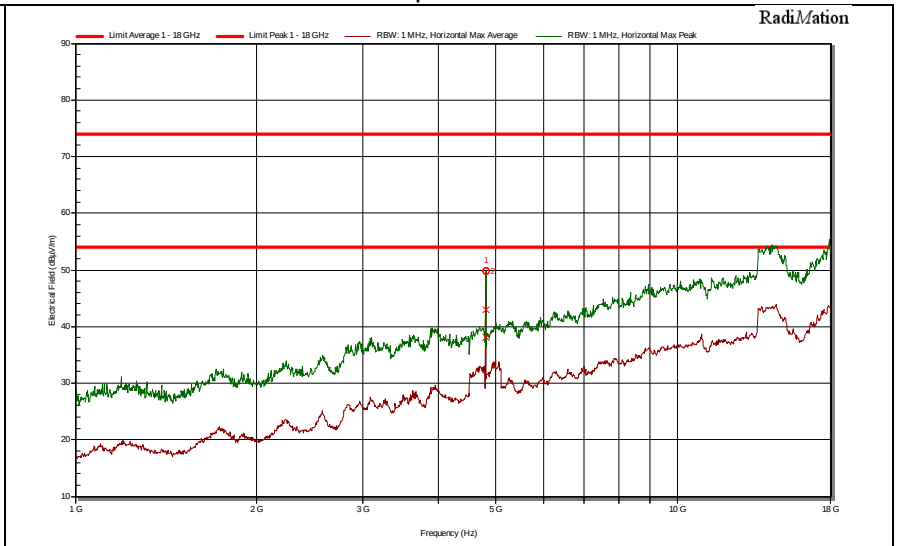
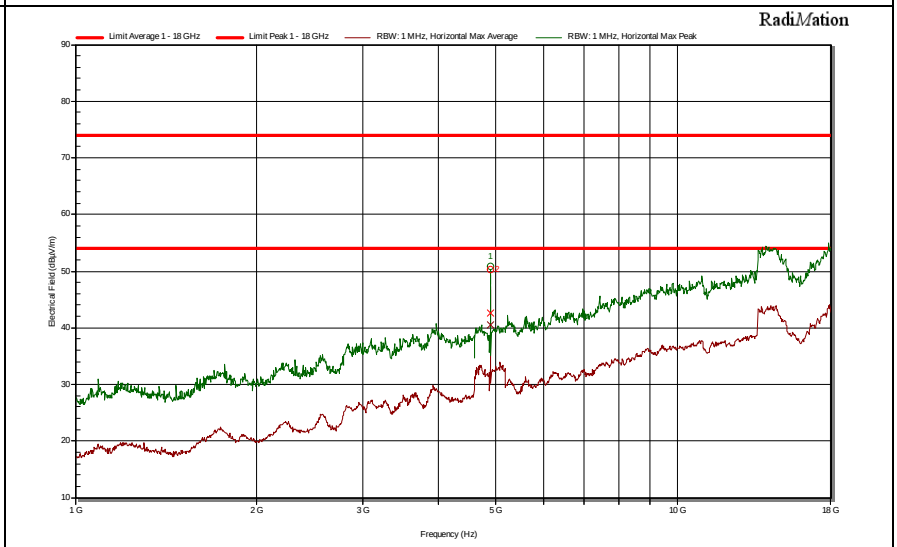
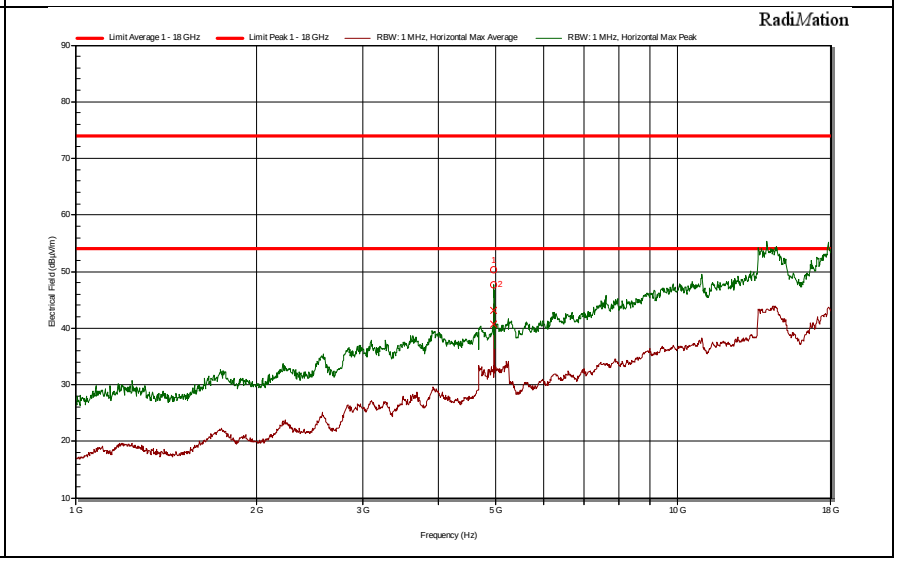
1 GHz to 18 GHz

Vertical polarization

Low ch	
Mid ch	
High ch	

1 GHz to 18 GHz

Horizontal polarization

Low ch	
Mid ch	
High ch	

Measured Peaks 1-18 GHz
Low channel

Frequency	Peak	Peak Limit	Average	Average Limit	Status	Angle	Height	Polarization
4,804 GHz	49,9 dBµV/m	74 dBµV/m	43 dBµV/m	54 dBµV/m	Pass	246 degrees	1,2 m	Horizontal
4,803 GHz	49,7 dBµV/m	74 dBµV/m	38,1 dBµV/m	54 dBµV/m	Pass	358 degrees	3 m	Vertical

Middle channel

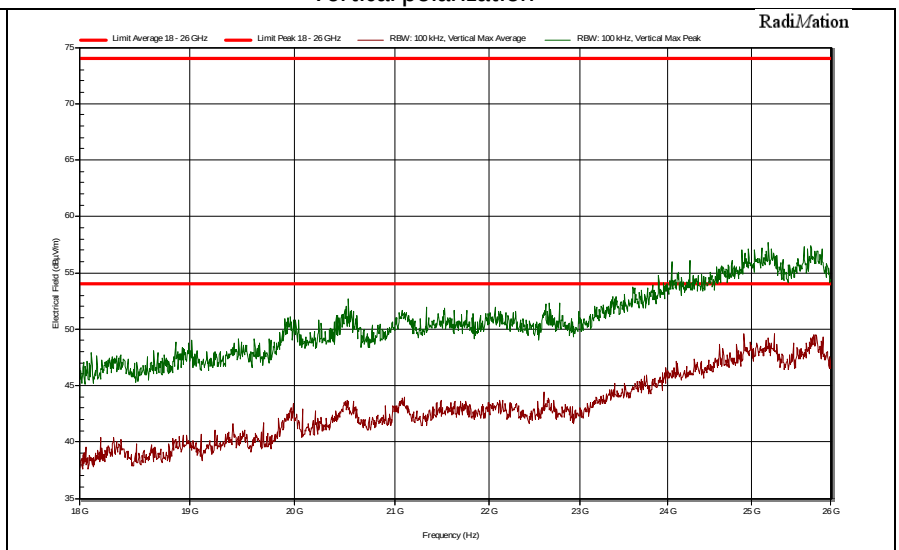
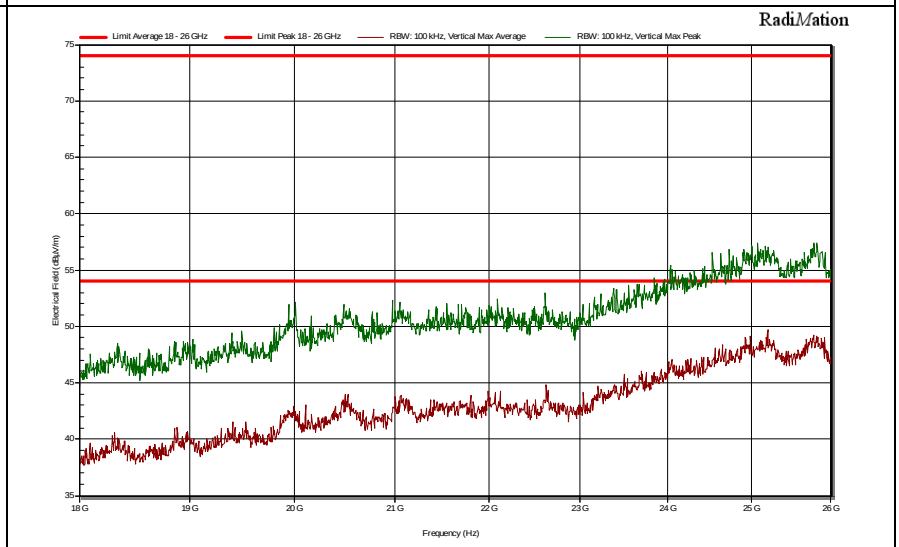
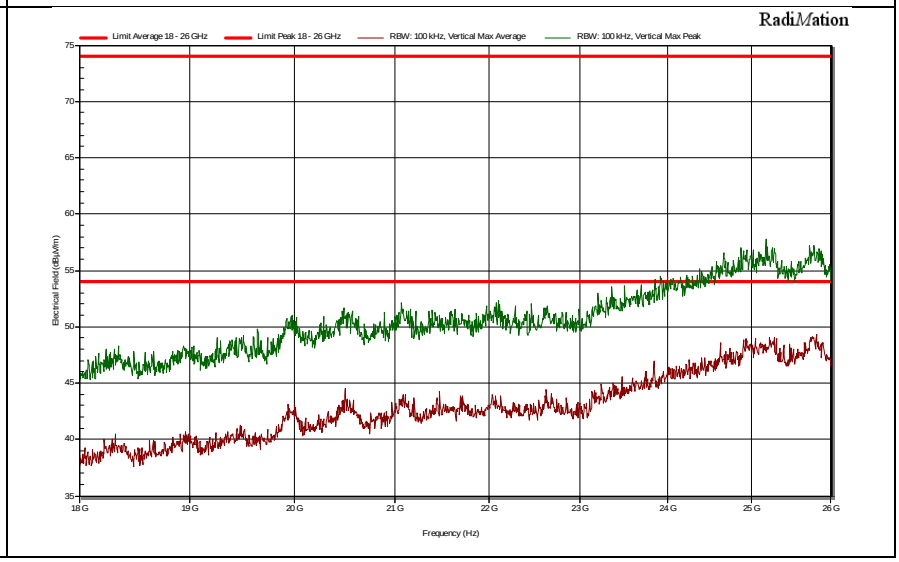
Frequency	Peak	Peak Limit	Average	Average Limit	Status	Angle	Height	Polarization
4,888 GHz	50,9 dBµV/m	74 dBµV/m	40,5 dBµV/m	54 dBµV/m	Pass	79 degrees	3,1 m	Vertical
4,888 GHz	50,3 dBµV/m	74 dBµV/m	42,6 dBµV/m	54 dBµV/m	Pass	55 degrees	1 m	Horizontal

High channel

Frequency	Peak	Peak Limit	Average	Average Limit	Status	Angle	Height	Polarization
4,96 GHz	50,2 dBµV/m	74 dBµV/m	43,1 dBµV/m	54 dBµV/m	Pass	145 degrees	4 m	Vertical
4,961 GHz	47,6 dBµV/m	74 dBµV/m	40,7 dBµV/m	54 dBµV/m	Pass	341 degrees	1 m	Horizontal

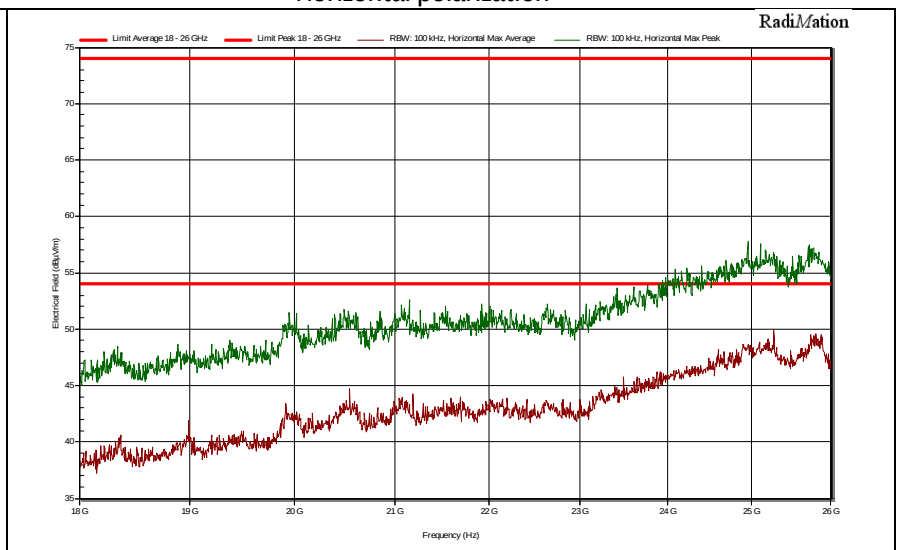
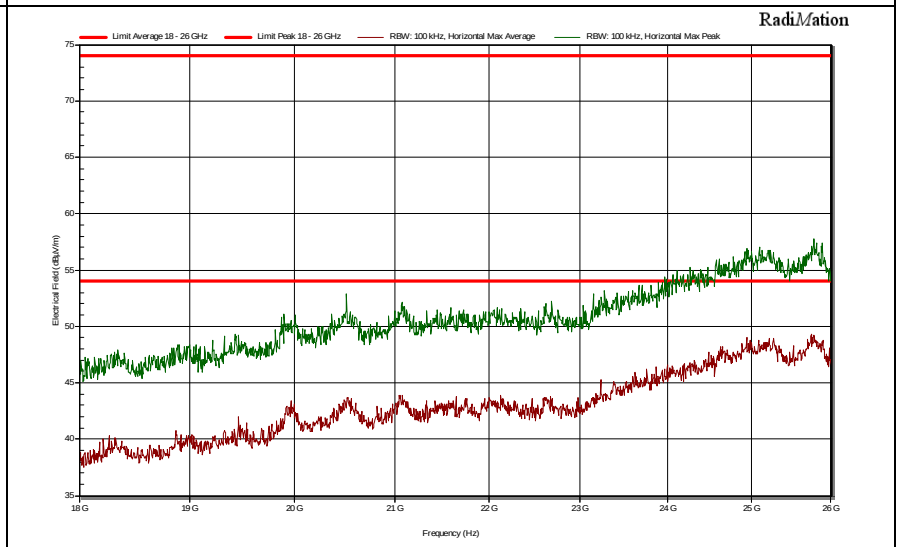
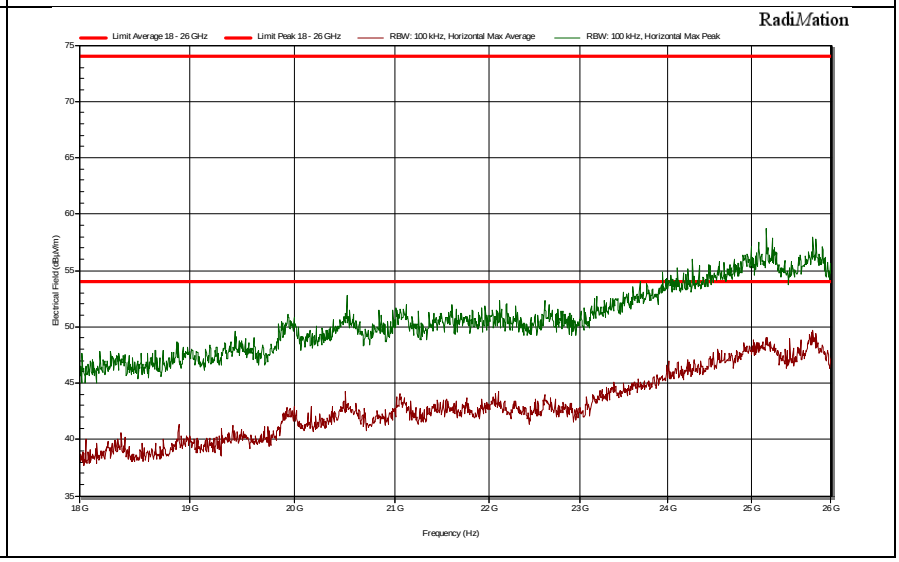
18 GHz to 26 GHz

Vertical polarization

Low ch	
Mid ch	
High ch	

18 GHz to 26 GHz

Horizontal polarization

Low ch	
Mid ch	
High ch	

3.2 6dB bandwidth Measurement

3.2.1 Limit

The minimum 6 dB Bandwidth shall be at least 500 kHz.

3.2.2 Measurement instruments

The measurement instruments are listed in chapter 2.4 of this report.

3.2.3 Test setup

The test setup is as shown in chapter 2.3 of this report.

3.2.4 Test procedure

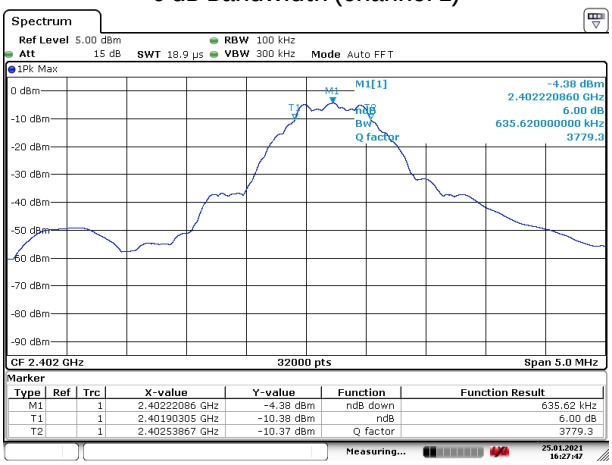
Tests according to ANSI C63.10
IRN 017 - Occupied bandwidth (Hz) Method 4 – DTS Bandwidth.

3.2.5 Test Results of the 6 dB bandwidth Measurement

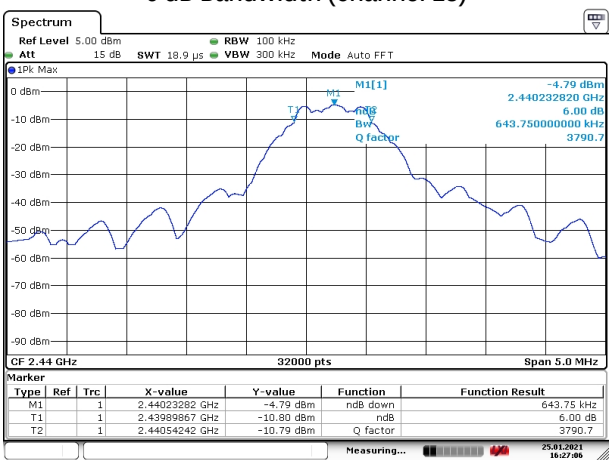
Technology Std.	Channel	Frequency (MHz)	Data rate	6dB bandwidth (kHz)
Bluetooth Low energy	1	2402	1 Mbps	635.6
	18	2440	1 Mbps	643.8
	39	2480	1 Mbps	647.2
Uncertainty	± 36.2 kHz			

3.2.6 Plots of the 6 dB bandwidth Measurement

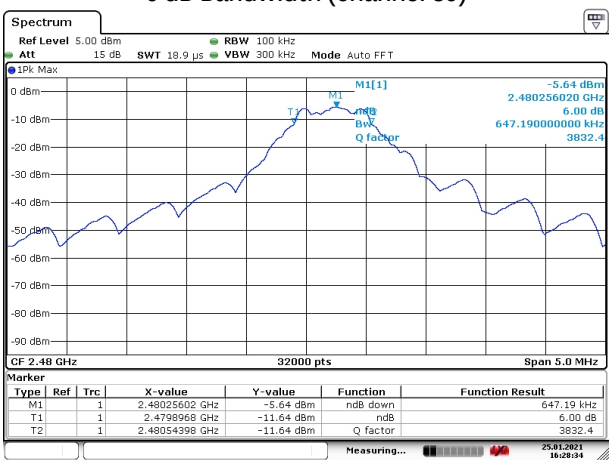
6 dB Bandwidth (Channel 1)



6 dB Bandwidth (Channel 18)



6 dB Bandwidth (Channel 39)



3.3 Output Power Measurement

3.3.1 Limit

For systems using digital modulation in the 2400-2483.5 MHz, the limit for the peak output power is 30 dBm. If transmitting antenna of directional gain greater than 6 dBi is used, the peak output power from the intentional radiator shall be reduced below the above stated value by the amount in dB that the directional gain of the antenna exceeds 6 dBi. In case of point to point operation, the limit has to be reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi.

3.3.2 Measurement instruments

The measurement instruments are listed in chapter 2.4 of this report.

3.3.3 Test setup

The test setup is as shown in chapter 2.3 of this report.

3.3.4 Test procedure

The testing follows FCC KDB Publication No. 558074 D01 DTS Meas. Guidance v05.
IRN 014 - RF power (W) - Method 1 – AVGSA (DTS) according to ANSI C63.10.

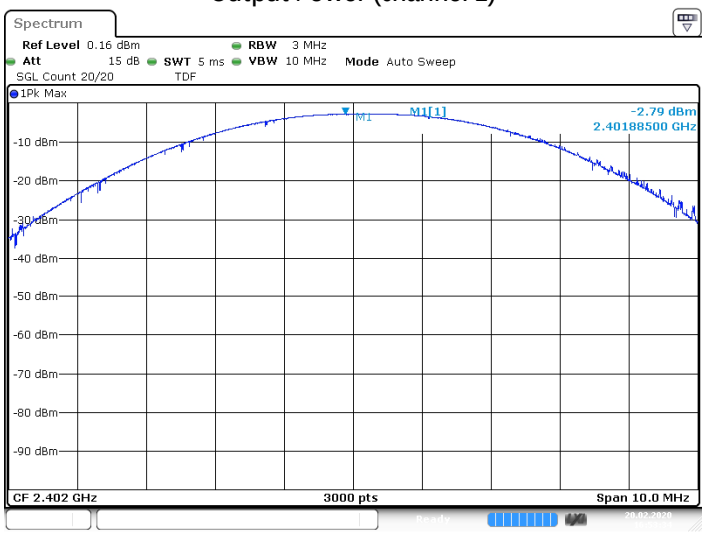
3.3.5 Test results of Output Power Measurement

Peak method

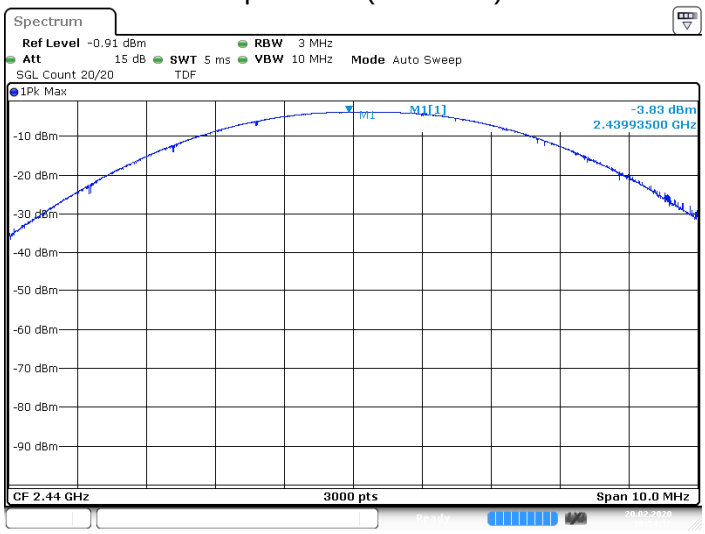
Technology Std.	Channel	Frequency (MHz)	Data rate	Peak output power (dBm)
Bluetooth Low Energy	1	2402	1 Mbps	-2.79
	18	2440	1 Mbps	-3.83
	39	2480	1 Mbps	-5.77
Uncertainty	±0.71 dB			

3.3.6 Plots of Output Power Measurement

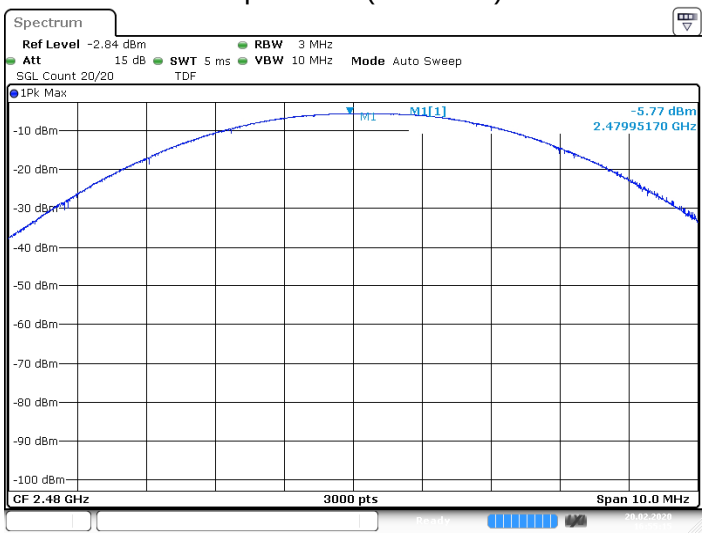
Output Power (channel 1)



Output Power (channel 18)



Output Power (channel 39)



3.4 Power Spectral Density

3.4.1 Limit

The peak power spectral density shall not be greater than 8 dBm in any 3 kHz band at any time interval of continuous transmission.

3.4.2 Measurement instruments

The measurement instruments are listed in chapter 2.4 of this report.

3.4.3 Test setup

The test setup is as shown in chapter 2.3 of this report.

3.4.4 Test procedure

The testing follows FCC KDB Publication No. 558074 D01 DTS Meas. Guidance v05.
IRN 030 - Spectral power density (W per n.Hz) - Method 5 – Peak method PKPSD (PSD in 3 kHz band)

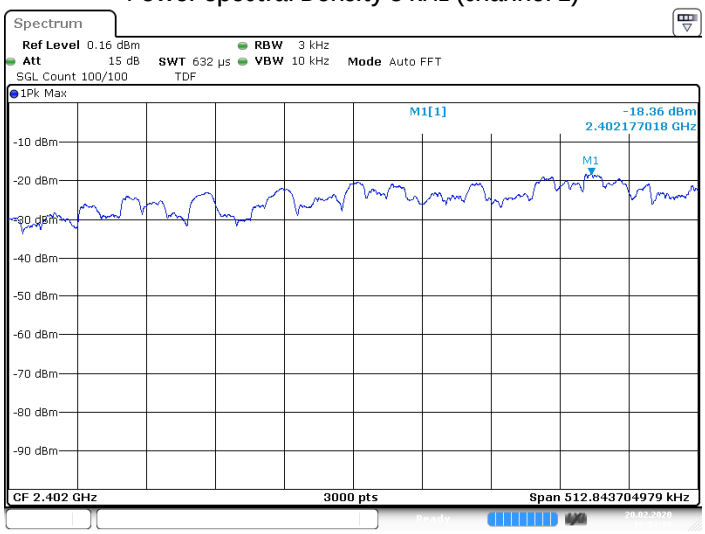
3.4.5 Test results of Power Spectral Density Measurement

Peak Power spectral density

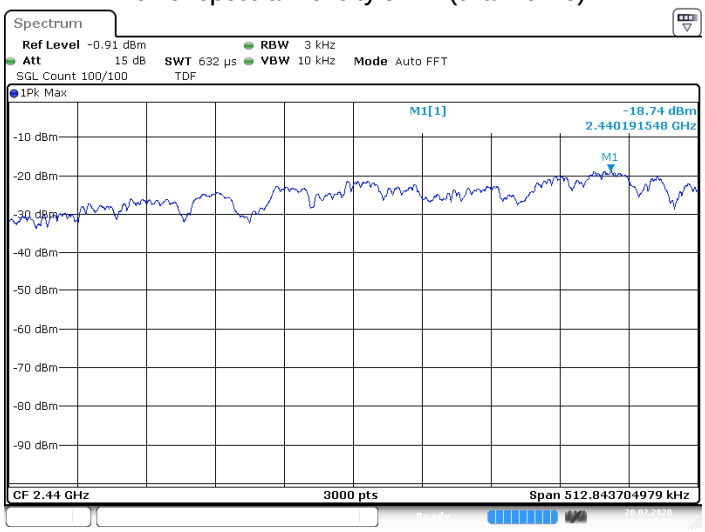
Technology Std.	Channel	Frequency (MHz)	Data rate	PSD (dBm/3 kHz)
Bluetooth Low Energy	1	2402	1 Mbps	-18.36
	18	2440	1 Mbps	-18.74
	39	2480	1 Mbps	-20.90
Uncertainty	±2 dB			

3.4.6 Plots of the Power Spectral Density Measurements

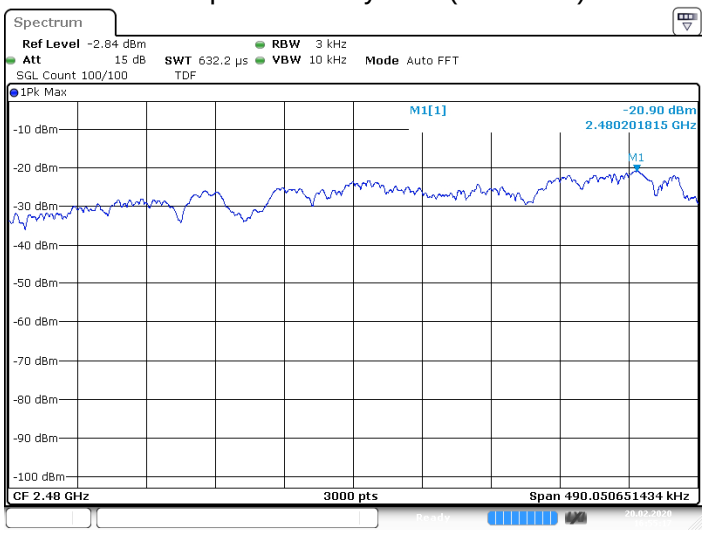
Power Spectral Density 3 kHz (channel 1)



Power Spectral Density 3 kHz (channel 18)



Power Spectral Density 3 kHz (channel 39)



3.5 Band edge Measurement

3.5.1 Limit

Band edge:
At the edge of the authorized band the RF power shall be at least 20 dB down.

3.5.2 Measurement instruments

The measurement instruments are listed in chapter 2.4 of this report.

3.5.3 Test setup

The test setup is as shown in chapter 2.3 of this report.

3.5.4 Test procedure

The testing follows FCC KDB Publication No. 558074 D01 DTS Meas. Guidance v05, sections 11.3 and 12.1. IRN 026 - Radiated electrical disturbance (V per m) Method 6 – Radiated electrical disturbance at the Authorized band edge.

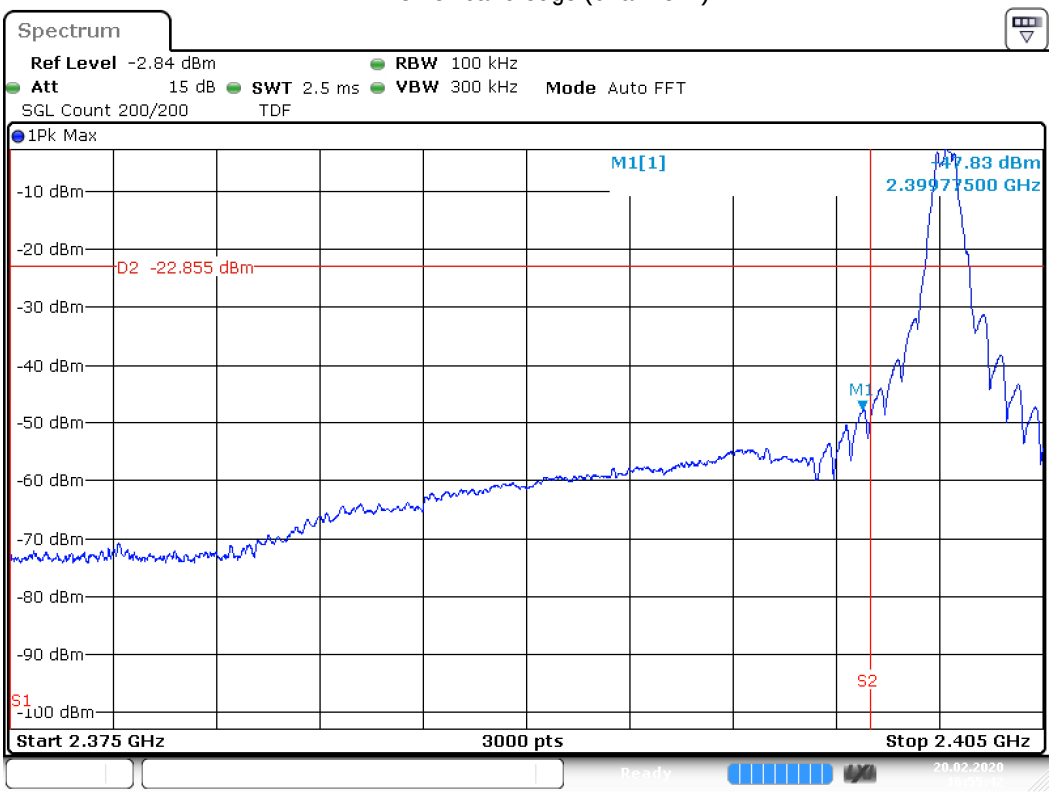
3.5.5 Measurement Uncertainty

± 5.7 dB.

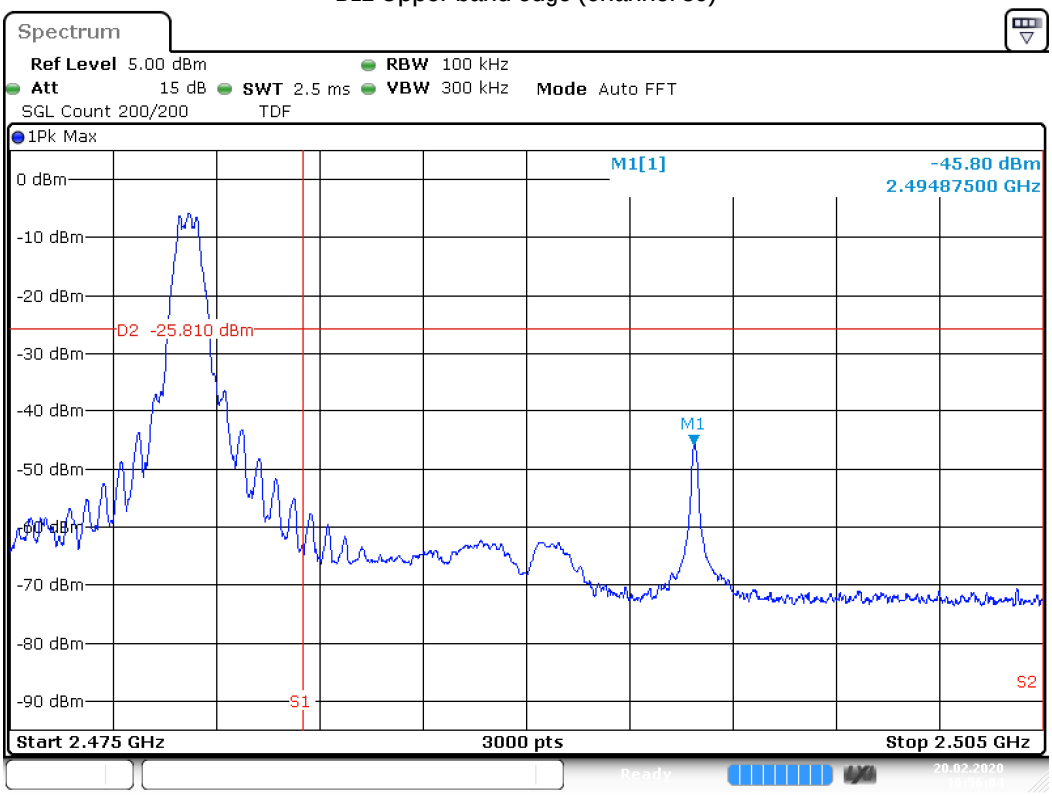
3.5.6 Results of the Band edge Measurements

Technology Std.	Channels	Frequency (MHz)	Data rate	Attenuation (dB)
Bluetooth Low Energy	37	2402	1 Mbps	-47.83
	39	2480	1 Mbps	-45.80
Uncertainty	+/- 2.53 dB			

BLE Lower band edge (Channel 1)



BLE Upper band edge (Channel 39)



3.6 Conducted emissions

3.6.1 Limit

According to 15.207 (c)

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.

Frequency of emission (MHz)	Conducted limit (dBµV)	
	Quasi-peak	Average
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.

3.6.2 Measurement instruments

The measurement instruments are listed in chapter 2.3 of this report.

3.6.3 Test setup

The test setup is as shown in chapter 2.2 of this report.

3.6.4 Test procedure

According to ANSI C63.4: 2014, section 13.3
IRN 029 – Method 1

3.6.5 Test results and plots of the AC mains conducted measurement

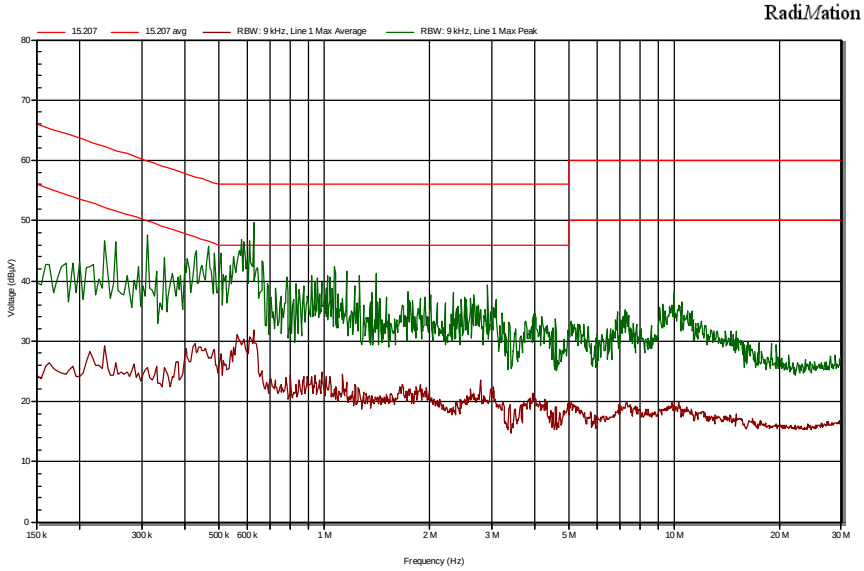
See next page.

3.6.6 Measurement uncertainty

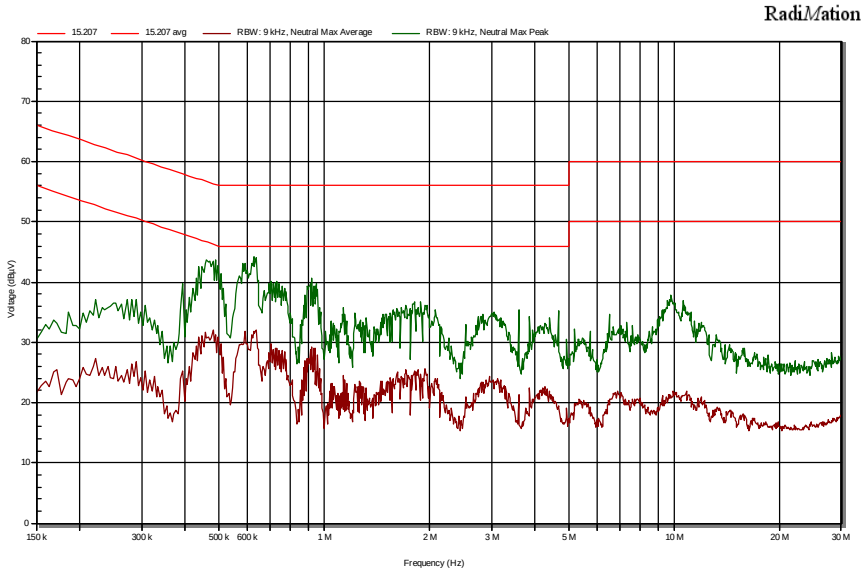
+/- 3.6 dB

3.6.7 Plots of the AC mains conducted spurious measurement

Phase



Neutral



4 Sample calculations

All formulas for data conversions and conversion factors are reported in this chapter.

Conducted emission Measurement (see chapter 3.9):

U_{lisn} (dBµV) = U (dBµV) + Corr. (dB)

Where:
U = Measuring receiver voltage
LISN insertion loss = Voltage division factor of LISN
Corr. = sum of single correction factors of used LISN, cables and pulse limiter.
Linear interpolation will be used for frequencies in between the values in the table.

Frequency (Mhz)	Voltage division LISN (db)	Insertion Loss Pulse limiter (dB)	Cable loss (dB)	Corr. (dB)
	TE 00208 SN: 892785/004 Rohde & Schwarz ESH3-Z5	TE 00756 SN: 5SM03153 Rohde & Schwarz ESH3-Z2	TE 11134	
0,15	0,09	9,87	0,02	9,98
0,2	0,1	9,87	0,03	10
0,3	0,1	9,87	0,03	10
0,5	0,1	9,87	0,08	10,05
0,7	0,12	9,87	0,25	10,24
0,8	0,12	9,87	0,25	10,24
1	0,13	9,87	0,11	10,11
2	0,16	9,87	0,15	10,18
3	0,19	9,87	0,21	10,27
5	0,26	9,88	0,21	10,35
7	0,36	9,89	0,25	10,5
8	0,39	9,89	0,25	10,53
10	0,46	9,91	0,29	10,66
15	0,77	9,93	0,34	11,04
20	0,95	9,96	0,37	11,28
25	1,12	9,99	0,43	11,54
30	1,1	10,04	0,45	11,59

Field Strength Measurement (see chapter 3.3):

E (dBµV/m) = U(dBµV) + AF (dB/m) + Corr. (dB)

Where:
E = Electric field strength
U = Measuring receiver voltage
AF = Antenna factor
CL = Cable loss

Corr. = sum of single correction factors of used cable and amplifier (if applicable).
Linear interpolation will be used for frequencies in between the values in the table.
Tables shows an extract of the values.

Frequency (Mhz)	AF (dB/m) TE 00967 Chase CBL6112A SN: 2308	Cable loss (dB) Id: SAR cable	Corr. (dB)
30	18,6	0,68	19,28
100	10,7	1,15	11,85
150	10,6	1,41	12,01
200	9,3	1,63	10,93
250	12,6	1,93	14,53
300	13,3	2,12	15,42
350	14,6	2,2	16,8
400	15,5	2,29	17,79
450	16,9	2,53	19,43
500	17,5	2,67	20,17
550	18,4	2,9	21,3
600	18,8	3,02	21,82
650	19,2	3,09	22,29
700	19	3,22	22,22
750	19,8	3,56	23,36
800	19,7	3,69	23,39
900	20,4	3,81	24,21
950	20,8	3,91	24,71
1000	21,2	4,3	25,5

Frequency (Mhz)	AF (dB/m) TE 00531 Emco 3115 SN: 9412-4377	Gain (dB) TE 11132 Miteq JS4-18004000-30-8P-A1	Cable loss (dB) TE 01315	Corr. (dB)
1000	23,6	40,4	2,0	66
1500	25,1	40,5	2,4	68
2000	27,1	40,5	2,7	70,3
2500	28,6	40,7	3,2	72,5
3000	30,5	40,7	3,2	74,4
3500	31,2	40,7	3,4	75,3
4000	32,7	40,9	4,9	78,5
4500	32,4	40,9	4,4	77,7
5000	33,2	40,7	4,6	78,5
5500	34,0	40,5	4,5	79
6000	34,6	40,0	5,2	79,8
6500	34,3	39,4	5,9	79,6
7000	35,2	38,6	5,7	79,5
7500	36,4	39,2	5,9	81,5
8000	37,0	38,9	6,3	82,2
8500	37,5	38,4	6,4	82,3
9000	38,1	37,4	6,5	82
9500	37,8	37,0	7,1	81,9
10000	38,2	36,5	7,3	82
10500	38,1	36,7	7,6	82,4
11000	38,3	36,9	8,3	83,5
11500	38,5	37,6	8,1	84,2
12000	39,1	38,3	8,4	85,8
12500	38,7	38,5	8,3	85,5
13000	39,2	38,9	9,2	87,3
13500	40,5	40,2	8,3	89
14000	41,1	40,0	8,2	89,3
14500	41,4	40,1	8,2	89,7
15000	40,2	41,4	8,3	89,9
15500	37,9	41,4	8,6	87,9
16000	37,5	42,8	9,2	89,5
16500	38,6	42,3	8,8	89,7
17000	41,1	43,1	9,4	93,6
17500	42,7	43,2	9,4	95,3
18000	44,0	44,2	9,8	98

Frequency (Mhz)	AF (dB/m) TE 00531 Emco 3115 SN: 9412-4377	Gain (dB) TE 11132 Miteq JS4-18004000-30-8P-A1	Cable loss (dB) TE 01315	Corr. (dB)
18000	31,3	26,2	9,8	67,3
19000	31,5	26,1	9,6	67,2
20000	31,7	25,9	11	68,6
21000	31,9	24,3	10,7	66,9
22000	32,1	18,3	10,5	60,9
23000	32,2	18,9	10,8	61,9
24000	32,3	23,6	11,4	67,3
25000	32,4	24,5	11,6	68,5
26000	32,5	25,3	11,7	69,5