

Report on the Radio Testing

For

Athlos

on

Wireless Intra-Oral Sensor / DC-Air (also known as Athlos-1 and Athlos-Air)

Report no. TRA-047057-45-00B

20 January 2021

RF915 7.1

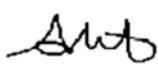


Report Number: TRA-047057-45-00B
Issue: A

REPORT ON THE RADIO TESTING OF A
Athlos
Wireless Intra-Oral Sensor / DC-Air (also known as Athlos-1 and Athlos-Air)
WITH RESPECT TO SPECIFICATION
FCC 47CFR 15.247

TEST DATE: 2020-11-02 to 2020-11-23

Tested by: Atif Tosif & David Garvey

Written by: 

Atif Tosif
Radio Test Engineer

Approved by:



Date:

20 January 2021

John Charters
Lab Manager

Digitally signed by John Charters
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Technology Ltd, email=john.charters@element.com,
c=GB
Reason: I am approving this document
Date: 2021.01.20 14:18:51 Z

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- [1] THIS DOCUMENT MAY BE REPRODUCED ONLY IN ITS ENTIRETY AND WITHOUT CHANGE
[2] THE RESULTS CONTAINED IN THIS DOCUMENT RELATE ONLY TO THE ITEM(S) TESTED

1 Revision Record

<i>Issue Number</i>	<i>Issue Date</i>	<i>Revision History</i>
A	10 December 2020	Original
B	20 January 2021	Antenna gain in section 7.4 updated

2 Summary

TEST REPORT NUMBER:	TRA-047057-45-00B
WORKS ORDER NUMBER:	TRA-047057-02
PURPOSE OF TEST:	Certification
TEST SPECIFICATION:	47CFR15.247
EQUIPMENT UNDER TEST (EUT):	Wireless Intra-Oral Sensor / DC-Air (also known as Athlos-1 and Athlos-Air)
FCC IDENTIFIER:	2AX53DC015
MANUFACTURER/AGENT:	Athlos
ADDRESS:	Klovinpellontie 1-3 Tower 2 Espoo 02180 Finland
CLIENT CONTACT:	Vasileios Grammatikakis ☎ +358-40-1362566 ✉ vasileios.grammatikakis@athlos.fi
ORDER NUMBER:	140
TEST DATE:	2020-11-02 to 2020-11-23
TESTED BY:	Atif Tosif & David Garvey Element

2.1 Test Summary

<i>Test Method and Description</i>	<i>Requirement Clause 47CFR15</i>	<i>Applicable to this equipment</i>	<i>Result</i>
Radiated spurious emissions (restricted bands of operation and cabinet radiation)	15.247 (d)	☒	Pass
AC power line conducted emissions	15.207	☒	Pass
Occupied bandwidth	15.247 (a) (2)	☒	Pass
Peak conducted carrier power	15.247 (b) (3)	☒	Pass
Out of band emissions	15.247 (d)	☒	Pass
Power spectral density	15.247 (e)	☒	Pass

Notes:

The results contained in this report relate only to the items tested, in the condition at time of test, and were obtained in the period between the date of initial receipt of samples and the date of issue of the report.

The apparatus was set up and exercised using the configurations, modes of operation and arrangements defined in this report only. Any modifications made are identified in Section 8 of this report.

Particular operating modes, apparatus monitoring methods and performance criteria required by the standards tested to have been performed except where identified in Section 5.2 of this test report (Deviations from Test Standards).

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4 Introduction

This report TRA-047057-45-00B presents the results of the Radio testing on a Athlos, Wireless Intra-Oral Sensor / DC-Air (also known as Athlos-1 and Athlos-Air) to specification 47CFR15 Radio Frequency Devices.

The testing was carried out for Athlos by Element, at the address detailed below.

☒	Element Hull Unit E South Orbital Trading Park Hedon Road Hull HU9 1NJ UK	☐	Element Skelmersdale Unit 1 Pendle Place Skelmersdale West Lancashire WN8 9PN UK
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This report details the configuration of the equipment, the test methods used and any relevant modifications where appropriate.

All test and measurement equipment under the control of the laboratory and requiring calibration is subject to an established programme and procedures to control and maintain measurement standards. The quality management system meets the principles of ISO 9001, and has quality control procedures for monitoring the validity of tests undertaken. Records and sufficient detail are retained to establish an audit trail of calibration records relating to its test results for a defined period. Under control of the established calibration programme, key quantities or values of the test & measurement instrumentation are within specification and comply with the relevant traceable internationally recognised and appropriate standard specifications, which are UKAS calibrated as such where these properties have a significant effect on results. Participation in inter-laboratory comparisons and proficiency testing ensures satisfactory correlation of results conform to Elements own procedures, as well as statistical techniques for analysis of test data providing the appropriate confidence in measurements.

Throughout this report EUT denotes equipment under test.

FCC Site Listing:

Element is accredited for the above sites under the US-EU MRA, Designation number UK0009.

The test site requirements of ANSI C63.4-2014 are met up to 1GHz.

The test site SVSWR requirements of CISPR 16-1-4:2010 are met over the frequency range 1 GHz to 18 GHz.

5 Test Specifications

5.1 Normative References

- FCC 47 CFR Ch. I – Part 15 – Radio Frequency Devices.
- ANSI C63.10-2013 – American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices.
- ANSI C63.4-2014 – American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.

5.2 Deviations from Test Standards

There were no deviations from the test standard.

6 Glossary of Terms

§	denotes a section reference from the standard, not this document
AC	Alternating Current
ANSI	American National Standards Institute
BW	bandwidth
C	Celsius
CFR	Code of Federal Regulations
CW	Continuous Wave
dB	decibel
dBm	dB relative to 1 milliwatt
DC	Direct Current
DSSS	Direct Sequence Spread Spectrum
EIRP	Equivalent Isotropically Radiated Power
ERP	Effective Radiated Power
EUT	Equipment under Test
FCC	Federal Communications Commission
FHSS	Frequency Hopping Spread Spectrum
Hz	hertz
ITU	International Telecommunication Union
LBT	Listen before Talk
m	metre
max	maximum
MIMO	Multiple Input and Multiple Output
min	minimum
MRA	Mutual Recognition Agreement
N/A	Not Applicable
PCB	Printed Circuit Board
PDF	Portable Document Format
Pt-mpt	Point-to-multipoint
Pt-pt	Point-to-point
RF	Radio Frequency
RH	Relative Humidity
RMS	Root Mean Square
Rx	receiver
s	second
SVSWR	Site Voltage Standing Wave Ratio
Tx	transmitter
UKAS	United Kingdom Accreditation Service
V	volt
W	watt
Ω	ohm

7 Equipment under Test

7.1 EUT Identification

- Name: Wireless Intra-Oral Sensor / DC-Air (also known as Athlos-1 and Athlos-Air)
- Model Number: WIOS-S2
- Software Revision: ATS_00001_RADIO_TEST-USBD-CLI_v1.0
- Build Level / Revision Number: 2.1

7.2 System Equipment

Equipment listed below forms part of the overall test setup and is required for equipment functionality and/or monitoring during testing. The compliance levels achieved in this report relate only to the EUT and not items given in the following list.

Yoga 82A2 Laptop with putty software
Intra-Oral Sensor Docking Station

7.3 EUT Mode of Operation

The EUT was transmitting continuously with modulation on bottom, middle and top channels, as required.

7.4 EUT Radio Parameters

Frequency of operation:	2402 MHz – 2480 MHz
Modulation type:	GFSK
Nominal Supply Voltage:	3.7 Vdc from internal rechargeable battery
Antenna Type:	Integral PCB
Antenna Gain:	-1.8 dBi

7.5 EUT Description

The EUT is a dental X-Ray device for use inside a patient's mouth. It contains a 2.4 GHz Bluetooth LE radio using a single antenna and using 1 and 2 Mbps data rates.

8 Modifications

No modifications were performed during this assessment.

9 EUT Test Setup

9.1 Photographs

The following photograph shows basic EUT radiated set-up:





9.2 *Measurement software*

Where applicable, the following software was used to perform measurements contained within this report.

Element Emissions R5
EMC32

10 General Technical Parameters

10.1 Normal Conditions

The EUT was tested under the normal environmental conditions of the test laboratory, except where otherwise stated. The normal power source applied was 3.7 Vdc from internal rechargeable battery.

10.2 Varying Test Conditions

There are no specific frequency stability requirements for the type of device. The results contained in this report demonstrate that the occupied bandwidth is contained within the authorised band.

Variation of supply voltage is required to ensure stability of the declared output power. During carrier power testing the following variations were made:

	Category	Nominal	Variation
☐	Mains	110 Vac +/-2 %	85 % and 115 %
☒	Battery	New battery	N/A

11 Duty Cycle

11.1 Definition

The ratio of the sum of all pulse durations to the total period, during a specified period of operation.

11.2 Test Parameters

Test Location:	Element Hull
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.6
Deviations From Standard:	None
Temperature Extreme Environment Test Range:	N/A
Voltage Extreme Environment Test Range:	N/A

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 °C to +35 °C (as declared)
Humidity: 45 % RH	20 % RH to 75 % RH (as declared)

11.3 Test Limit

N/A.

11.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure vii, the duty of the EUT was calculated from the sum of total on and off times over the observation period.

The measurements were performed with EUT set at its maximum duty. All modulation schemes, bandwidths, data rates and power settings were measured

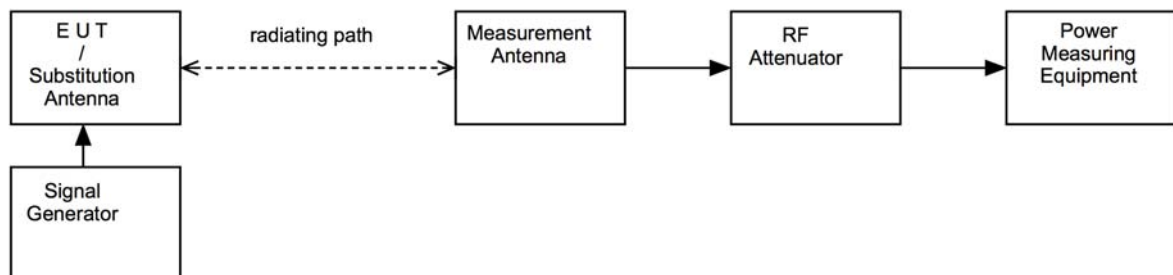
[1] Single antenna output devices

Duty was measured at a distance of 3 m.

The duty cycle correction factor, DC, shall be added to the measurement results prior to comparing with the emission limit to compute the emission level that would have been measured had the test been performed at 100% duty cycle. The correction factor is computed as:

- 1) If power averaging (rms) mode was used in step f), then the applicable correction factor is $[10 \log (1 / D)]$, where D is the duty cycle.
- 2) If linear voltage averaging mode was used in step f), then the applicable correction factor is $[20 \log (1 / D)]$, where D is the duty cycle.
- 3) If a specific emission is demonstrated to be continuous ($D \geq 98\%$) rather than turning ON and OFF with the transmit cycle, then no duty cycle correction is required for that emission.

Figure vii Test Setup

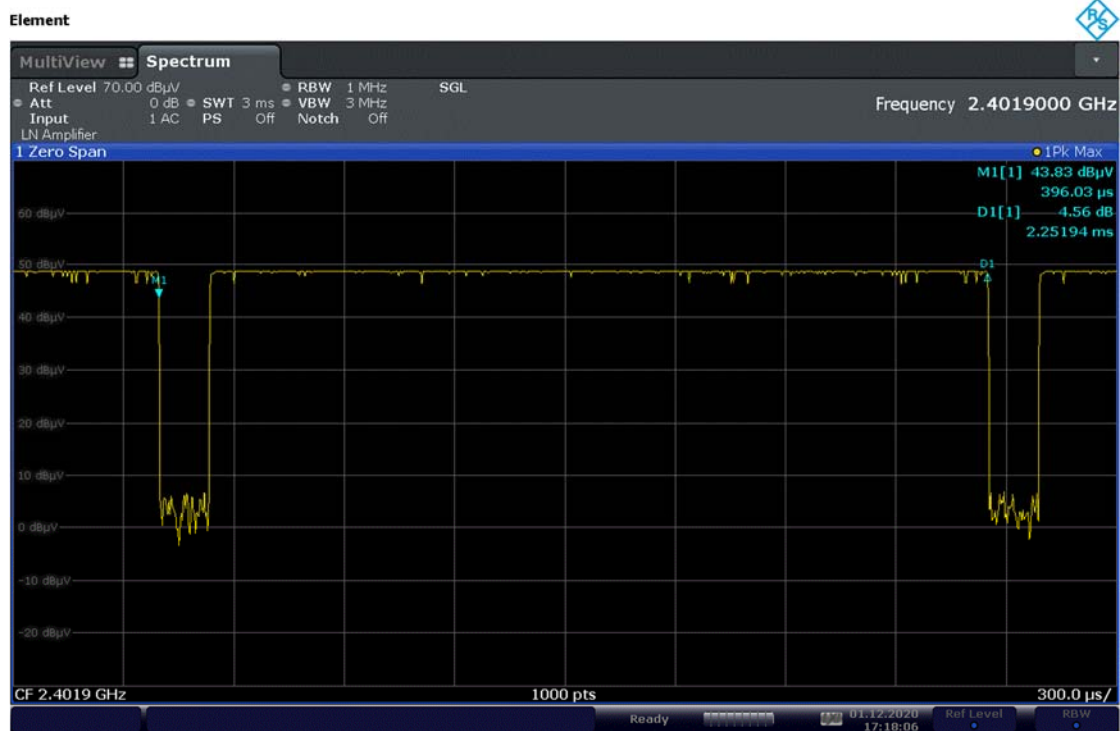


11.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
Ferrite Lined Chamber	Rainford	Chamber	REF2259	2022-08-03
EMI Test Receiver	R&S	ESW26	REF2235	2021-08-31
LB-10180-NF	A Info Inc	Horn Antenna	REF2241	2022-07-13

11.6 Test Results

BLE Data Rate: 1 Mbps				
Test Environment		TxOn time (us)	Frame Period (us)	Calculated Factor (dB)
V _{nominal}	T _{nominal}	2114.75	2251.94	0.6

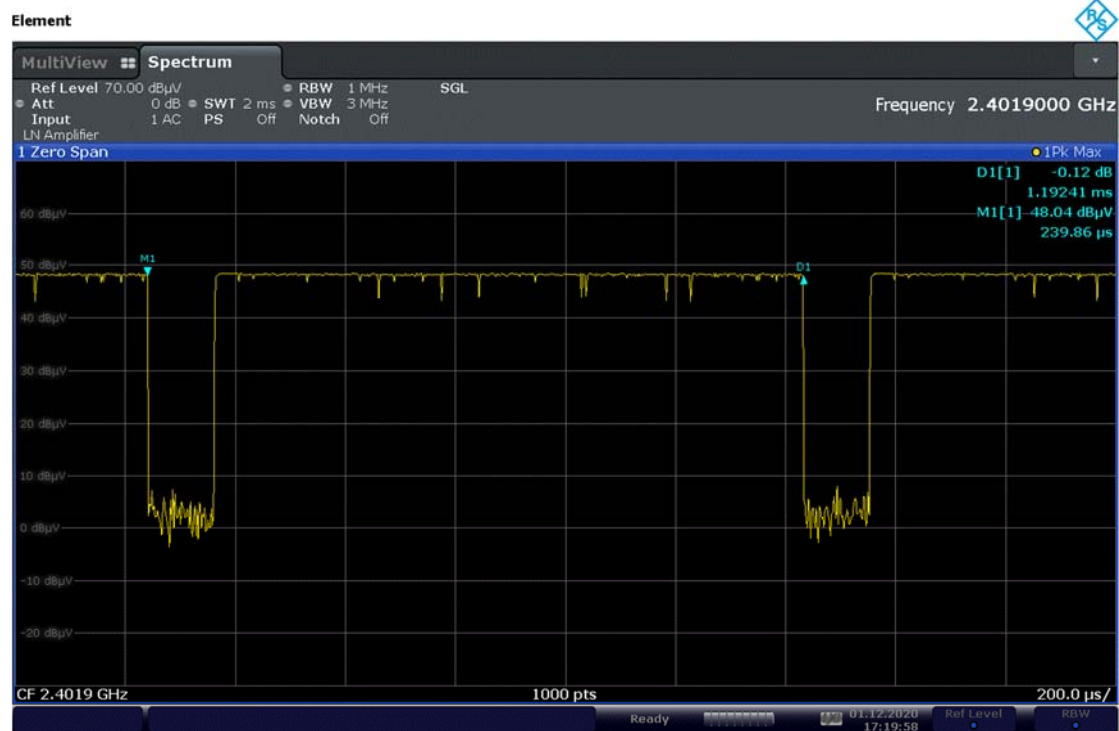


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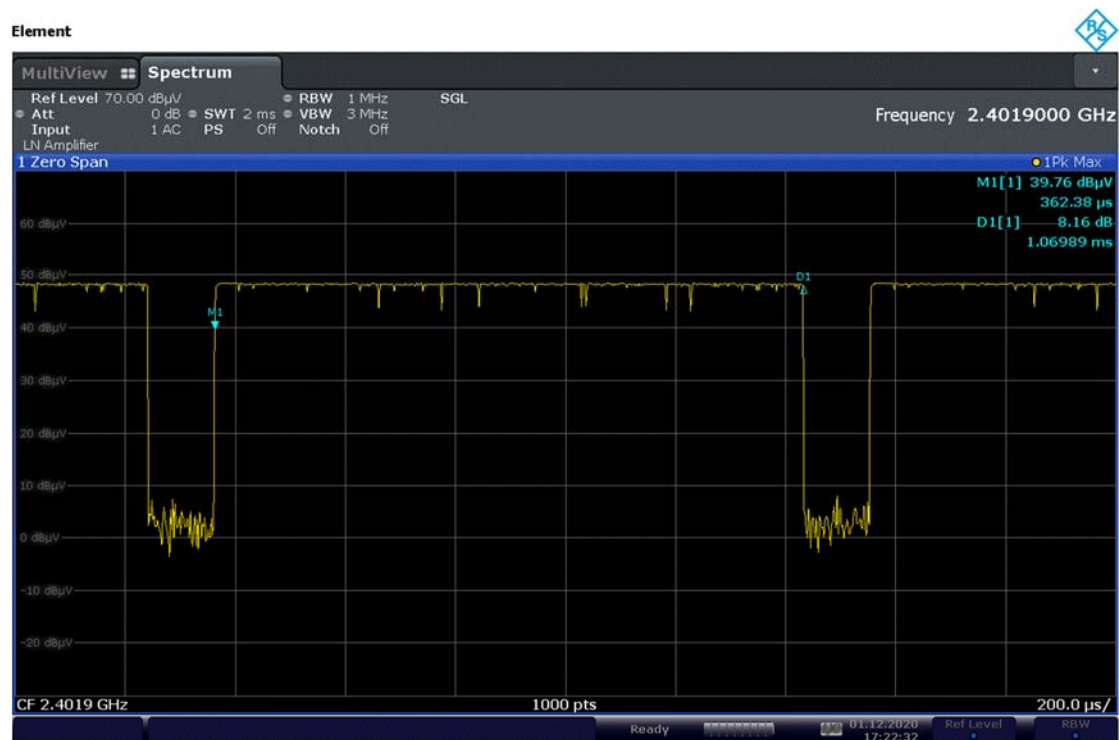


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BLE Data Rate: 2 Mbps				
Test Environment		TxOn time (us)	Frame Period (us)	Calculated Factor (dB)
V _{nominal}	T _{nominal}	1069.89	1192.41	0.9



17:19:59 01.12.2020



17:22:32 01.12.2020

12 Radiated emissions

12.1 Definitions

Spurious emissions

Emissions on a frequency or frequencies, which are outside the necessary bandwidth and the level of which may be reduced without affecting the corresponding transmission of information. Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products, but exclude out-of-band emissions.

Restricted bands

A frequency band in which intentional radiators are permitted to radiate only spurious emissions but not fundamental signals.

12.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Wireless Lab 3
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5 and 6.6
EUT Frequencies Measured:	2402 MHz, 2440 MHz & 2480 MHz
Deviations from Standard:	None
Measurement BW:	30 MHz to 1 GHz: 120 kHz; Above 1 GHz: 1 MHz
Measurement Detector:	Up to 1 GHz: quasi-peak; Above 1 GHz: RMS average and Peak

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 °C to +35 °C (as declared)
Humidity: 45 % RH	20 % RH to 75 % RH (as declared)

12.3 Test Limit

Unwanted emissions that fall within the restricted frequency bands shall comply with the limits specified:

General Field Strength Limits for License-Exempt Transmitters at Frequencies above 30 MHz

<i>Frequency (MHz)</i>	<i>Field Strength (μV/m at 3 m)</i>	<i>Field Strength (dBμV/m at 3 m)</i>
30 to 88	100	40.0
88 to 216	150	43.5
216 to 960	200	46.0
Above 960	500	54.0

On frequencies below or equal to 1000 MHz, the limits shown are based on measuring equipment employing a CISPR quasi-peak detector function. On frequencies above 1000 MHz, the radiated emission limits are based on the use of measurement instrumentation employing an average detector function. The limit on peak radio frequency emissions is 20 dB above the maximum permitted average emission limit.

12.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure i, the emissions from the EUT were measured on a spectrum analyzer / EMI receiver.

Radiated electromagnetic emissions from the EUT are checked first by preview scans. Preview scans for all spectrum and modulation characteristics are checked, using a peak detector and where applicable worst-case determined for function, operation, orientation, etc. for both vertical and horizontal polarisations. Pre-scan plots are shown with a peak detector and 100 kHz RBW.

If the EUT connects to auxiliary equipment and is table or floor standing, the configurations prescribed in ANSI C63.10 are followed. Alternatively, a layout closest to normal use (as declared by the provider) is employed, (see EUT setup photographs for more detail).

Emissions between 30 MHz and 1 GHz are measured using calibrated broadband antennas. Emissions above 1 GHz are characterized using standard gain horn antennas. Pre-amplifiers and filters are used where required. Care is taken to ensure that test receiver resolution bandwidth, video bandwidth and detector type(s) meet the regulatory requirements.

For both horizontal and vertical polarizations, the EUT is then rotated through 360 degrees in azimuth until the highest emission is detected. At the previously determined azimuth the test antenna is raised and lowered from 1 to 4 m in height until a maximum emission level is detected, this maximum value is recorded.

Power values measured on the test receiver / analyzer are converted to field strength, FS, in dBμV/m at the regulatory distance, using:

$$FS = PR + CL + AF - PA + DC - CF$$

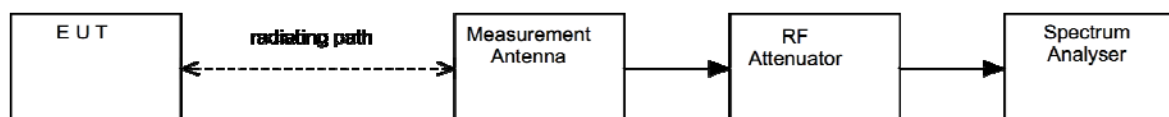
$$\text{Factor} = CL + AF - PA$$

Where,

PR is the power recorded on the receiver / spectrum analyzer in dBμV;
 CL is the cable loss in dB;
 AF is the test antenna factor in dB/m;
 PA is the pre-amplifier gain in dB (where used);
 DC is the duty correction factor in dB (where used, e.g. harmonics of pulsed fundamental);
 CF is the distance factor in dB (where measurement distance different to limit distance);

This field strength value is then compared with the regulatory limit.

Figure i Test Setup



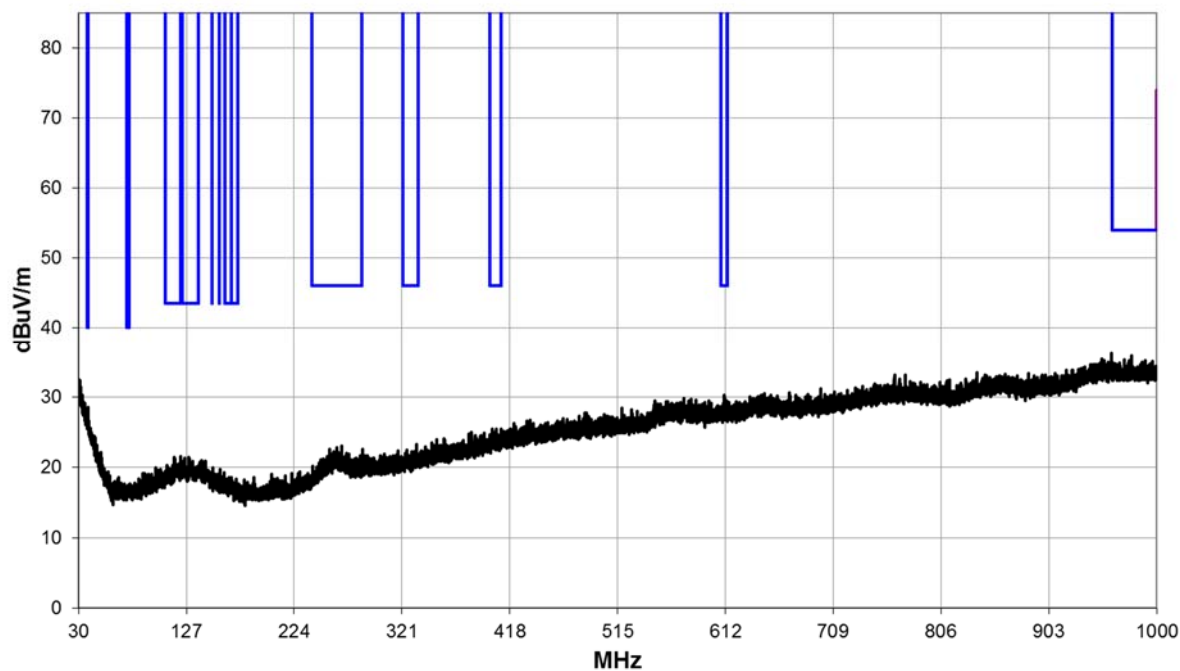
12.5 Test Equipment

<i>Equipment Description</i>	<i>Manufacturer</i>	<i>Equipment Type</i>	<i>Element No</i>	<i>Due For Calibration</i>
Chamber	Rainford	-	REF2259	2022-08-03
EMI Test Receive	R&S	ESW26	REF2235	2021-08-31
Bilog Antenna	Chase	CBL6111B	REF2218	2021-10-23
Horn Antenna	A Info Inc	LB-10180-NF	REF2241	2022-07-13
Horn Antenna	A Info Inc	LB-90-25-C2-SF	REF2243	2022-07-17
Horn Antenna	A Info Inc	LB-62-25-C-SF	REF2244	2022-07-17
Horn Antenna	A Info Inc	LB-180400-25-C-KF	REF2246	2022-07-28
Radiated Test Software	Element	Emissions R5	REF9000	Cal not required

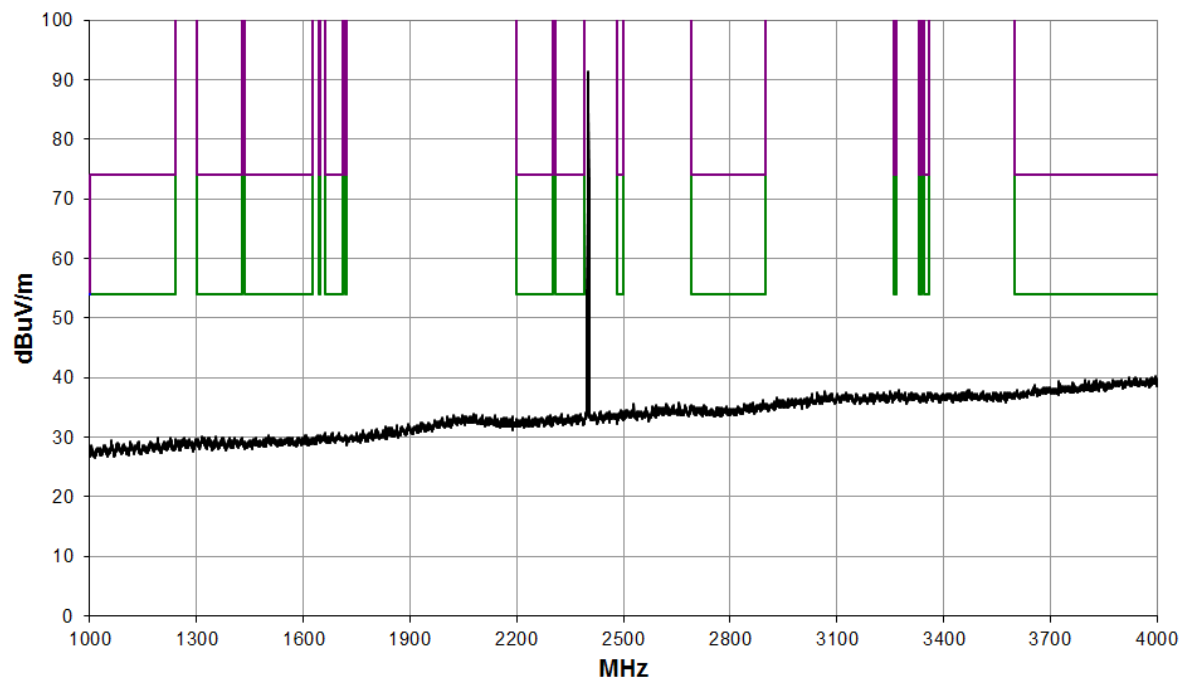
12.6 Test Results

Frequency: 2402 MHz; Power Setting: 8 dBm ; Modulation: GFSK; Data Rate: 1 Mbps								
Detector	Freq. (MHz)	Meas'd Emission (dBμV)	Factor (dB)	Duty Cycle Corr'n (dB)	Distance Extrap'n Factor (dB)	Field Strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
PK	12008.4	14.1	39.9	0.0	0.0	54.0	74.0	-20.0
AV	12011.7	-2.1	39.9	0.6	0.0	38.4	54.0	-15.6

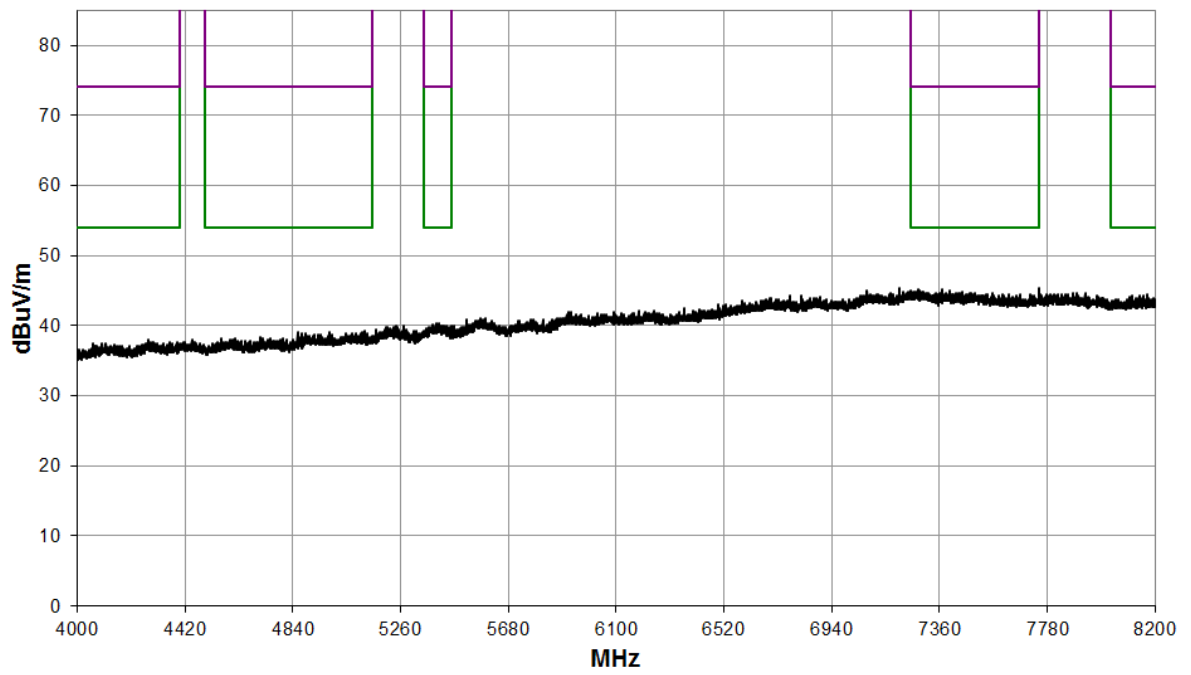
30 MHz to 1 GHz



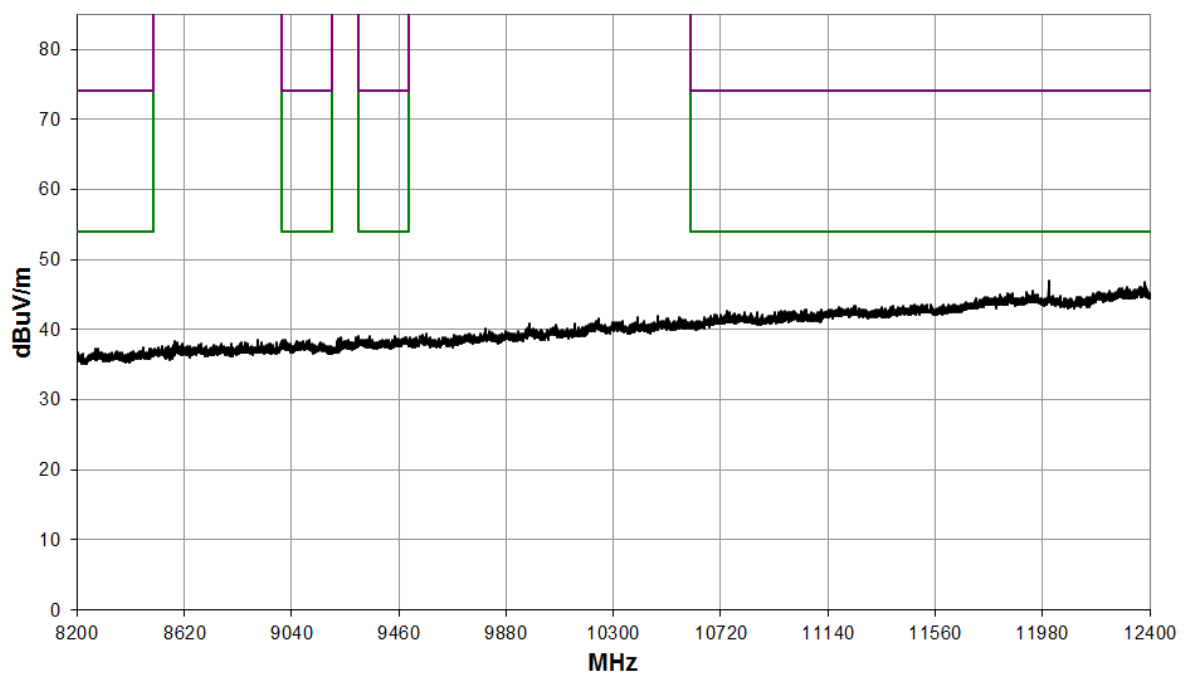
1 GHz to 4 GHz



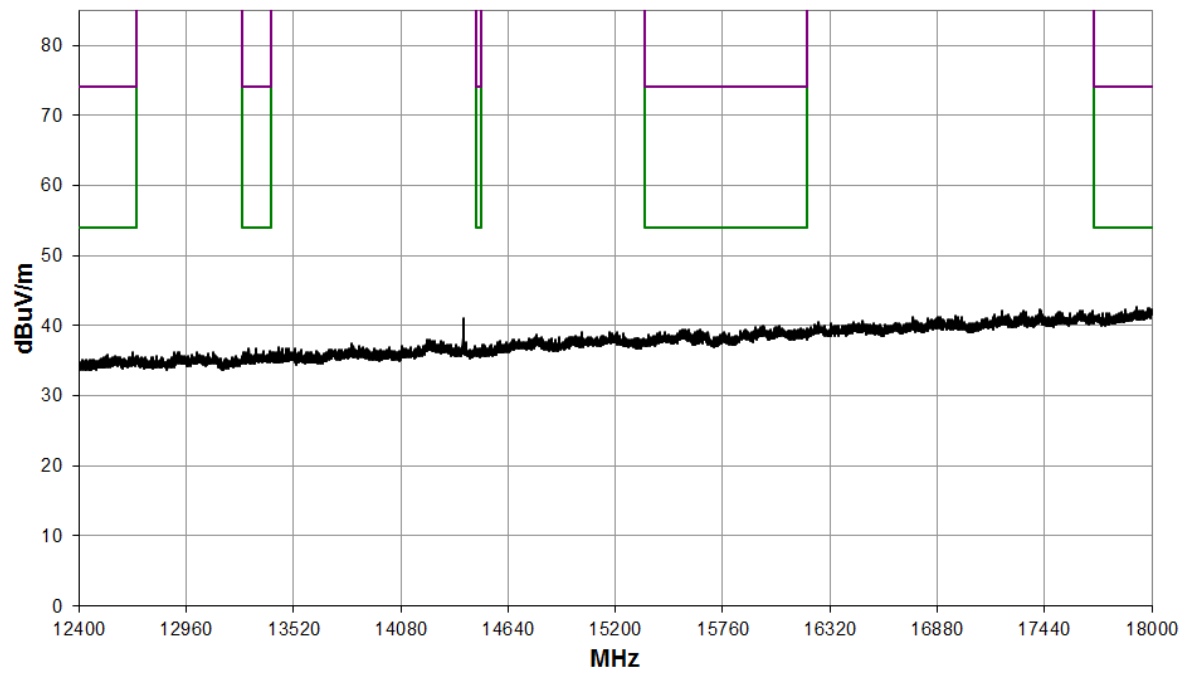
4 GHz to 8.2 GHz



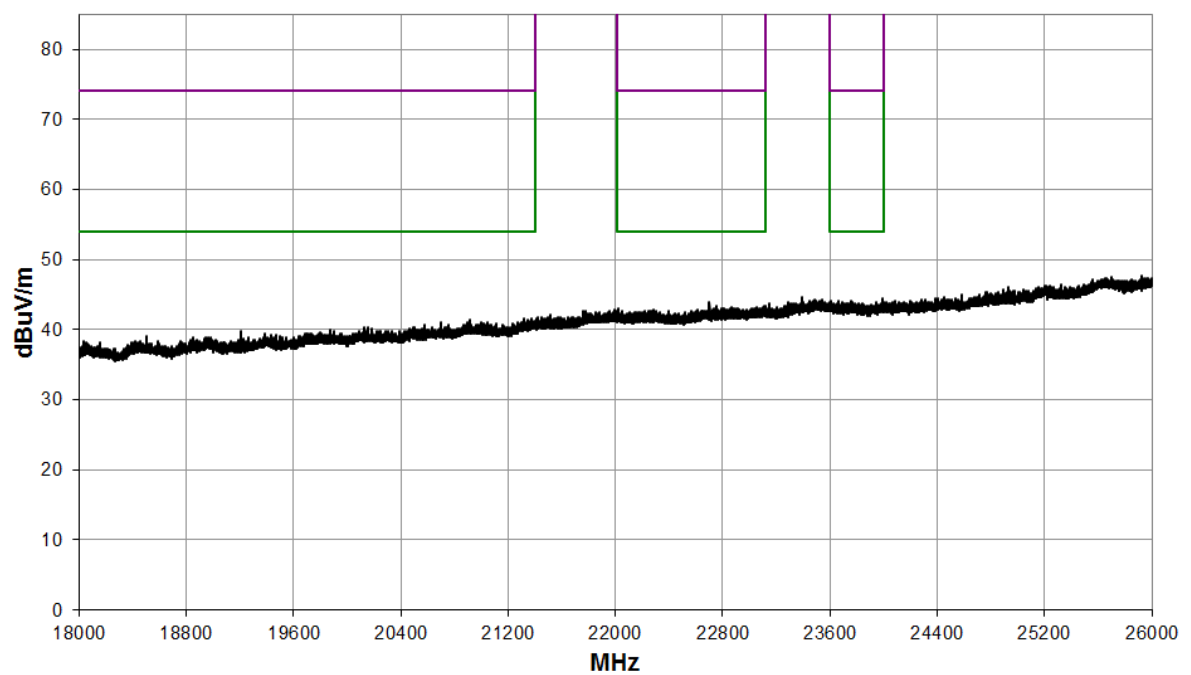
8.2 GHz to 12.4 GHz



12.4 GHz to 18 GHz

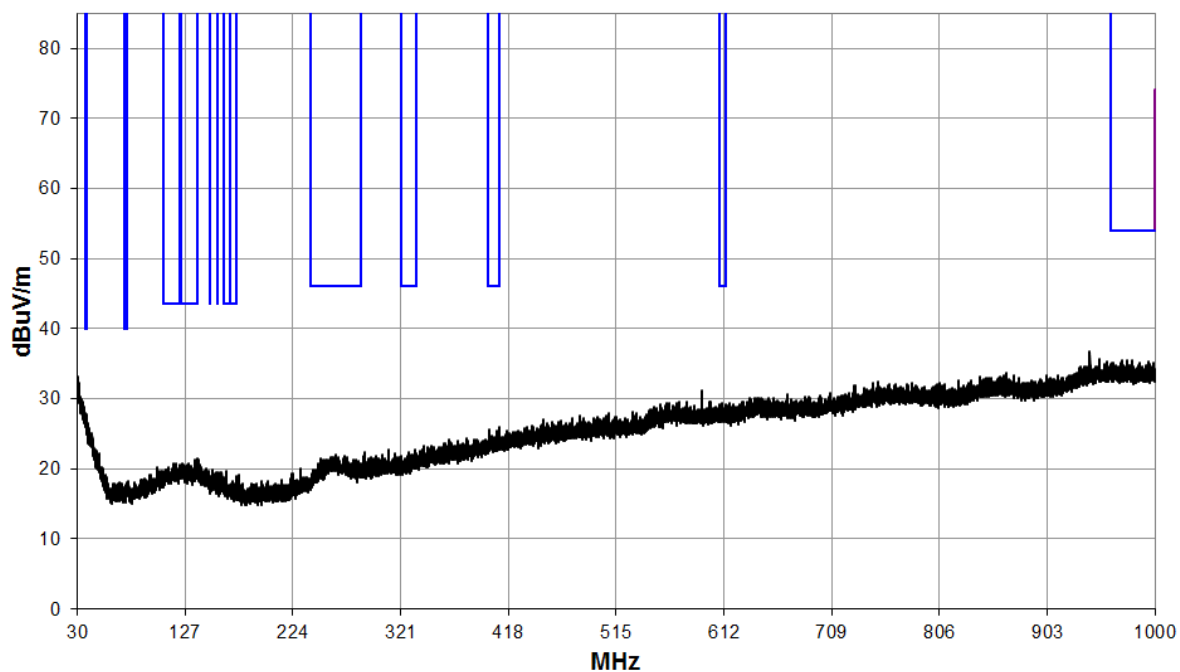


18 GHz to 26 GHz

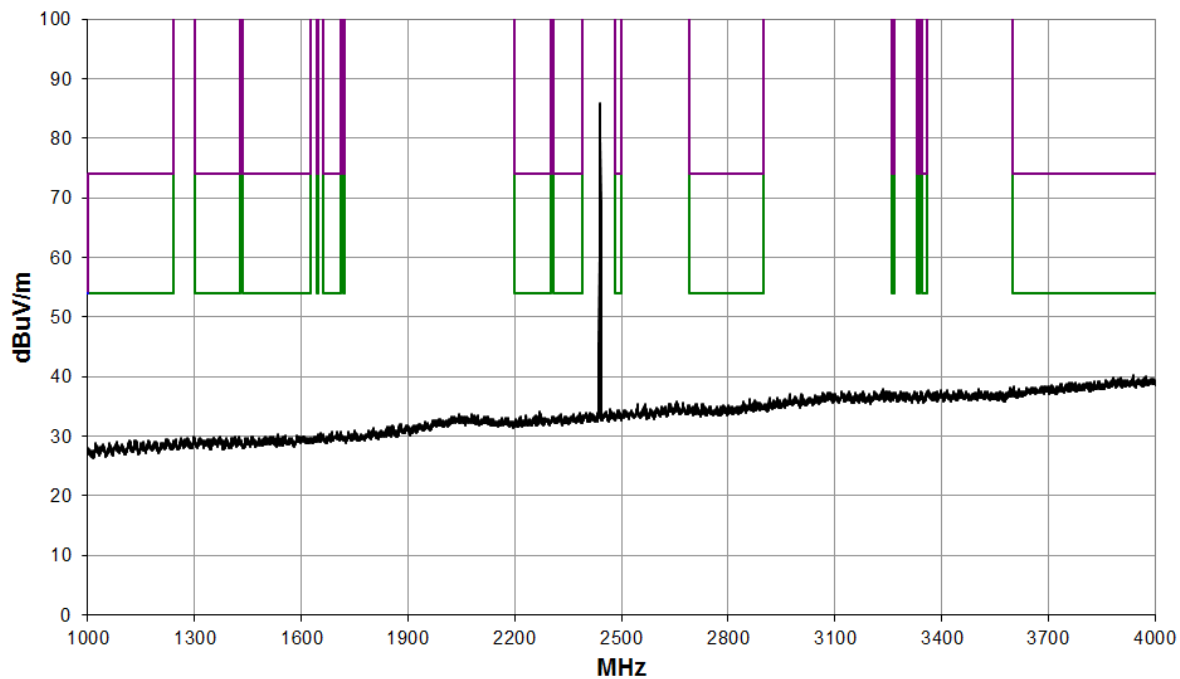


Frequency: 2440 MHz; Power Setting: 8 dBm; Modulation: GFSK; Data Rate: 1 Mbps								
Detector	Freq. (MHz)	Meas'd Emission (dBμV)	Factor (dB)	Duty Cycle Corr'n (dB)	Distance Extrap'n Factor (dB)	Field Strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
AV	7318.1	-4.4	45.3	0.6	-3.5	38.0	54.0	-16.0
PK	7321.0	12.3	45.3	0.0	-3.5	54.1	74.0	-19.9
PK	12199.3	15.2	40.3	0.0	0.0	55.5	74.0	-18.5
AV	12201.5	1.1	40.3	0.6	0.0	42.0	54.0	-12.0

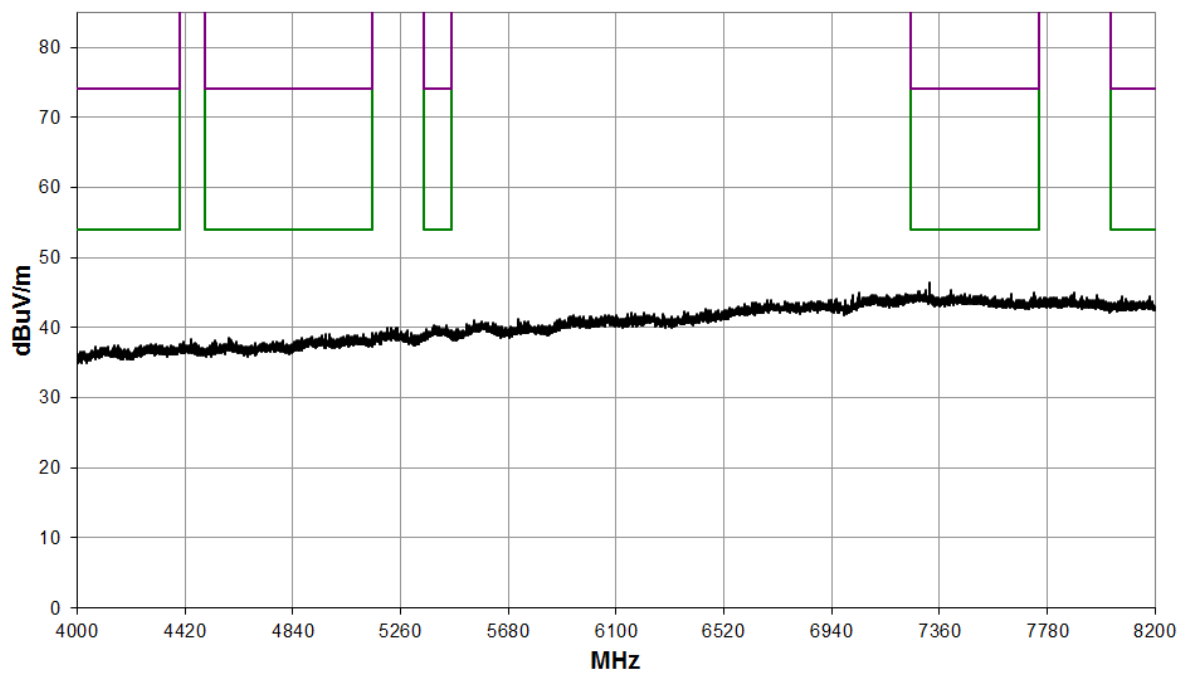
30 MHz to 1 GHz



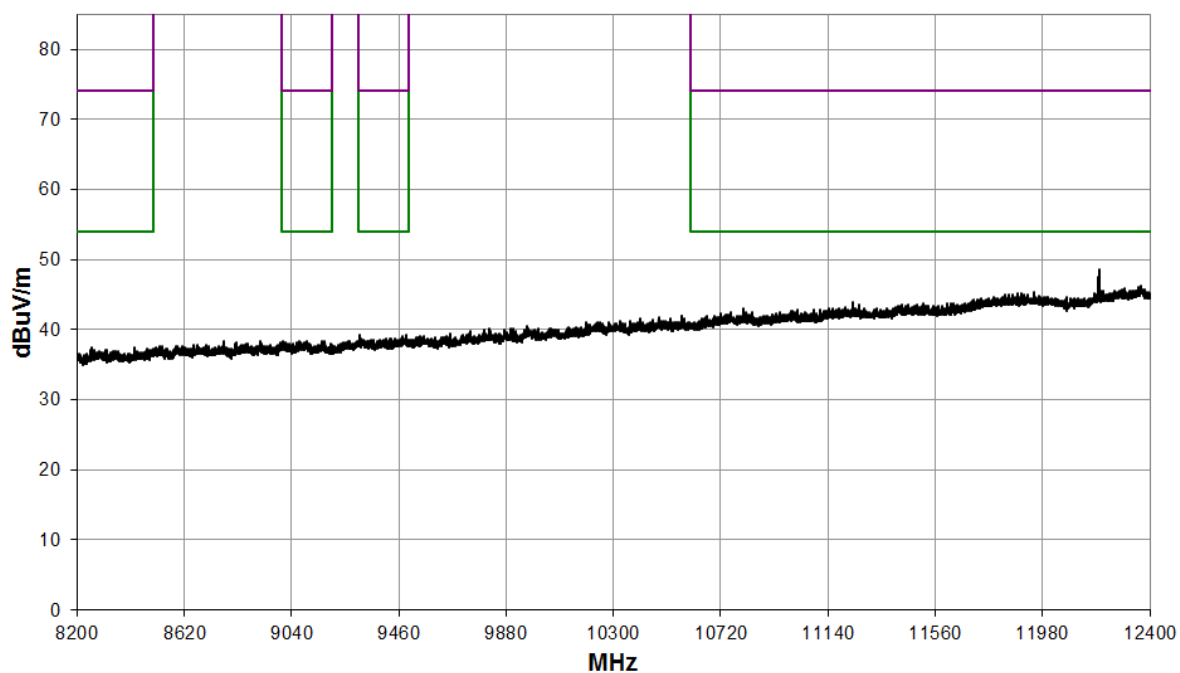
1 GHz to 4 GHz



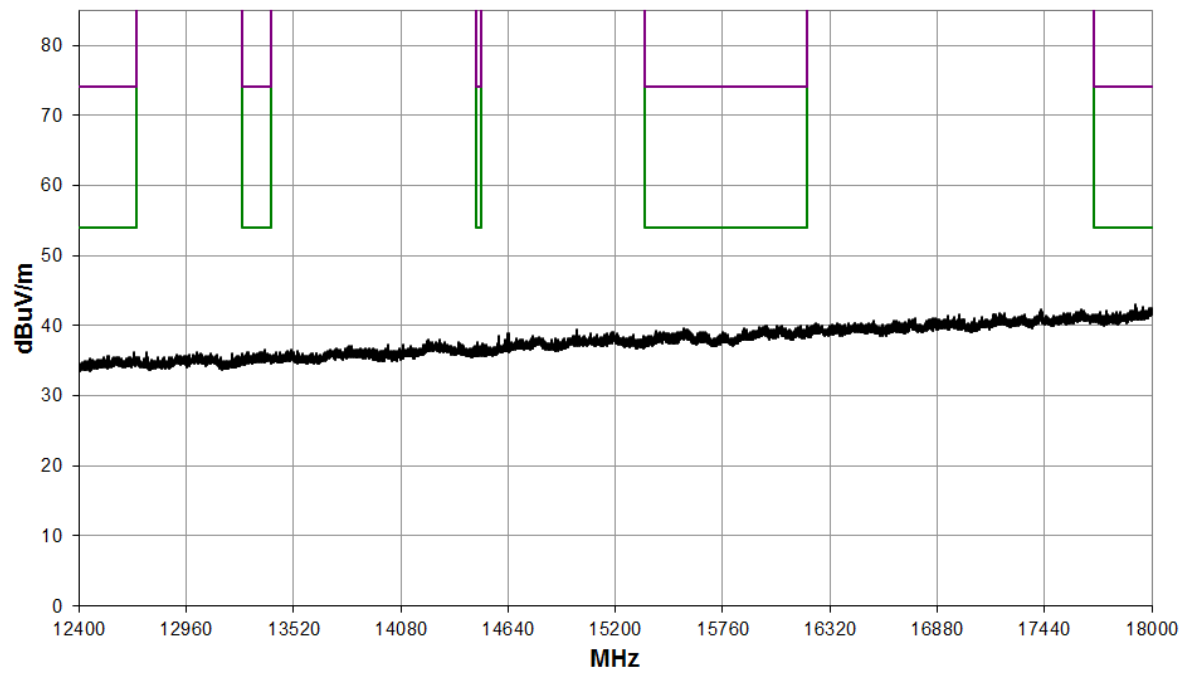
4 GHz to 8.2 GHz



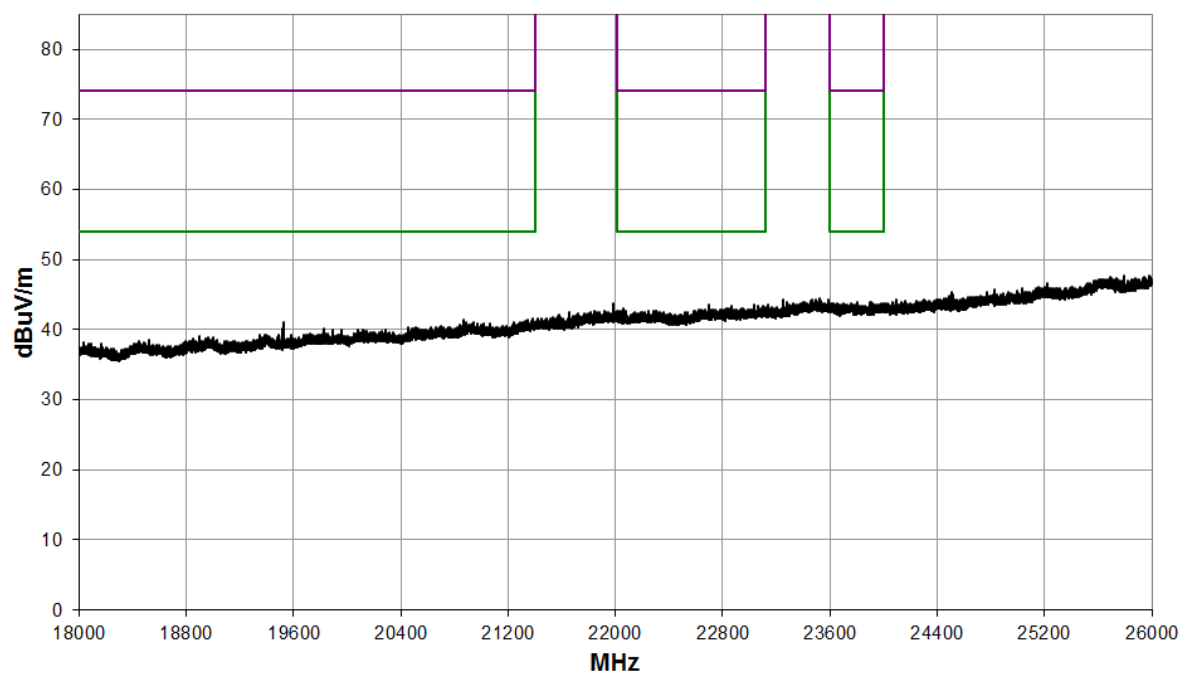
8.2 GHz to 12.4 GHz



12.4 GHz to 18 GHz



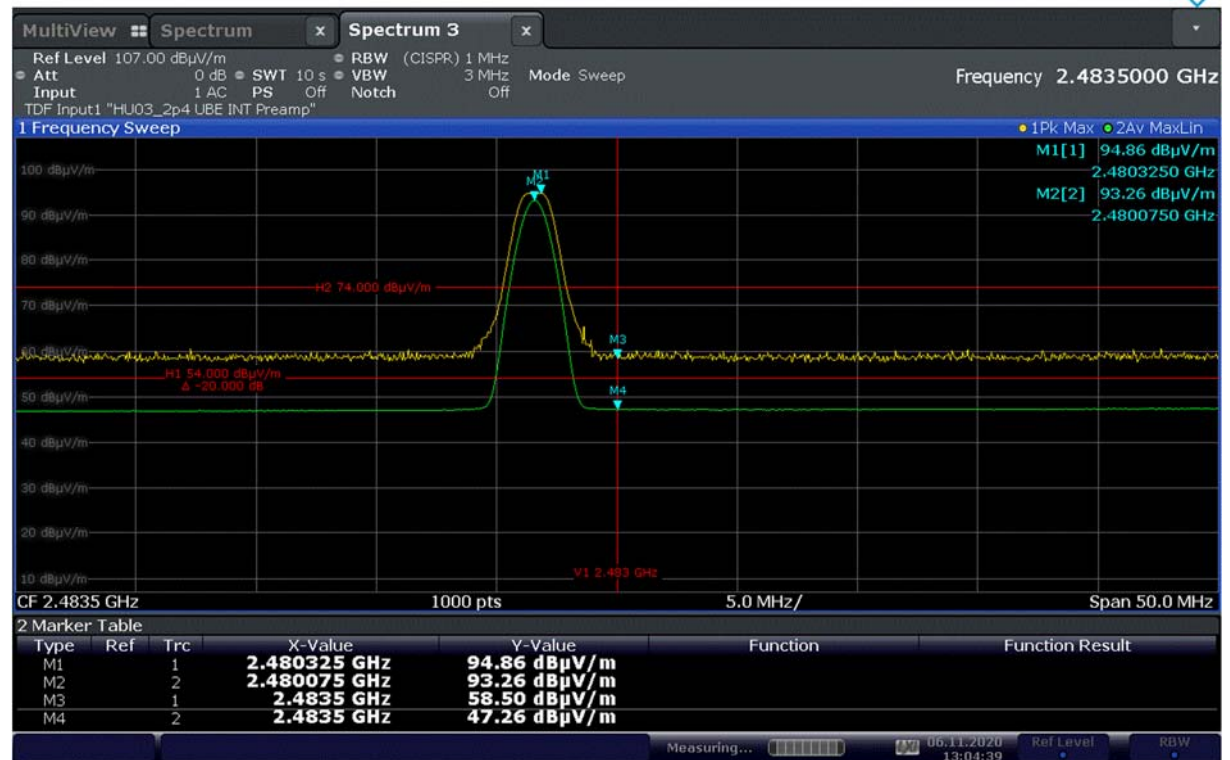
18 GHz to 26 GHz



Frequency: 2480 MHz; Power Setting: 8 dBm ; Modulation: GFSK; Data Rate: 1 Mbps								
Detector	Freq. (MHz)	Meas'd Emission (dBμV)	Factor (dB)	Duty Cycle Corr'n (dB)	Distance Extrap'n Factor (dB)	Field Strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
AV	12399.2	1.2	40.3	0.6	0.0	42.1	54.0	-11.9
PK	12399.3	15.8	40.3	0.0	0.0	56.1	54.0	-17.9

Band Edge

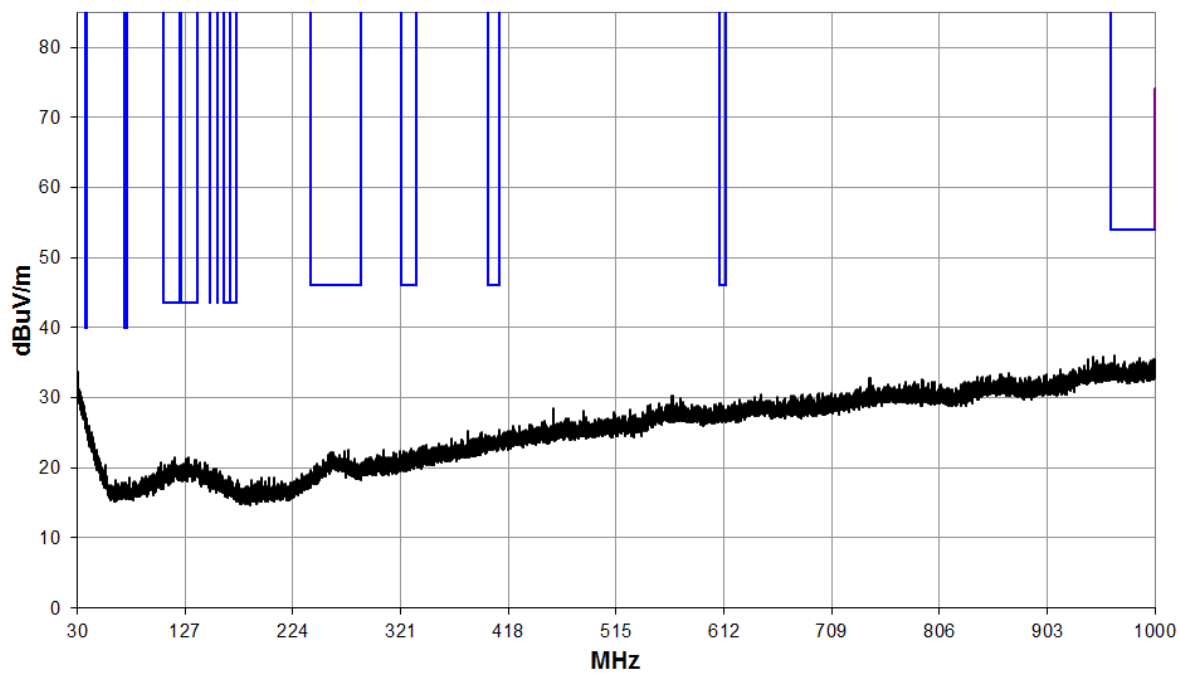
Element



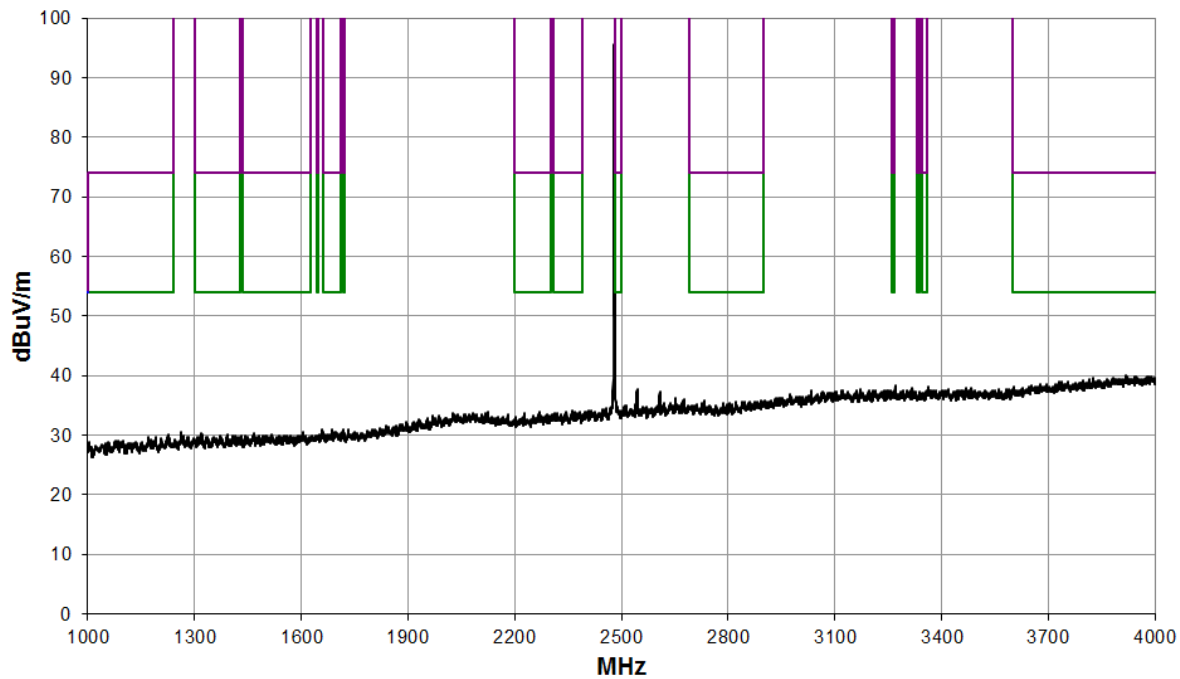
13:04:39 06.11.2020

Band Edge Measurement; Frequency: 2480 MHz; Power Setting: 8 dBm ; Modulation: GFSK; Data Rate: 1 Mbps						
Detector	Freq. (MHz)	Meas'd Emission (dBμV/m)	Duty Cycle Corr'n (dB)	Field Strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
AV	2483.5	47.26	0.6	47.86	54.0	6.14

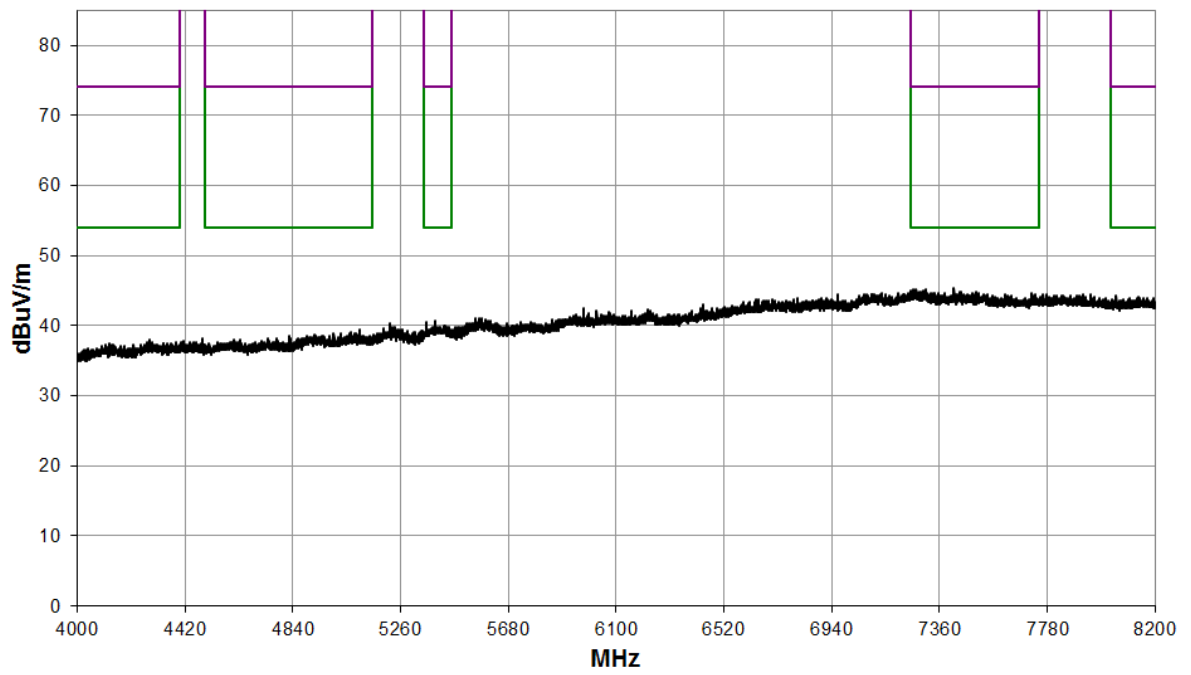
30 MHz to 1 GHz



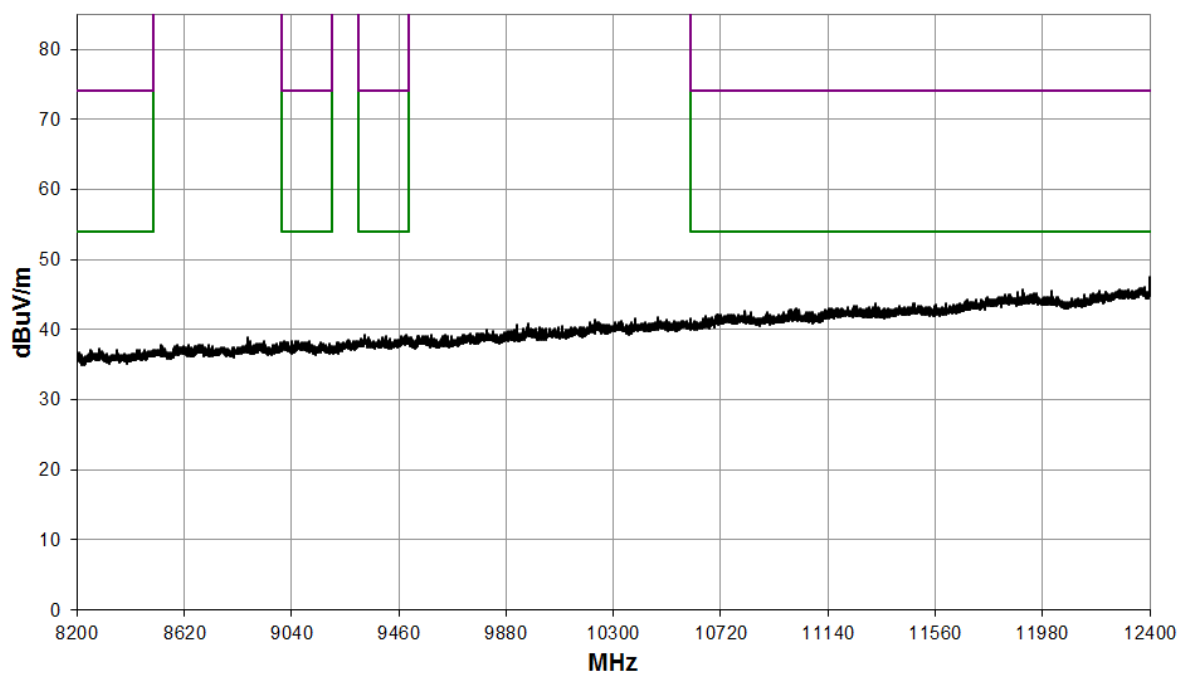
1 GHz to 4 GHz



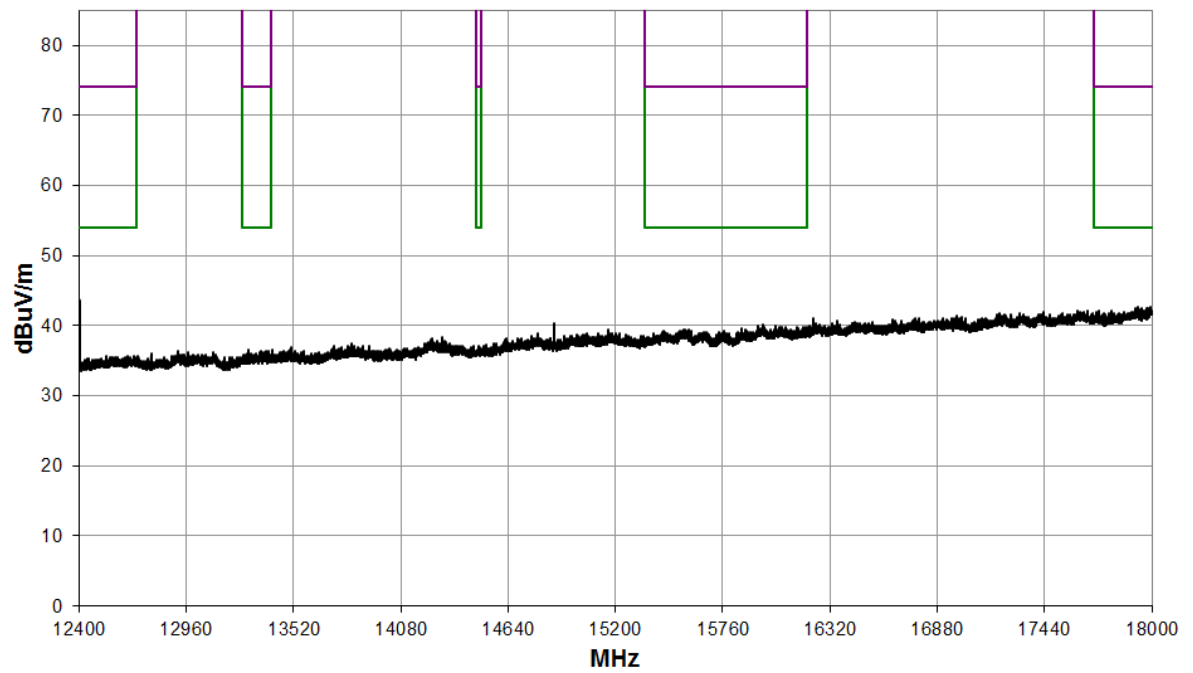
4 GHz to 8.2 GHz



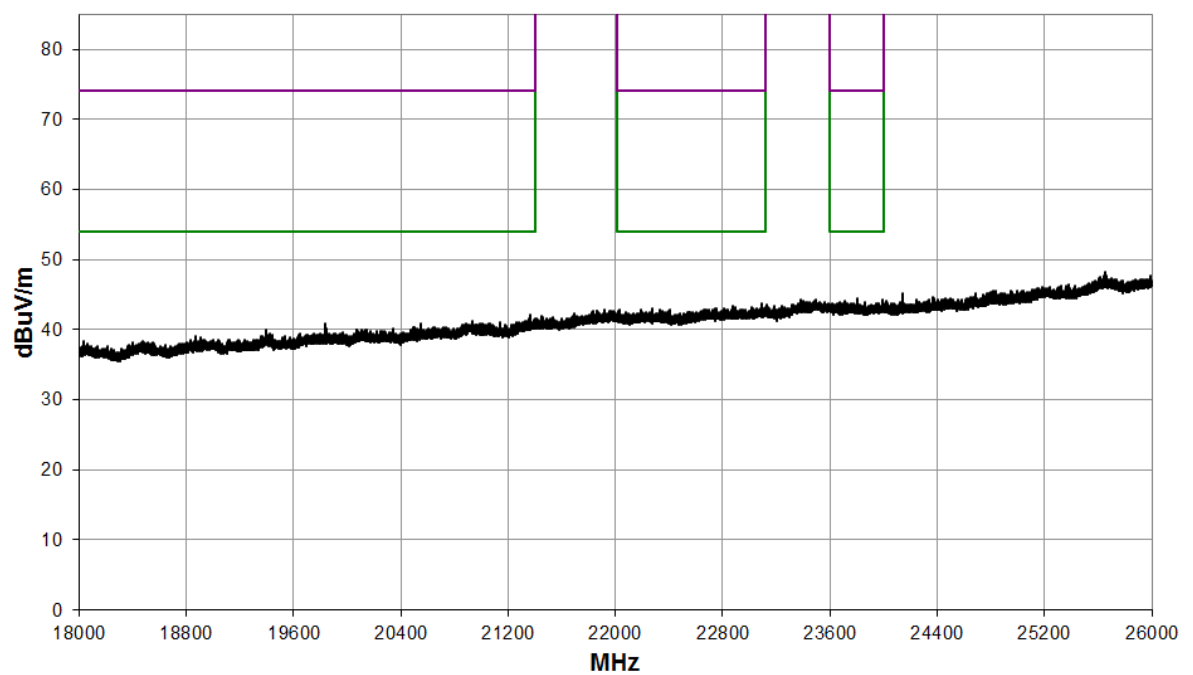
8.2 GHz to 12.4 GHz



12.4 GHz to 18 GHz

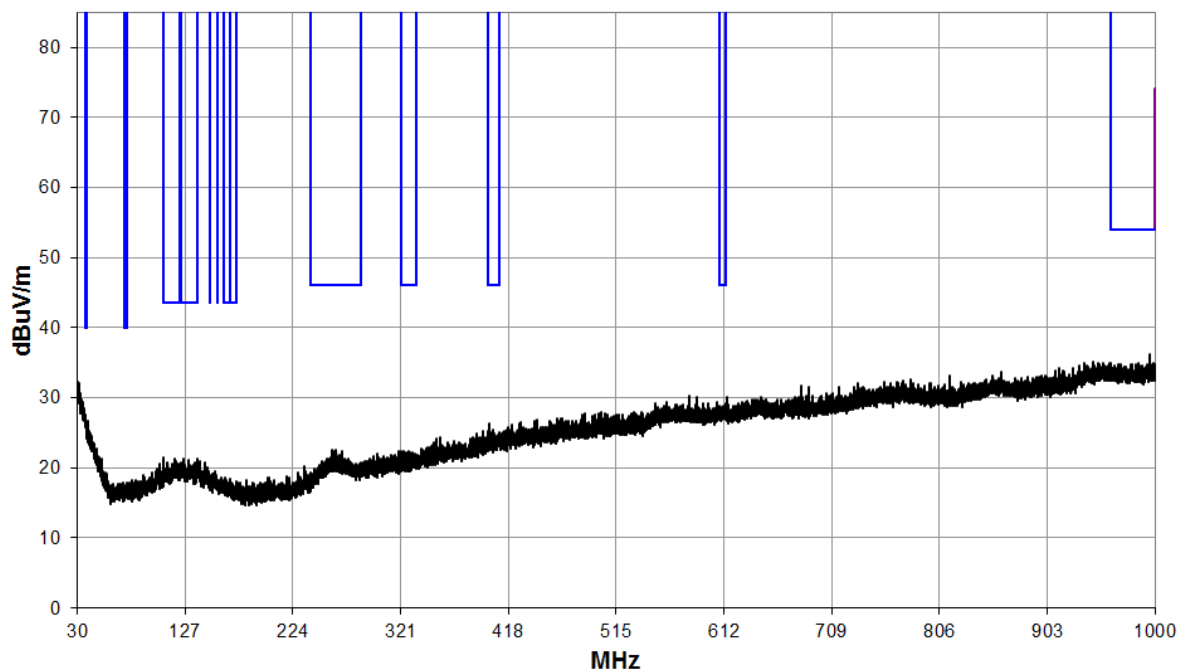


18 GHz to 26 GHz

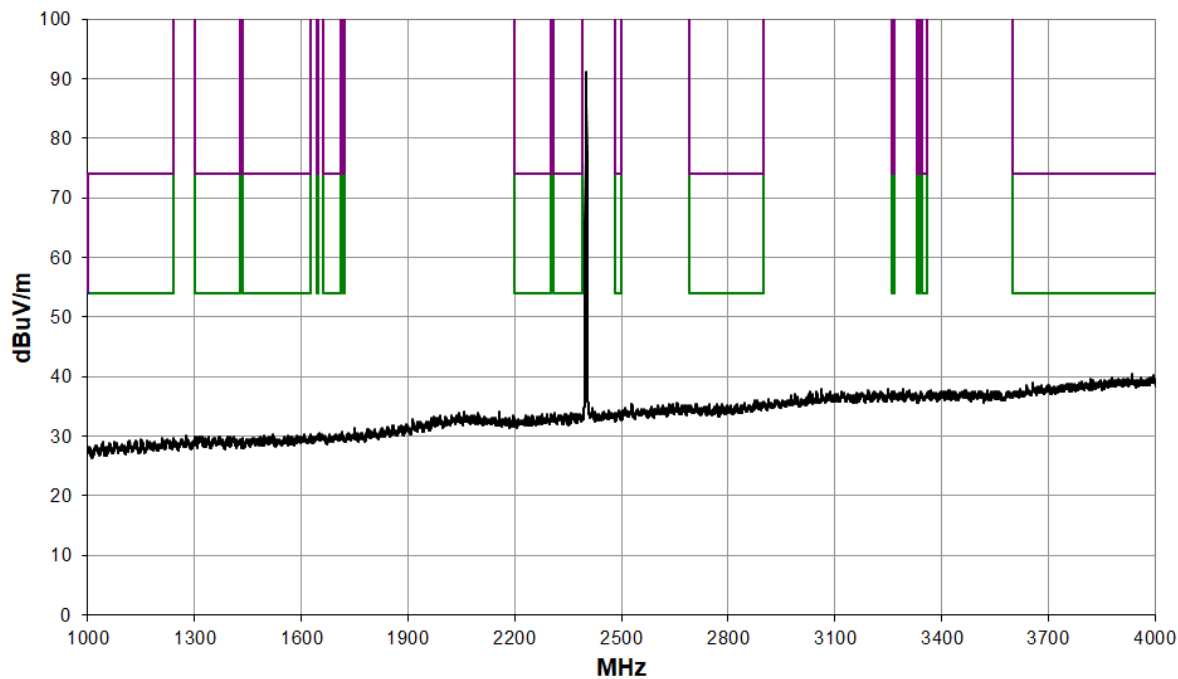


Frequency: 2402 MHz; Power Setting: 8 dBm ; Modulation: GFSK; Data Rate: 2 Mbps								
Detector	Freq. (MHz)	Meas'd Emission (dBμV)	Factor (dB)	Duty Cycle Corr'n (dB)	Distance Extrap'n Factor (dB)	Field Strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
PK	12006.7	16.1	39.8	0.0	0.0	55.9	74.0	-18.1
AV	12007.6	0.1	39.9	0.9	0.0	40.9	54.0	-13.1

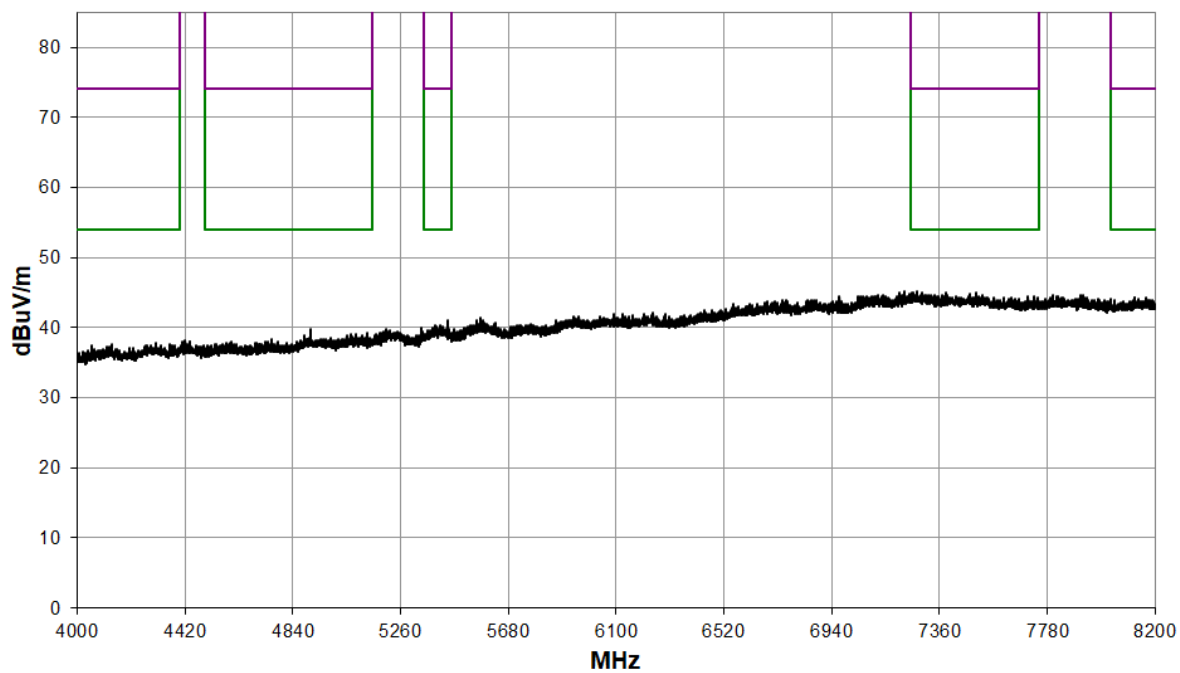
30 MHz to 1 GHz



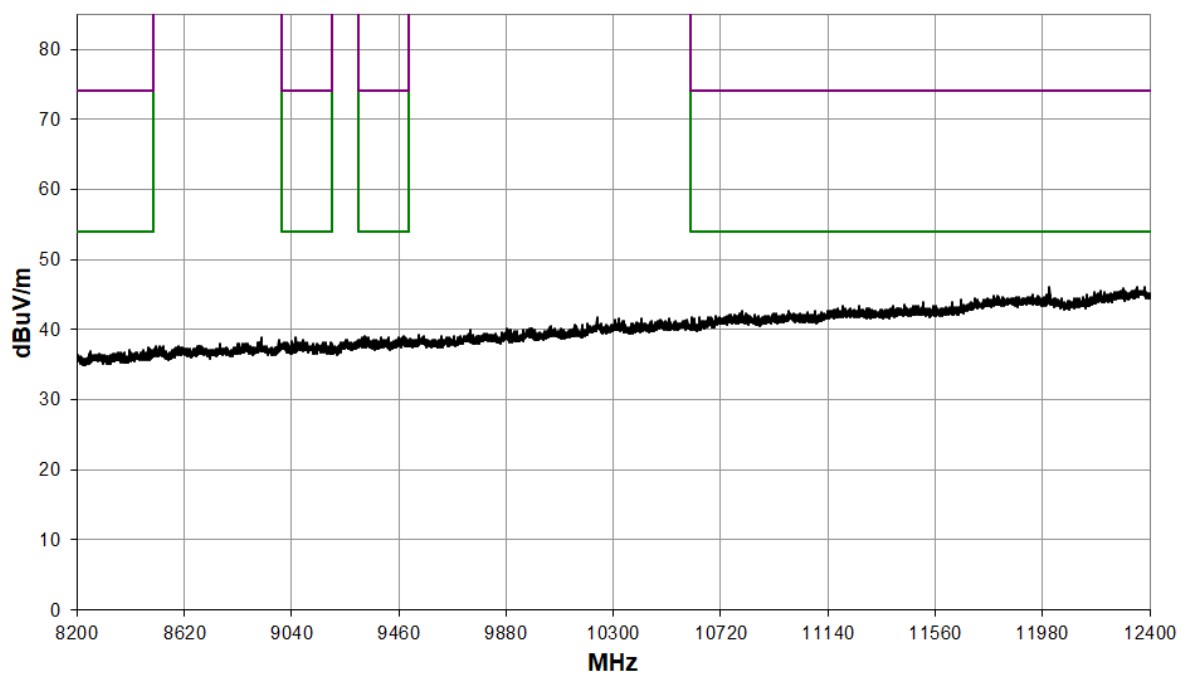
1 GHz to 4 GHz



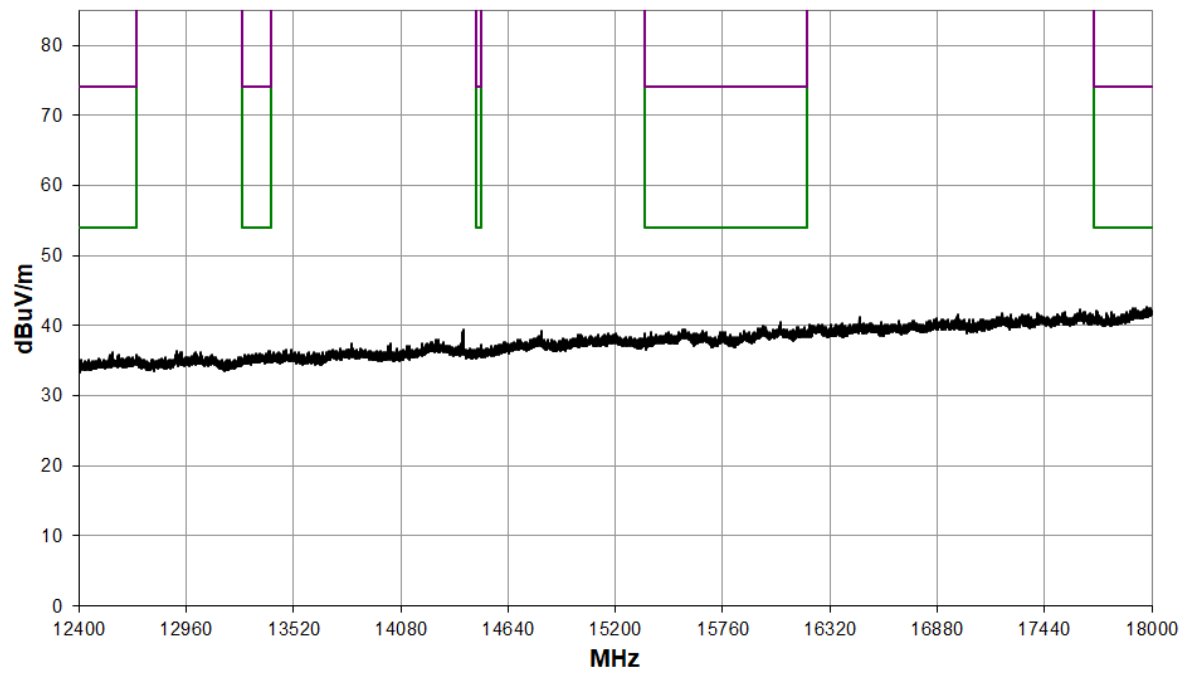
4 GHz to 8.2 GHz



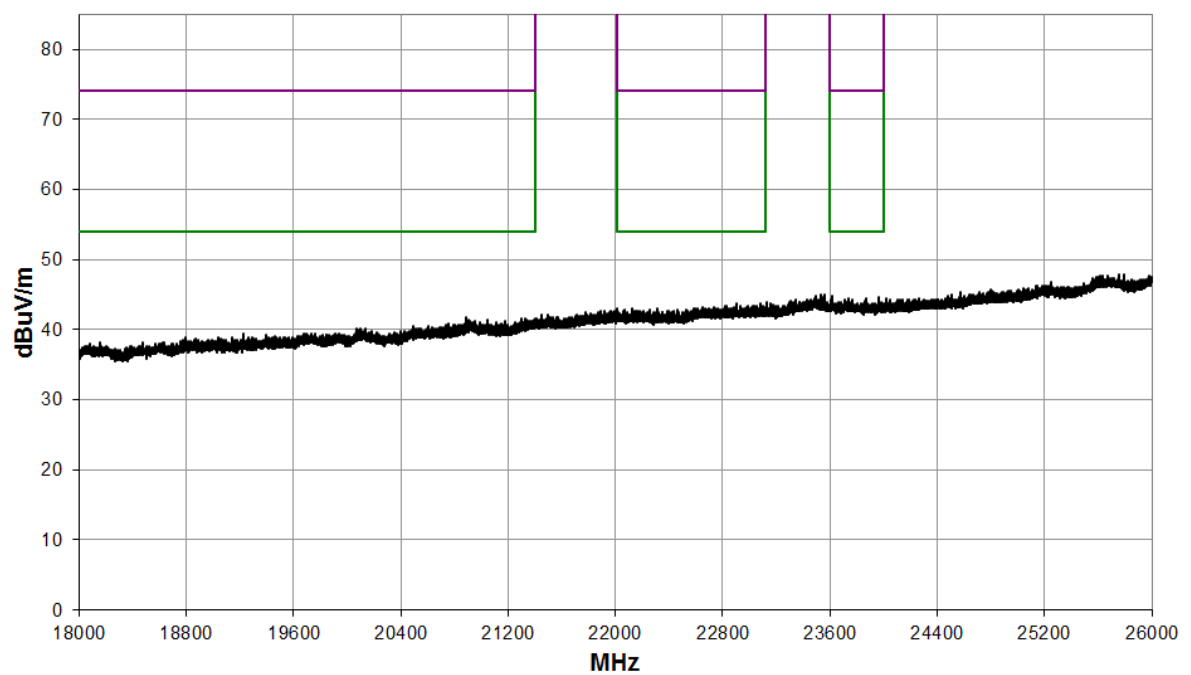
8.2 GHz to 12.4 GHz



12.4 GHz to 18 GHz

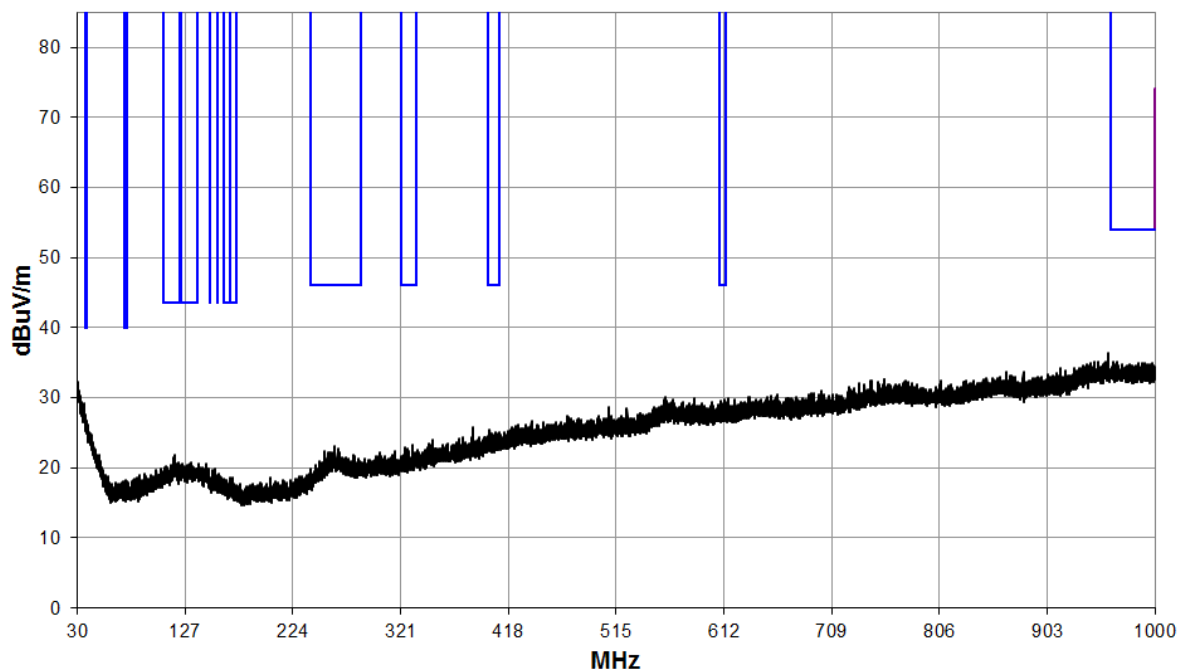


18 GHz to 26 GHz

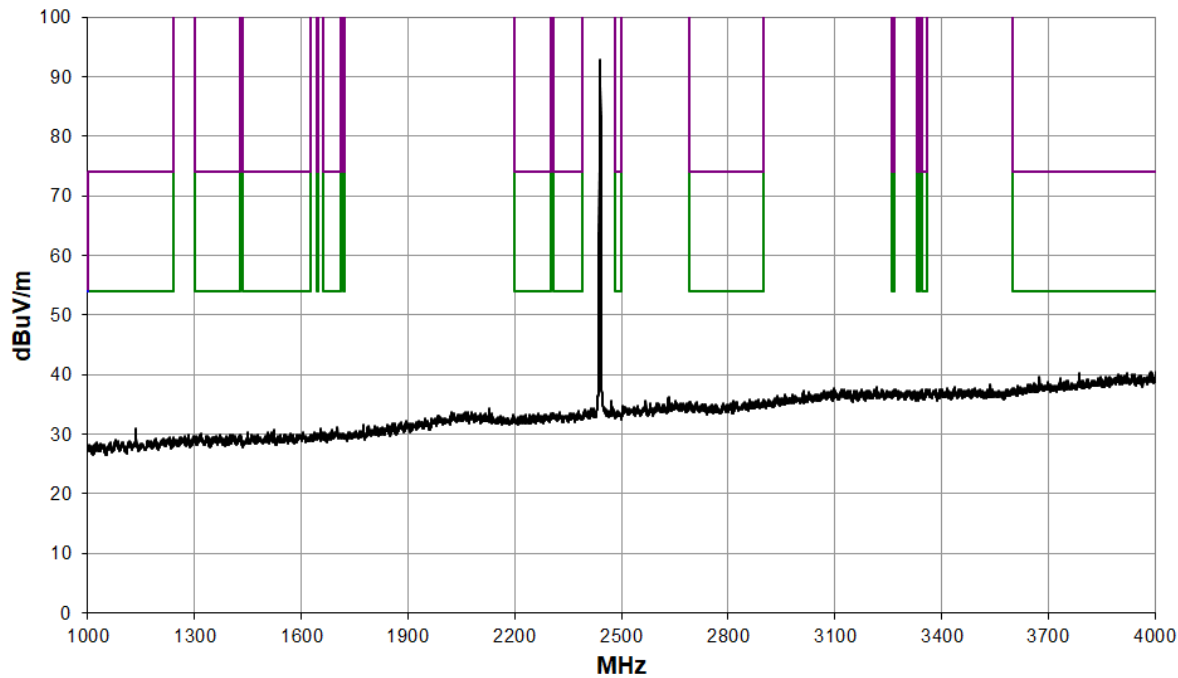


Frequency: 2440 MHz; Power Setting: 8 dBm; Modulation: GFSK; Data Rate: 2 Mbps								
Detector	Freq. (MHz)	Meas'd Emission (dBμV)	Factor (dB)	Duty Cycle Corr'n (dB)	Distance Extrap'n Factor (dB)	Field Strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
No emissions within 10 dB of the Limit								

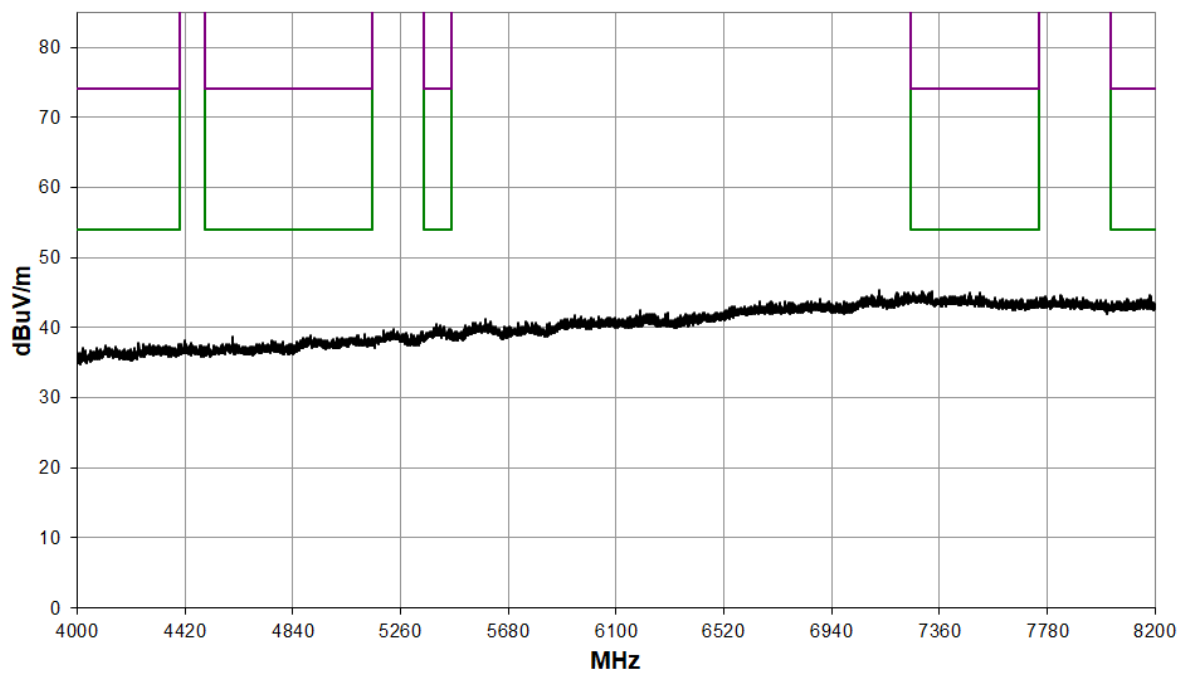
30 MHz to 1 GHz



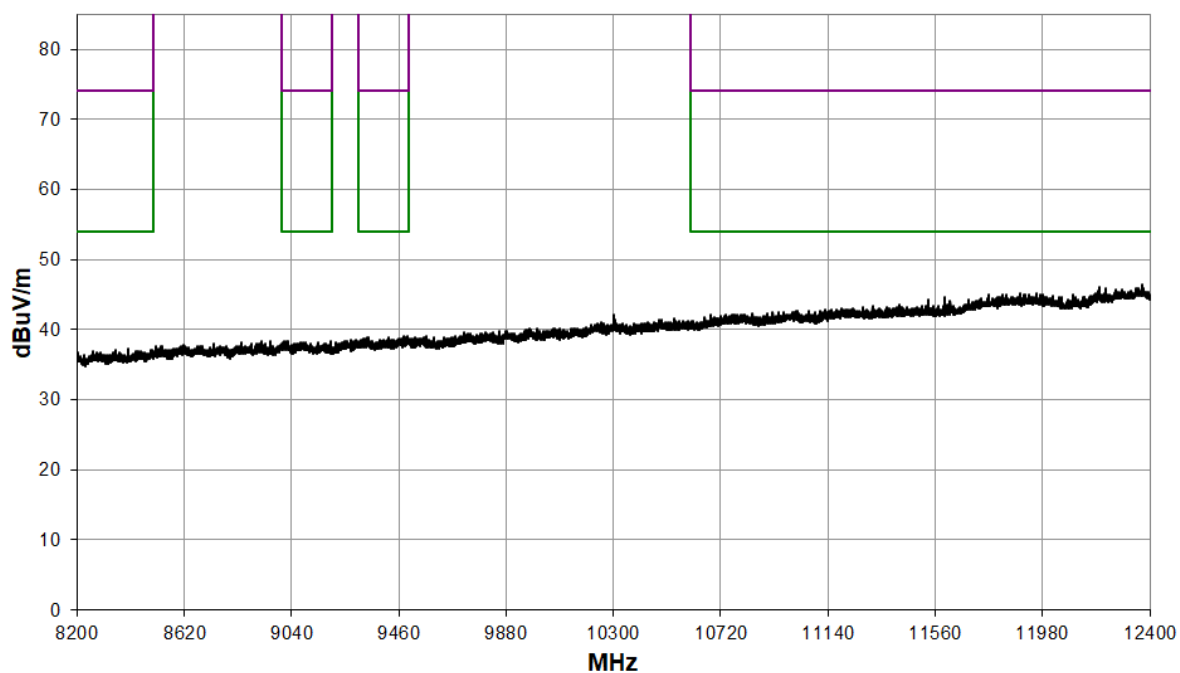
1 GHz to 4 GHz



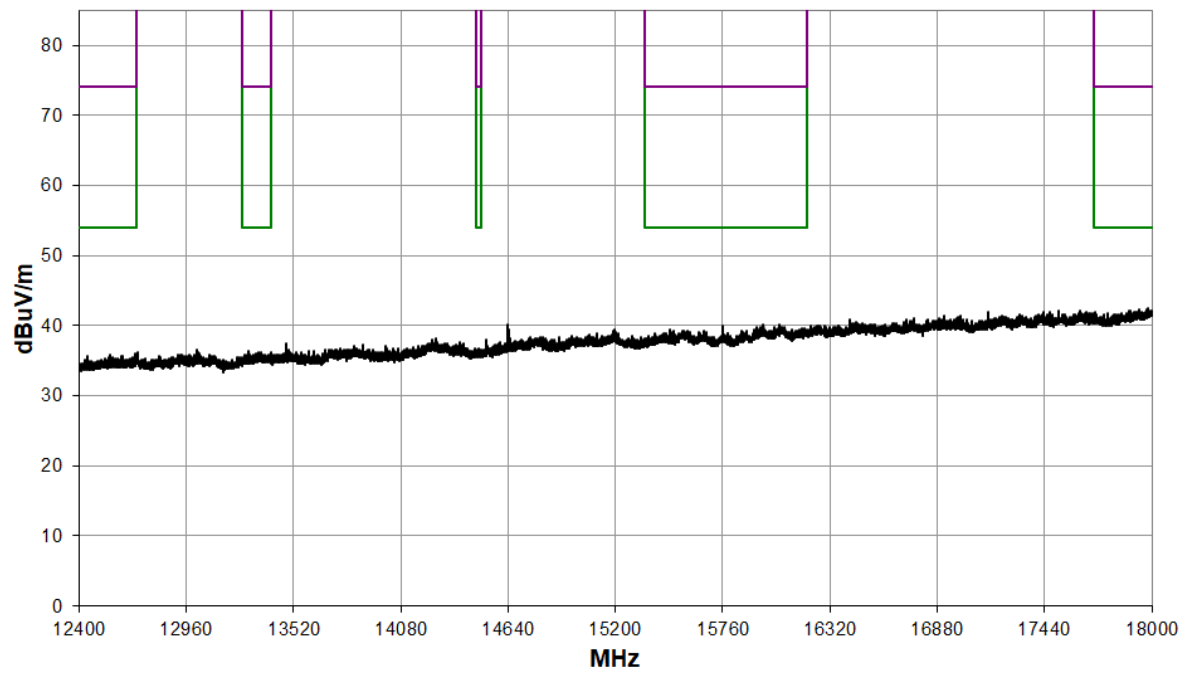
4 GHz to 8.2 GHz



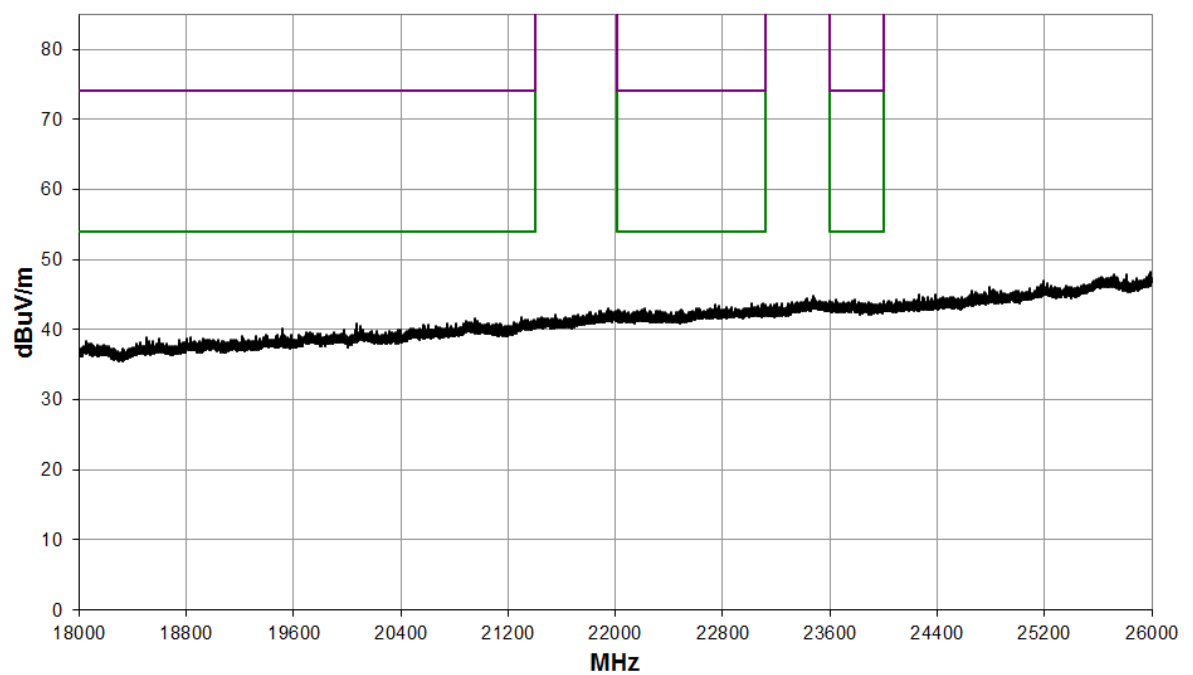
8.2 GHz to 12.4 GHz



12.4 GHz to 18 GHz



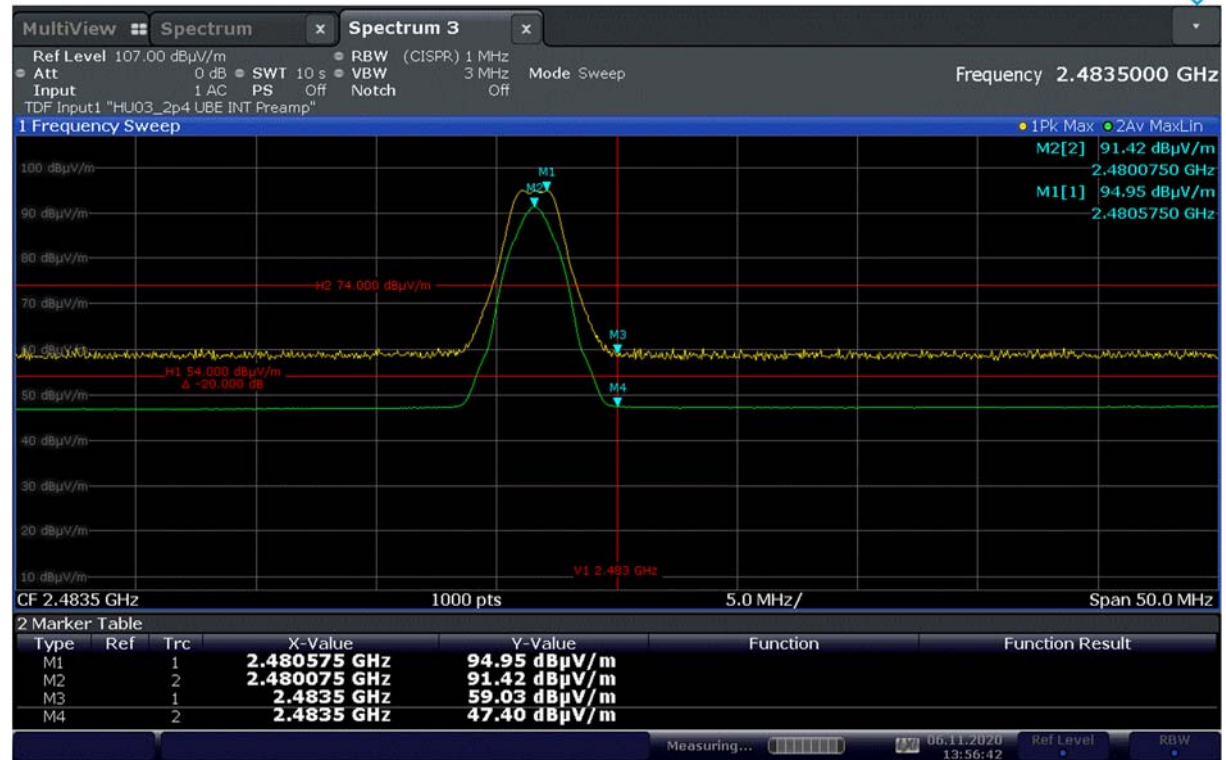
18 GHz to 26 GHz



Frequency: 2480 MHz; Power Setting: 8 dBm ; Modulation: GFSK; Data Rate: 2 Mbps								
Detector	Freq. (MHz)	Meas'd Emission (dBμV)	Factor (dB)	Duty Cycle Corr'n (dB)	Distance Extrap'n Factor (dB)	Field Strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
No emissions within 10 dB of the Limit								

Band Edge

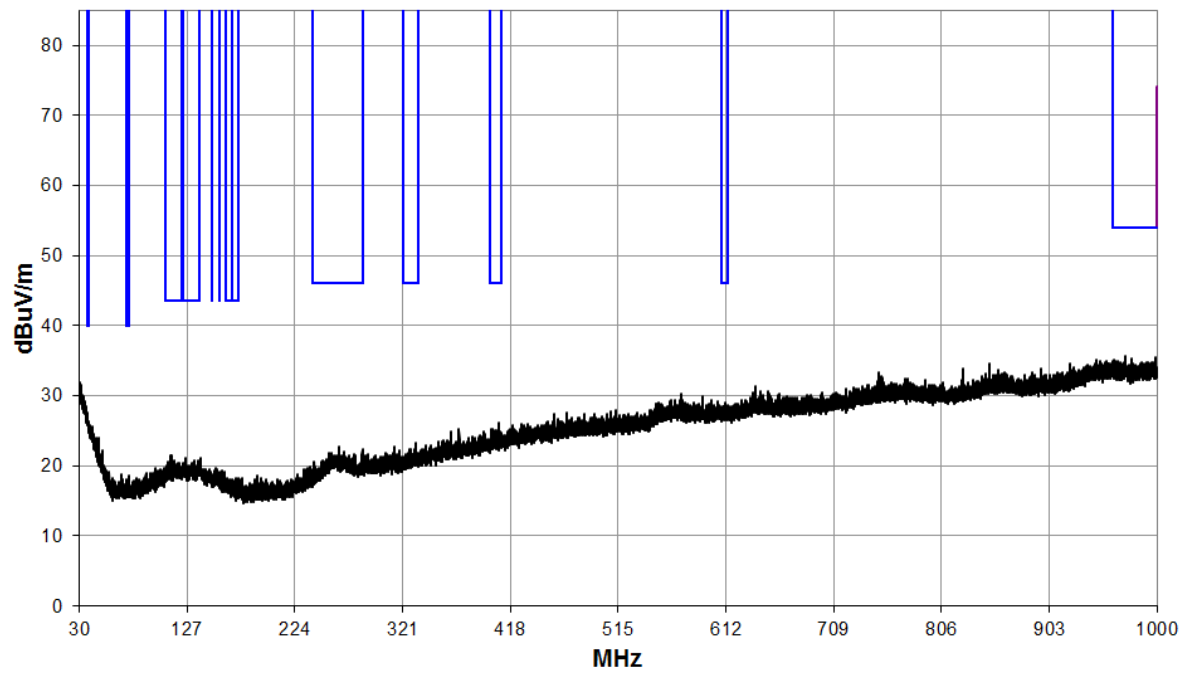
Element



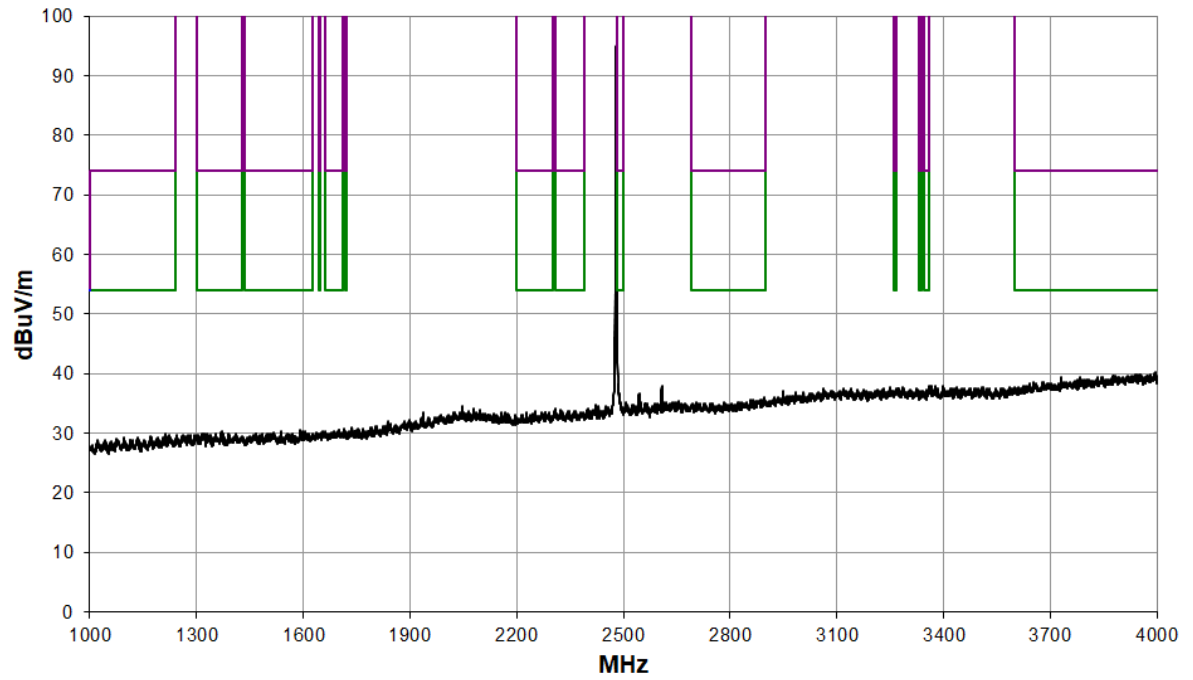
13:56:42 06.11.2020

Band Edge Measurement; Frequency: 2480 MHz; Power Setting: 8 dBm ; Modulation: GFSK; Data Rate: 2 Mbps						
Detector	Freq. (MHz)	Meas'd Emission (dBμV/m)	Duty Cycle Corr'n (dB)	Field Strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
AV	2483.5	47.40	0.9	48.30	54.0	5.7

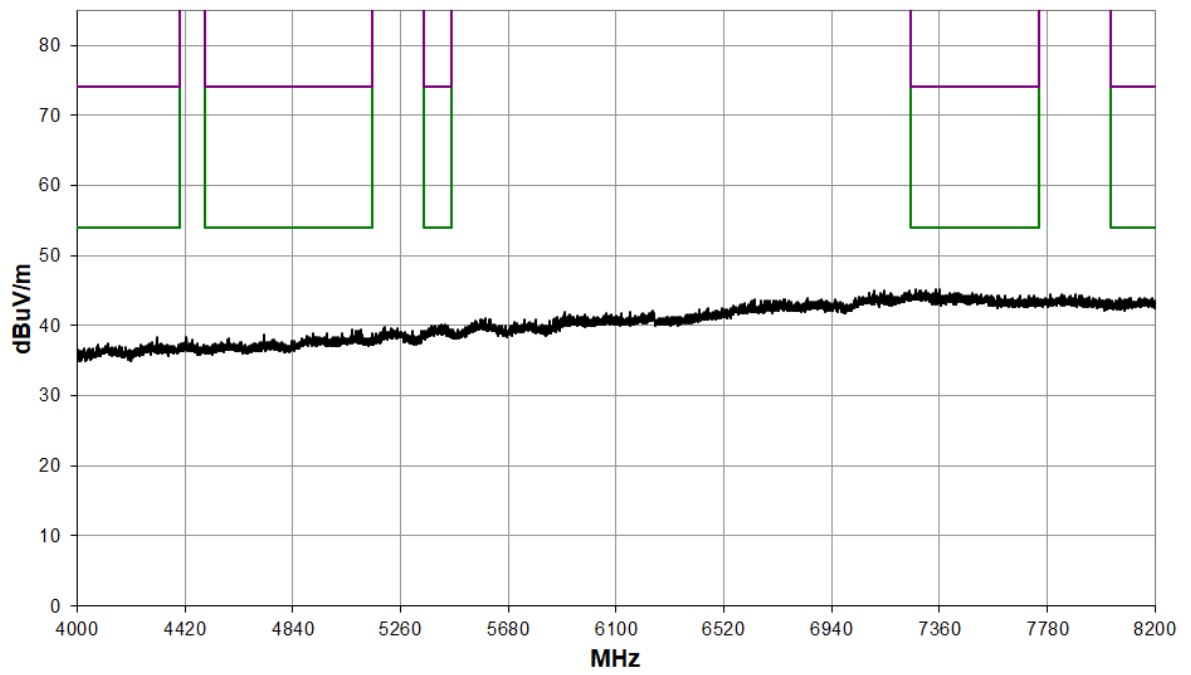
30 MHz to 1 GHz



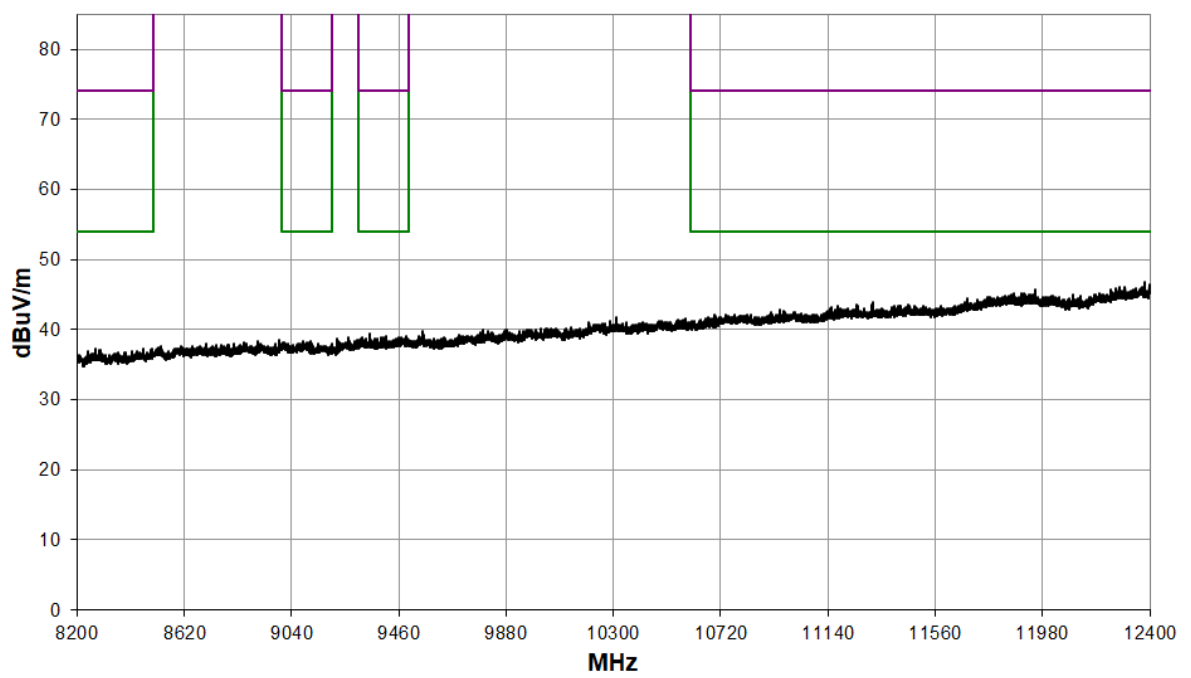
1 GHz to 4 GHz



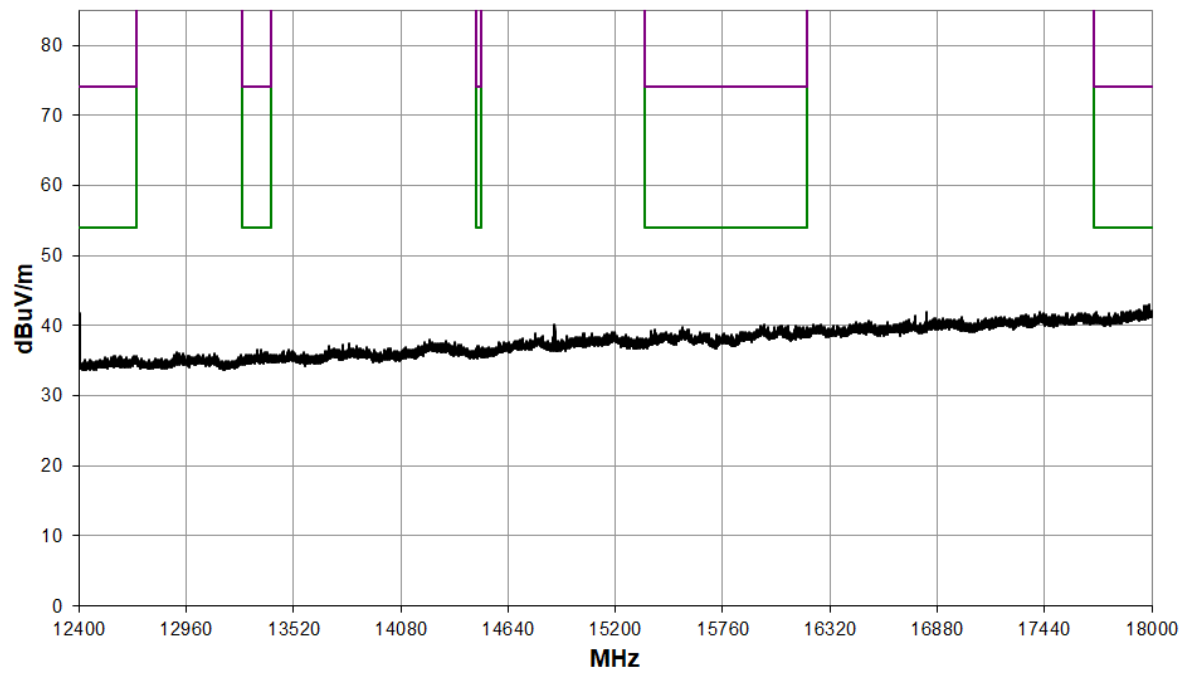
4 GHz to 8.2 GHz



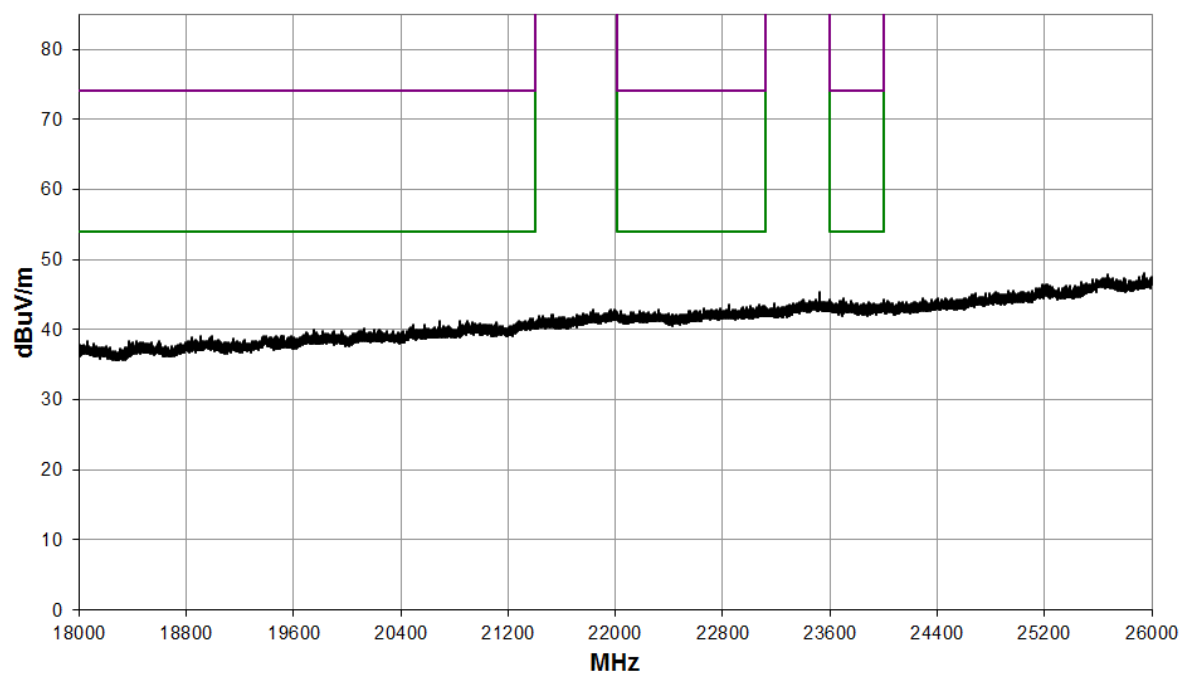
8.2 GHz to 12.4 GHz



12.4 GHz to 18 GHz



18 GHz to 26 GHz



13 AC power-line conducted emissions

13.1 Definition

Line-to-ground radio-noise voltage that is conducted from all of the EUT current-carrying power input terminals that are directly (or indirectly via separate transformers or power supplies) connected to a public power network.

13.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Screen Room 2
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.2
Deviations From Standard:	None
Measurement Detectors:	Quasi-Peak and Average

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 °C to +35 °C (as declared)
Humidity: 38 % RH	20 % RH to 75 % RH (as declared)

13.3 Test Limit

A radio apparatus that is designed to be connected to the public utility (AC) power line shall ensure that the radio frequency voltage, which 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 Table 3.

Table 3 – AC Power Line Conducted Emission Limits

Frequency (MHz)	Conducted limit (dB μ V)	
	Quasi-Peak	Average ^{**}
0.15 to 0.5	66 to 56 [*]	56 to 46 [*]
0.5 to 5	56	46
5 to 30	60	50

*The level decreases linearly with the logarithm of the frequency.

**A linear average detector is required.

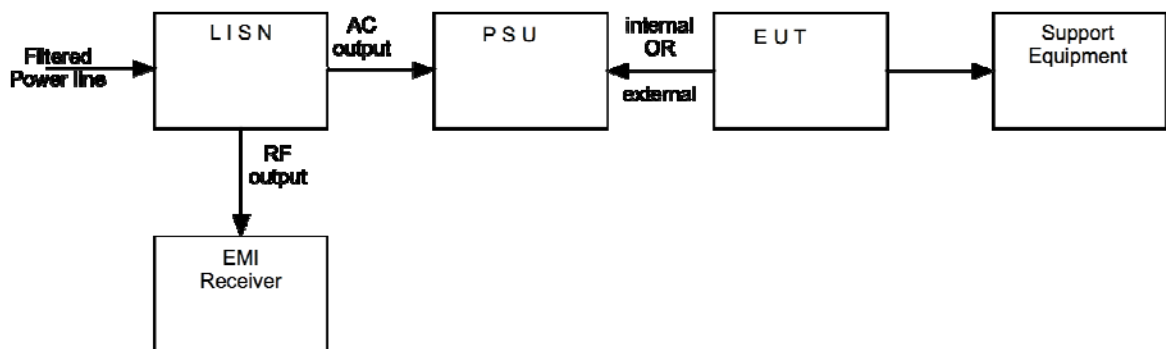
13.4 Test Method

With the EUT setup in a screened room, as per section 9 of this report and connected as per Figure ii, the power line emissions were measured on a spectrum analyzer / EMI receiver.

AC power line conducted emissions from the EUT are checked first by preview scans with peak and average detectors covering both live and neutral lines. A spectrum analyzer is used to determine if any periodic emissions are present.

Formal measurements using the correct detector(s) and bandwidth are made on frequencies identified from the preview scans. Final measurements were performed with EUT set at its maximum duty in transmit and receive modes.

Figure ii Test Setup



13.5 Test Set-up Photograph



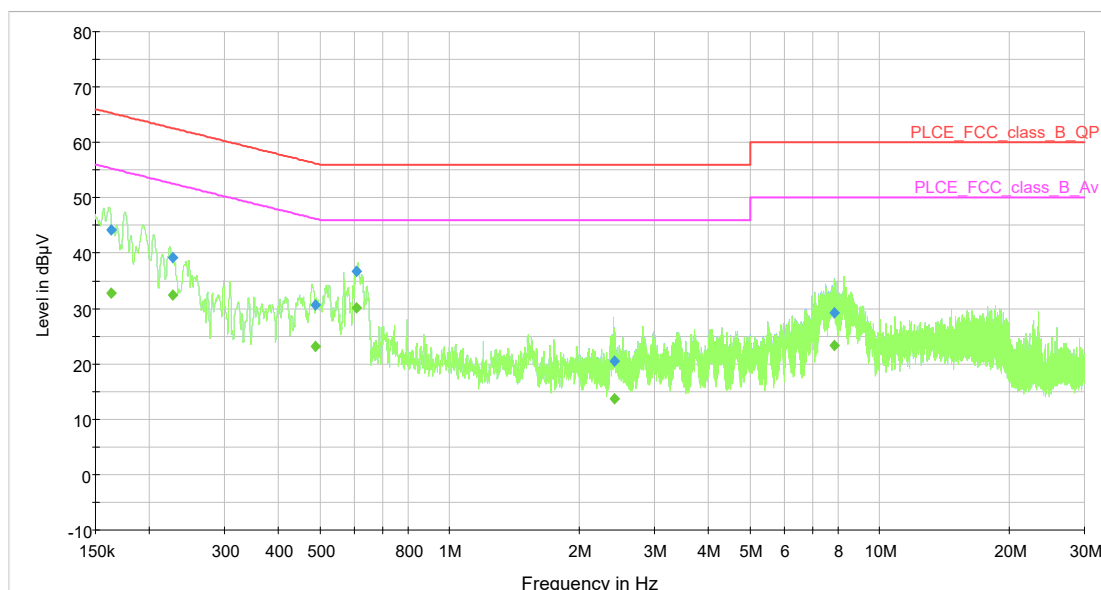
13.6 Test Equipment

Equipment Description	Manufacturer	Equipment Type	Element No	Due For Calibration
Measuring Receiver	R&S	ESCI7	RFG715	2021-01-10
LISN	R&S	ESH3-Z5	RFG732	2021-05-18
Pulse Limiter	R&S	ESH3-Z2	RFG680	2021-06-09

13.7 Test Results

Results measured using the quasi-peak detector						
Reference Number	Frequency (MHz)	Conductor	Result (dBuV)	Limit (dBuV)	Margin (dB)	Result Summary
1	0.163	L1	44.1	65.3	21.2	PASS
2	0.226	N	39.3	62.6	23.3	PASS
3	0.487	N	30.6	56.2	25.7	PASS
4	0.608	L1	36.6	56.0	19.4	PASS
5	2.414	L1	20.4	56.0	35.6	PASS
6	7.864	N	29.3	60.0	30.7	PASS

Results measured using the average detector						
Reference Number	Frequency (MHz)	Conductor	Result (dBuV)	Limit (dBuV)	Margin (dB)	Result Summary
1	0.163	L1	32.8	55.3	22.5	PASS
2	0.226	N	32.4	52.6	20.2	PASS
3	0.487	N	23.2	46.2	23.0	PASS
4	0.608	L1	30.1	46.0	15.9	PASS
5	2.414	L1	13.7	46.0	32.3	PASS
6	7.864	N	23.4	50.0	26.6	PASS



14 Occupied Bandwidth

14.1 Definition

The emission bandwidth (x dB) is defined as the frequency range between two points, one above and one below the carrier frequency, at which the spectral density of the emission is attenuated x dB below the maximum in-band spectral density of the modulated signal.

14.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Wireless Lab 2
Test Standard and Clauses:	ANSI C63.10-2013, Clause 11.8
EUT Frequencies Measured:	2402 MHz, 2440 MHz & 2480 MHz
Deviations From Standard:	None
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 19 °C	+15 °C to +35 °C (as declared)
Humidity: 40 % RH	20 % RH to 75 % RH (as declared)

14.3 Test Limit

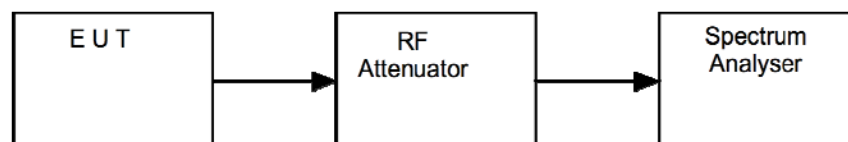
The minimum -6 dB bandwidth shall be at least 500 kHz.

14.4 Test Method

With the EUT connected as per Figure iii, the bandwidth of the EUT was measured on a spectrum analyser.

The measurements were performed with EUT set at its maximum duty. All modulation schemes, data rates and power settings were used to observe the worst-case configuration in each bandwidth.

Figure iii Test Setup

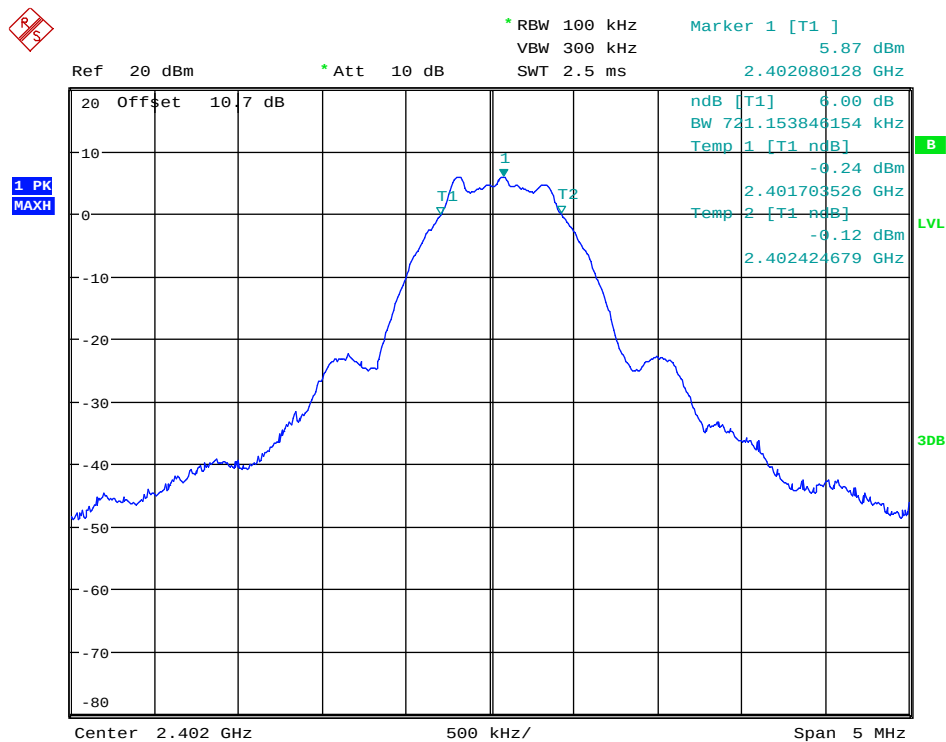


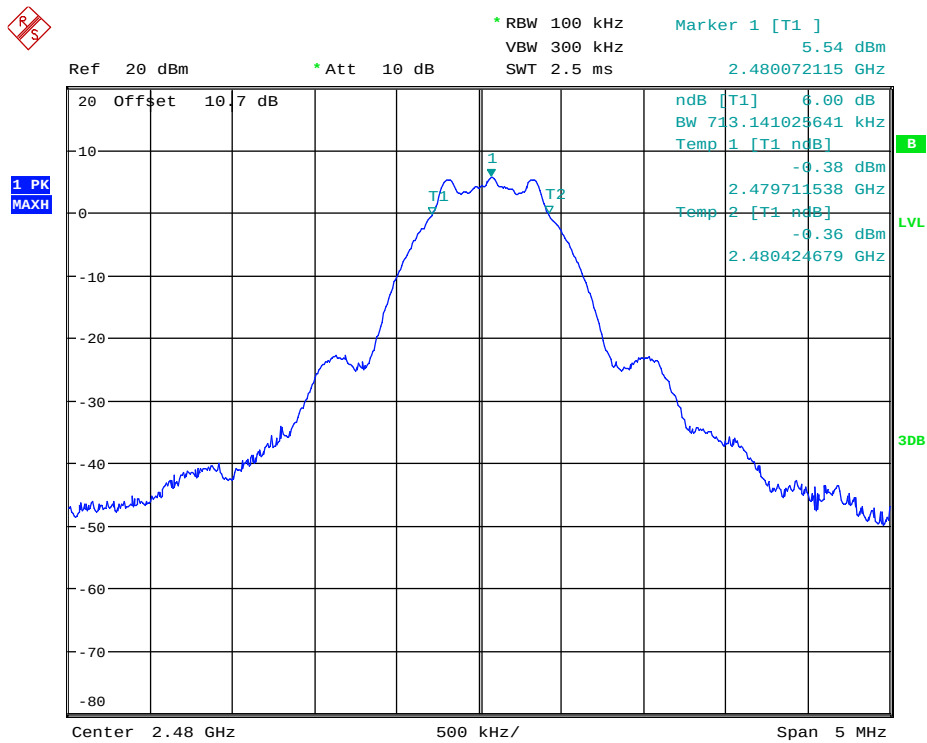
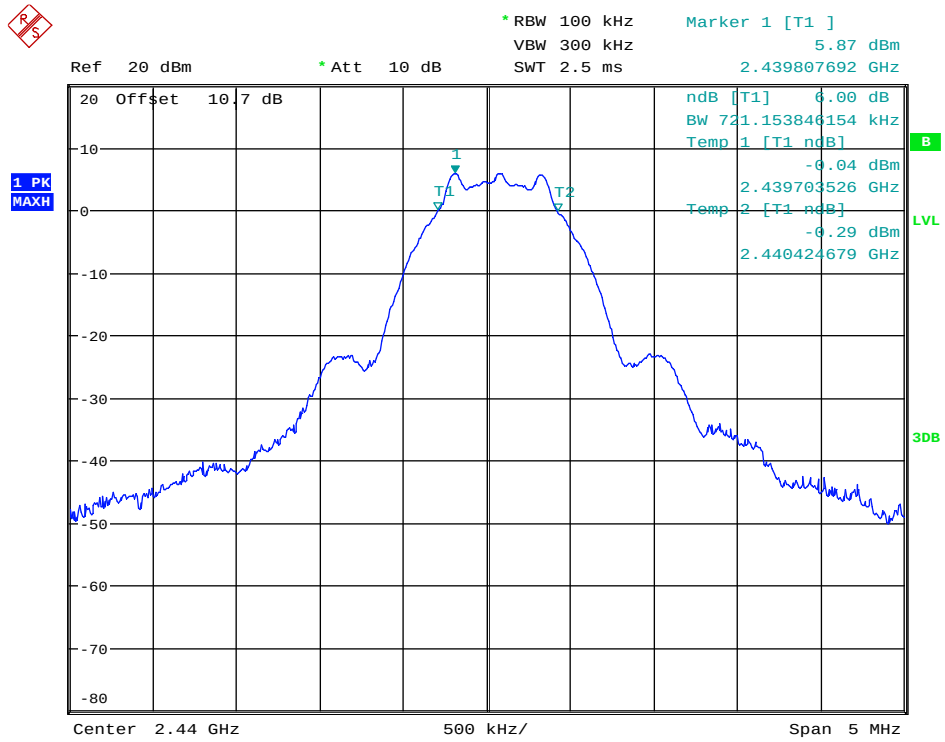
14.5 Test Equipment

Equipment Description	Manufacturer	Equipment Type	Element No	Due For Calibration
Spectrum Analyser	R&S	FSU50	U544	2021-06-17

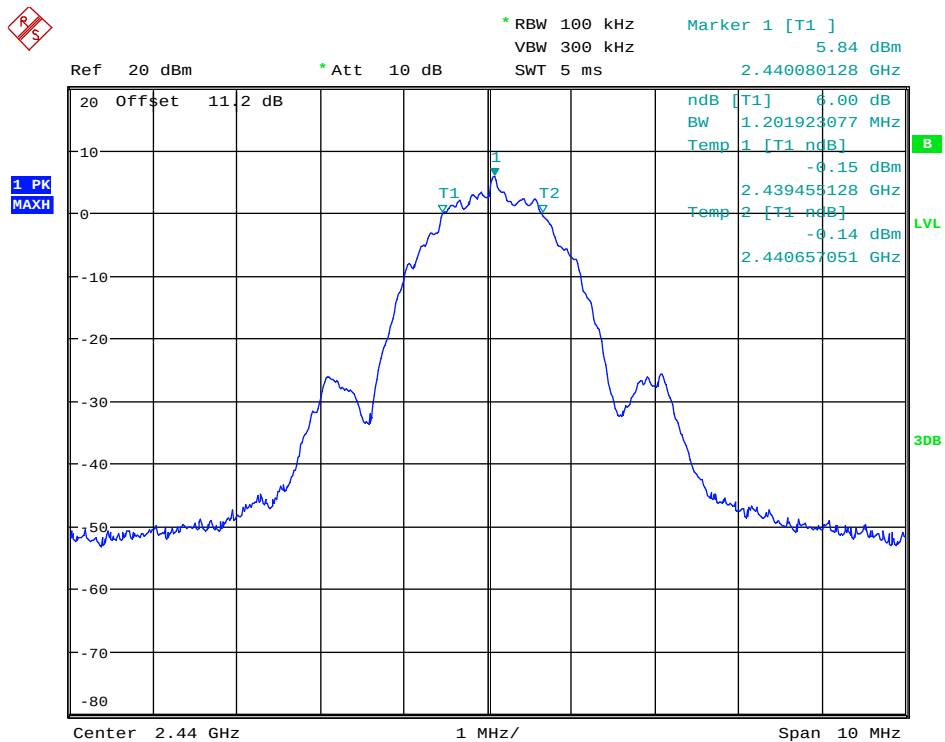
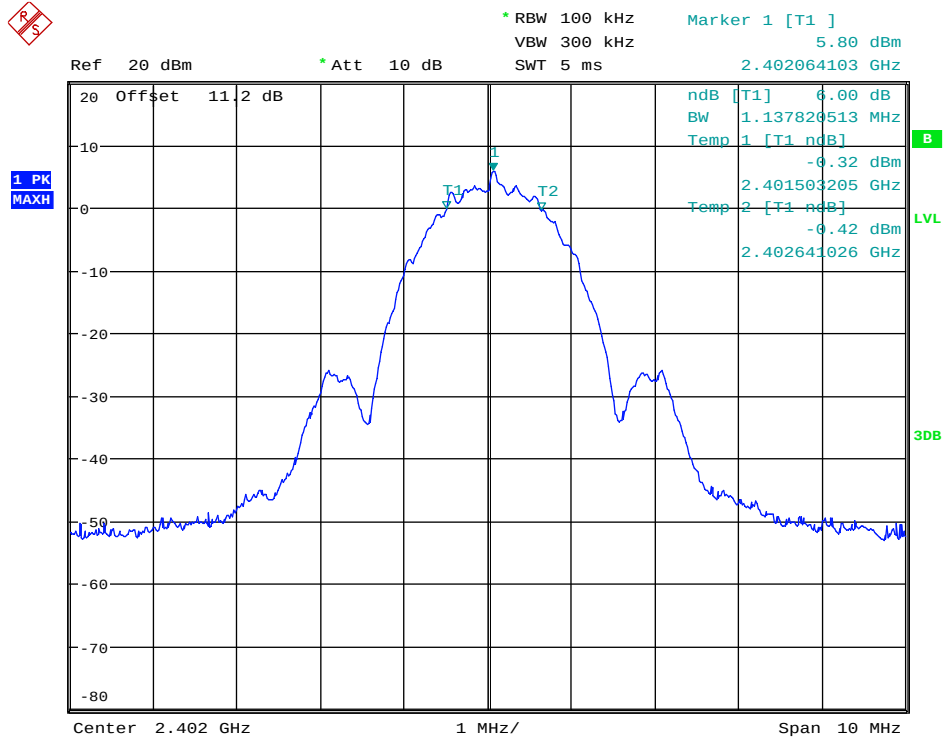
14.6 Test Results

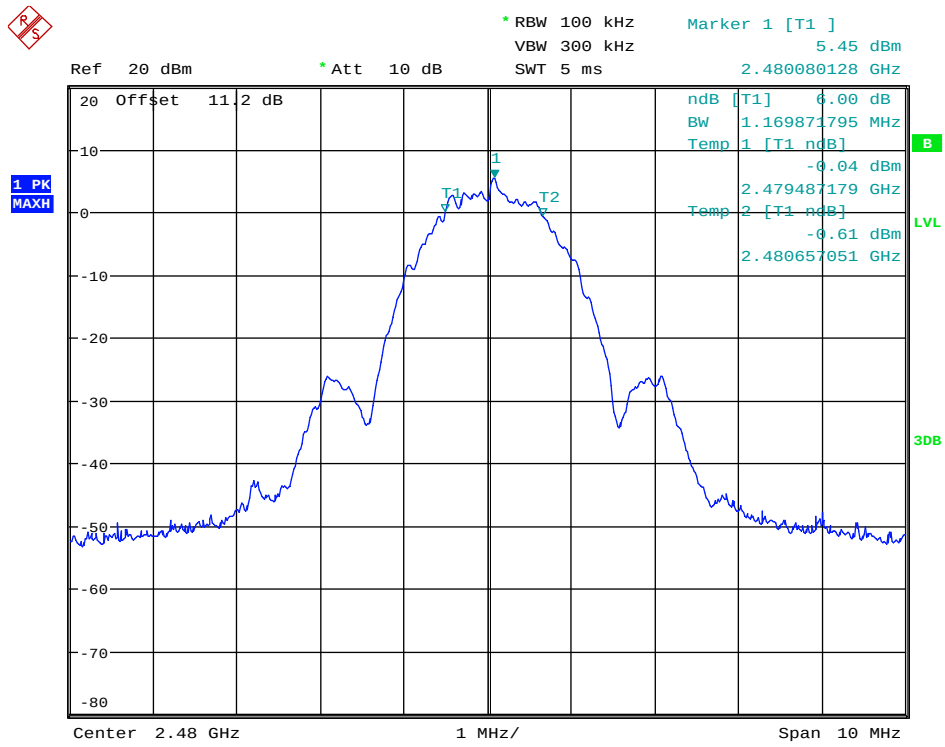
Power Setting: 8 dBm; Data Rate: 1 Mbps				
Frequency (MHz)	F_L (MHz)	F_H (MHz)	6 dB Bandwidth (kHz)	Result
2402	2401.703526	2402.424679	721.153	PASS
2440	2439.703526	2440.424679	721.153	PASS
2480	2479.711538	2480.424679	713.141	PASS





Power Setting: 8 dBm; Data Rate: 2 Mbps				
Frequency (MHz)	F_L (MHz)	F_H (MHz)	6 dB Bandwidth (kHz)	Result
2402	2401.503205	2402.641026	1137.821	PASS
2440	2439.455128	2440.657051	1201.923	PASS
2480	2479.487179	2480.657051	1169.872	PASS





15 Maximum peak conducted output power

15.1 Definition

The maximum peak conducted output power is defined as the maximum power level measured with a peak detector using a filter with width and shape of which is sufficient to accept the signal bandwidth.

15.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Wireless Lab 2
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.9
EUT Frequencies Measured:	2402 MHz, 2440 MHz & 2480 MHz
Deviations From Standard:	None

Environmental Conditions (Normal Environment)

Temperature: 19 °C	+15 °C to +35 °C (as declared)
Humidity: 40 % RH	20 % RH to 75 % RH (as declared)

15.3 Test Limit

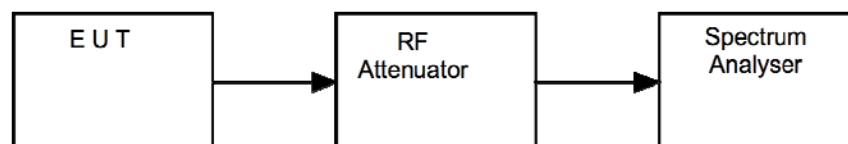
For systems employing digital modulation techniques operating in the bands 902 to 928 MHz, 2400 to 2483.5 MHz and 5725 to 5850 MHz, the maximum peak conducted output power shall not exceed 1 W.

15.4 Test Method

With the EUT connected as per Figure iv, the resolution bandwidth of the spectrum analyser was increased above the EUT occupied bandwidth and the peak emission data noted.

The measurements were performed with EUT set at its maximum duty. All modulation schemes, data rates and power settings were used to observe the worst-case configuration in each bandwidth.

Figure iv Test Setup

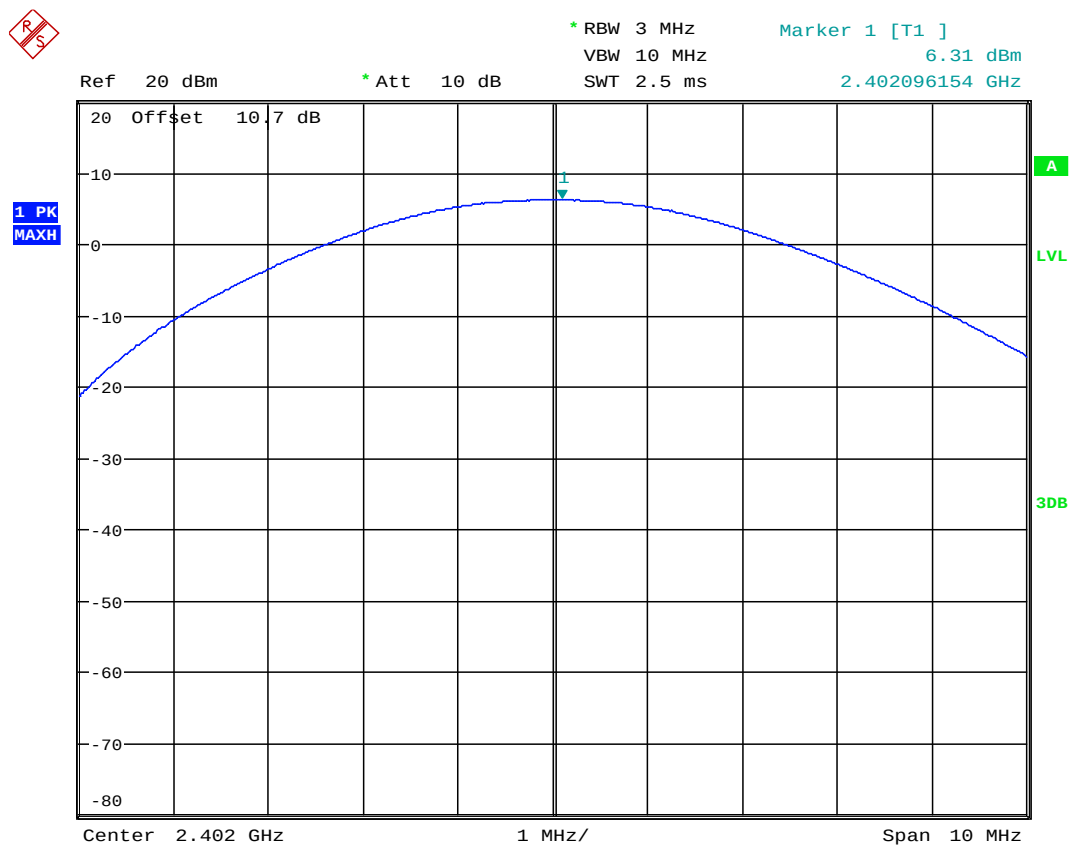


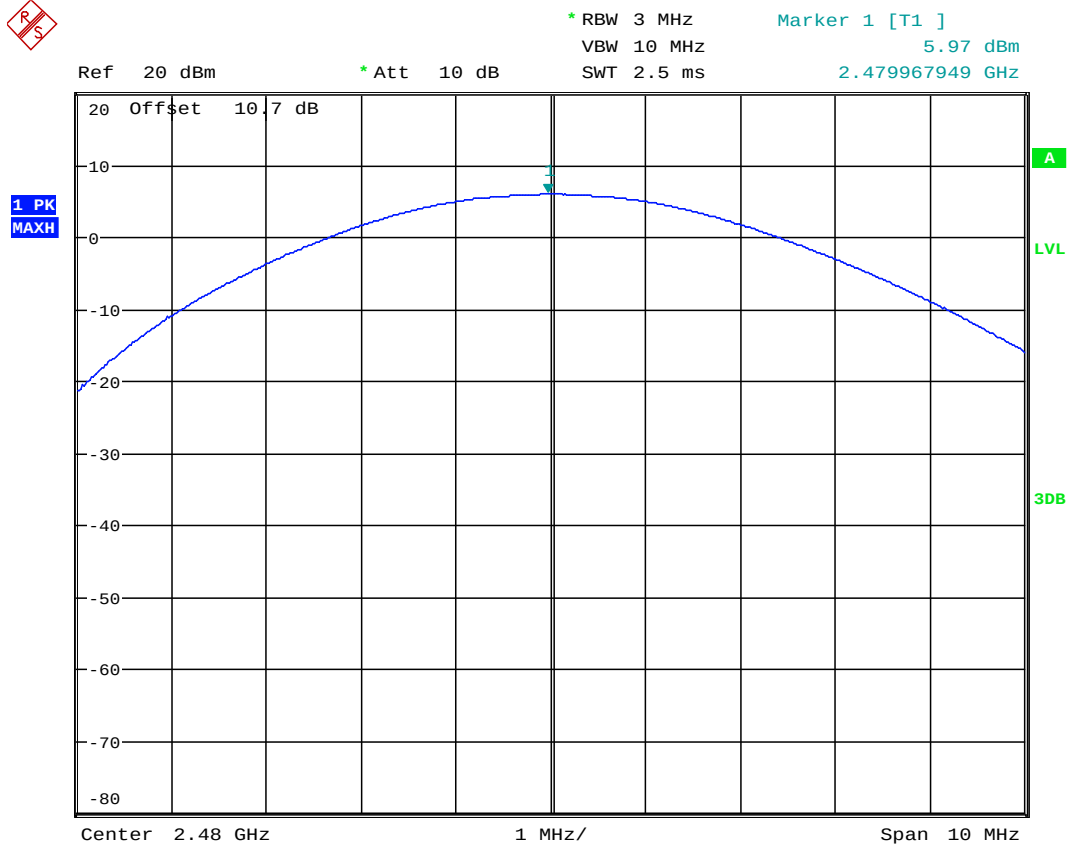
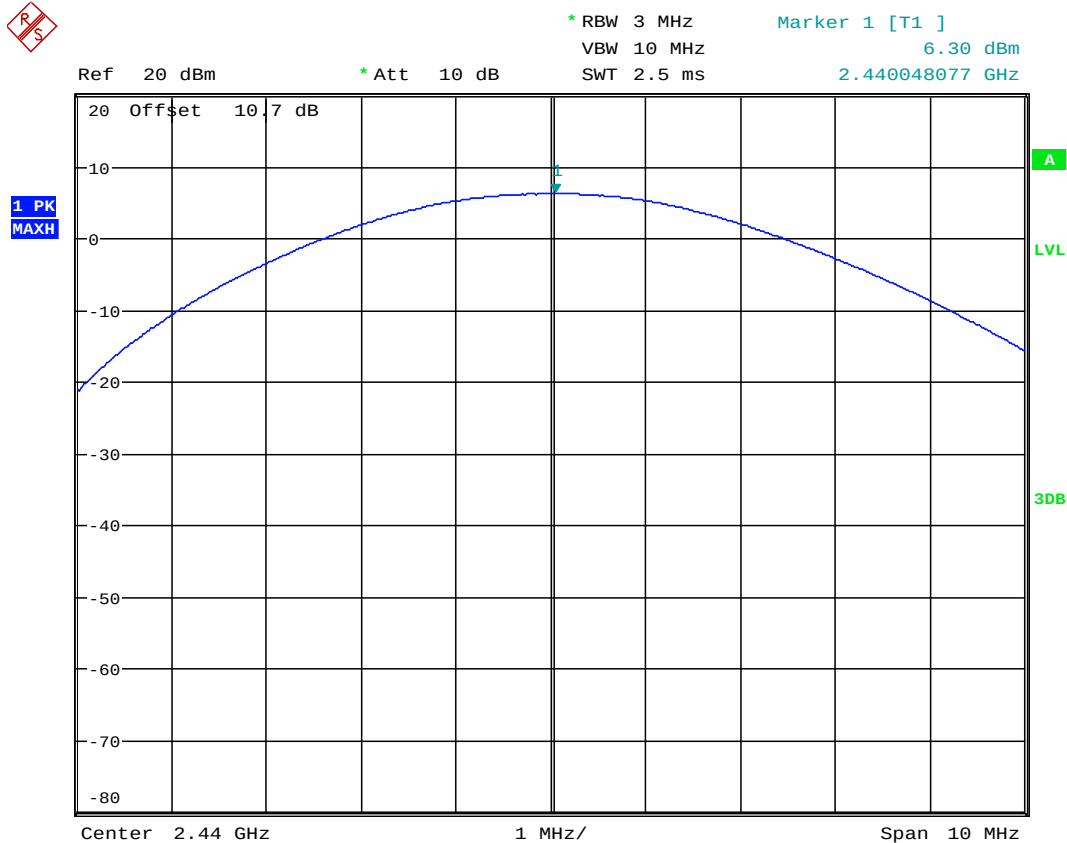
15.5 Test Equipment

<i>Equipment Description</i>	<i>Manufacturer</i>	<i>Equipment Type</i>	<i>Element No</i>	<i>Due For Calibration</i>
Spectrum Analyser	R&S	FSU50	U544	2021-06-17

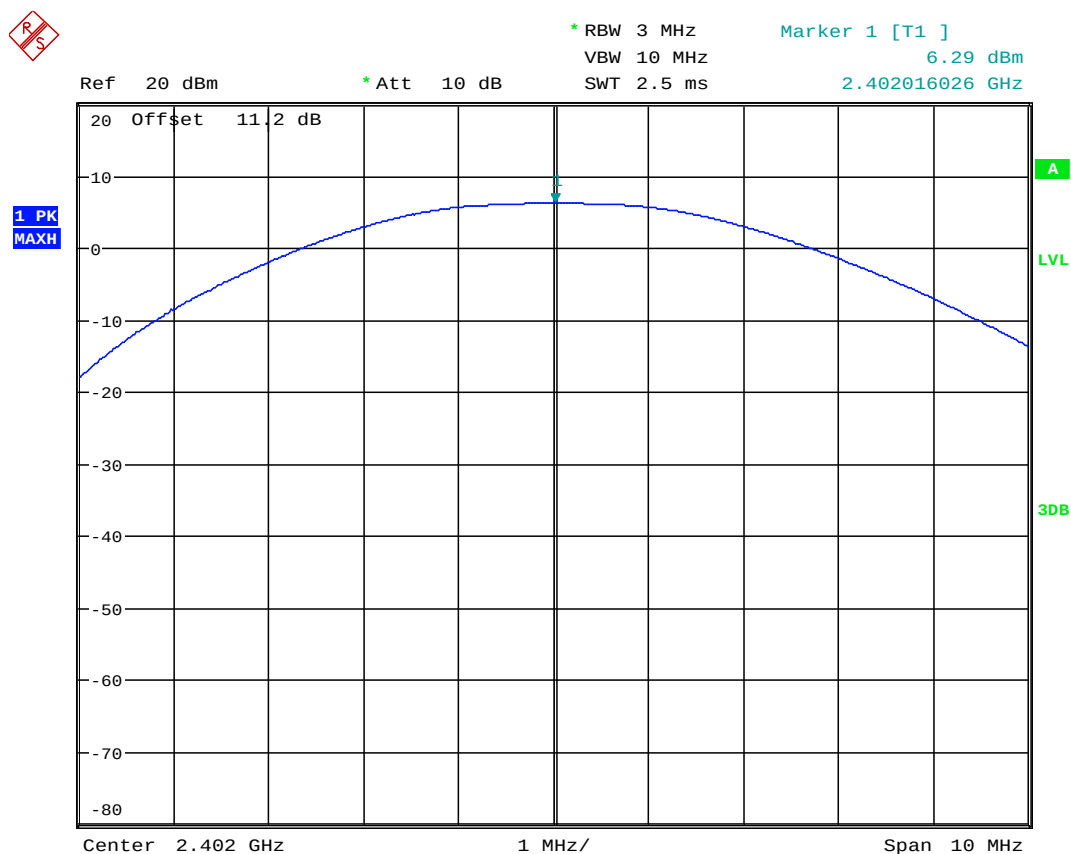
15.6 Test Results

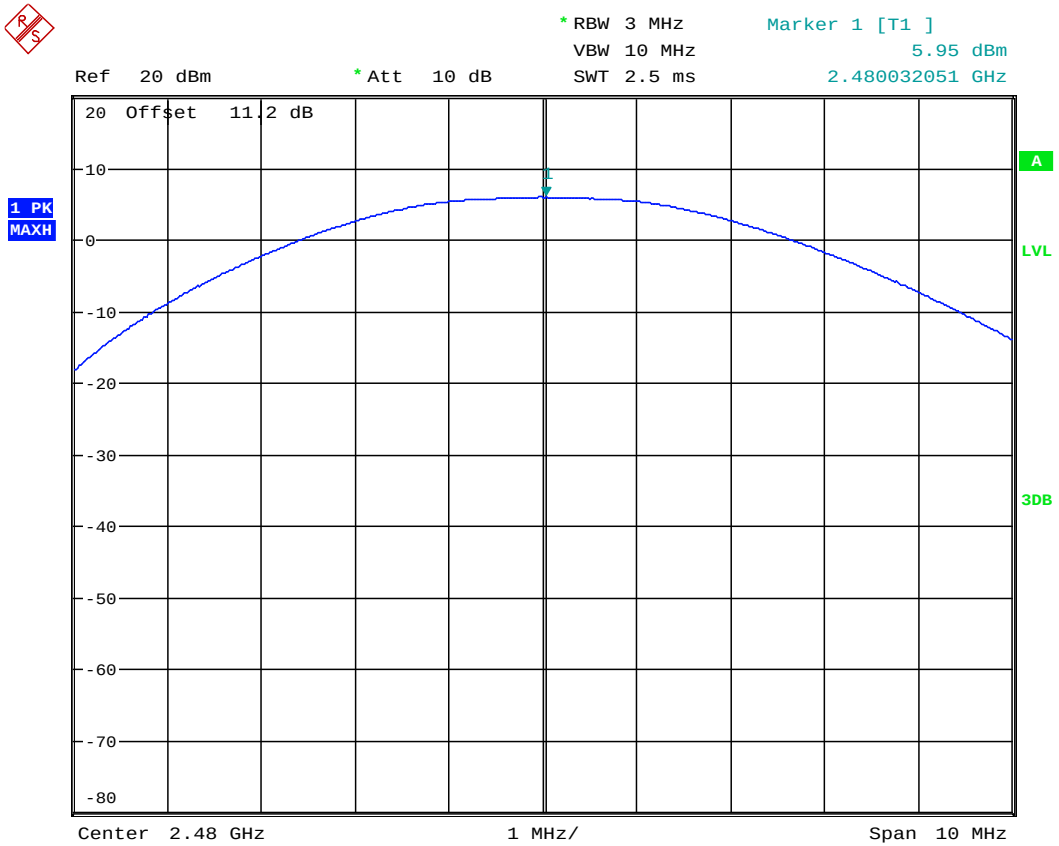
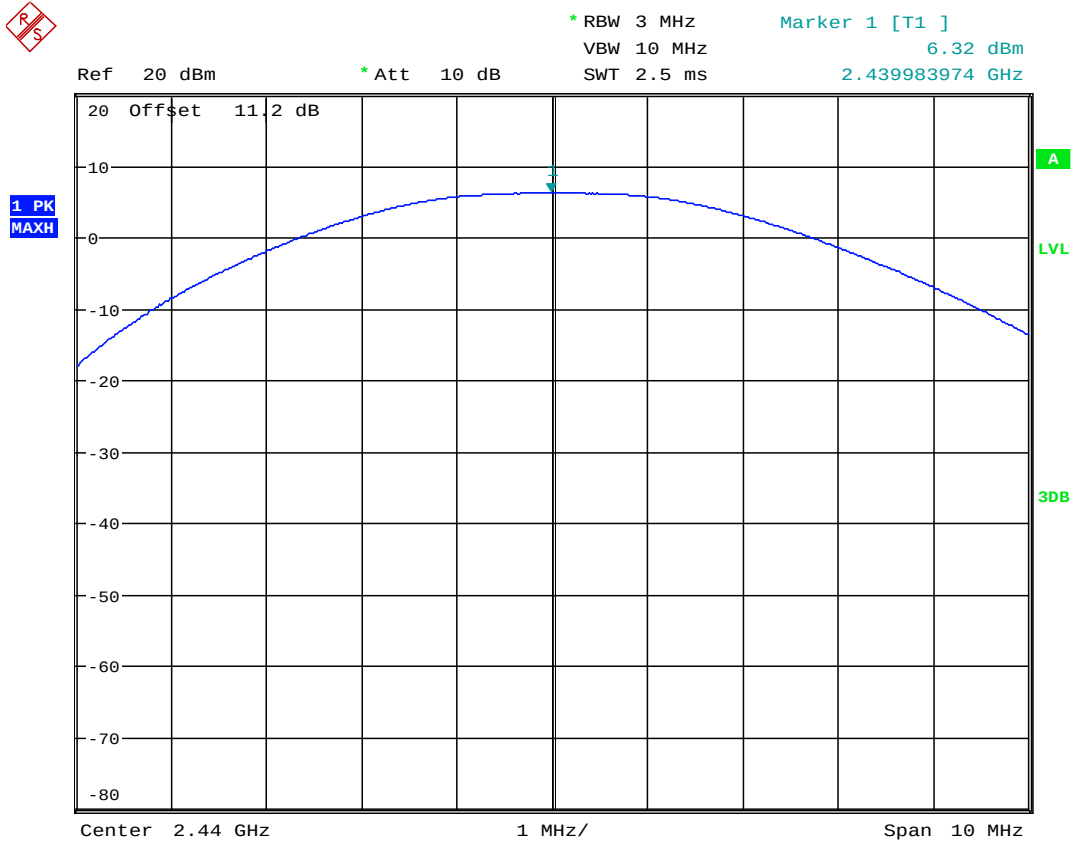
Power Setting: 8 dBm; Data Rate: 1 Mbps			
Frequency (MHz)	Maximum peak conducted output power (dBm)	Maximum peak conducted output power (W)	Result
2402	6.31	0.00428	PASS
2440	6.30	0.00427	PASS
2480	5.97	0.00395	PASS





Power Setting: 8 dBm; Data Rate: 2 Mbps			
Frequency (MHz)	Maximum peak conducted output power (dBm)	Maximum peak conducted output power (W)	Result
2402	6.29	0.00426	PASS
2440	6.32	0.00429	PASS
2480	5.95	0.00394	PASS





16 Out-of-band and conducted spurious emissions

16.1 Definition

Out-of-band emission

Emission on a frequency or frequencies immediately outside the necessary bandwidth that results from the modulation process but excluding spurious emissions.

Spurious emission

Emission on a frequency or frequencies that are outside the necessary bandwidth and the level of which may be reduced without affecting the corresponding transmission of information. Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products, and frequency conversion products, but exclude out-of-band emissions.

16.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Wireless Lab 2
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.11
EUT Frequencies Measured:	2402 MHz, 2440 MHz & 2480 MHz
Deviations From Standard:	None
Measurement Bandwidth:	100 kHz
Video Bandwidth:	300 kHz
Measurement Detector:	Peak
Measurement Range:	9 kHz to 25 GHz

Environmental Conditions (Normal Environment)

Temperature: 20 °C	+15 °C to +35 °C (as declared)
Humidity: 40 % RH	20 % RH to 75 % RH (as declared)

16.3 Test Limit

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced 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 that the transmitter demonstrates compliance with the peak conducted power limits.

If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, the attenuation required shall be 30 dB instead of 20 dB.

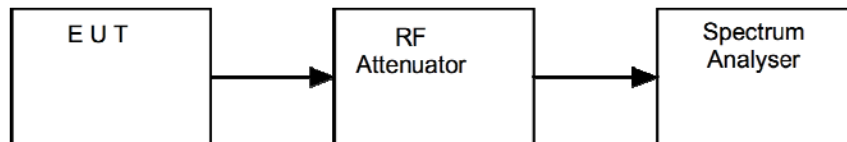
Attenuation below the general field strength limits specified in FCC 47CFR15.209(a) is not required.

16.4 Test Method

With the EUT connected as per Figure v, the emissions from the EUT were measured on a spectrum analyser.

The measurements were performed with EUT set at its maximum duty. All modulation schemes, data rates and power settings were used to observe the worst case configuration in each bandwidth.

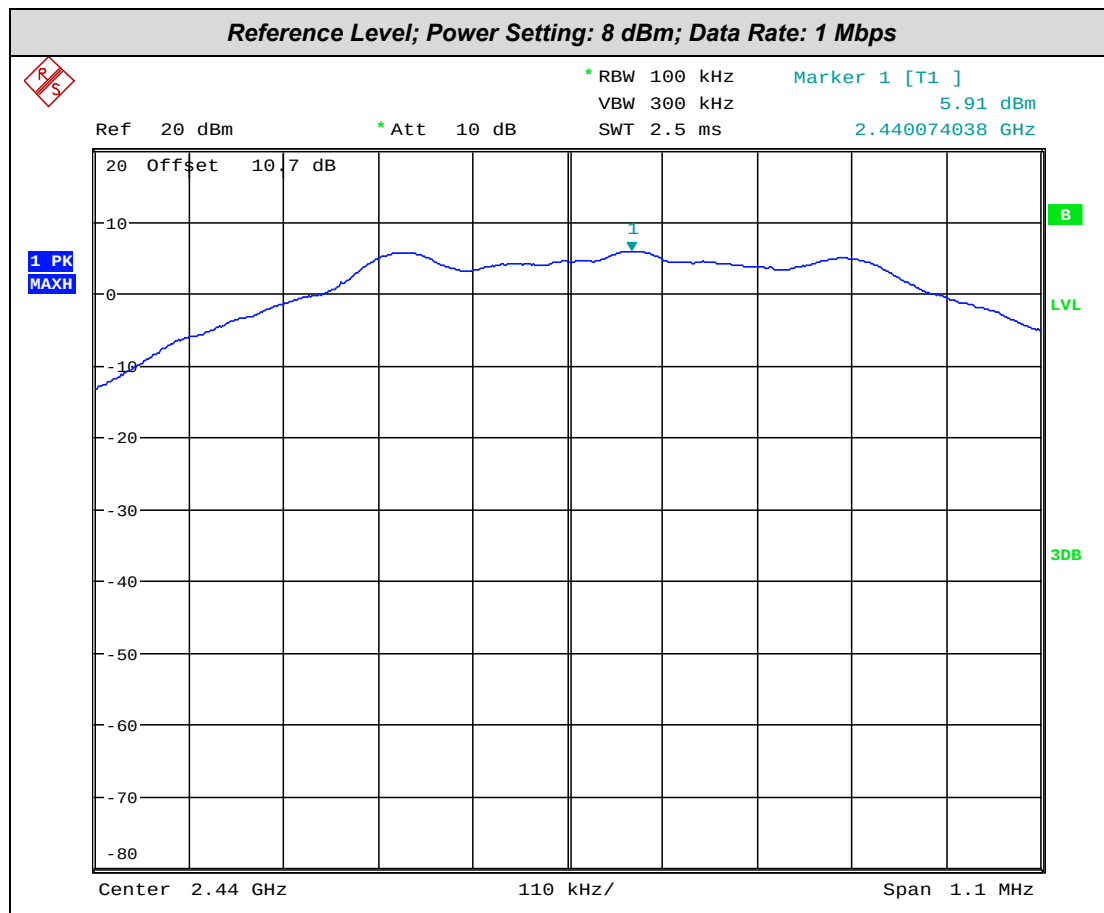
Figure v Test Setup

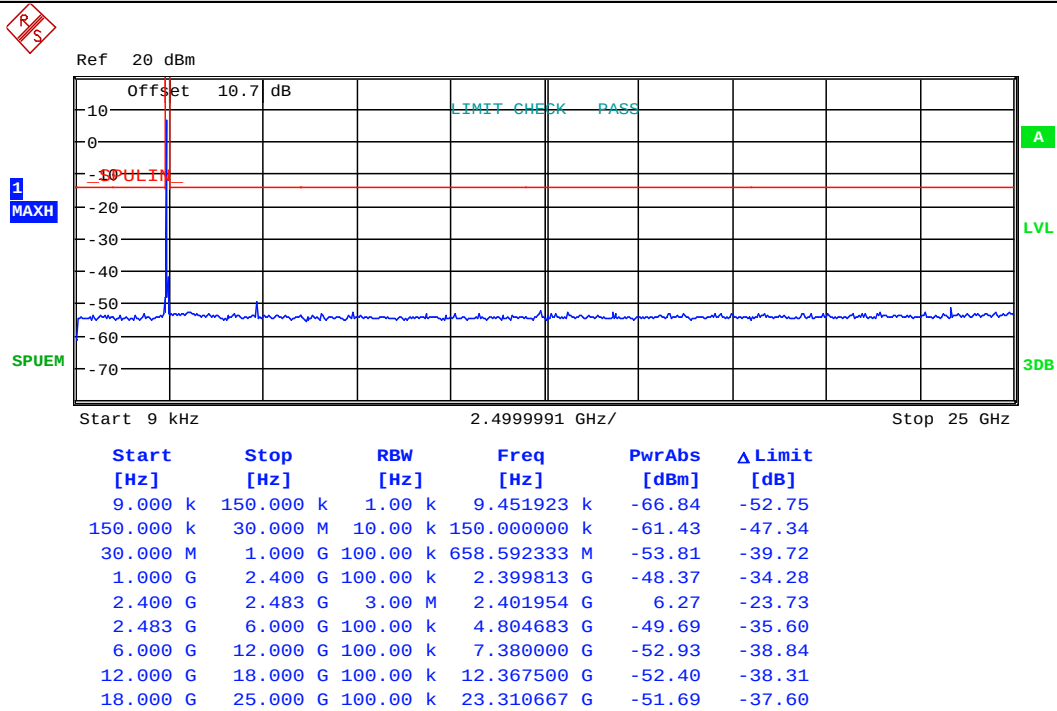
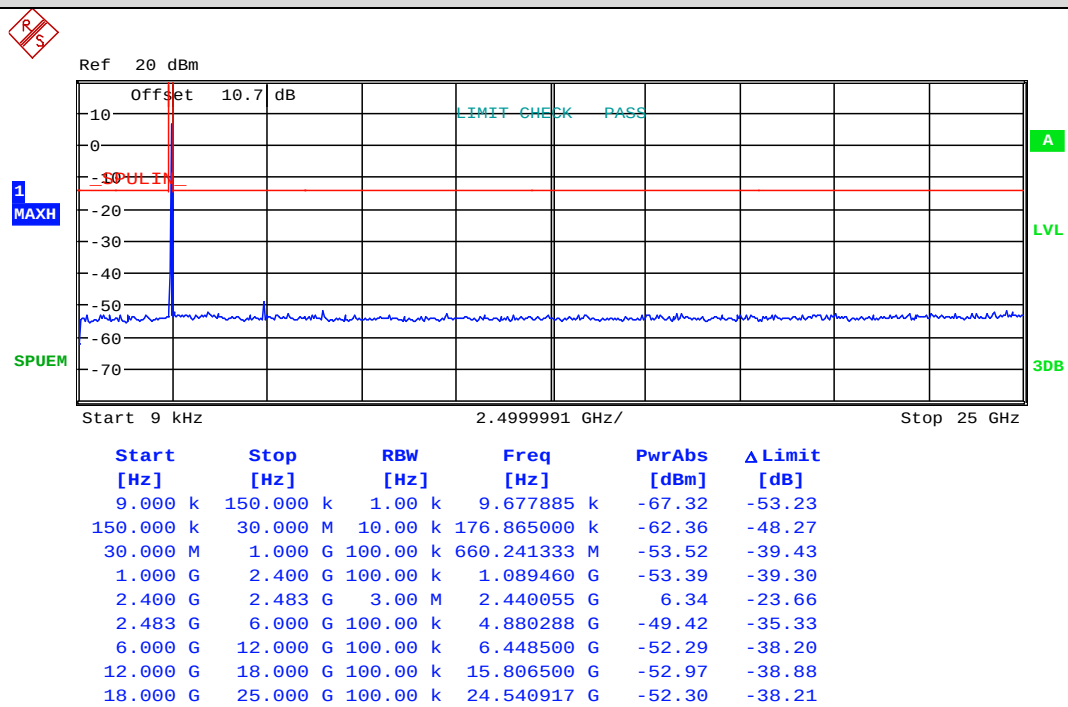


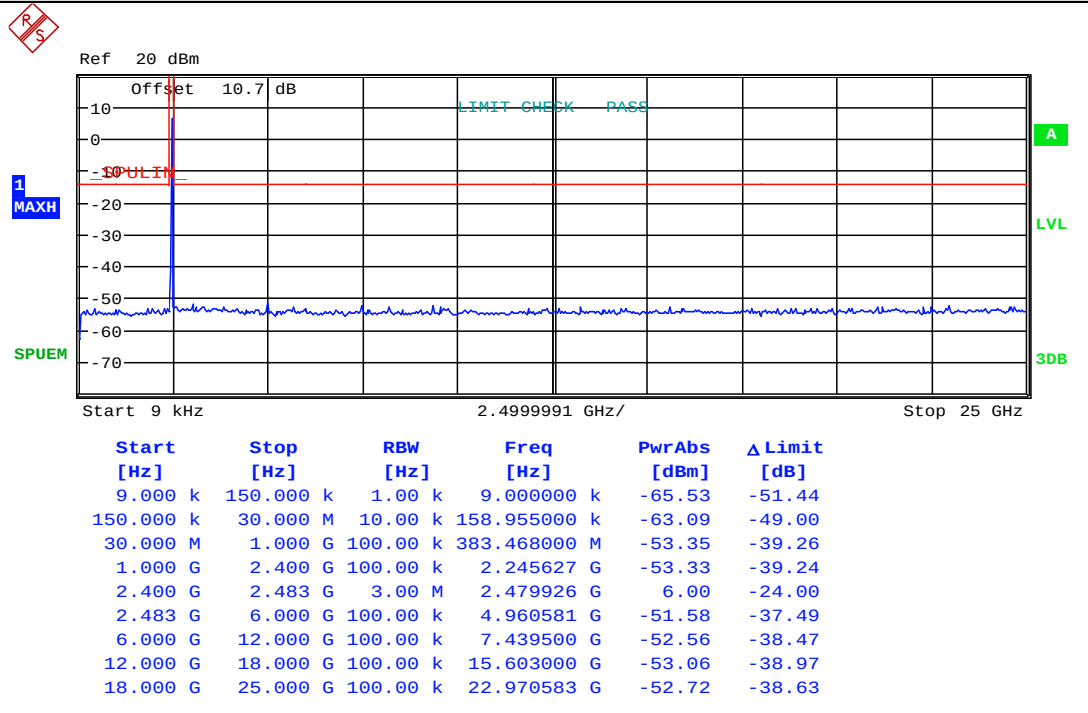
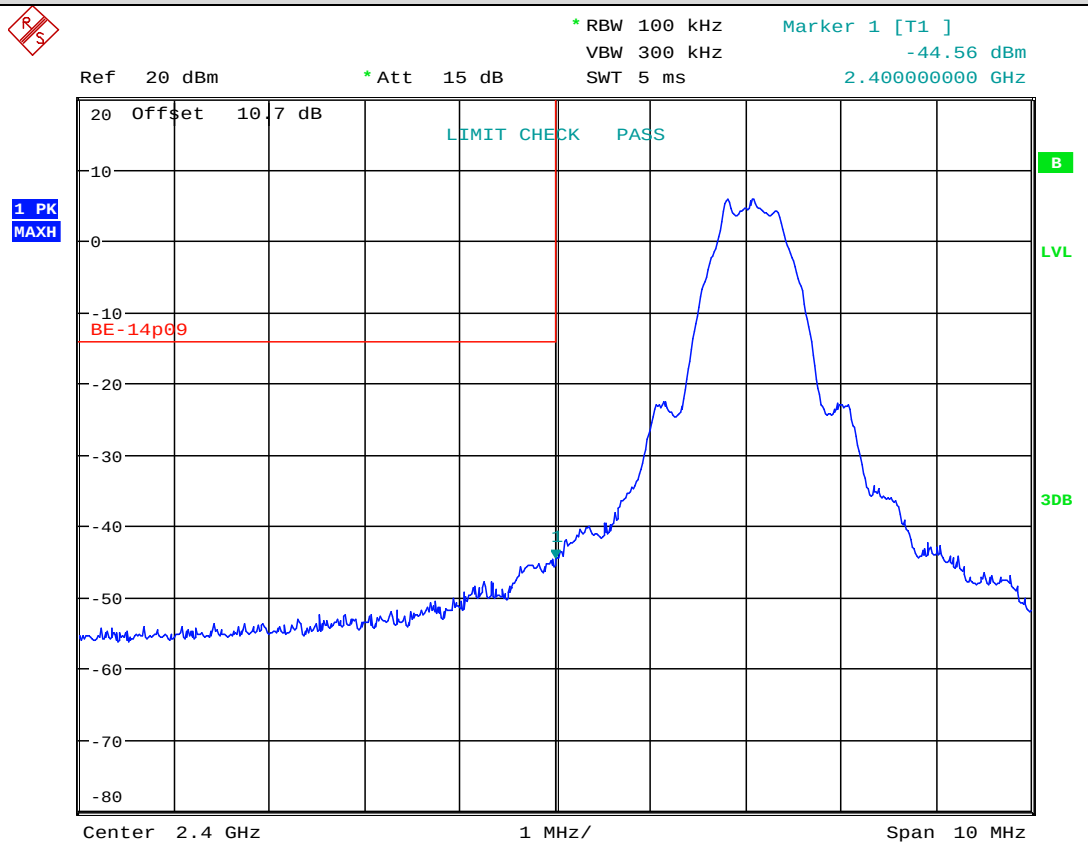
16.5 Test Equipment

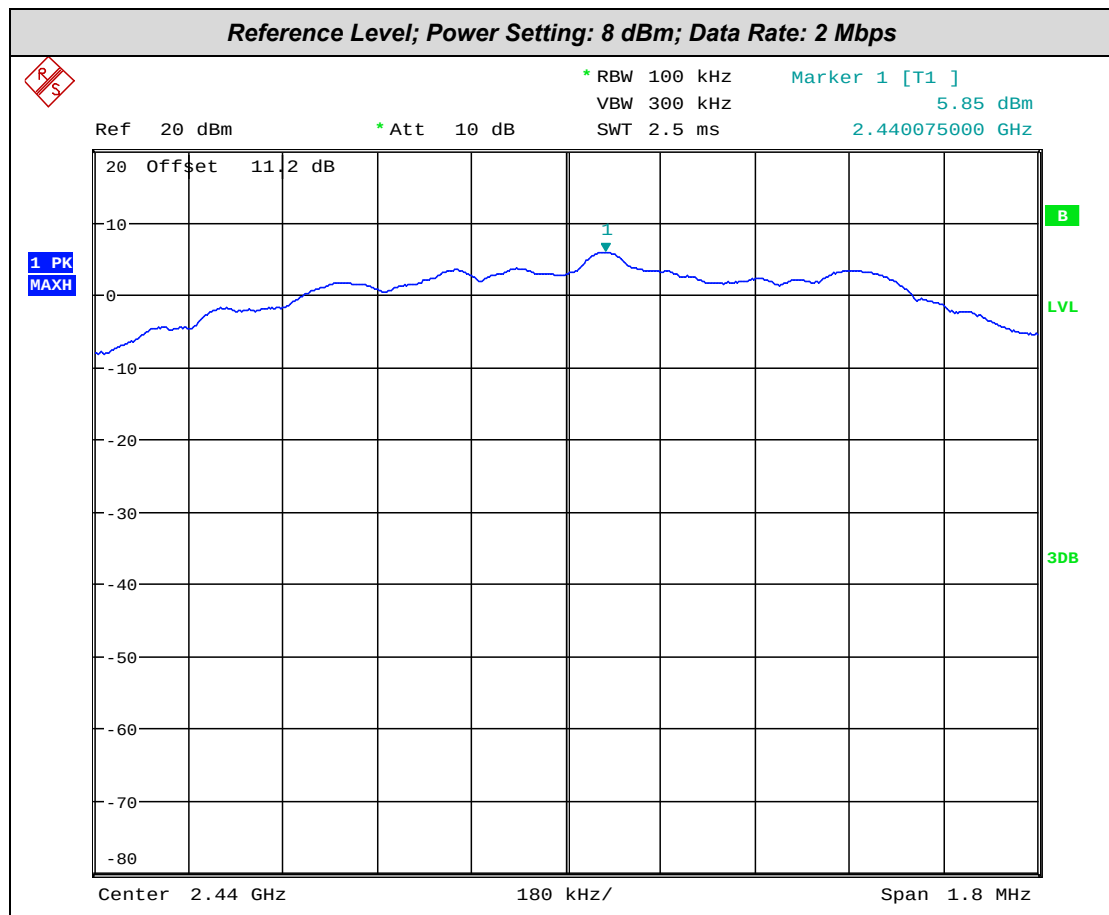
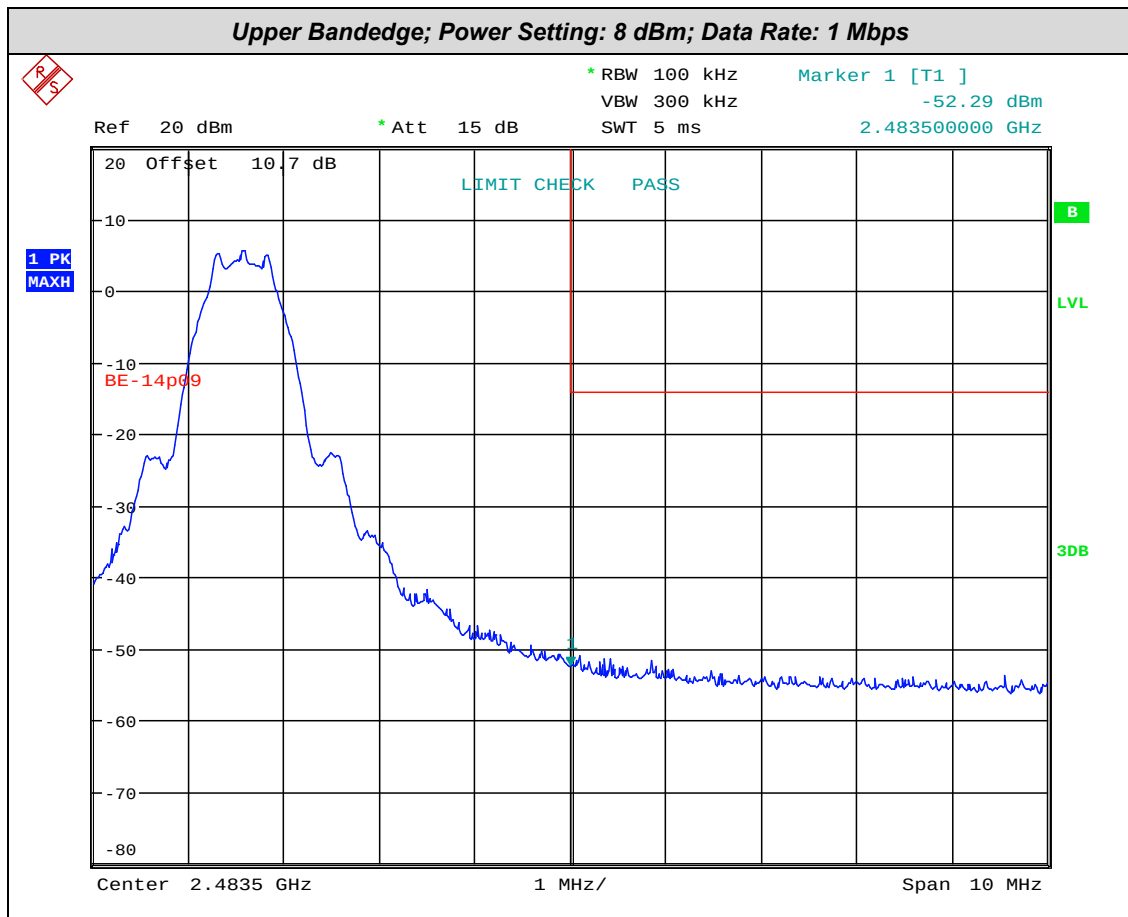
Equipment Description	Manufacturer	Equipment Type	Element No	Due For Calibration
Spectrum Analyser	R&S	FSU50	U544	2021-06-17

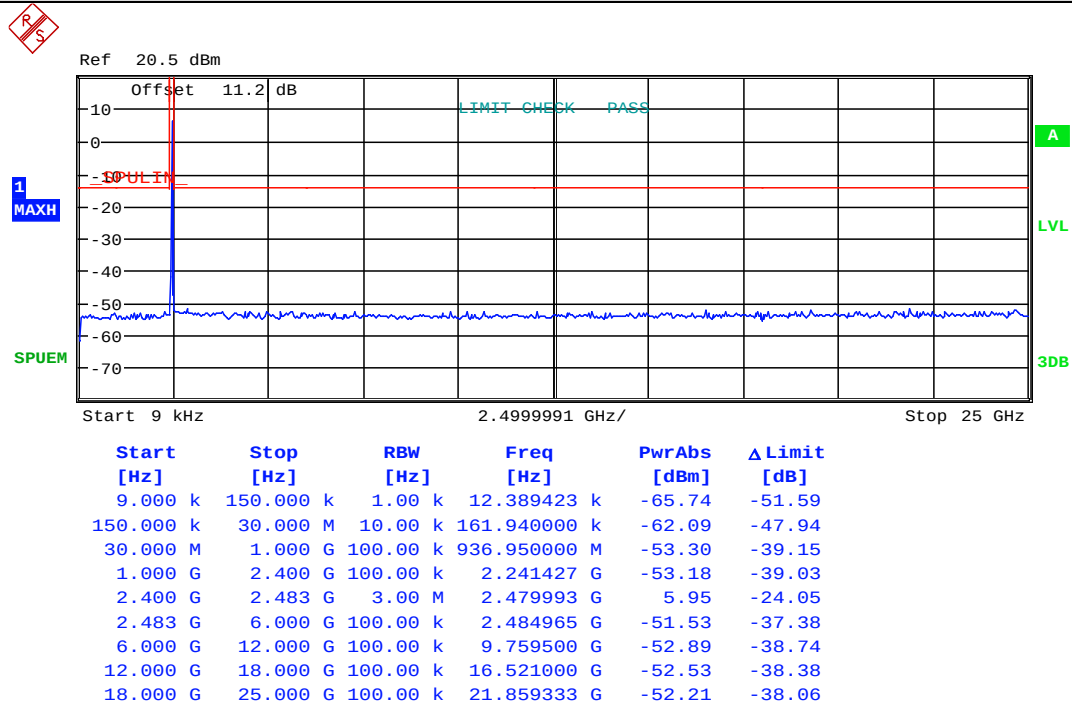
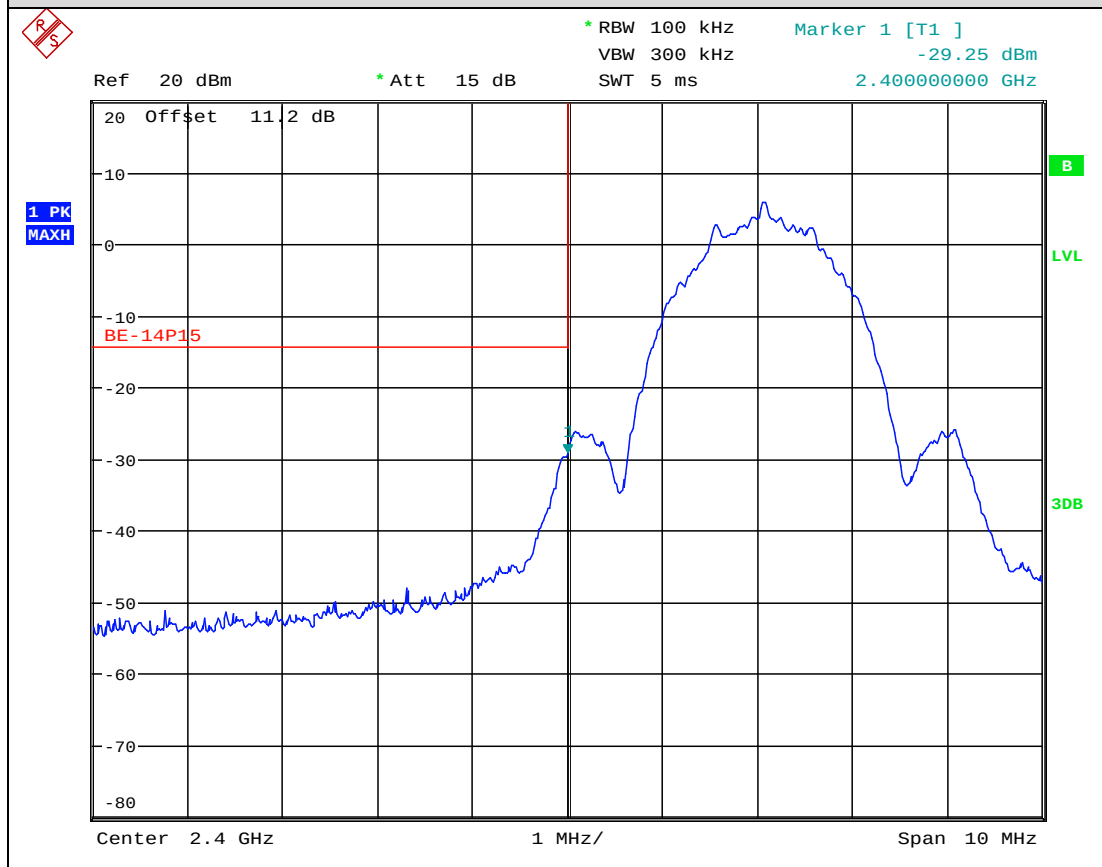
16.6 Test Results

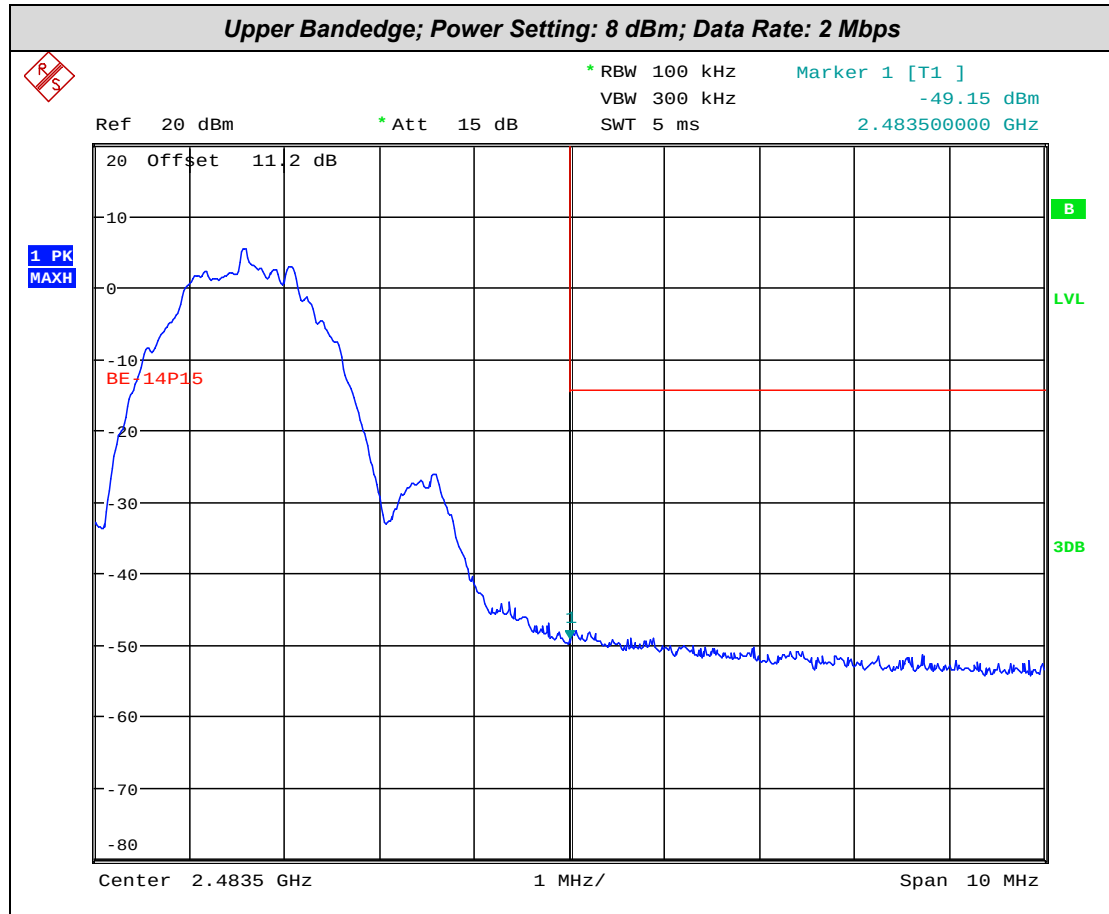


Out of Band Emissions; Frequency: 2402 MHz; Power Setting: 8 dBm; Data Rate: 1 Mbps**Out of Band Emissions; Frequency: 2440 MHz; Power Setting: 8 dBm; Data Rate: 1 Mbps**

Out of Band Emissions; Frequency: 2480 MHz; Power Setting: 8 dBm; Data Rate: 1 Mbps**Lower Bandedge; Power Setting: 8 dBm; Data Rate: 1 Mbps**



Out of Band Emissions; Frequency: 2480 MHz; Power Setting: 8 dBm; Data Rate: 2 Mbps**Lower Bandedge; Power Setting: 8 dBm; Data Rate: 2 Mbps**



17 Power spectral density

17.1 Definition

The power per unit bandwidth.

17.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Wireless Lab 2
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.10
EUT Frequencies Measured:	2402 MHz, 2440 MHz & 2480 MHz
Deviations From Standard:	None

Environmental Conditions (Normal Environment)

Temperature: 19 °C	+15 °C to +35 °C (as declared)
Humidity: 40 % RH	20 % RH to 75 % RH (as declared)

17.3 Test Limit

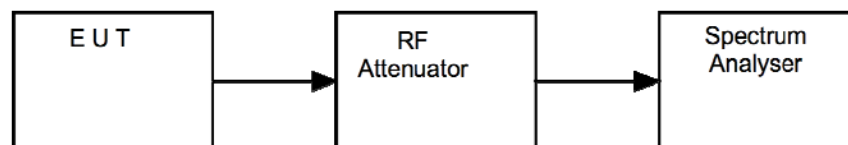
The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

17.4 Test Method

With the EUT connected as per Figure vi, the peak emission of the EUT was measured on a spectrum analyser, with path losses taken into account.

The measurements were performed with EUT set at its maximum duty. All modulation schemes, data rates and power settings were used to observe the worst case configuration in each bandwidth.

Figure vi Test Setup

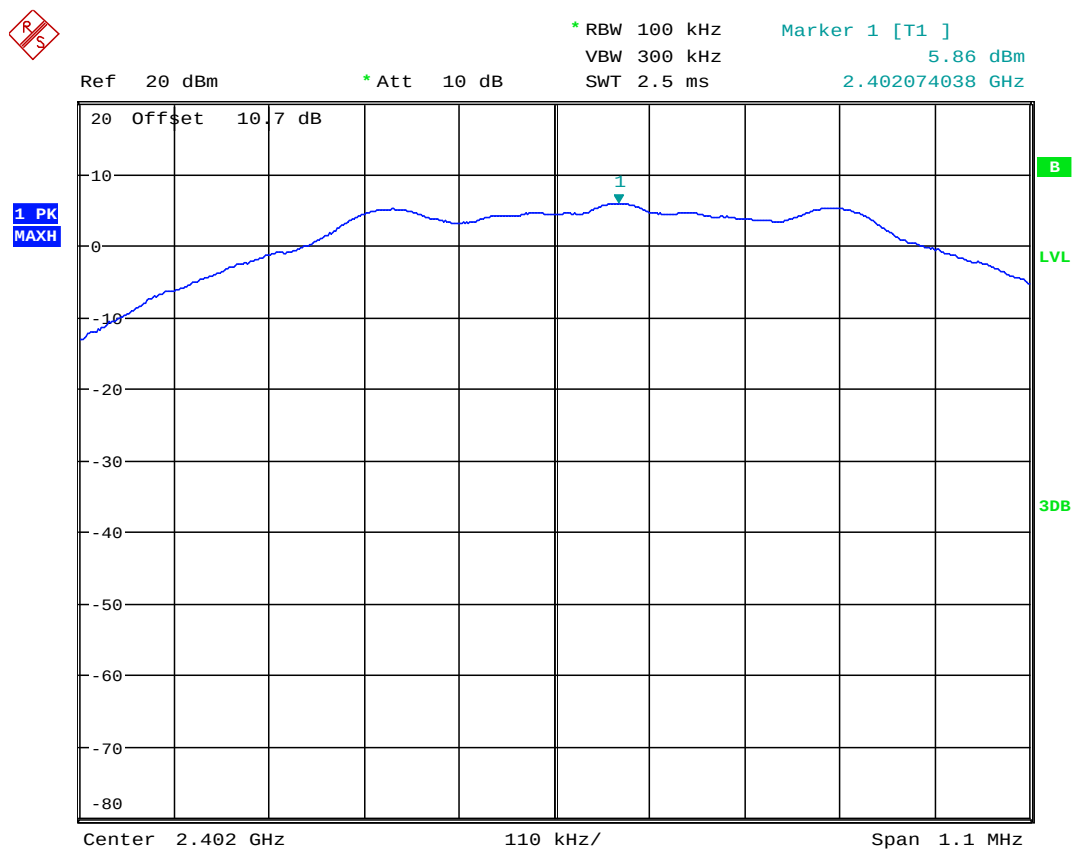


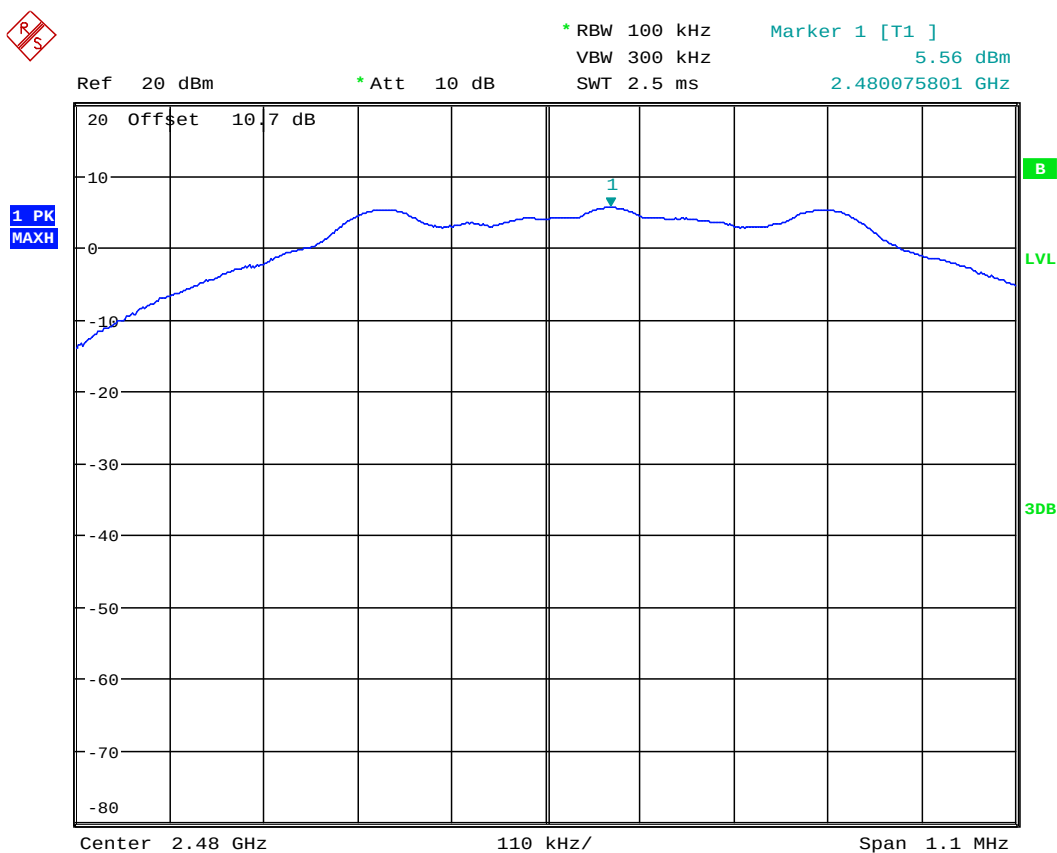
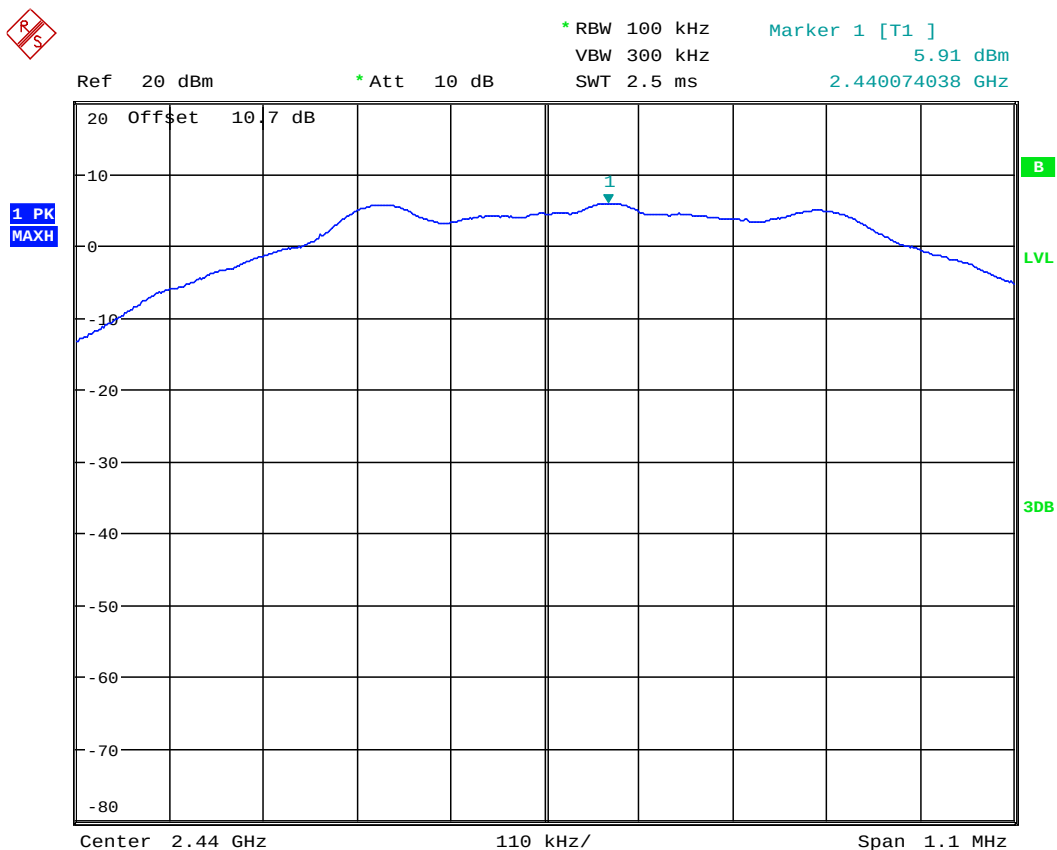
17.5 Test Equipment

<i>Equipment Description</i>	<i>Manufacturer</i>	<i>Equipment Type</i>	<i>Element No</i>	<i>Due For Calibration</i>
Spectrum Analyser	R&S	FSU50	U544	2021-06-17

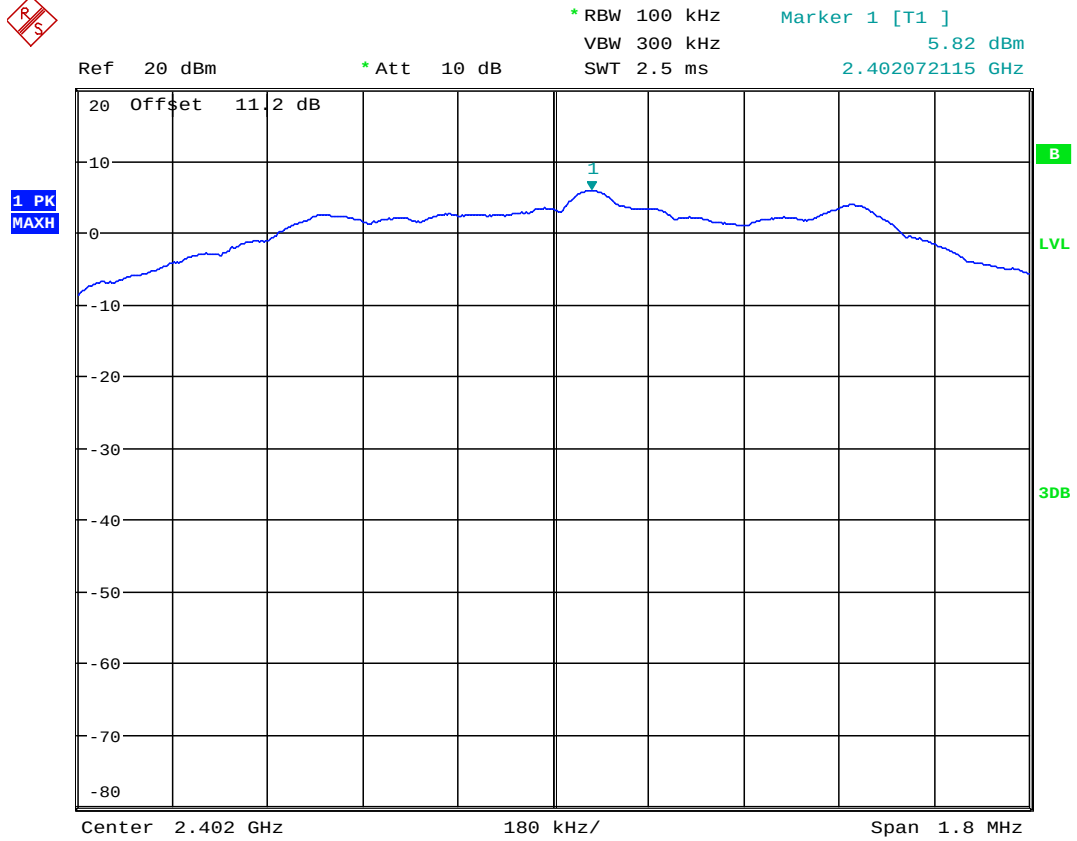
17.6 Test Results

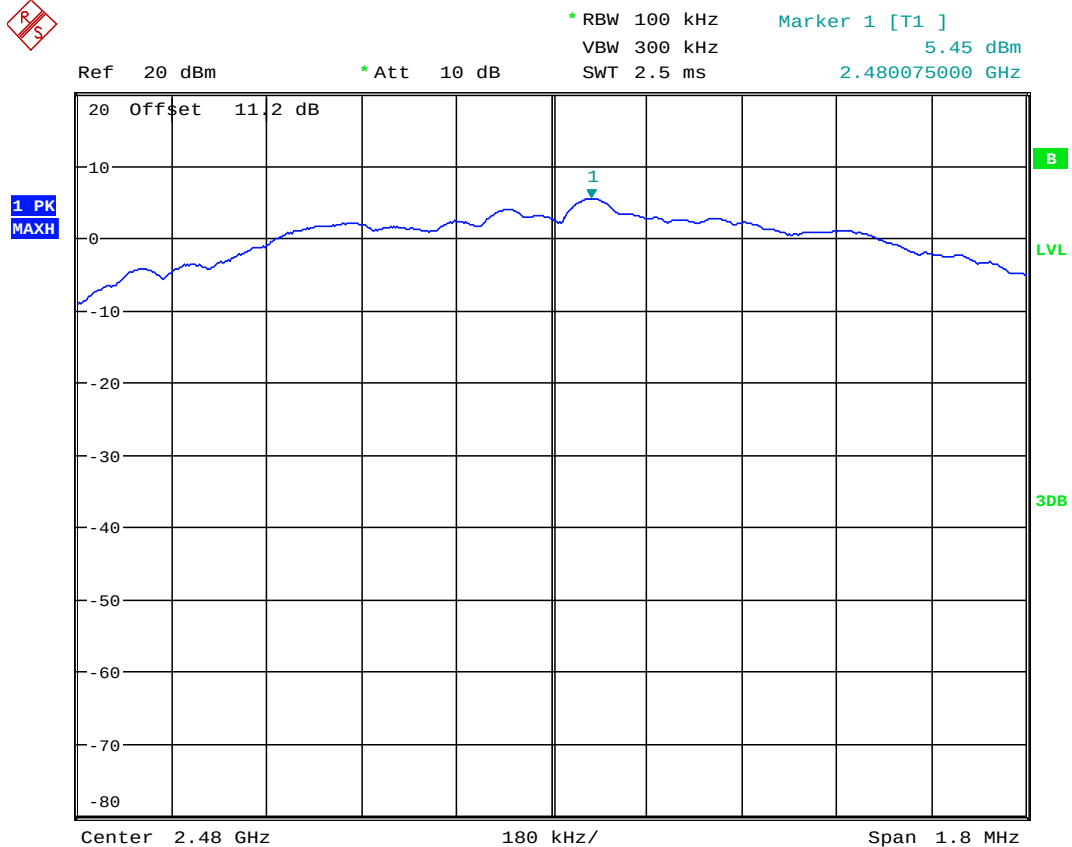
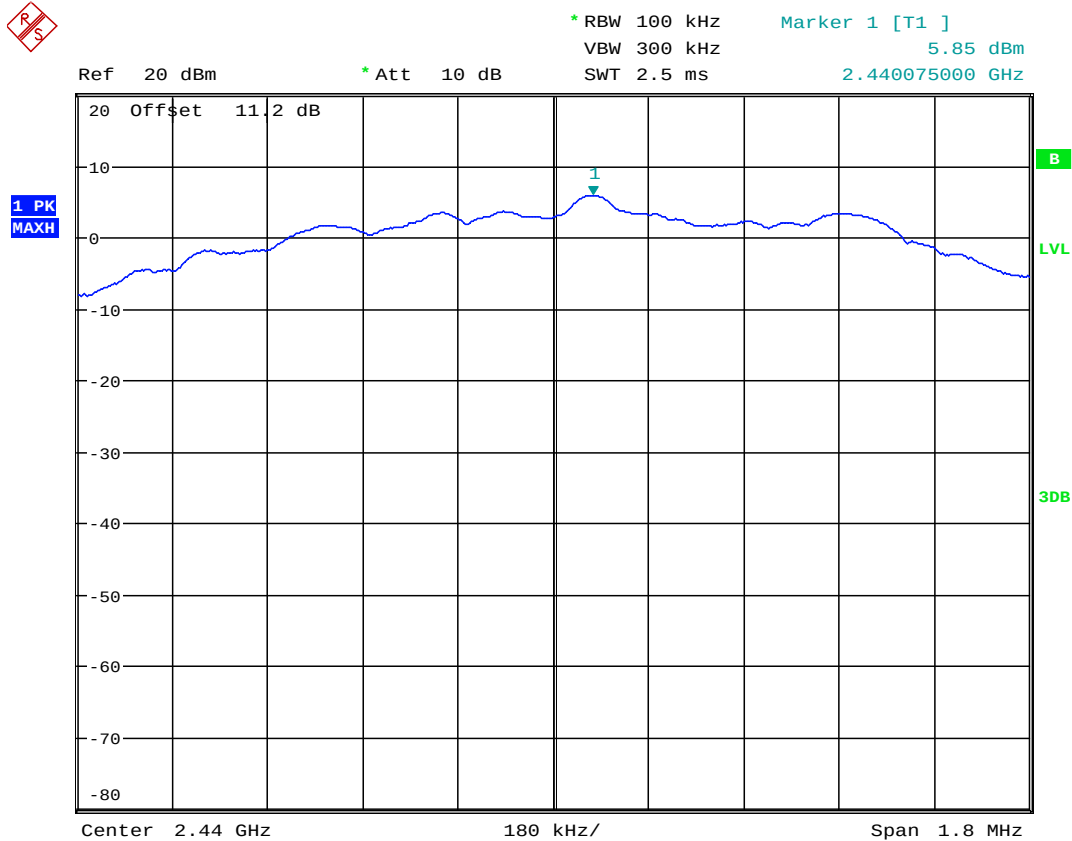
Power Setting: 8 dBm; Data Rate: 1 Mbps		
Frequency (MHz)	Power Spectral Density (dBm)	Result
2402	5.86	PASS
2440	5.91	PASS
2480	5.56	PASS





Power Setting: 8 dBm; Data Rate: 2 Mbps		
Frequency (MHz)	Power Spectral Density (dBm)	Result
2402	5.82	PASS
2440	5.85	PASS
2480	5.45	PASS





18 Measurement Uncertainty

Radio Testing – General Uncertainty Schedule

All statements of uncertainty are expanded standard uncertainty using a coverage factor of 1.96 to give a 95 % confidence where no required test level exists.

Reference No.	Parameter	Description	Value	Unit
1	Adjacent Channel Power	Uncertainty in test result	1.86	dB
2	Carrier Power	Uncertainty in test result (Power Meter) Uncertainty in test result (Spectrum Analyser)	0.070 3.11	dB
3	Effective Radiated Power	Uncertainty in test result	4.71	dB
4	Radiated Spurious Emissions	Uncertainty in test result (30 MHz to 1 GHz) Uncertainty in test result (1 GHz to 18 GHz)	4.75 4.46	dB
5	Maximum Frequency Error	Uncertainty in test result (CMTA)	113.441	Hz
6	Radiated Emissions, Field Strength OATS 9 kHz – 110 GHz Electric Field	Uncertainty in test result (9 kHz – 30 MHz) Uncertainty in test result (30 MHz – 1 GHz) Uncertainty in test result (1 GHz – 18 GHz) Uncertainty in test result (18 GHz – 26 GHz) Uncertainty in test result (26 GHz – 40 GHz) Uncertainty in test result (40 GHz – 50 GHz) Uncertainty in test result (50 GHz – 75 GHz) Uncertainty in test result (75 GHz – 110 GHz)	2.3 4.75 4.46 3.2 3.3 3.5 3.6 3.6	dB
7	Frequency Deviation	Uncertainty in test result	3.7	%
8	Magnetic Field Emissions	Uncertainty in test result	2.3	dB
9	Conducted Spurious	Uncertainty in test result Up to 26 GHz	0.921	dB
10	Channel Bandwidth	Uncertainty in test result	15.71	%

Reference No.	Parameter	Description	Value	Unit
11	Spectrum Mask Measurements	Uncertainty in test result (frequency)	2.59	%
		Uncertainty in test result (amplitude)	1.32	dB
12	Adjacent Sub Band Selectivity	Uncertainty in test result	1.24	dB
13	Receiver Blocking – Listen Mode, Radiated	Uncertainty in test result	3.23	dB
14	Receiver Blocking – Talk Mode, Radiated	Uncertainty in test result	3.36	dB
15	Receiver Blocking – Talk Mode, Conducted	Uncertainty in test result	1.24	dB
16	Receiver Threshold	Uncertainty in test result	3.42	dB
17	Transmission Time Measurement	Uncertainty in test result	4.40	%