TÜV SÜD Canada
EMC & RF Test Report

As per

RSS 247 Issue 2: 2017
&
FCC Part 15 Subpart C: 2017

For

Unlicensed Intentional Radiators

Operating in the 2.400 – 2.4835 GHz band

on the

MD-1150

Zigbee Module

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Testing produced for

Mircom™

See *Appendix A* for full customer & EUT details.

Industry Canada
Registration # 6844A-3

Testing Laboratory Certificate #2955.02

Registration # CA6844

R-4023, G-506 T-1246, C-4498

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Report Scope

This report addresses the EMC certification testing and test results of the **MD-1150 Zigbee module** from **Mircom**. This unit is herein referred to as EUT (Equipment Under Test). Testing is performed at TÜV SÜD Canada Labs.

The EUT was tested for compliance against the following standards:

RSS 247 Issue 2:2017
FCC Part 15 Subpart C 15.247:2017

Test procedures, results, justifications, and engineering considerations, if any, follow later in this report.

The results contained in this report relate only to the item(s) tested.

This report does not imply product endorsement by A2LA or any other accreditation agency, any government, or TÜV SÜD Canada.

Opinions/interpretations expressed in this report, if any, are outside the scope of TÜV SÜD Canada accreditation. Any opinions expressed do not necessarily reflect the opinions of TÜV SÜD Canada, unless otherwise stated.

Client	Mircom	
Product	MD-1150 Zigbee module	
Standard(s)	RSS 247 Issue 2 / FCC Part 15 Subpart C 15.247	

Summary

The results contained in this report relate only to the item(s) tested.

FCC Certification # (FCC ID):	**2ABFD-MD1150**
ISED Certification # (IC):	**1156A-MD1150**
EUT passed all tests performed.	Yes
Tests conducted by	Raymond Lee Au

Client	Mircom
Product	MD-1150 Zigbee module
Standard(s)	RSS 247 Issue 2 / FCC Part 15 Subpart C 15.247

Results Summary

Standard/Method	Description	Limit/Requirement	Result
FCC 15.203	Antenna requirement	Unique	Pass
FCC 15.205 RSS-247 3.3 RSS-Gen (Table 6)	Restricted bands of operation	QuasiPeak Average	Pass
FCC 15.209 RSS- Gen (Table 4)	Spurious radiated emissions and band edges	QuasiPeak Average	Pass
FCC 15.247(a)(2) RSS-247 5.2(a)	6 dB Bandwidth	≥ 500 kHz	Pass
FCC 15.247(b)(3) RSS-247 5.4(d)	Max peak conducted output power	≤ 1 W (≤ 30 dBm)	Pass
RSS-247 5.4(d)	Max peak E.I.R.P output	≤ 4 W (≤ 36 dBm)	Pass
FCC 15.247(b)(4)	Antenna Gain	≤ 6 dBi	Pass
FCC 15.247(d) RSS-247 5.5	Unwanted emissions (Antenna Spurious Conducted Emissions)	≤ 20 dBc in 100 kHz bandwidths outside transmission band	Pass
FCC 15.247(e) RSS-247 5.2(b)	Power spectral density	≤ 8 dBm per 3 kHz bandwidth	Pass
FCC 15.247(i) RSS-102	Maximum RF exposure	> 20 cm separation.	Pass
Overall Result			**PASS**

See *Notes, Justifications, or Deviations* section for more details.

Testing is performed by Raymond Lee Au.

If the product as tested or evaluated complies with the specification, the EUT is deemed to comply with the requirement, and is allotted a result of “Pass.” If not, a “Fail” will be issued. Note that a “Pass” or “Fail” status is independent of any measurement uncertainties.

Notes, Justifications, or Deviations

The following justifications for tests not performed or deviations from the above listed specifications apply:

The EUT uses a unique reverse SMA connector.

Two antenna are to be used with the EUT. Both have a peak gain of < 6 dBi. The EUT is tested with the Nearson S151AH-2450S antenna, as it has a much higher gain than the alternate. The two antennas are below.

Molex 47950-2001
PCB trace
Peak gain = 2.9 dBi rated maximum

Nearson S151AH-2450S
Whip
Peak gain = 5 dBi rated maximum

The EUT is not a hybrid system.

The EUT was tested positioned in the 3 orthogonal axis. Worst case results are presented.

The EUT's output level is set to the maximum output setting used. Note that the output power of the highest channel (26) is lower than the other channels, as indicated in the *Detailed Test Results* Section.

For maximum permissible exposure, this device meets SAR test exemption requirements for mobile devices used at > 20 cm distance.

Applicable Standards, Specifications and Methods

ANSI C63.4:2014	Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
ANSI C63.10:2013	American national standard for testing unlicensed wireless devices
CFR 47 FCC 15:2017	Code of Federal Regulations – Radio Frequency Devices
CISPR 22:2008	Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement
FCC KDB 558074	FCC KDB 558074 Digital Transmission Systems, measurements and procedures
ISO 17025:2005	General Requirements for the competence of testing and calibration laboratories
RSS-Gen Issue 4:2014	General Requirements and Information for the Certification of Radio Apparatus
RSS 102 Issue 5:2015	Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands)
RSS-247 Issue 2:2017	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

Sample calculation(s)

Margin = limit – (received signal + antenna factor + cable loss – pre-amp gain)
Margin = 50.5dBuV/m – (50dBuV + 10dB + 2.5dB – 20dB)
Margin = 8 dB

Document Revision Status

Release 000 August 15, 2018
- Initial release.

Definitions and Acronyms

The following definitions and acronyms are applicable in this report.
See also ANSI C63.14.

AE – Auxiallary Equipment.

BW – Bandwidth.

DTSs – Digital Transmission Systems.

E.I.R.P. – Equivalent Isotropically Radiated Power.

EMC – Electro-Magnetic Compatibility

EMI – Electro-Magnetic Immunity

EUT – Equipment Under Test

FHSs – Frequency Hopping Systems

ITE – Information Technology Equipment with a primary function(s) of entry, storage, display, retrieval, transmission, processing, switching, or control, of data.

LISN – Line impedance stabilization network

NCR – No Calibration Required

RF – Radio Frequency

Testing Facility

Testing for EMC on the EUT was carried out at TÜV SÜD Canada near Toronto, Ontario, Canada. The testing lab consists of a 3m semi-anechoic chamber calibrated to be able to allow measurements on an EUT with a maximum width or length of up to 2m and height up to 3m. The chamber is equipped with a turn table that is capable of testing devices up to 3300lb in weight. This facility is capable of testing products that are rated for a variety of input voltages, including 120 and 240 Vac single phase, and 208 Vac 3 phase. DC capability is also available. The chamber is equipped with an antenna mast that controls polarization and height from the control room adjoining the shielded chamber. Radiated emissions measurements are performed using Loop, Bilog, or Horn antennas as applicable. Conducted emissions, unless otherwise stated, are performed using a LISN.

Calibrations and Accreditations

The 3m semi-anechoic chamber is registered with Federal Communications Commission (FCC, CA6844), Industry Canada (IC, 6844A-3) and VCCI (R-4023, G-506, T-1246, and C-4498). This semi-anechoic chamber complies with the requirements of EN55016-2-3:2006, section 7.5 and the site attenuation requirements of EN55016-1-4. This chamber was additionally calibrated for Normalized Site Attenuation (NSA) using test procedures outlined in ANSI C63.4 “Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz”. The chamber is lined with ferrite tiles and absorption cones to minimize any undesired reflections. The NSA data is kept on file at TÜV SÜD Canada. For radiated susceptibility testing, a 16 point field calibration has been performed on the chamber. The field uniformity data is kept on file at TÜV SÜD Canada. TÜV SÜD Canada is accredited to ISO 17025 by A2LA with Testing Certificate #2955.02. The laboratories current scope of accreditation listing can be found as listed on the A2LA website. All measuring equipment is calibrated on an annual or bi-annual basis as listed for each respective test.

Client	Mircom
Product	MD-1150 Zigbee module
Standard(s)	RSS 247 Issue 2 / FCC Part 15 Subpart C 15.247

Testing Environmental Conditions and Dates

Following are the environmental conditions in the facility during time of testing.

Date	Test(s)	Init.	Temperature (ºC)	Humidity (%)	Pressure (kPa)
Jun. 16, 2018	6 dB Bandwidth	RA	20-24ºC	39 - 50%	96 -102kPa
Jun. 16, 2018	20 dB bandwidth.	RA	20-24ºC	39 - 50%	96 -102kPa
Jun. 16, 2018	Max peak conducted output power.	RA	20-24ºC	39 - 50%	96 -102kPa
Jun. 6, 2018	Max peak E.I.R.P output.	RA	20-24ºC	39 - 50%	96 -102kPa
Jun. 7, 2018	Spurious radiated emissions	RA	20-24ºC	39 - 50%	96 -102kPa
Jun. 7, 2018	Restricted bands of operation.	RA	20-24ºC	39 - 50%	96 -102kPa
Jun. 19, 2018	Unwanted emissions in 100 kHz bandwidths outside transmission band.	RA	20-24ºC	39 - 50%	96 -102kPa
Jun. 19, 2018	Power spectral density	RA	20-24ºC	39 - 50%	96 -102kPa

Detailed Test Results Section

6 dB, 20 dB, and 99% Bandwidths

Purpose

The purpose of this test is to ensure that the bandwidth occupied exceeds the stated minimum. This helps ensure the utilization of the frequency allocation is sufficiently wide, and helps prevent corruption of data by ensuring adequate separation to distinguish the reception of the intended information.

Limits & Method

The Limit is as specified in FCC Part 15.247(a)2 and RSS-247 5.2(a).

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

There is no requirement for the 20 dB bandwidth and 99% power bandwidths for DTSs.

The method is described in ANSI C63.10, 6.9.

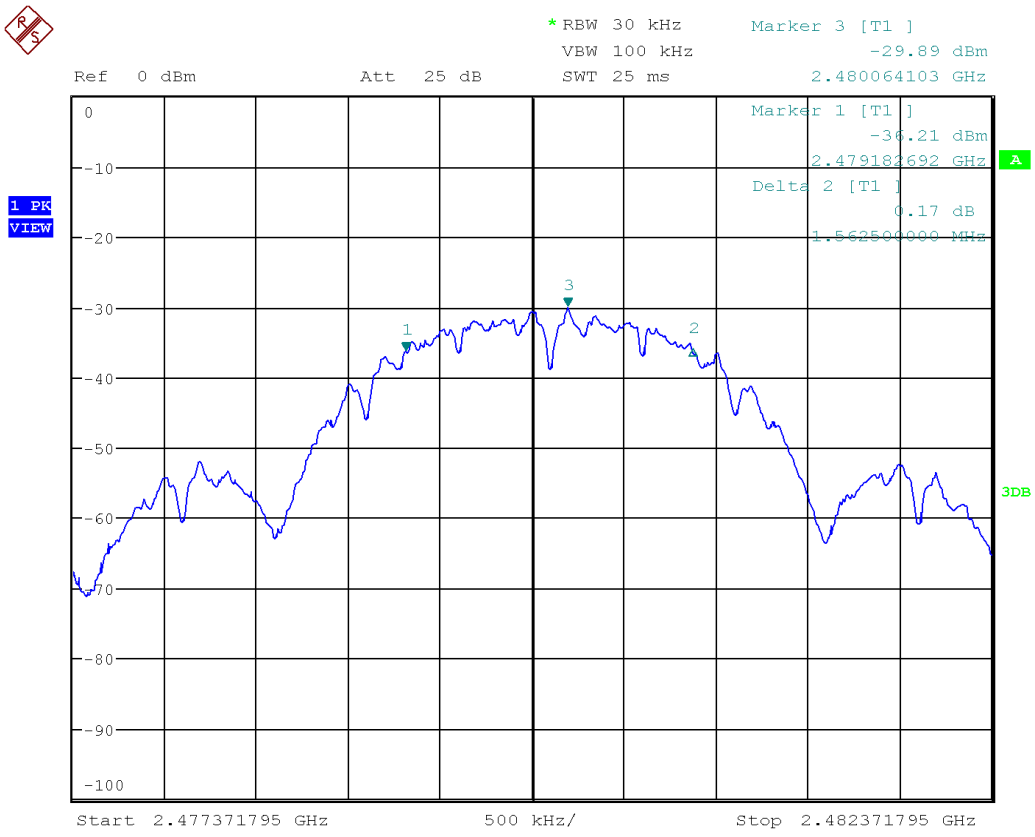
Results

The EUT passed. The minimum 6 dB BW measured was 1.563 MHz.

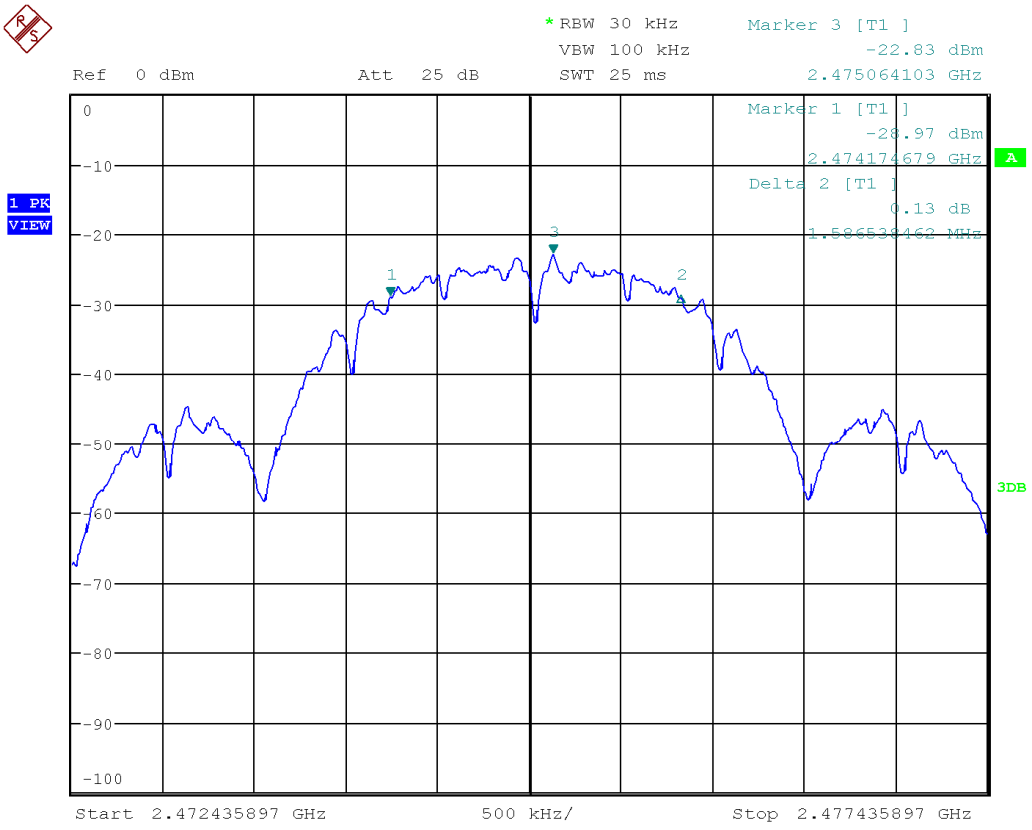
Graph(s)

The graphs below show the 6 dB bandwidth during the operation of the device. This is measured by a max hold on the spectrum analyzer and a 30 kHz resolution bandwidth during operation of the EUT. This measurement is a peak measurement. Max hold is performed for a duration of not less than 1 minute. Worst case results obtained are shown.

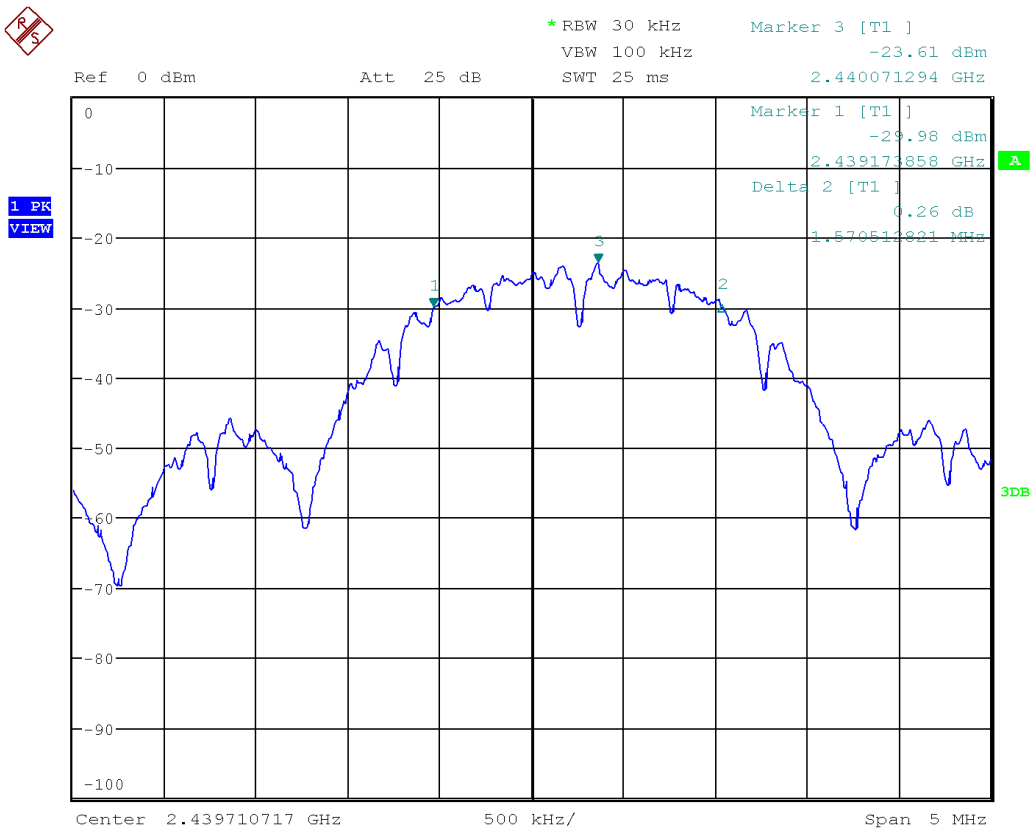
High Channel 26
Power setting 23
6 dB Bandwidth = 1.563 MHz



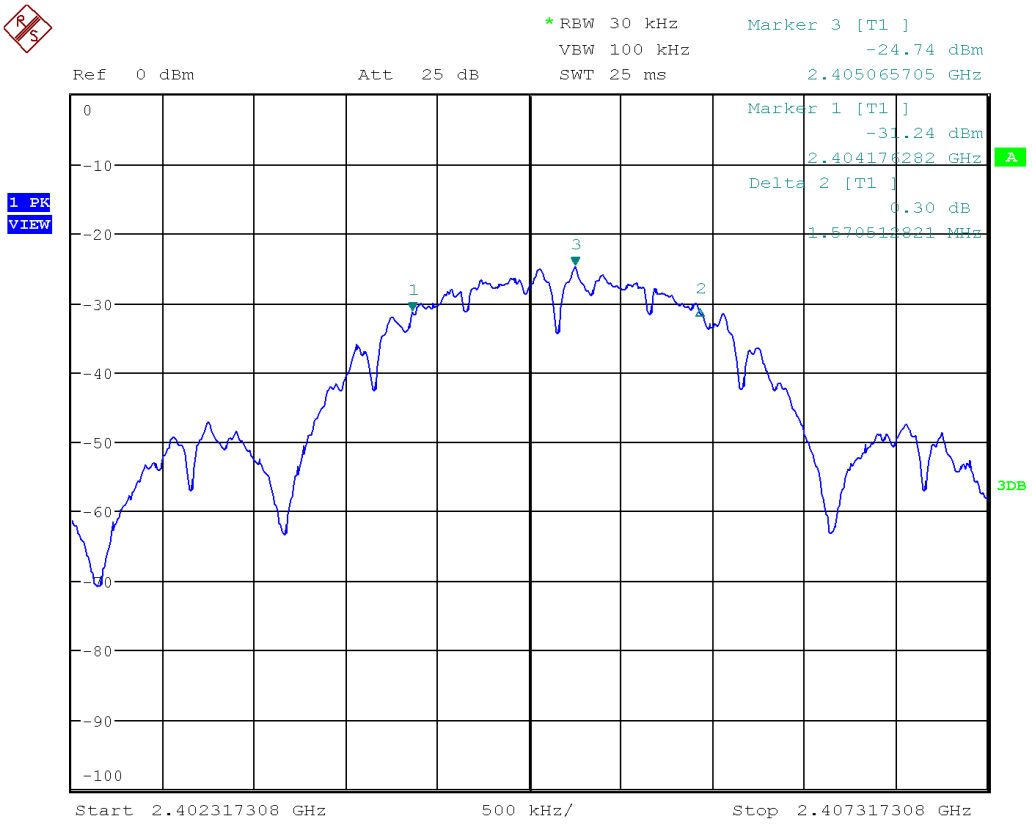
High Channel 25
Power setting 31
6 dB Bandwidth = 1.587 MHz



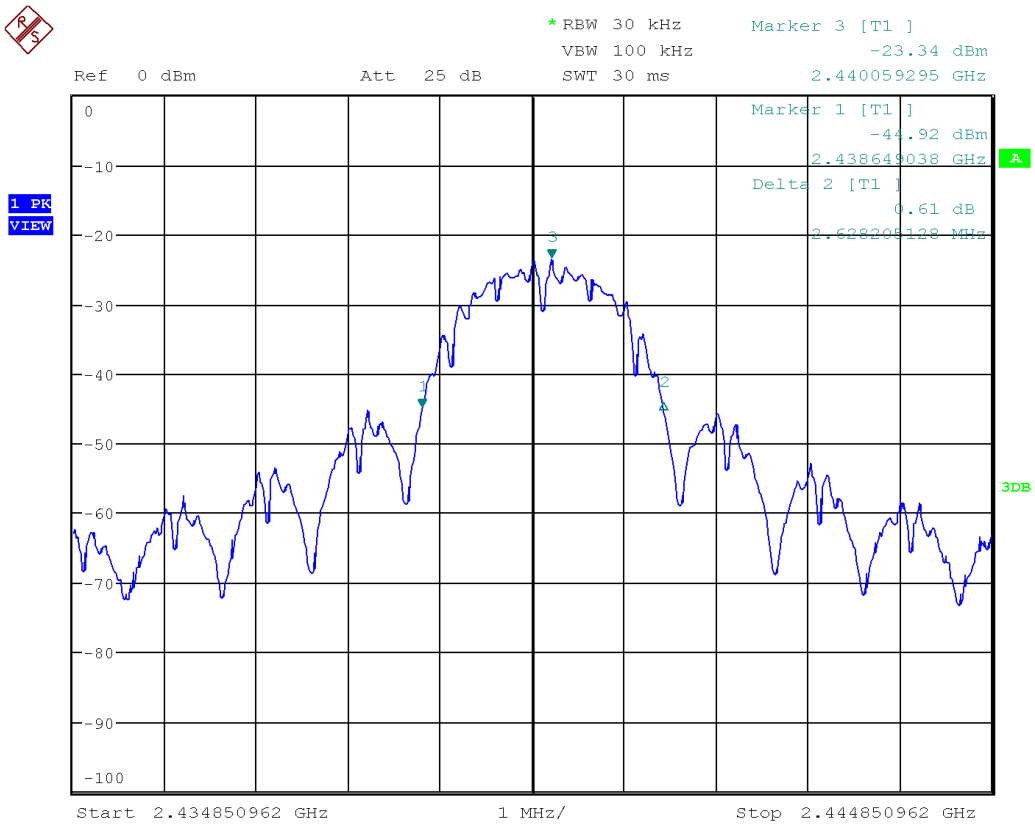
Middle Channel 18
Power setting 31
6 dB Bandwidth = 1.571 MHz



Low Channel 11
Power setting 31
6 dB Bandwidth = 1.571 MHz

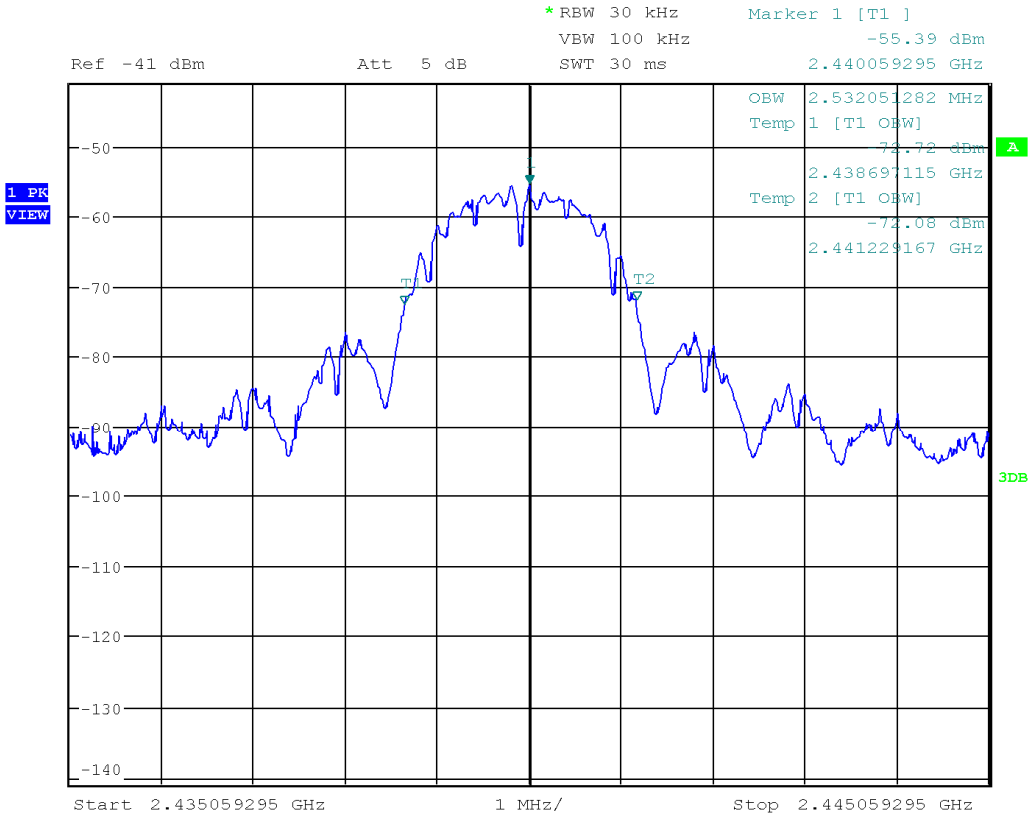


For information purposes, the maximum 20 dB bandwidth is 2.628 MHz.



Note: See 'Appendix B – EUT & Test Setup Photographs' for photos showing the test set-up.

For information purposes, the maximum 99% bandwidth is 2.532 MHz



Test Equipment List

Equipment	Model No.	Manufacturer	Last calibration date	Next calibration due date	Asset #
Spectrum Analyzer	ESL6	Rohde & Schwarz	Dec. 27, 2017	Dec. 27, 2019	GMEC 160

Maximum Peak Conducted Output Power

Purpose

The purpose of this test is to ensure that the maximum power conducted to the radiating element does not exceed the limits specified. This ensures that if the end-user replaces the antenna, that the maximum power does not exceed an amount which may create an excessive power level.

Limits

The limits are defined in FCC Part 15.247(b)3 and RSS-247 5.4(d).

For systems using digital modulation in the 2400-2483.5 MHz band, the peak conducted output limit is 1 watt (or 30 dBm = 125.2 dBµV at 3m distance). The e.i.r.p. limit is 4 watts (or 36 dBm = 131.2 dBµV at 3m distance)

Results

The EUT passed. The peak power measured is 5.7 dBm (3.72 mW).

Table(s)

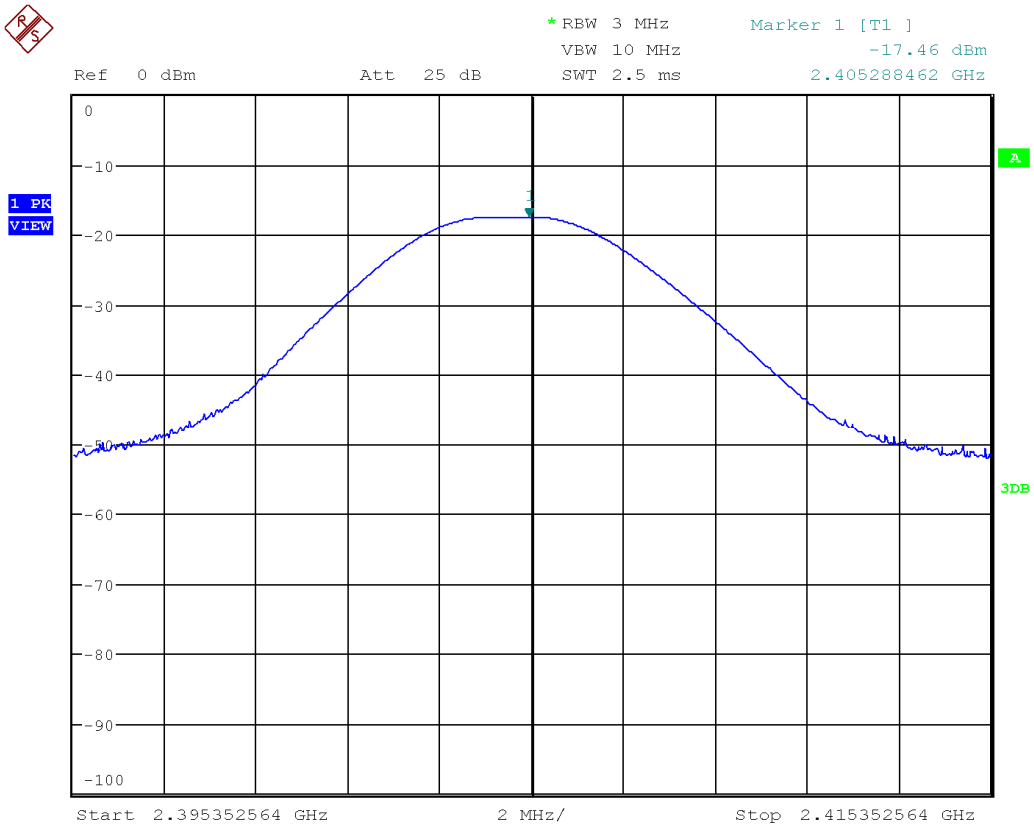
The table below shows the peak power output of the device during the antenna conducted measurement during transmit operation of the EUT. Peak detector was used with max hold. The EUT was transmitting continuous modulated data at the maximum output power used by the manufacturer.

Table 1 - Max peak conducted output power

Test Frequency (MHz)	Channel	Measured Reading (dBm)	External Attenuator (dB)	Cable Loss (dB)	Output Power (dBm)	Output Limit (dBm)	Margin (dB)	Result
2405	Low 11	-17.46	20	1.8	4.34	30	25.66	Pass
2440	Middle 18	-16.46	20	1.8	5.34	30	24.66	Pass
2475	High 25	-16.1	20	1.8	**5.7**	30	24.3	Pass
2480	High 26	-23.28	20	1.8	-1.48	30	31.48	Pass

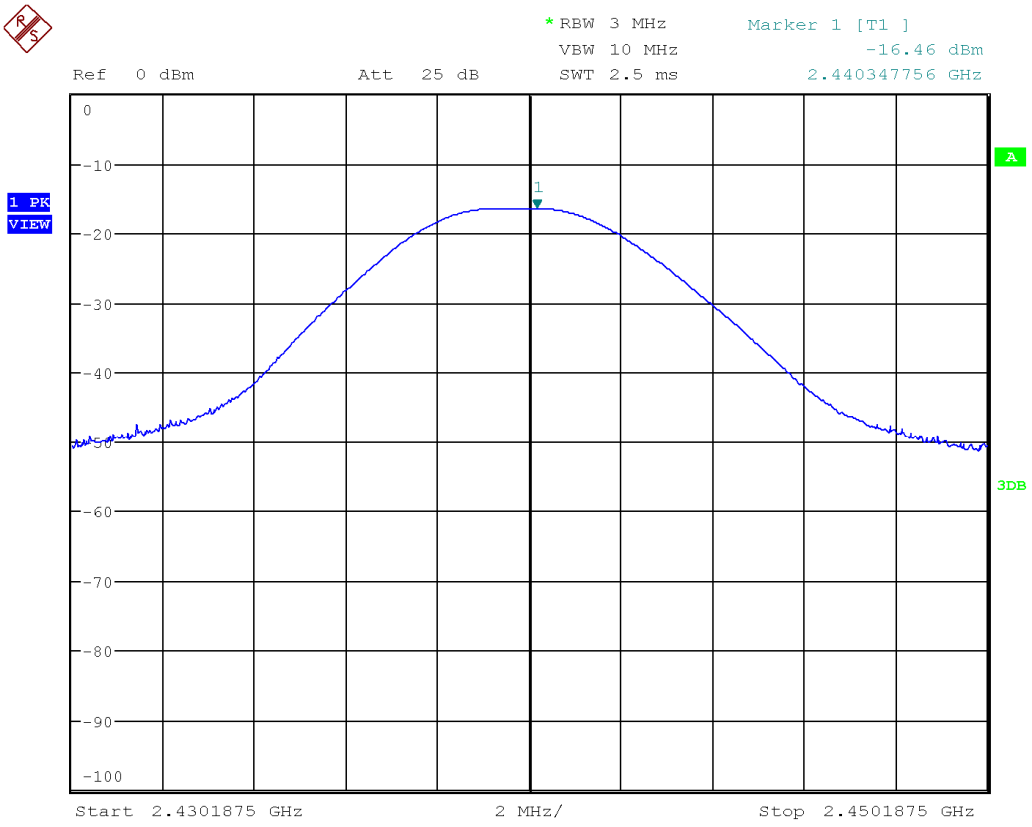
Low Channel 11
Power setting 31

Note: 20 dB attenuator used when making measurements shown below.



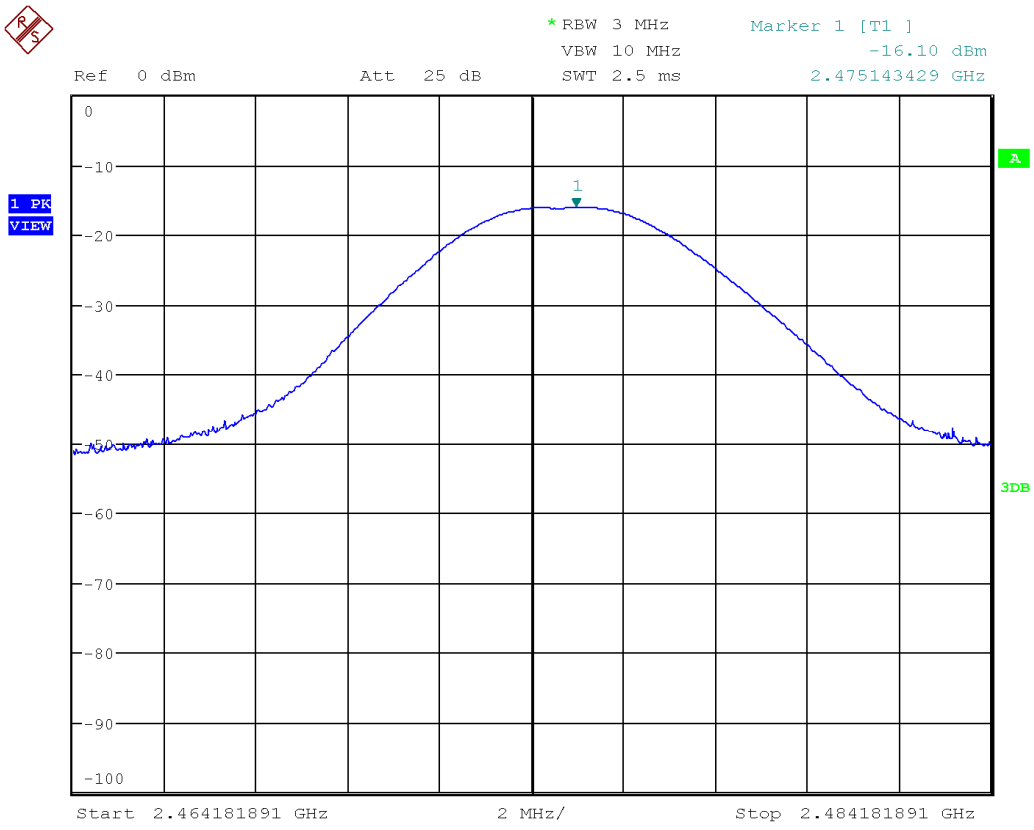
Middle Channel 18
Power setting 31

Note: 20 dB attenuator used when making measurements shown below.



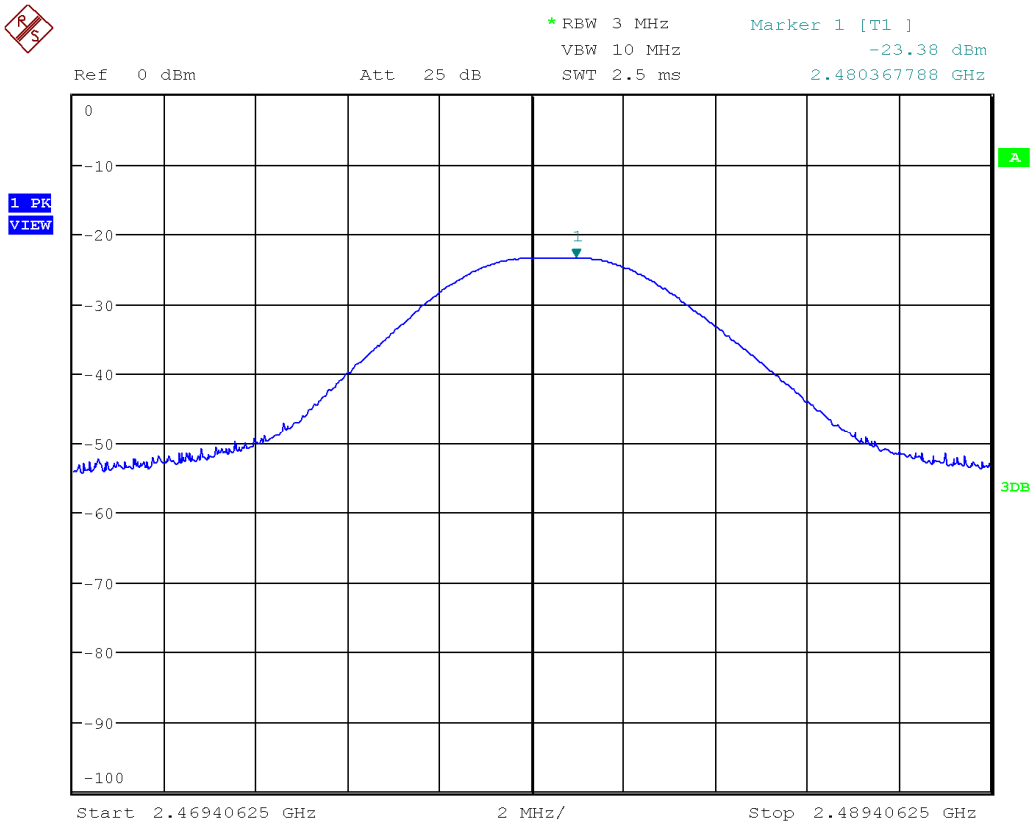
High Channel 25
Power setting 31

Note: 20 dB attenuator used when making measurements shown below.



High Channel 26
Power setting 23

Note: 20 dB attenuator used when making measurements shown below.



Test Equipment List

Equipment	Model No.	Manufacturer	Last calibration date	Next calibration due date	Asset #
Spectrum Analyzer	ESL6	Rohde & Schwarz	Dec. 27, 2017	Dec. 27, 2019	GMEC 160

Maximum Peak E.I.R.P Output

Purpose

The purpose of this test is to ensure that the maximum power output does not exceed the limits specified when used with the antenna, which may provide gain. This ensures that the maximum power does not exceed an amount which may create an excessive power level.

Limits

The limits are defined in RSS-247 5.4(d).
For DTSs operating in the 2400-2483.5 MHz band, the peak E.I.R.P. limit is 4 Watts (or 36 dBm = 131.2 dBµV at a 3m distance).

Results

The EUT passed. The peak E.I.R.P. is 9.9 dBm (9.77 mW, 0.00977 W, or 105.1 dBµV/m at 3 m).

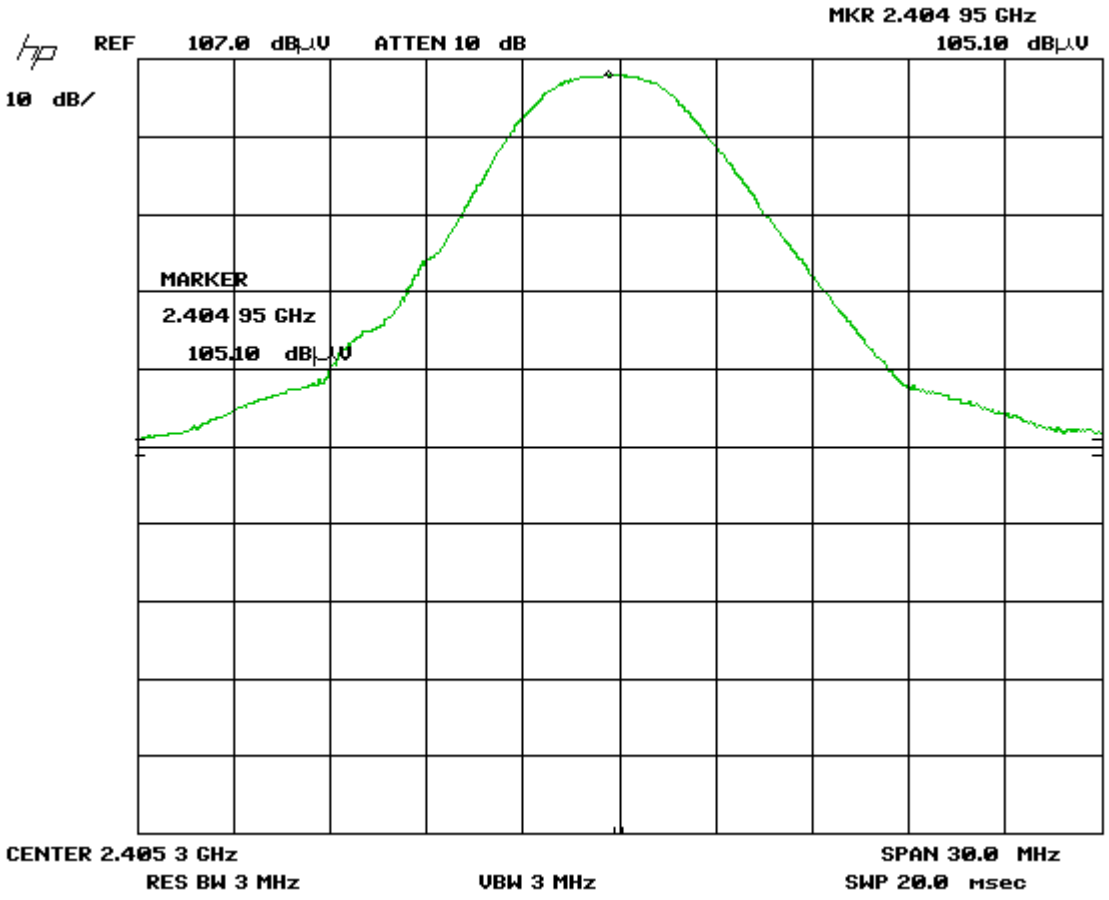
Table(s)

The table below shows the measured peak power output of the device. Peak measurements were made during transmit operation of the EUT with continuous modulated data at the maximum output power used by the manufacturer. Worst case plots are shown.

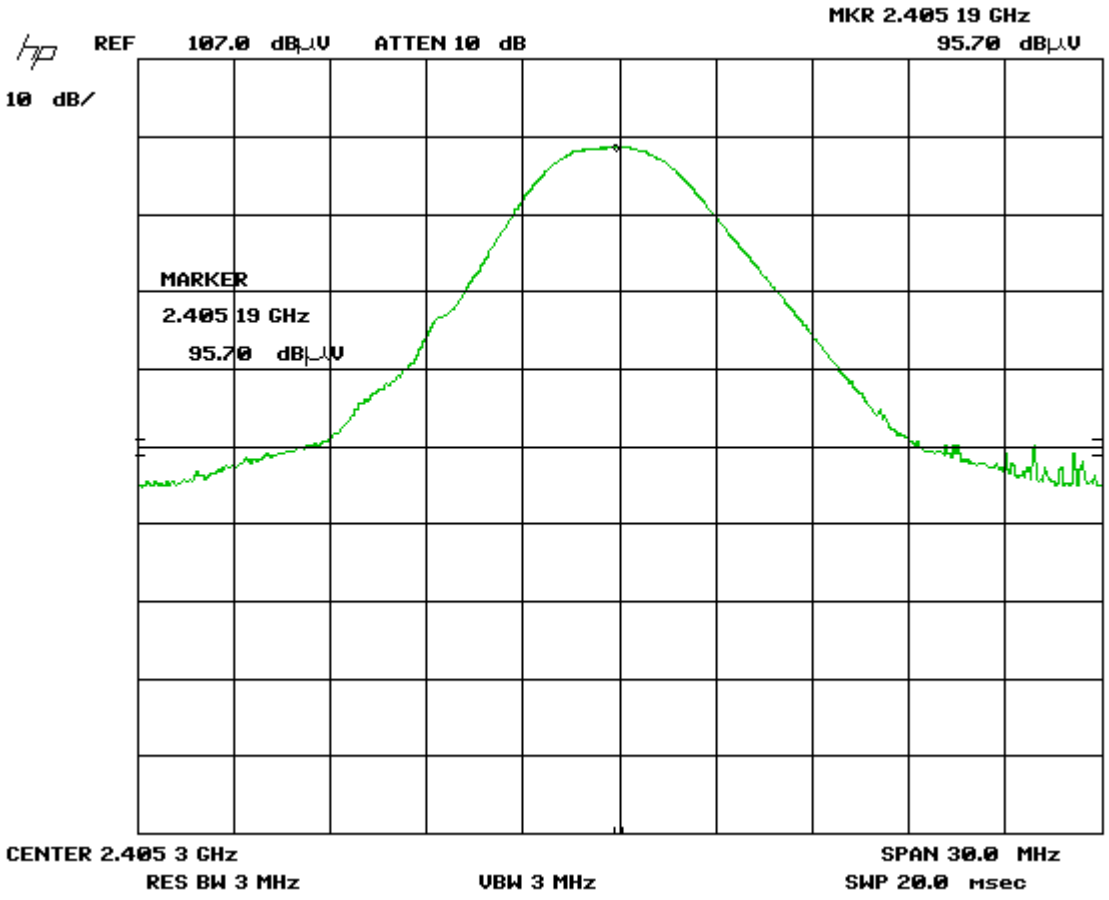
Table 2 – Max peak E.I.R.P. output

Test Frequency (MHz)	Channel	Antenna polarity	Received Reading dB(µV)	Antenna factor (dB)	Cable Loss (dB)	Pre-Amp Gain (dB)	Received signal at 3m (dBµV)	EIRP (dBm)	Emission limit dB(µV)	Margin dB(µV)	Result
2405.0	Low 11	Vertical	105.1	26.7	3.7	33.7	101.8	6.6	125.20	23.4	Pass
2405.2	Low 11	Horizontal	95.7	26.7	3.7	33.7	92.4	-2.8	125.20	32.8	Pass
2440.3	Middle 18	Vertical	107.0	26.3	4.6	33.2	104.7	9.5	125.20	20.5	Pass
2440.1	Middle 18	Horizontal	96.4	26.3	4.6	33.2	94.1	-1.1	125.20	31.1	Pass
2475.1	**High 25**	**Vertical**	**107.6**	**26.2**	**4.6**	**33.3**	**105.1**	**9.9**	**125.20**	**20.1**	**Pass**
2475.1	High 25	Horizontal	96.9	26.2	4.6	33.3	94.4	-0.8	125.20	30.8	Pass
2480.2	High 26	Vertical	100.7	26.2	4.6	33.3	98.2	3	125.20	27.0	Pass
2480.4	High 26	Horizontal	89.2	26.2	4.6	33.3	86.7	-8.5	125.20	38.5	Pass

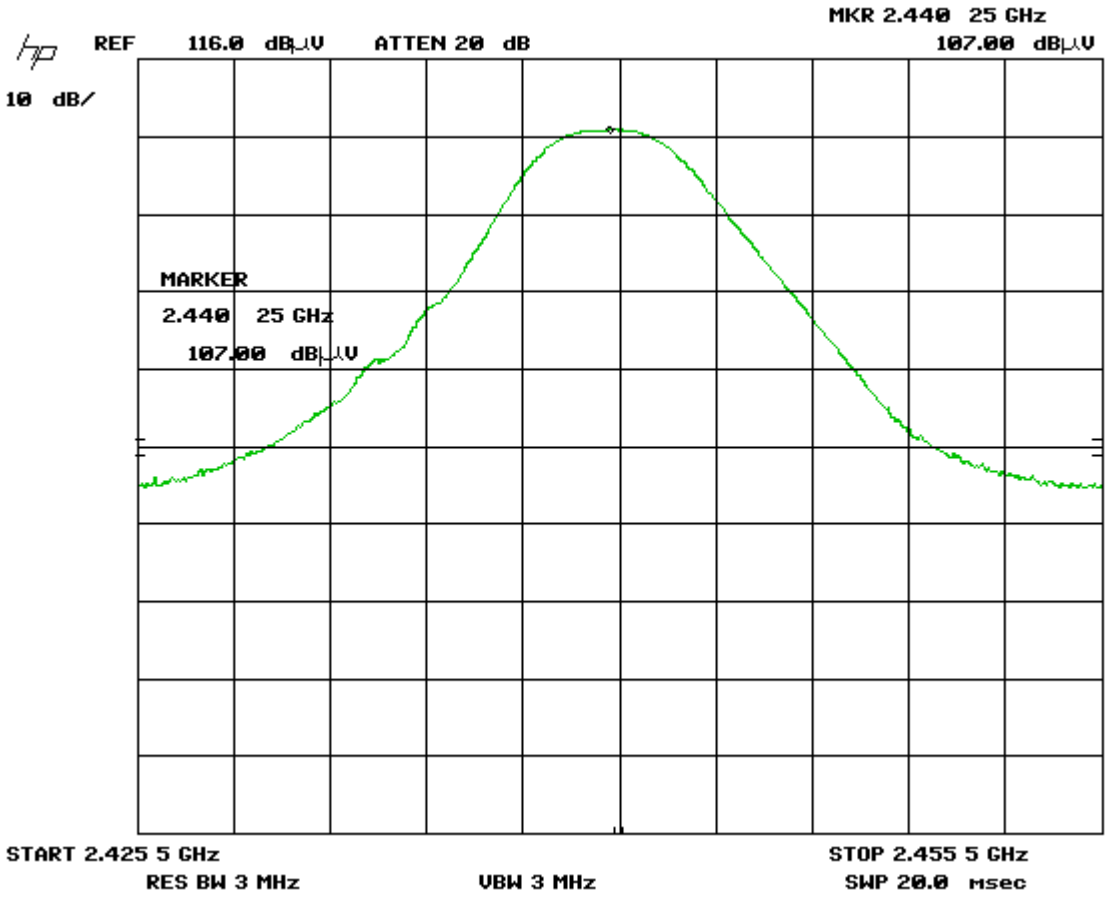
Low Channel 11
Power setting 31
Vertical Antenna Polarity



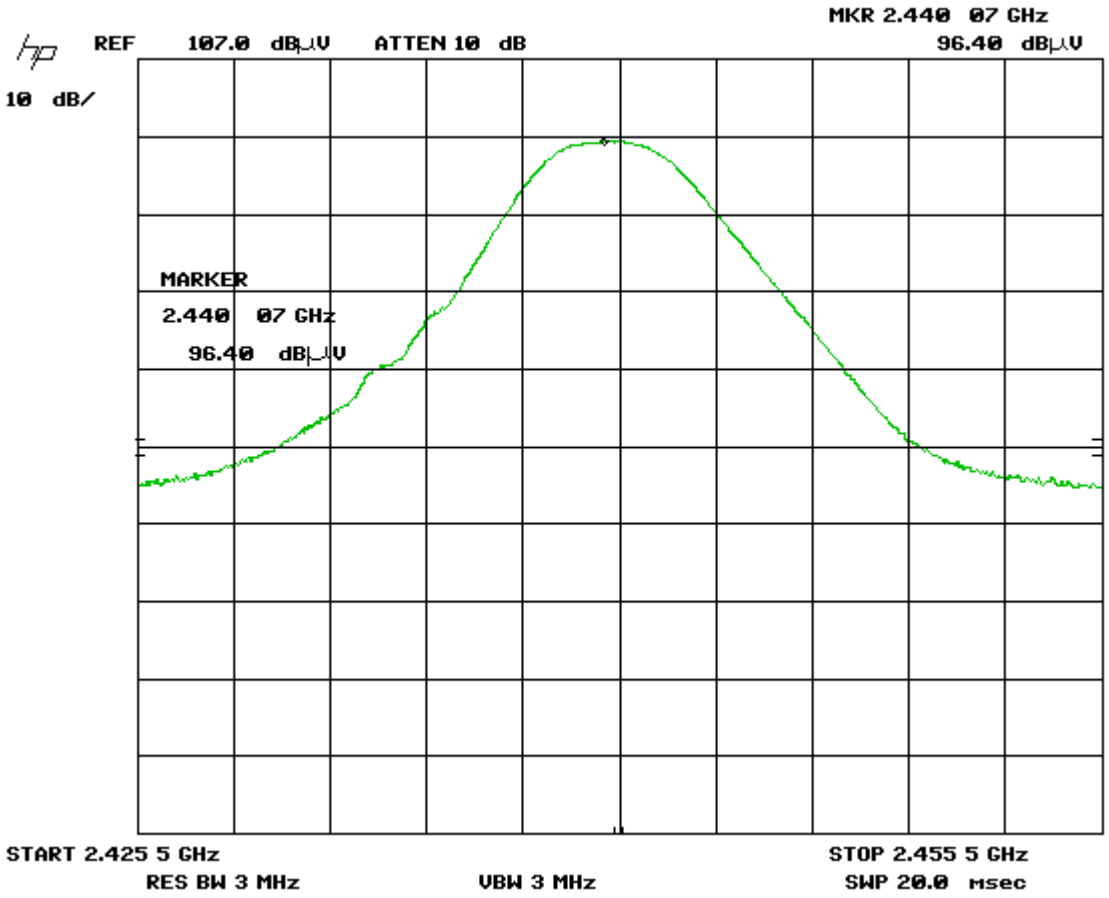
Low Channel 11
Power setting 31
Horizontal Antenna Polarity



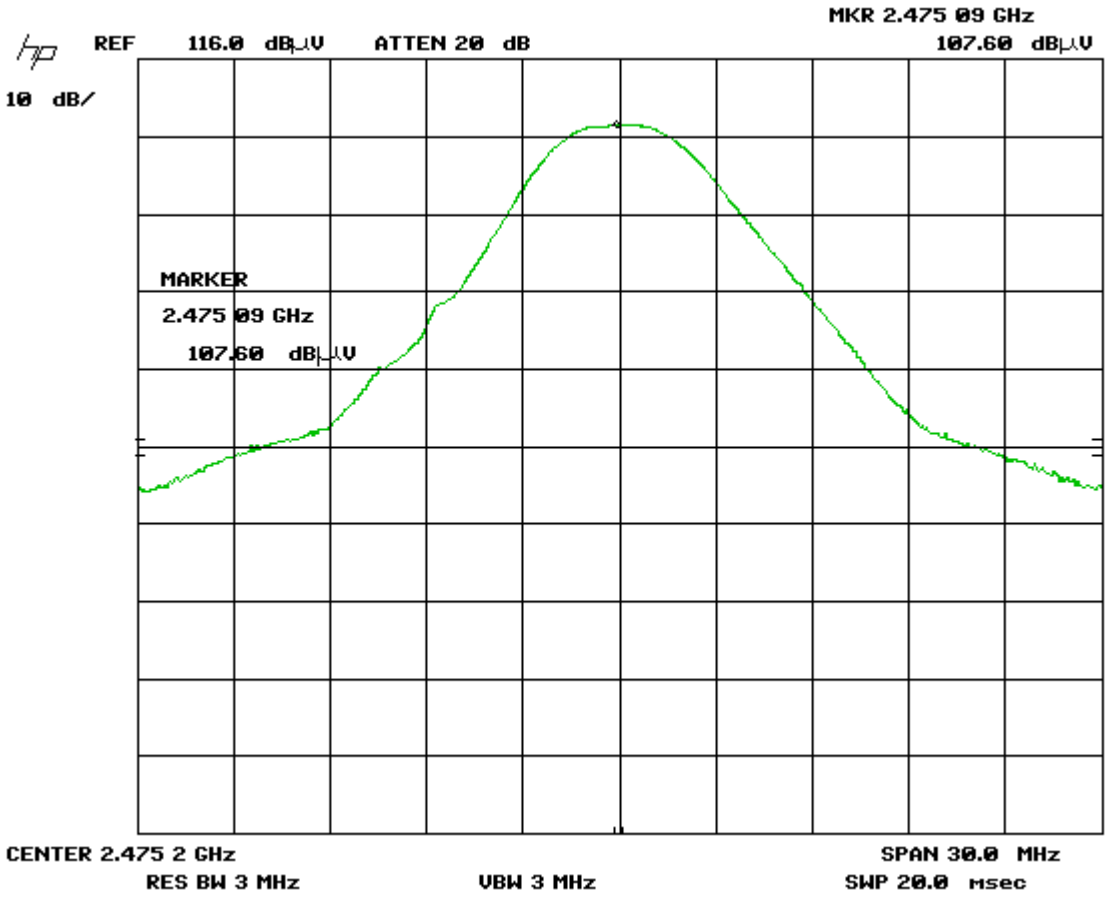
Middle Channel 18
Power setting 31
Vertical Antenna Polarity



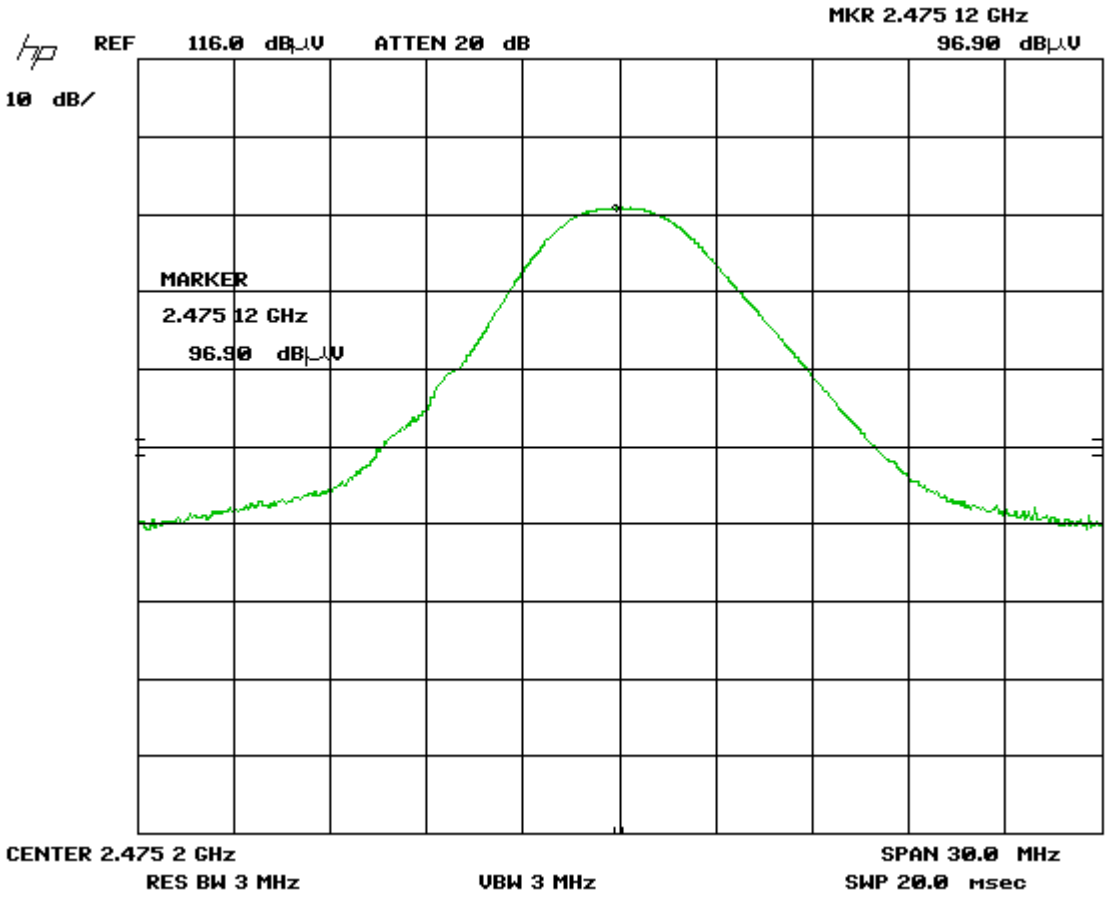
Middle Channel 18
Power setting 31
Horizontal Antenna Polarity



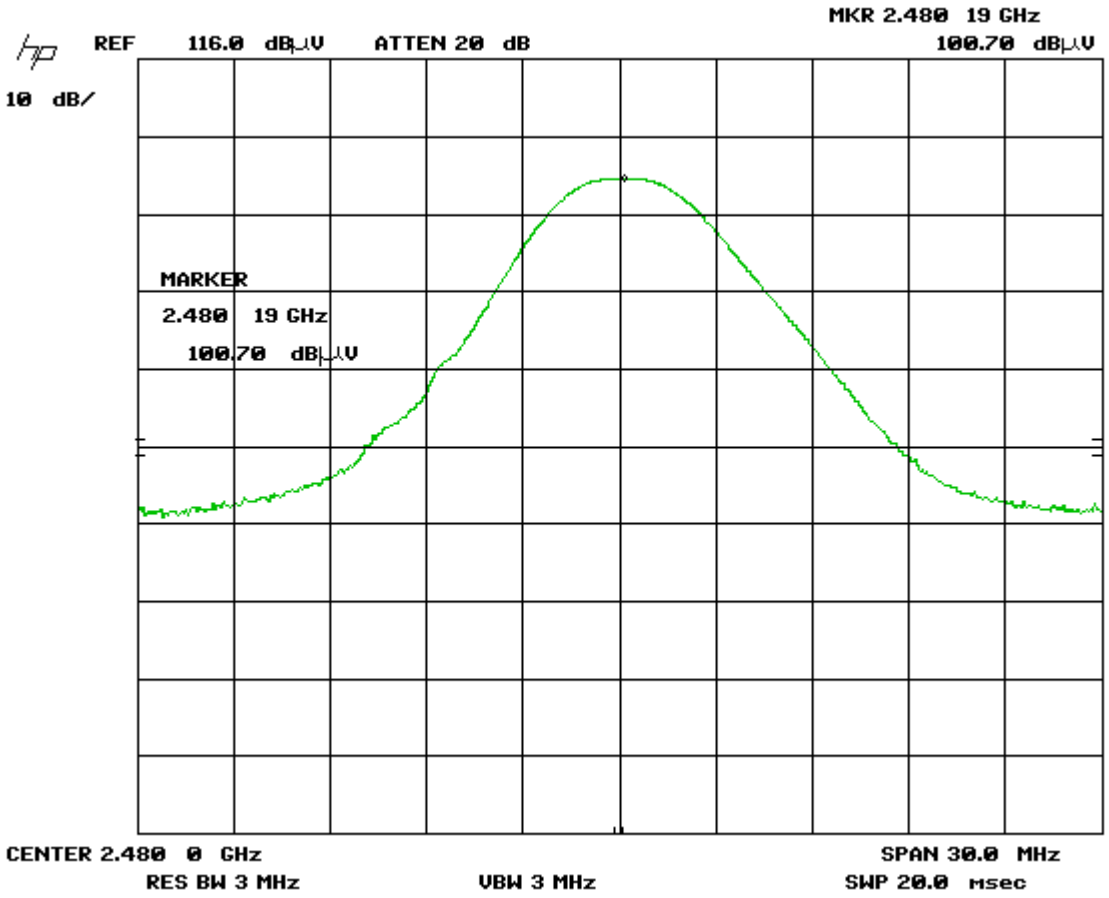
High Channel 25
Power setting 31
Vertical Antenna Polarity



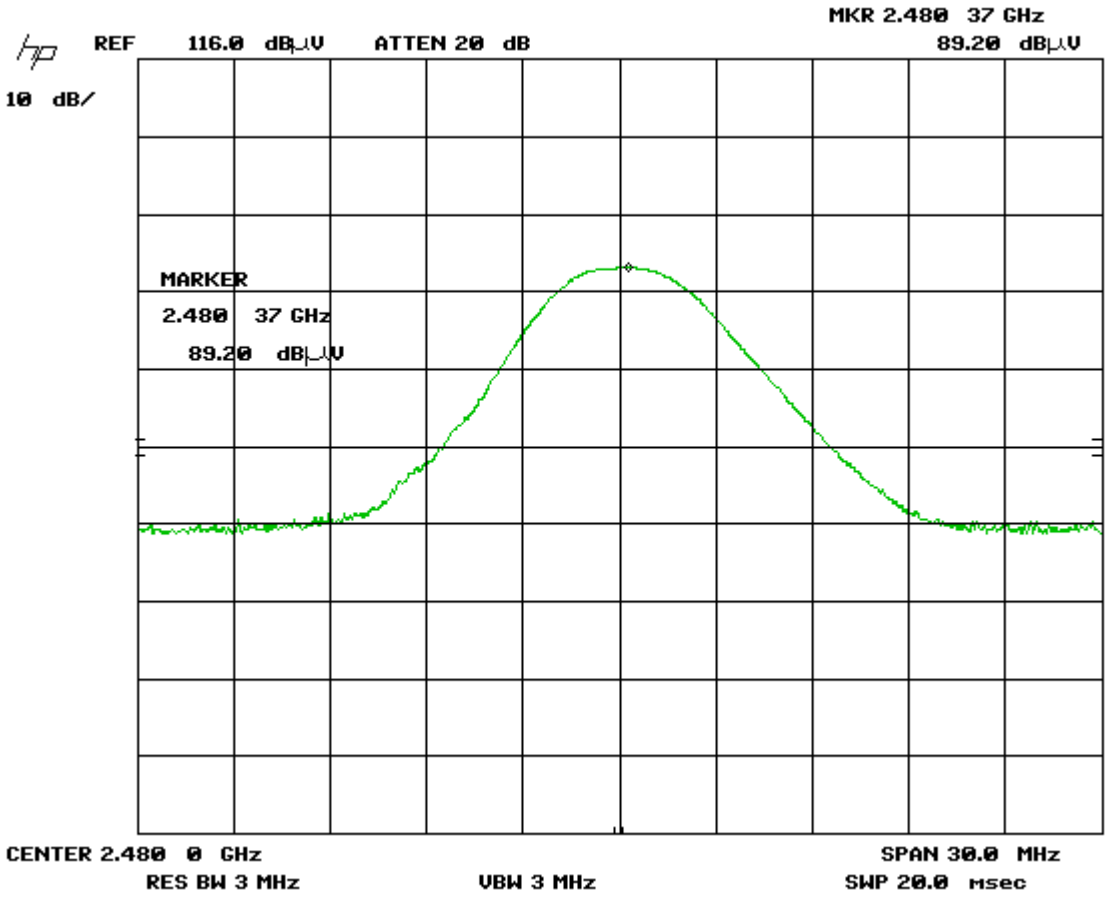
High Channel 25
Power setting 31
Horizontal Antenna Polarity



High Channel 26
Power setting 23
Vertical Antenna Polarity



High Channel 26
Power setting 23
Horizontal Antenna Polarity



Note: See ‘Appendix B – EUT & Test Setup Photographs’ for photos showing the test set-up.

Test Equipment List

Equipment	Model No.	Manufacturer	Last calibration date	Next calibration due date	Asset #
Spectrum Analyzer	8566B	HP	Dec. 13, 2017	Dec. 13, 2019	GEMC 190
Quasi-Peak Adapter	85650A	HP	Dec. 13, 2017	Dec. 13, 2019	GEMC 191
Horn Antenna	AH-118	Com-Power Corporation	July 12, 2017	July 12, 2019	GEMC 214
Pre-amp	HP 8449B	HP	Nov. 15, 2017	Nov. 15, 2019	GEMC 189
RF Cable 7m	LMR-400-7M-50OHM-MN-MN	LexTec	NCR	NCR	GEMC 28
RF Cable 1m	LMR-400-1M-50OHM-MN-MN	LexTec	NCR	NCR	GEMC 29
Emissions Software	0.1.94	Global EMC	Not required	Not required	GEMC 58

Antenna Spurious Conducted Emissions (-20 dBc)

Purpose

The purpose of this test is to ensure that the maximum power conducted to the radiating element at frequencies outside of the authorized spectrum does not exceed the limits specified. This ensures that the only the intended signal is delivered to the radiating element.

Limits

The limits are defined in FCC Part 15.247(d) and RSS-247 5.5. In any 100 kHz band outside the frequency band in which the intentional radiator is operating, the peak spurious harmonics emissions must be at least 20 dB below the fundamental. Spurious conducted emissions are to be evaluated up to the 10^{th} harmonic. This -20 dBc requirement also applies at the 'band edge' or 2.4 GHz and 2.4835 GHz.

Results

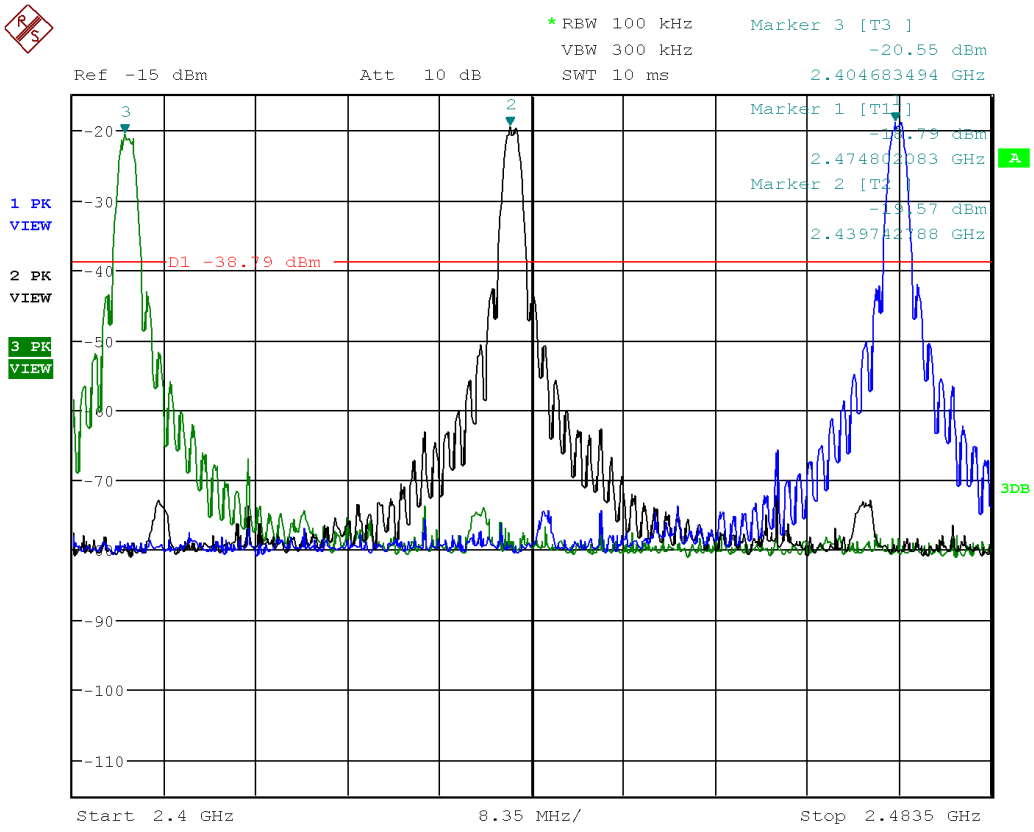
The EUT passes. Low, middle and high channels were measured. The worst case is presented as a graph for the spectrum. The -20 dBc requirement is shown for the lower band edge at 2.4 GHz in the low band, and for the high band edge at 2.4835 GHz in the high band.

Graph(s)

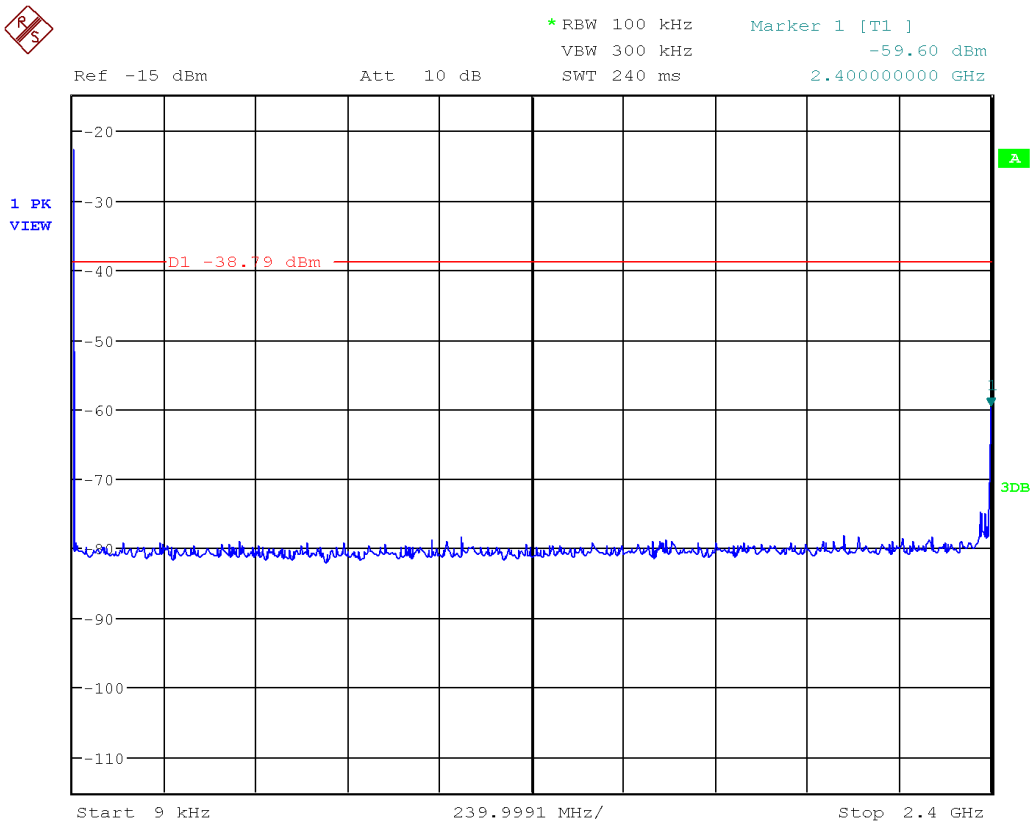
The graphs shown below shows the peak conducted power output of the device during transmit operation of the EUT at max output power, continuous transmission of data.

Notes:
20 dB of external attenuation is used during these measurements.
20dB below max fundamental in 100 kHz bandwidth is marked with line D1 at -38.79 dBm.

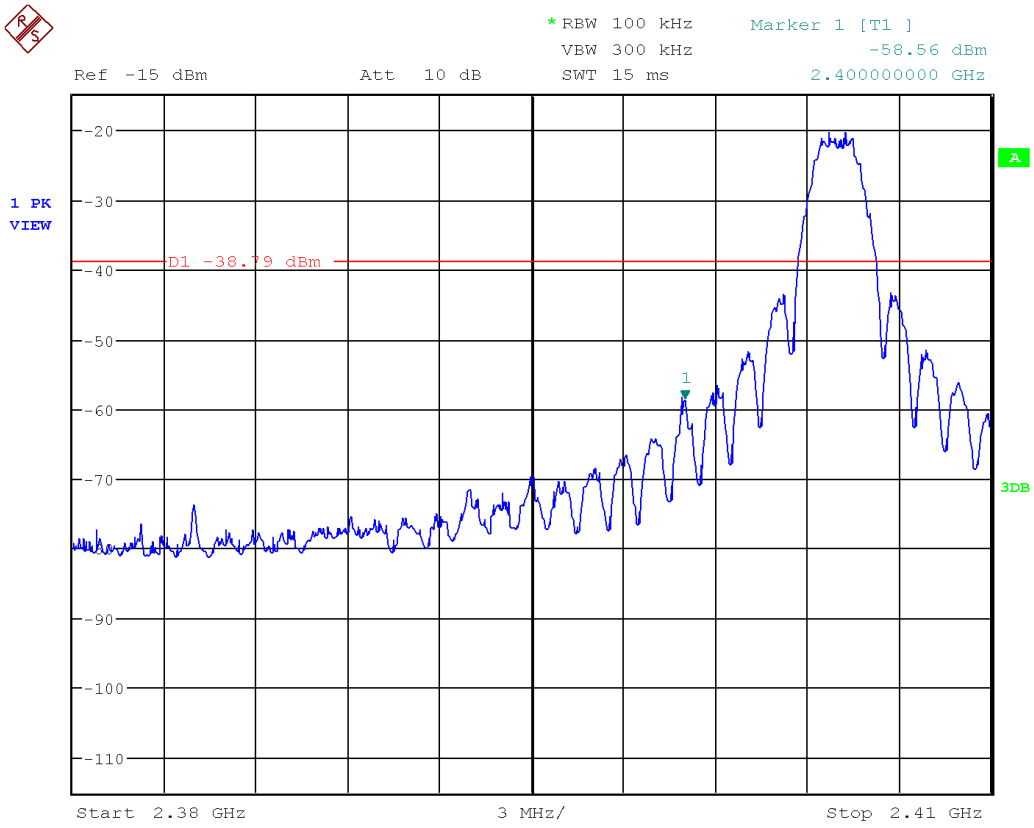
2400 MHz – 2483.5 MHz
Showing Low (11), Middle (18), and High (25) Channels
Overlaid to identify max fundamental in 100 kHz bandwidth



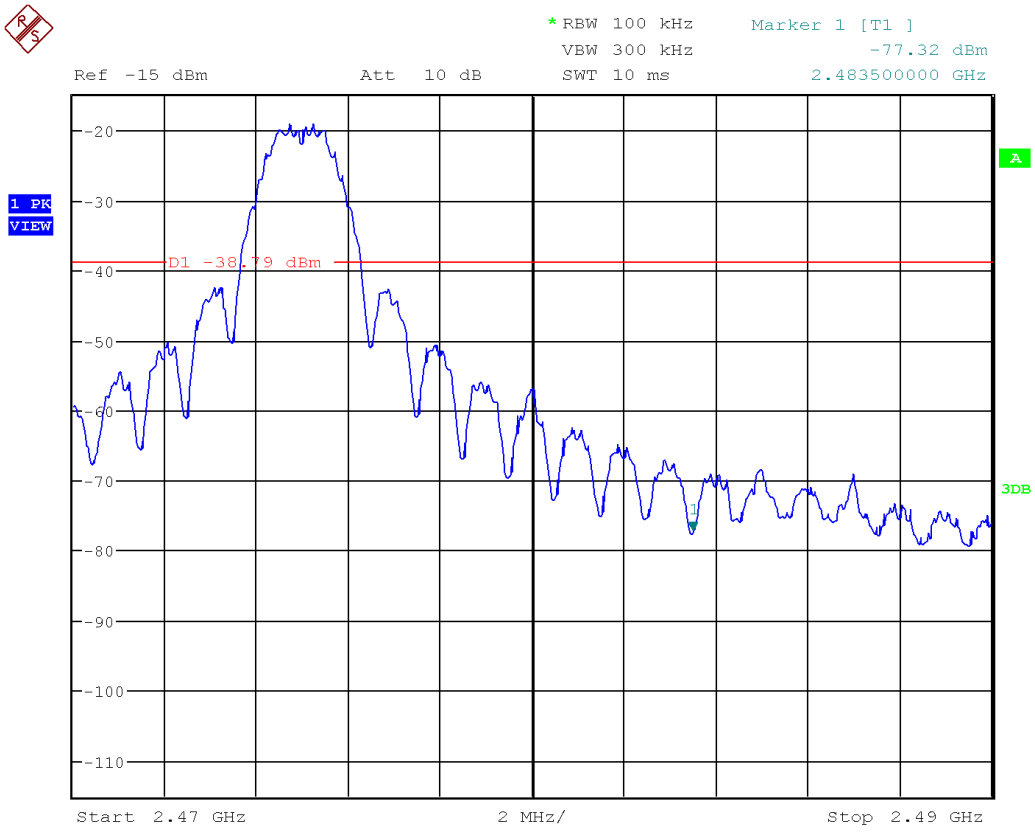
9 kHz – 2400 MHz



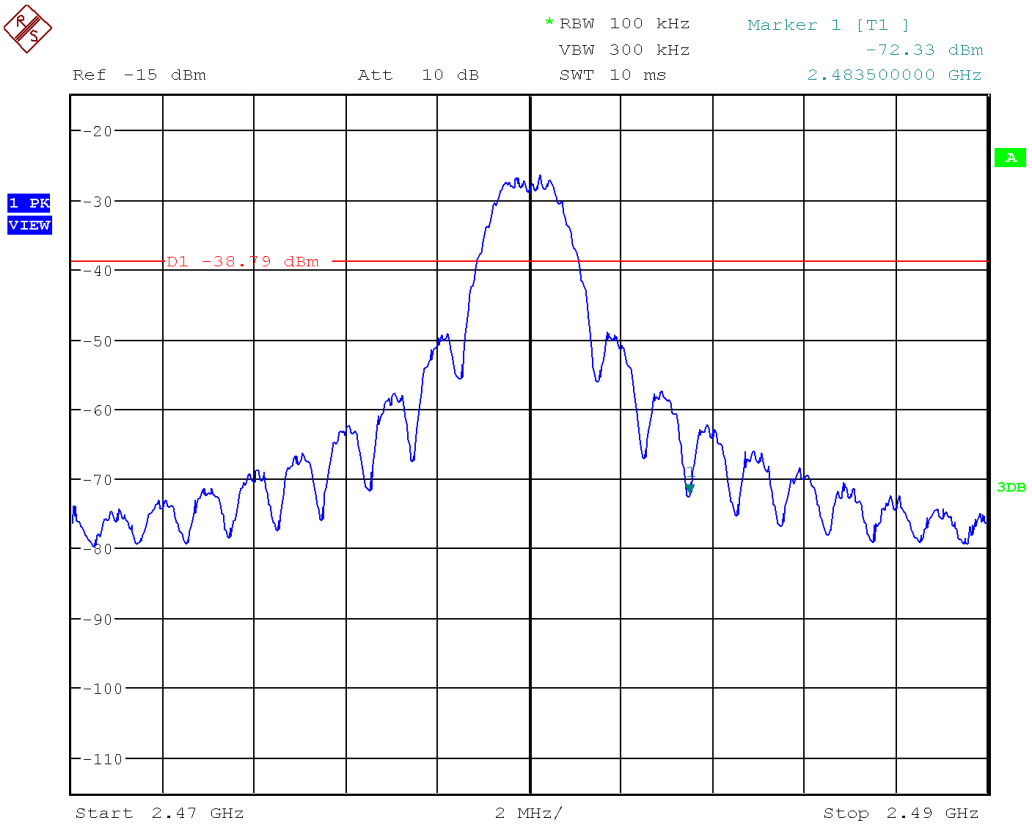
2380 MHz – 2410 MHz, Low Channel 11
Showing Lower Band Edge at 2400 MHz



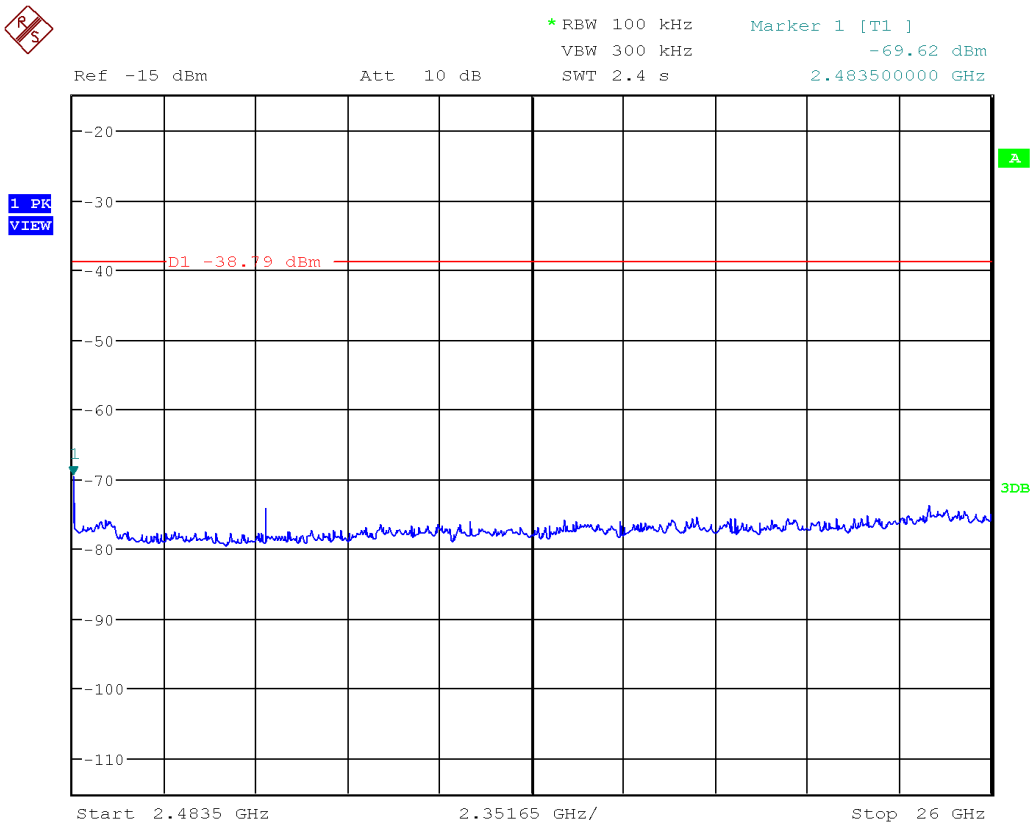
2470 MHz – 2490 MHz, High Channel 25
Showing Upper Band Edge at 2483.5 MHz



2470 MHz – 2490 MHz, High Channel 26
Showing Upper Band Edge at 2483.5 MHz



2483.5 MHz – 26 GHz



Test Equipment List

Equipment	Model No.	Manufacturer	Last calibration date	Next calibration due date	Asset #
Spectrum Analyzer	8566B	HP	Dec. 13, 2017	Dec. 13, 2019	GEMC 190
Quasi-Peak Adapter	85650A	HP	Dec. 13, 2017	Dec. 13, 2019	GEMC 191

Power Spectral Density

Purpose

The purpose of this test is to ensure that the maximum power spectral density to the radiating element does not exceed the limits specified. This ensures that the modulation is significantly wide enough, or low enough in power that it will allow for co-operation of other wireless devices operating within this frequency allocation.

Limits

The limits are defined in FCC Part 15.247(e) and RSS-247 5.2(b).

For digitally modulated systems, the Power Spectral Density (PSD) conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

Results

The EUT passed. Low, middle, and high channel was tested. Peak measurements were made for each with a 3 kHz resolution bandwidth, during transmit operation of the EUT with continuous modulated data. The power spectral density is < 8dBm.

High Channel 25 is tested for worst case results.

Table 3: Maximum Power Spectral Density

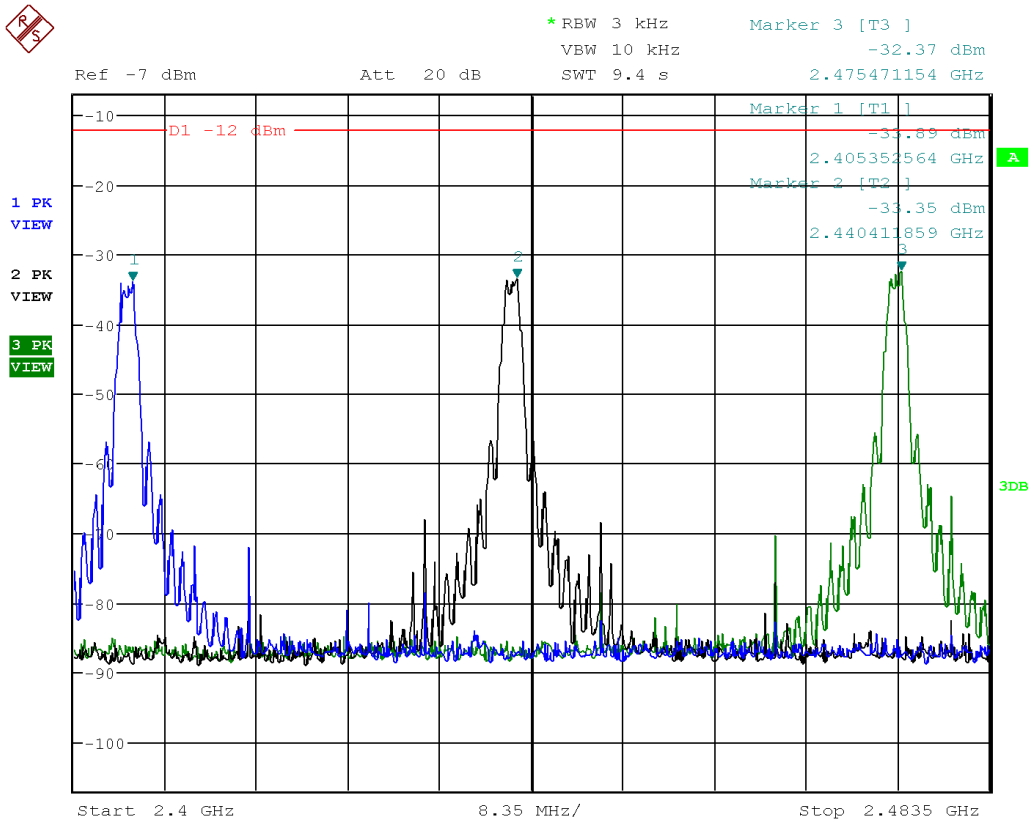
Test Frequency (MHz)	Channel	Measured Reading (dBm)	External Attenuator (dB)	Cable Loss (dB)	Output Power (dBm)	Output Limit (dBm)	Margin (dB)	Result
2405	Low 11	-33.9	20	1.8	-12.1	8	20.1	Pass
2440	Middle 18	-33.4	20	1.8	-11.6	8	19.6	Pass
2475	High 25	-32.4	20	1.8	-10.6	8	18.6	Pass

Graph(s)

The graph shown below show the power spectral density of the device during the operation of the EUT. Low, middle, and high channels were investigated.

Note: 20 dB attenuator was used to make the measurements shown below.

2400 MHz – 2483.5 MHz
Showing Low (11), Middle (18), and High (25) Channels
Overlaid to identify max fundamental in 100 kHz bandwidth



Test Equipment List

Equipment	Model No.	Manufacturer	Last calibration date	Next calibration due date	Asset #
Spectrum Analyzer	ESL6	Rohde & Schwarz	Dec. 27, 2017	Dec. 27, 2019	GMEC 160

Spurious Radiated Emissions & Restricted Bands

Purpose

The purpose of this test is to ensure that the RF energy unintentionally emitted from the EUT does not exceed the limits listed below as defined in the applicable test standard, as measured from a receiving antenna. This helps protect broadcast radio services such as television, FM radio, pagers, cellular telephones, emergency services, and so on, from unwanted interference.

Limit(s) and Method

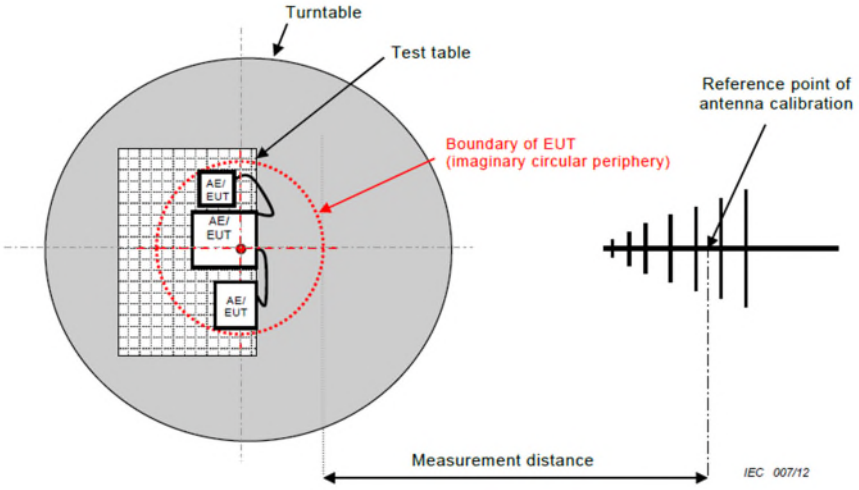
The method is as defined in ANSI C63.4.
The restricted bands are defined in 47 CFR FCC Part 15.205 and RSS-Gen (Table 6).
The limits are as defined in 47 CFR FCC Part 15.209 and RSS- Gen (Table 4).
The requirement is stated in 47 CFR FCC Part 15 Section FCC 15.247(d), and RSS-247 5.5.

The limits for unintentional radiated emissions apply for those emissions that fall in the restricted bands. These limits are as follows:

0.009 MHz – 0.490 MHz, 2400/F(kHz) uV/m at 300 m [1]
0.490 MHz – 1.705 MHz, 24000/F(kHz) uV/m at 30 m [1]
1.705 MHz – 30 MHz, 30 uV/m at 30 m [1]
30 MHz – 88 MHz, 100 uV/m (40.0 dBuV/m [1]) at 3 m
88 MHz – 216 MHz, 150 uV/m (43.5 dBuV/m [1]) at 3 m
216 MHz – 960 MHz, 200 uV/m (46.0 dBuV/m[1]) at 3 m
Above 960 MHz, 500 uV/m (54.0 dBuV/m [1]) at 3 m
Above 1000 MHz, 500 uV/m (54 dBuV/m [2]) at 3m
Above 1000 MHz, 5011.9 uV/m (74 dBuV/m [3]) at 3m

[1]Limit is with Quasi Peak detector with bandwidths as defined in CISPR-16-1-1.
[2]Limit is with 1 MHz measurement bandwidth and using an Average detector.
[3]Limit is with 1 MHz measurement bandwidth and using a Peak detector.

Typical Radiated Emissions Setup



Measurement Uncertainty

The expanded measurement uncertainty is calculated in accordance with CISPR 16-4-2 and is +/-4.4 dB with a ‘k=2’ coverage factor and a 95% confidence level.

Preliminary Graphs

Note the graphs shown below are for graphical illustration only. For final measurements with the appropriate detector, please refer to the final measurement table where applicable. The graphs shown below are maximized peak measurement graphs, measured with a resolution bandwidth greater than or equal to, the final required detector and over a full 0-360° rotation. This peaking process is done as a worst case measurement. This process enables the detection of frequencies of concern for final measurement, and provides considerable time savings.

In accordance with FCC Part 15, Subpart A, Section 15.33, the device was scanned to the 10^{th} harmonic.

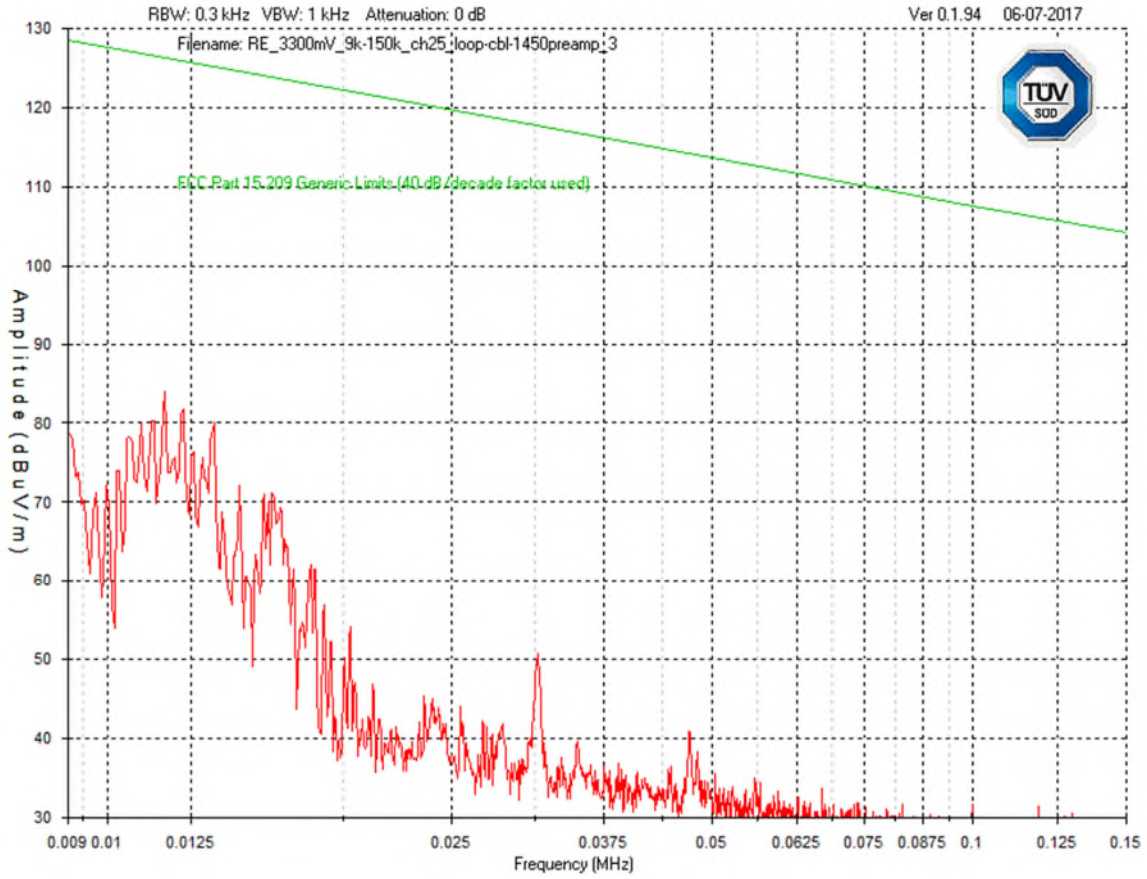
Devices scanned may be scanned at alternate test distances, and in accordance with FCC Part 15, Subpart A, Section 15.31, an extrapolation factor of 20 dB/decade was used above 30 MHz and 40 dB/decade below 30 MHz. For example, for 1 meter measurements, an extrapolation factor 9.5 dB from 20 Log (1m/3m) is applied.

See *Final Measurements* section for measurement data.

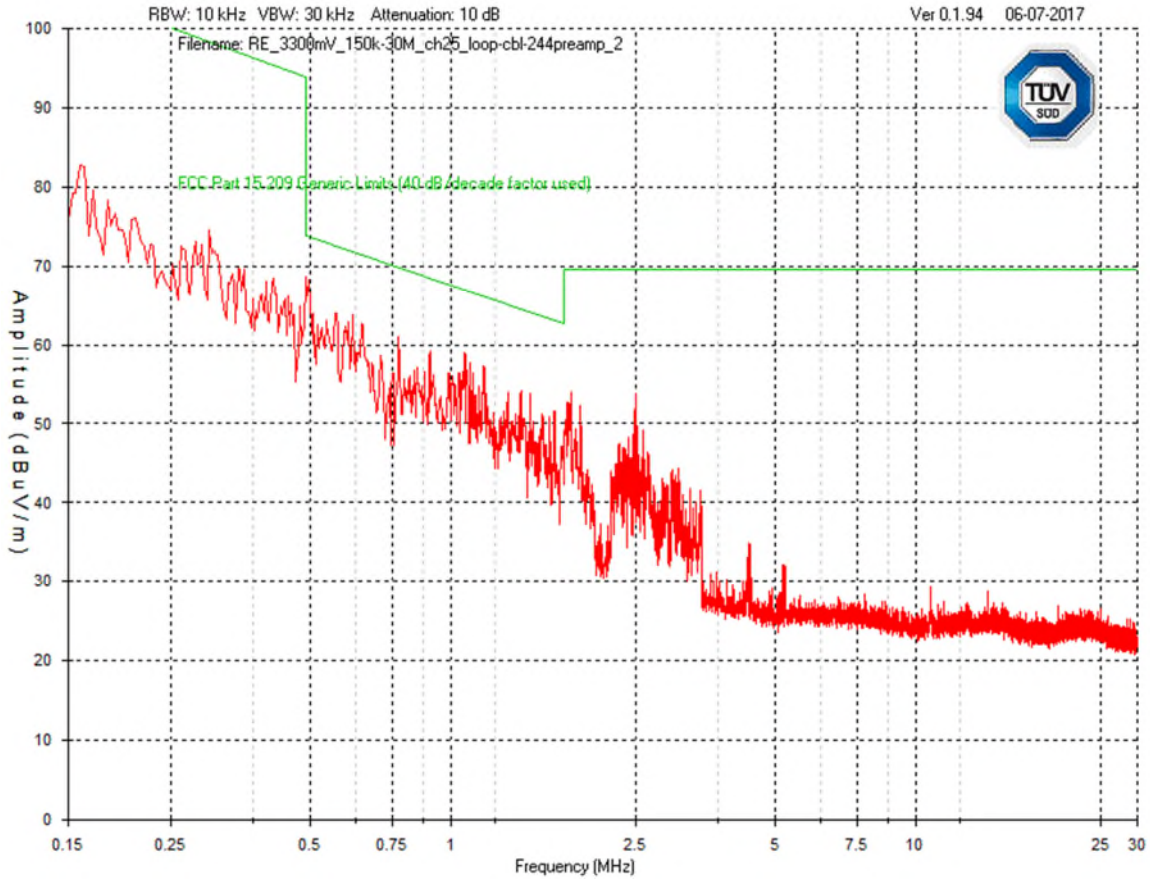
EUT was scanned at low, middle, and high channels. Worst case data is presented.

All transmitters in the EUT are on and transmitting continuous modulated data at the maximum power setting used by the manufacturer.

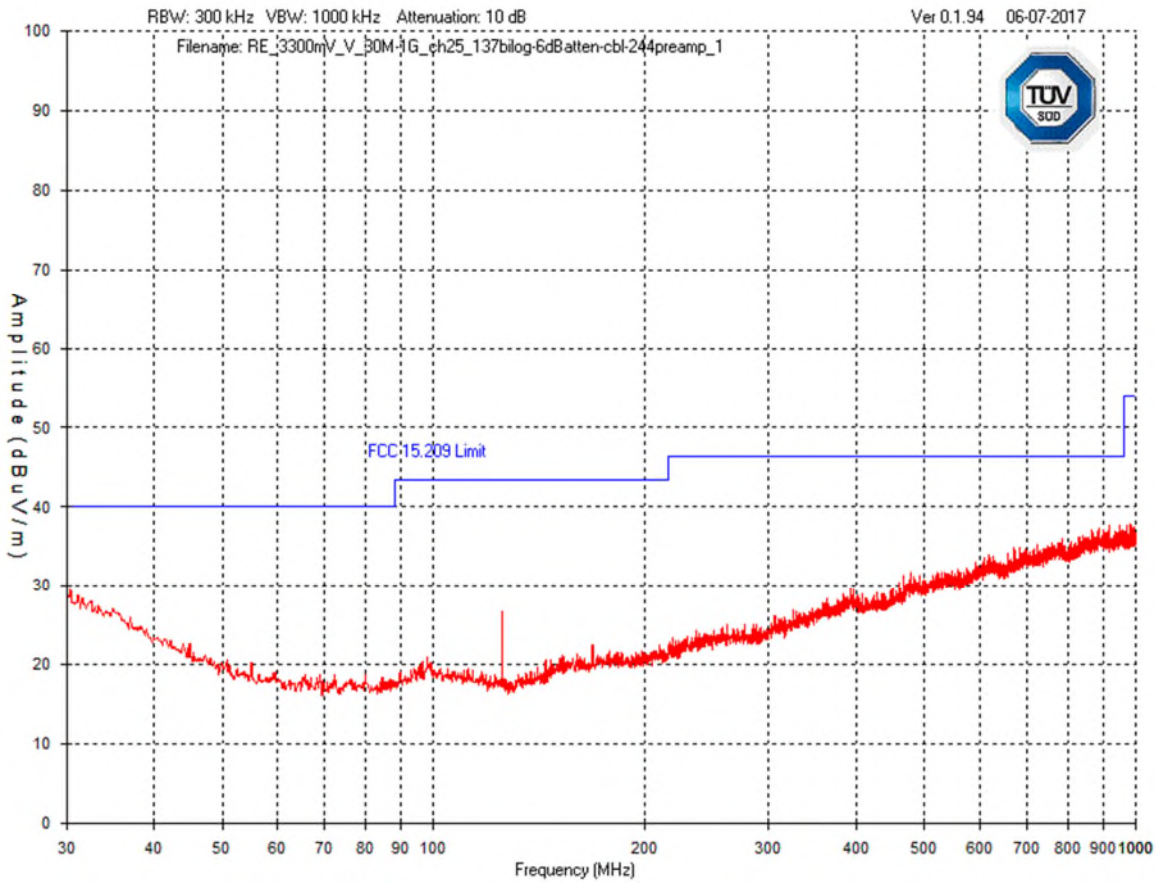
Peak Emissions Graph
9 kHz to 150 kHz



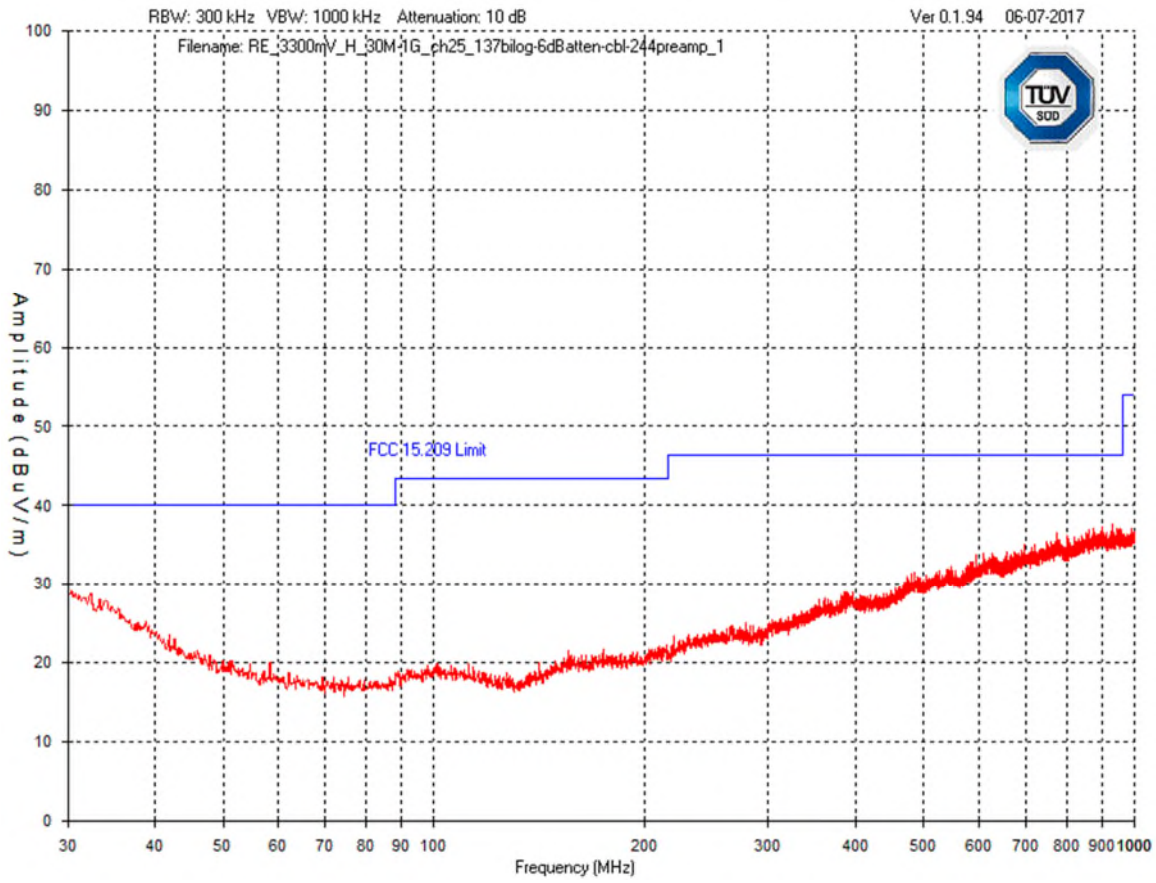
Peak Emissions Graph
150 kHz to 30 MHz



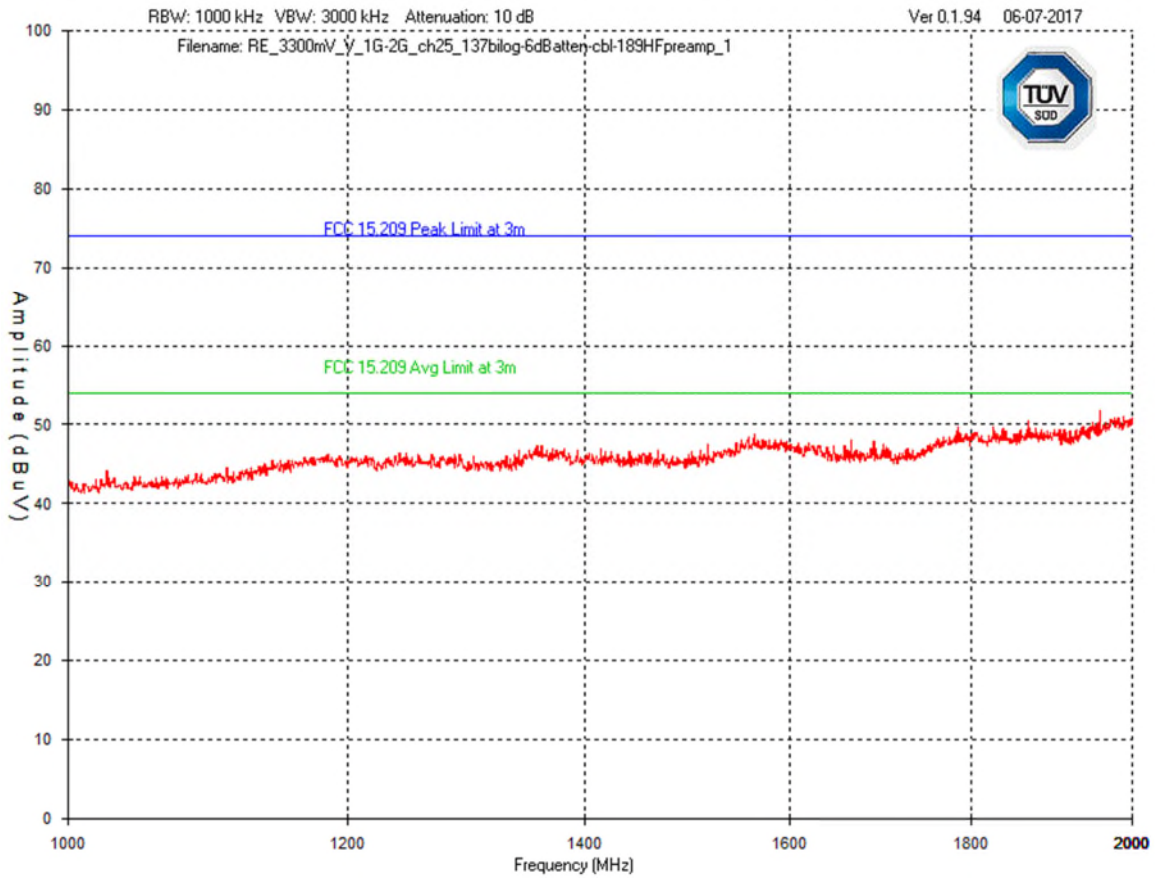
Peak Emissions Graph
Vertical Antenna Polarity
30 MHz to 1 GHz



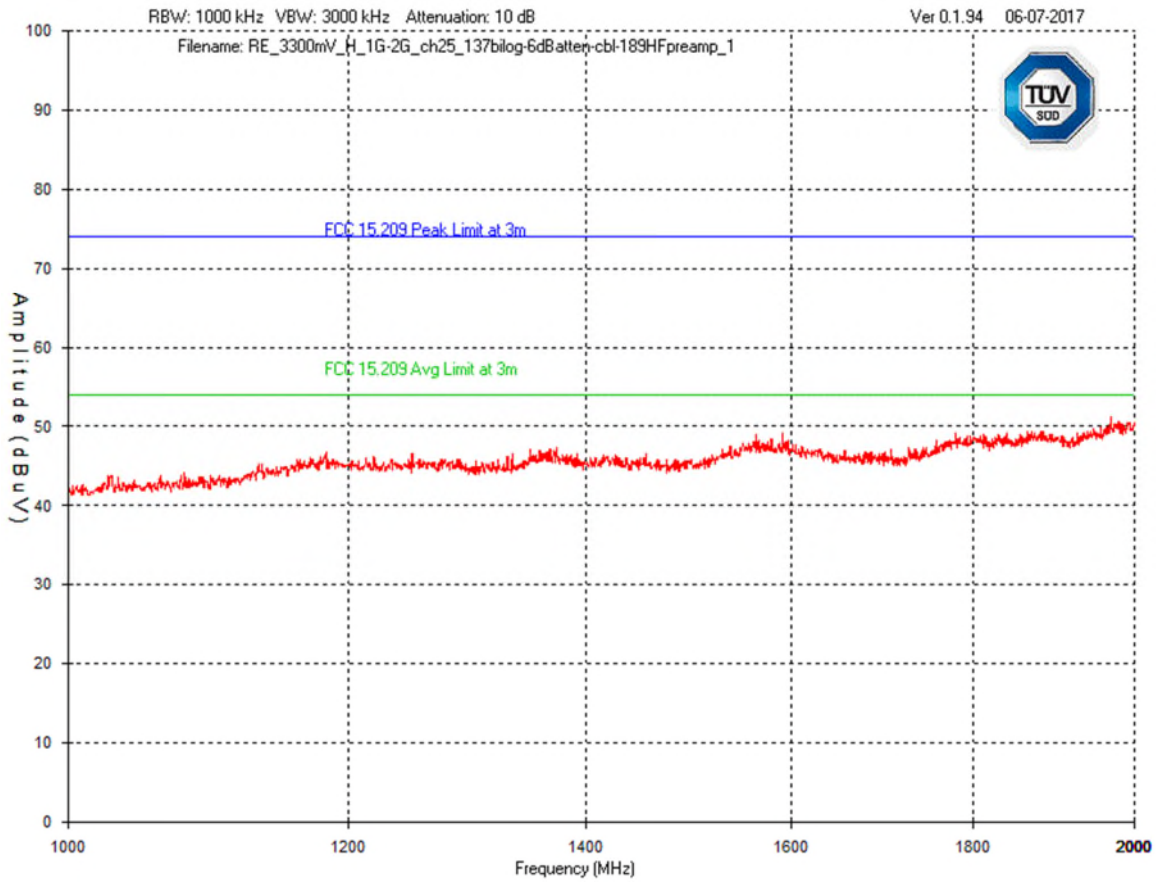
Peak Emissions Graph
Horizontal Antenna Polarity
30 MHz to 1 GHz



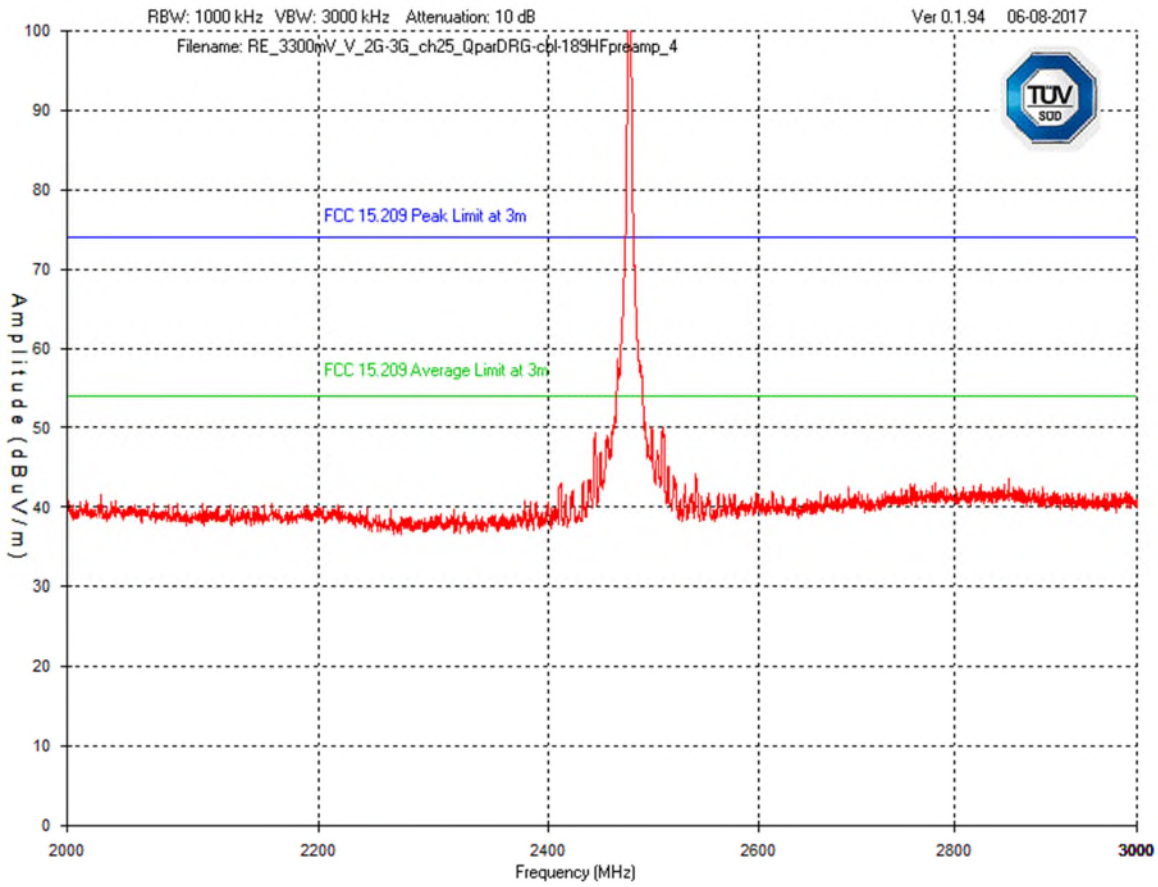
Peak Emissions Graph
Vertical Antenna Polarity
1 GHz to 2 GHz



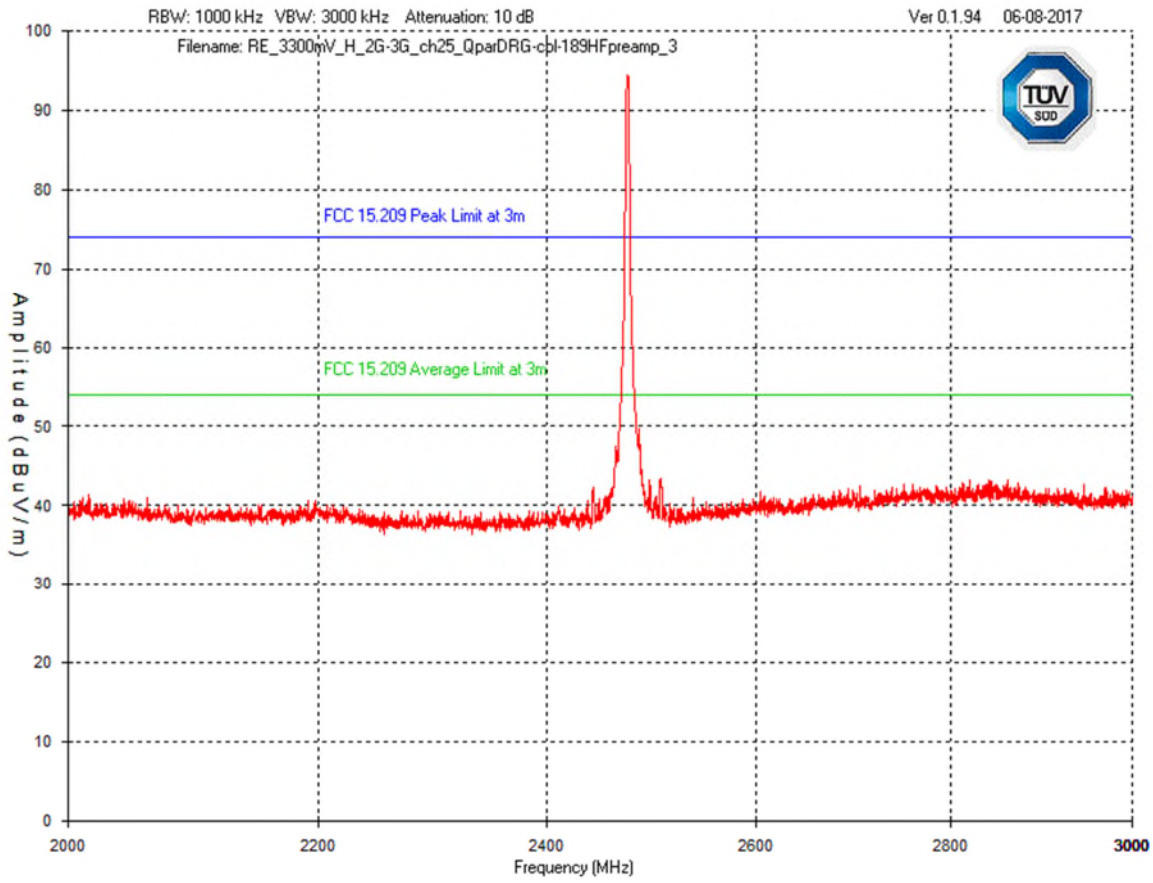
Peak Emissions Graph
Horizontal Antenna Polarity
1 GHz to 2 GHz



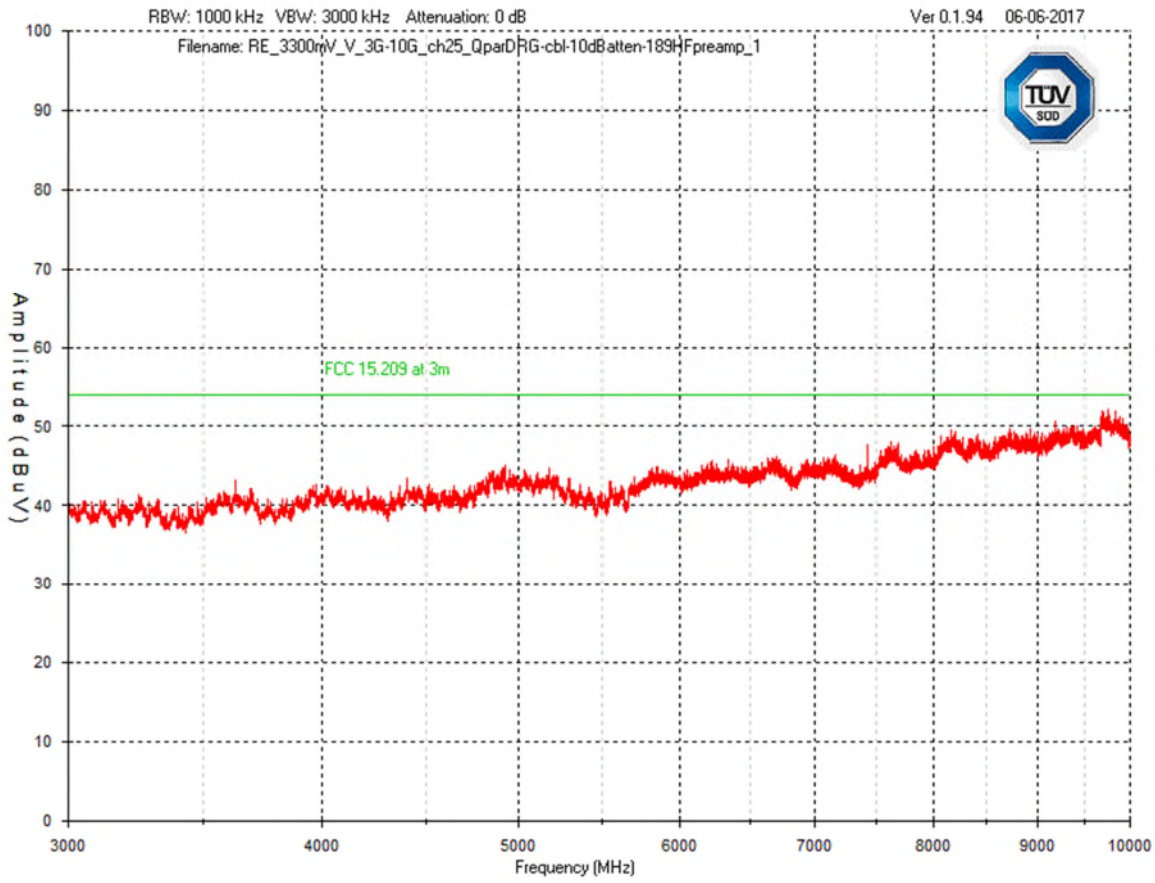
Peak Emissions Graph
Vertical Antenna Polarity
2 GHz to 3 GHz



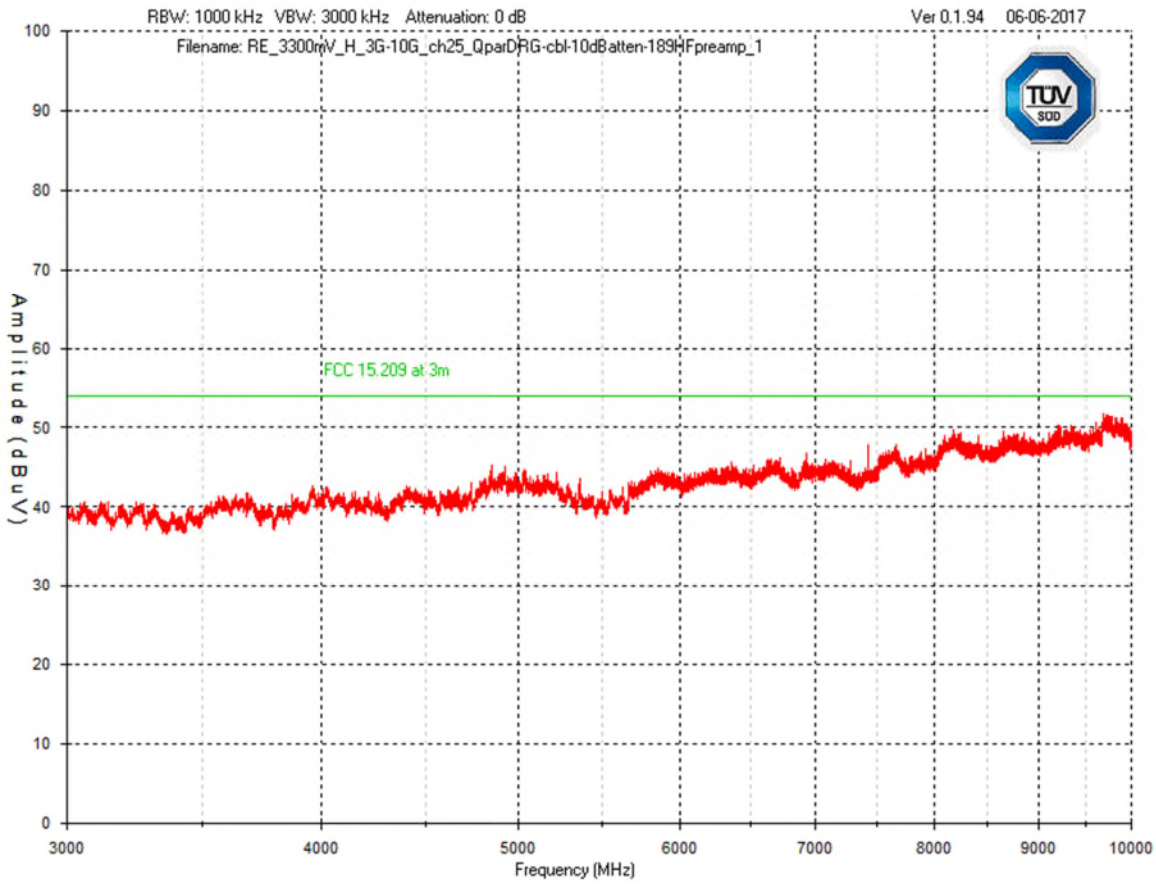
Peak Emissions Graph
Horizontal Antenna Polarity
2 GHz to 3 GHz



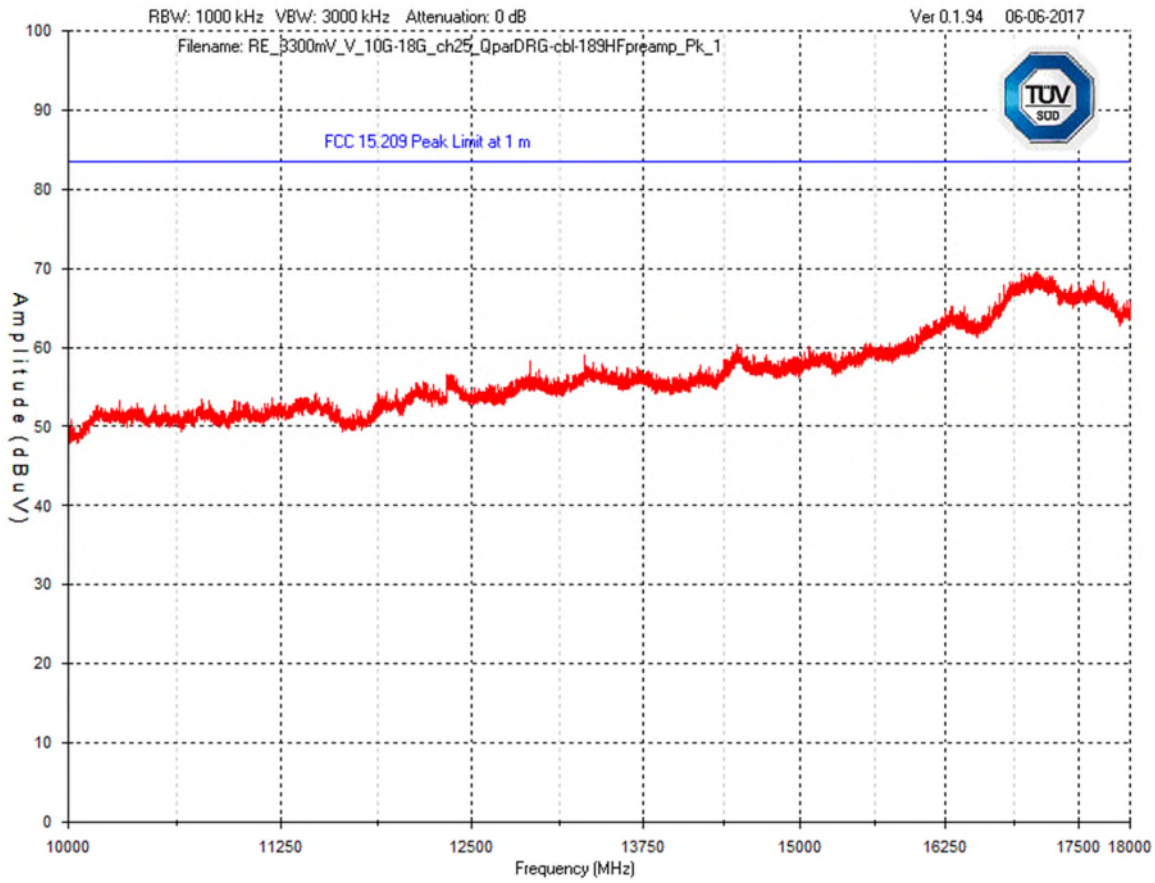
Peak Emissions Graph
Vertical Antenna Polarity
3 GHz to 10 GHz



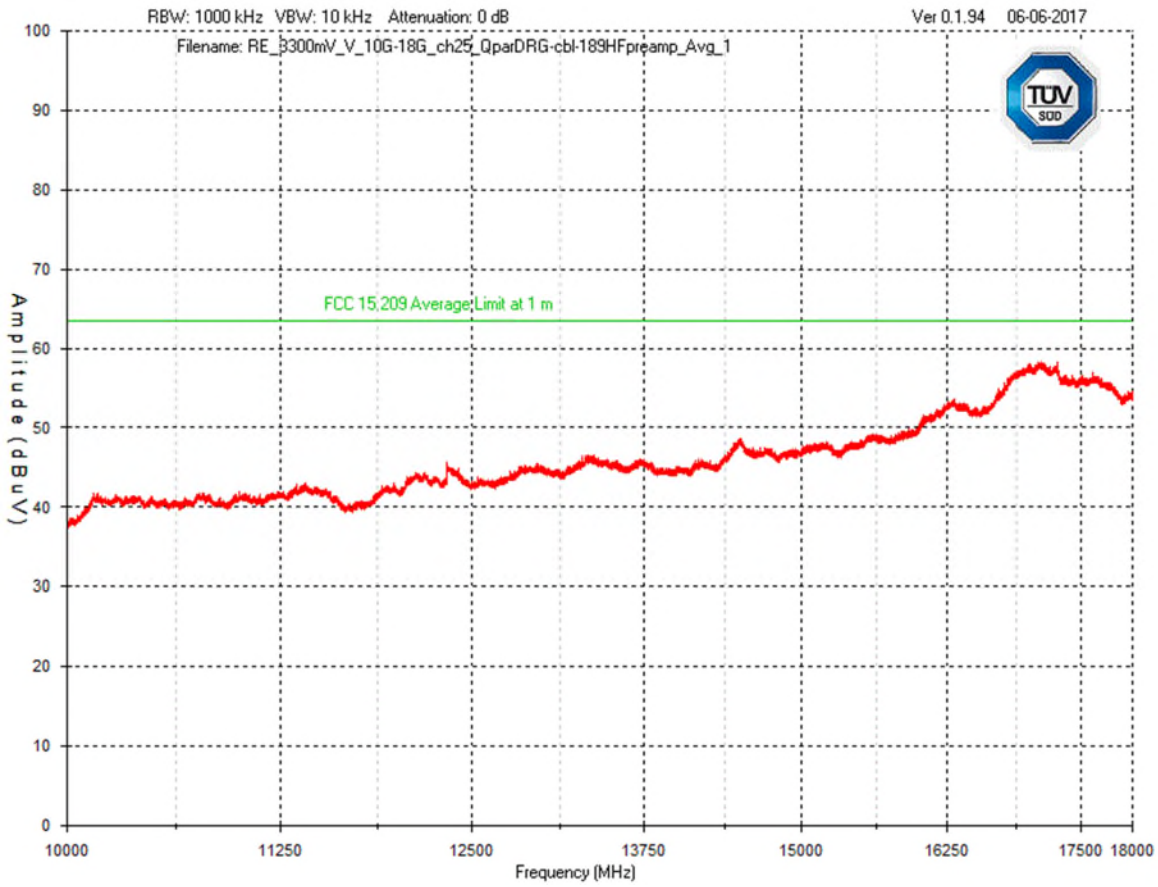
Peak Emissions Graph
Horizontal Antenna Polarity
3 GHz to 10 GHz



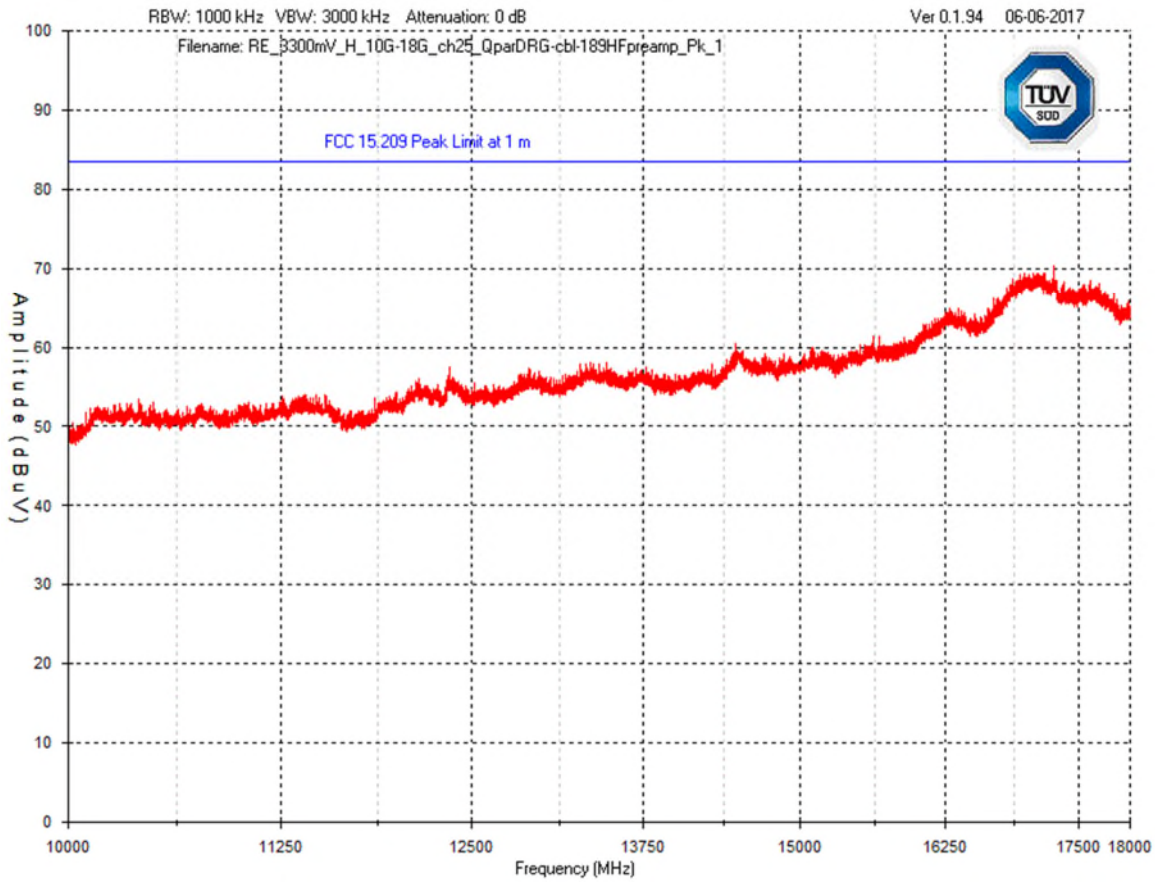
Peak Emissions Graph
Vertical Antenna Polarity
10 GHz to 18 GHz



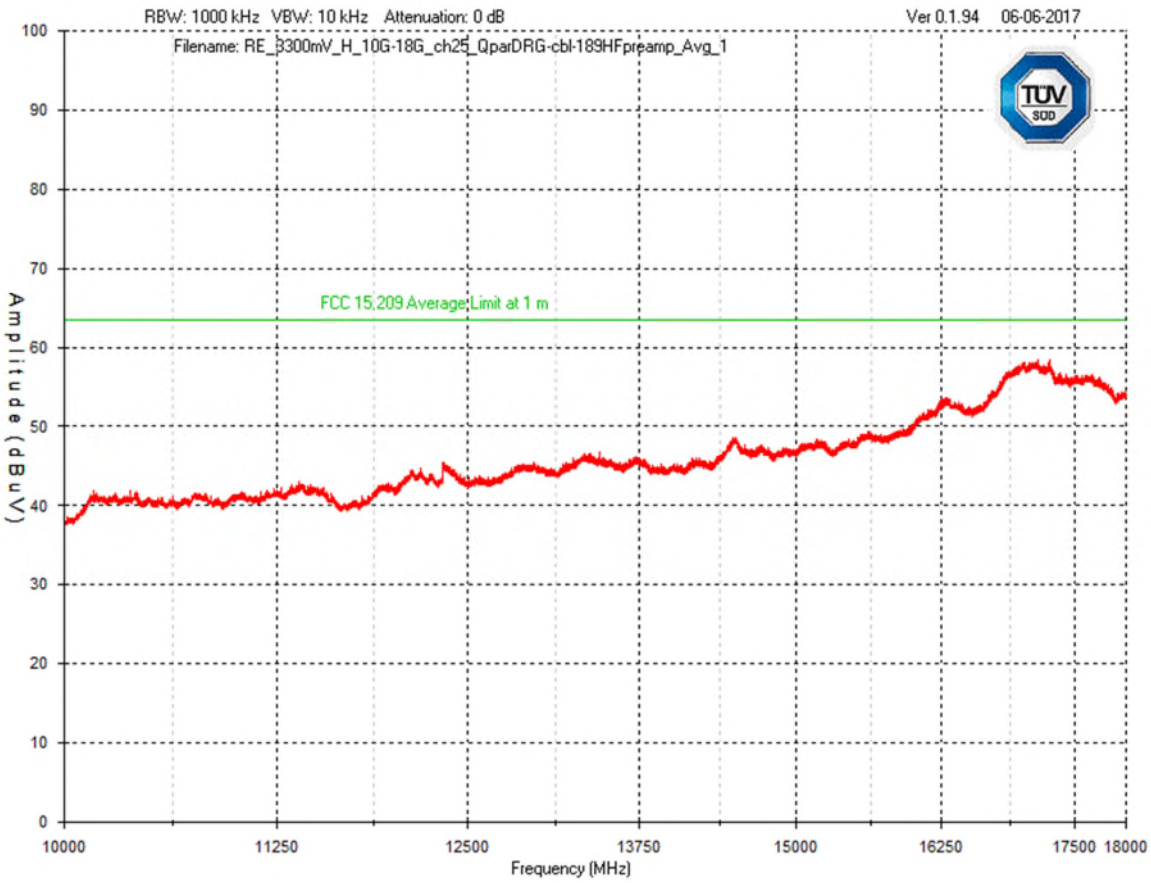
Average Emissions Graph
Vertical Antenna Polarity
10 GHz to 18 GHz



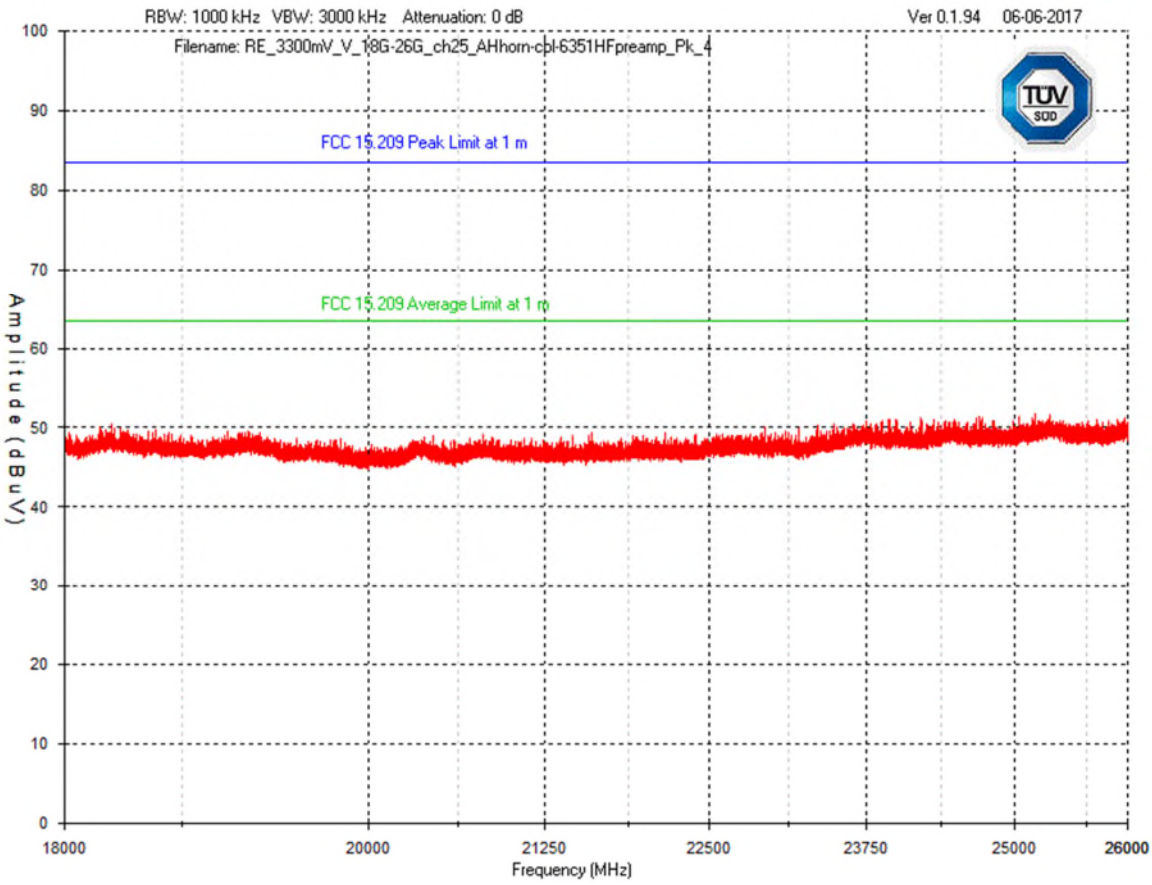
Peak Emissions Graph
Horizontal Antenna Polarity
10 GHz to 18 GHz



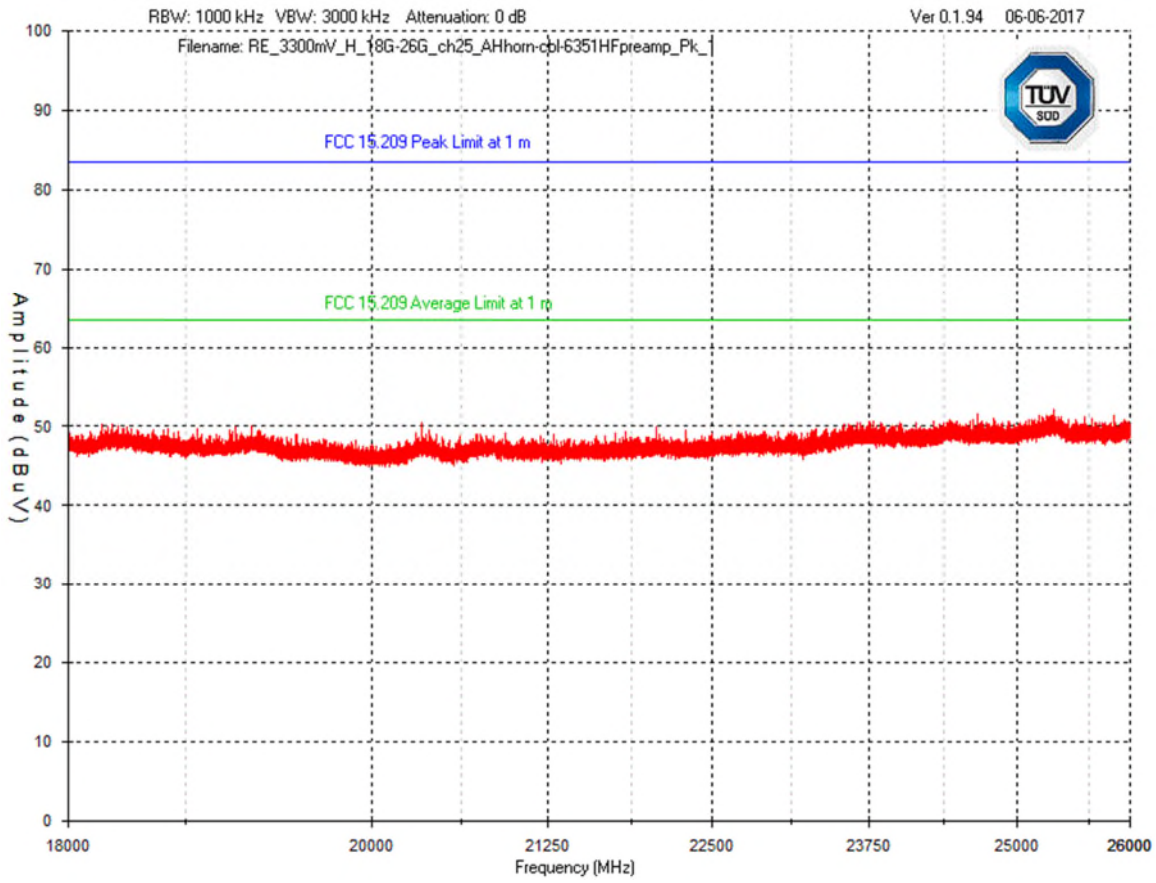
Average Emissions Graph
Horizontal Antenna Polarity
10 GHz to 18 GHz



Peak Emissions Graph
Vertical Antenna Polarity
18 GHz to 26 GHz

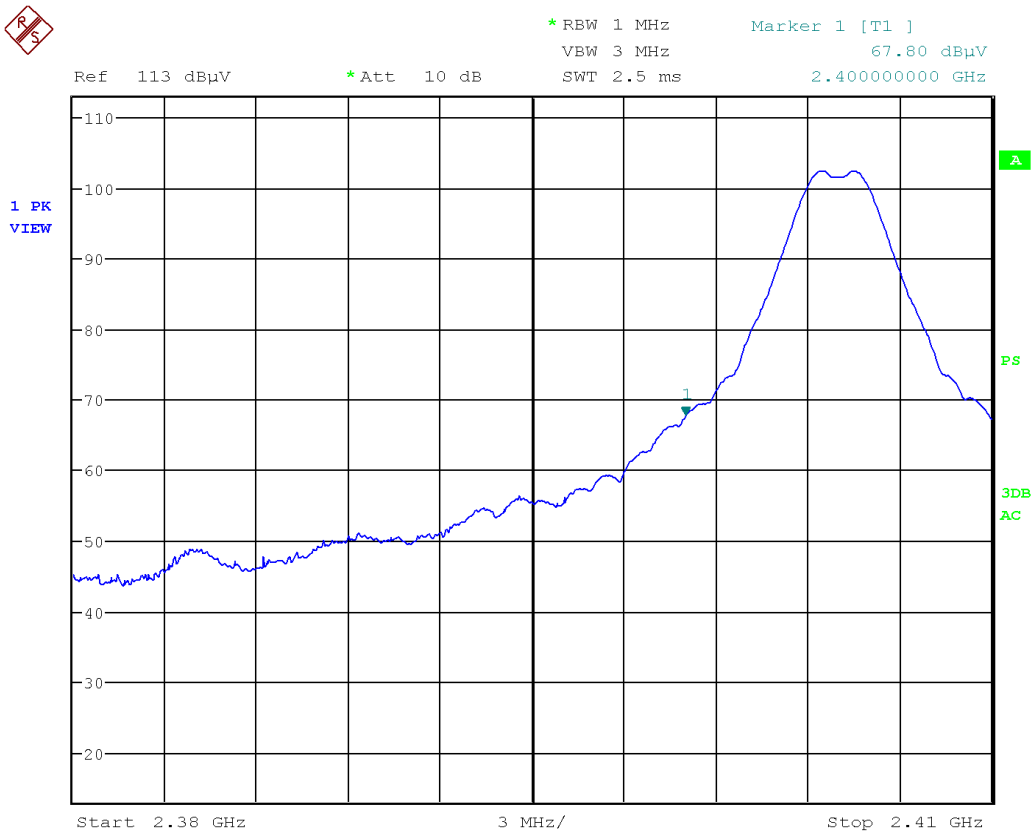


Peak Emissions Graph
Horizontal Antenna Polarity
18 GHz to 26 GHz



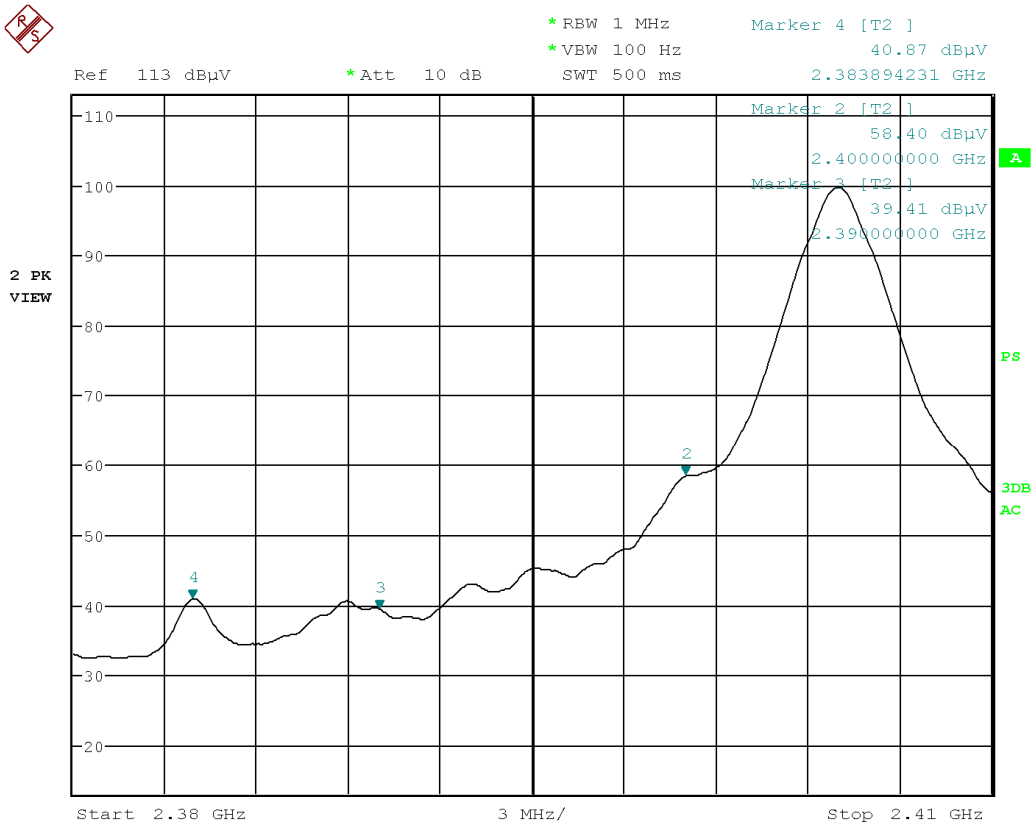
Restricted Band Edges Emissions Graph (Peak)
At 2.400 GHz, Vertical Antenna Polarity
Low Channel (Ch. 11), Power set to 31 (max)

Notes:
Emission at 2.39 GHz is < that at 2.4 GHz.
Factors not incorporated. See table in *Final Measurements* for final factored values.



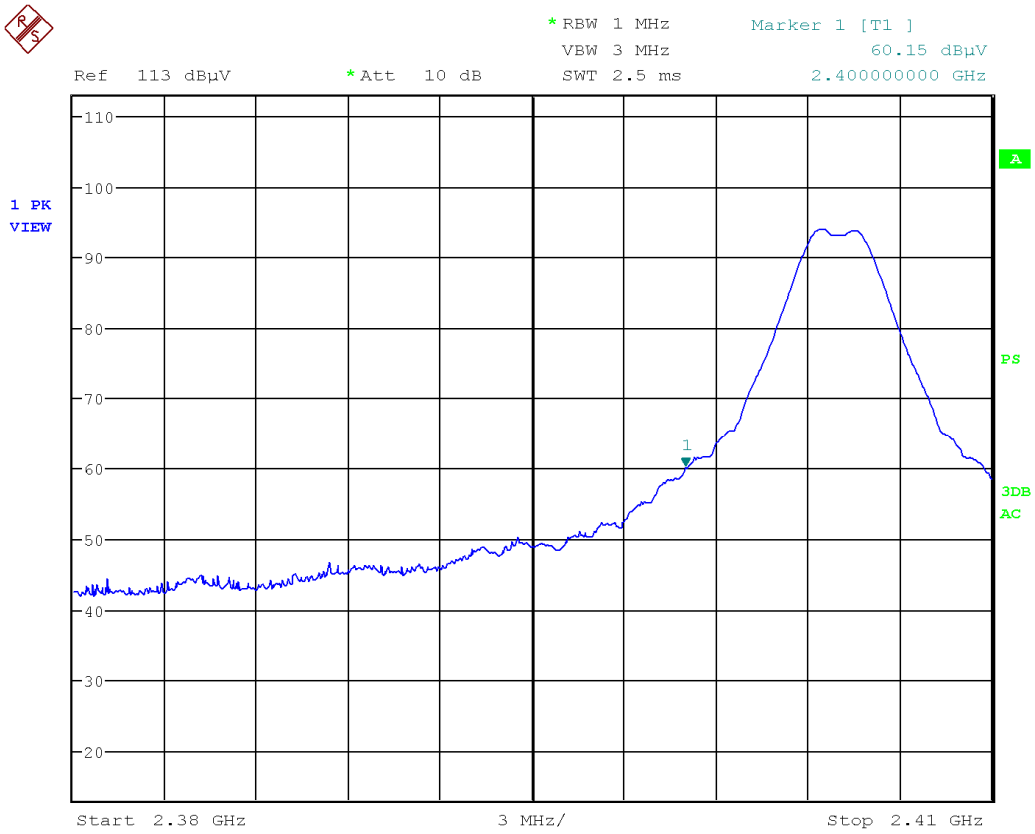
Restricted Band Edges Emissions Graph (Average)
At 2.390 GHz, Vertical Antenna Polarity
Low Channel (Ch. 11), Power set to 31 (max)

Notes:
Factors not incorporated. See table in *Final Measurements* for final factored values.



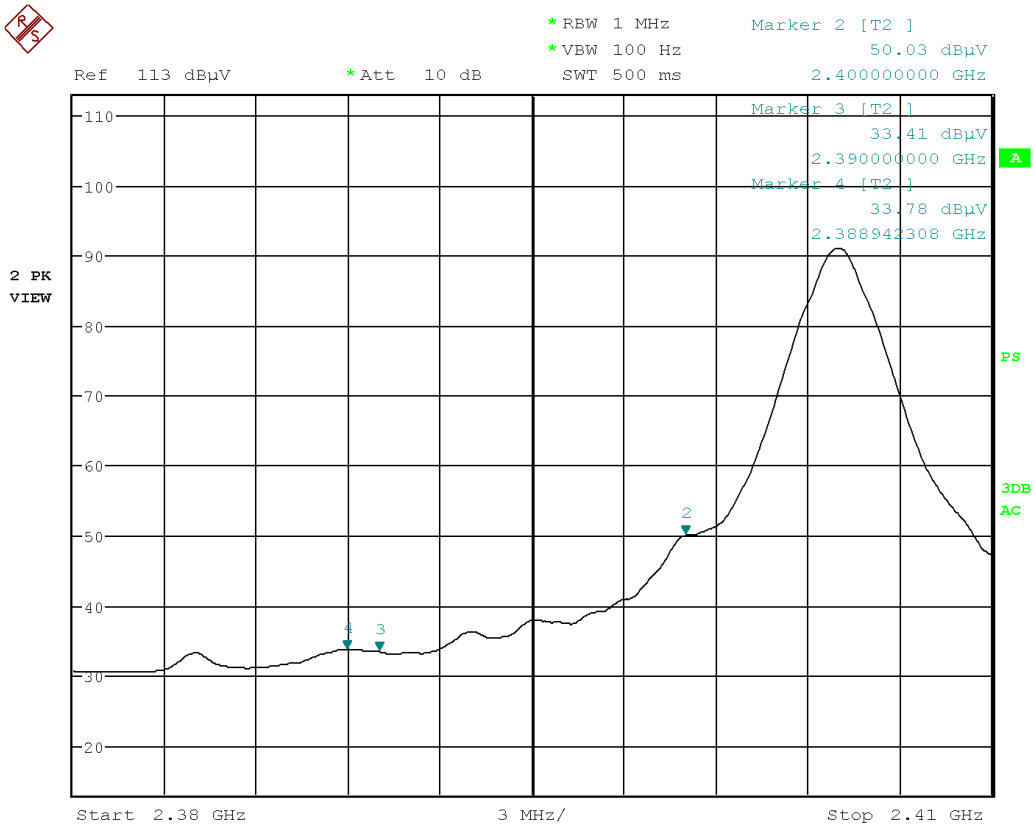
Restricted Band Edges Emissions Graph (Peak)
At 2.400 GHz, Horizontal Antenna Polarity
Low Channel (Ch. 11), Power set to 31 (max)

Notes:
Emission at 2.39 GHz is < that at 2.4 GHz.
Factors not incorporated. See table in *Final Measurements* for final factored values



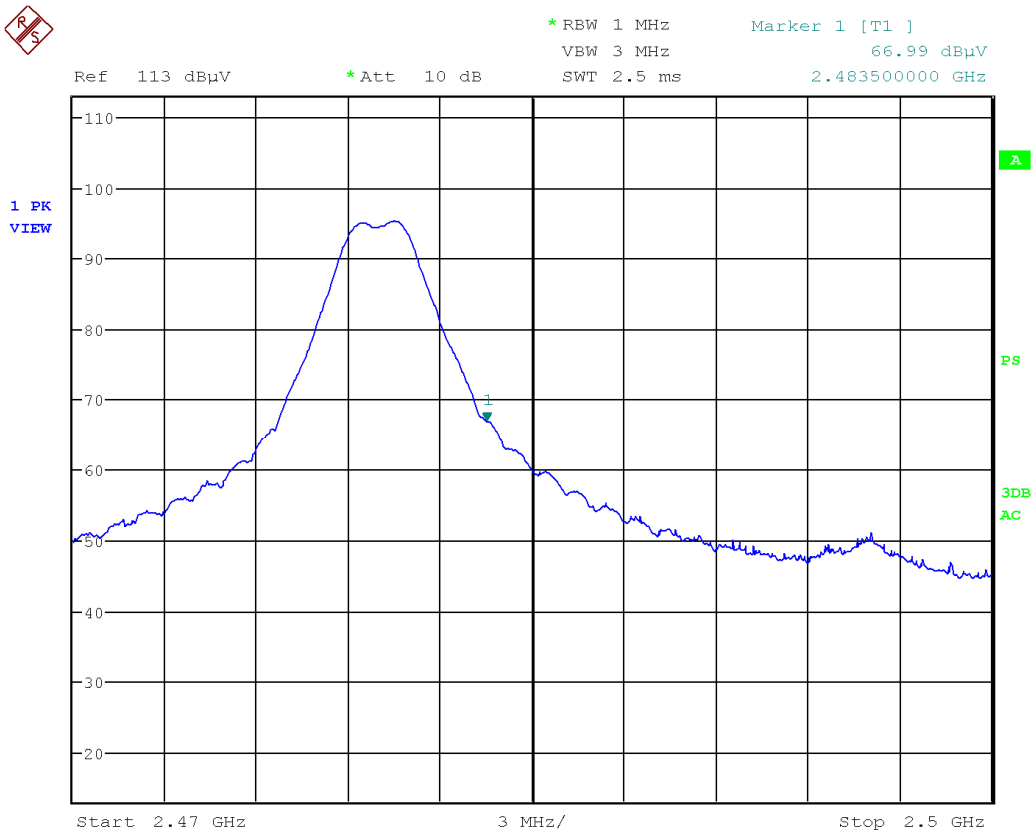
Restricted Band Edges Emissions Graph (Average)
At 2.390 GHz, Horizontal Antenna Polarity
Low Channel (Ch. 11), Power set to 31 (max)

Notes:
Factors not incorporated. See table in *Final Measurements* for final factored values.



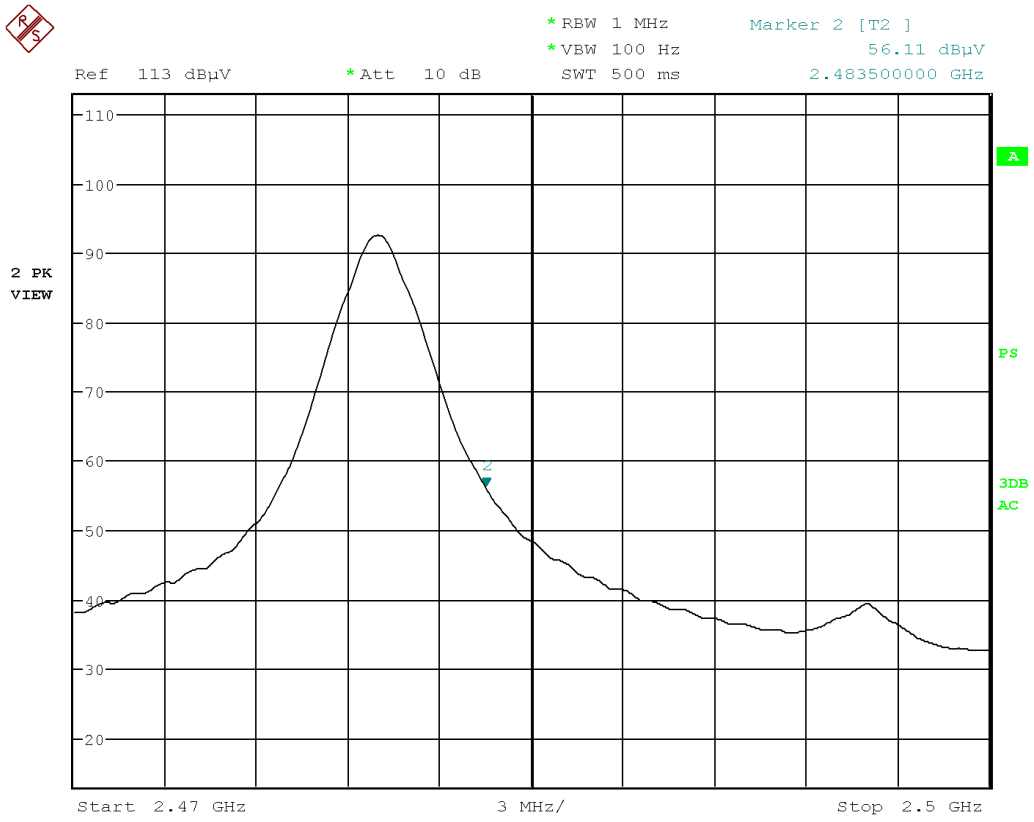
Restricted Band Edges Emissions Graph (Peak)
At 2.4835 GHz, Vertical Antenna Polarity
High Channel (Ch. 26), Power set to 23

Notes:
Factors not incorporated. See table in *Final Measurements* for final factored values.



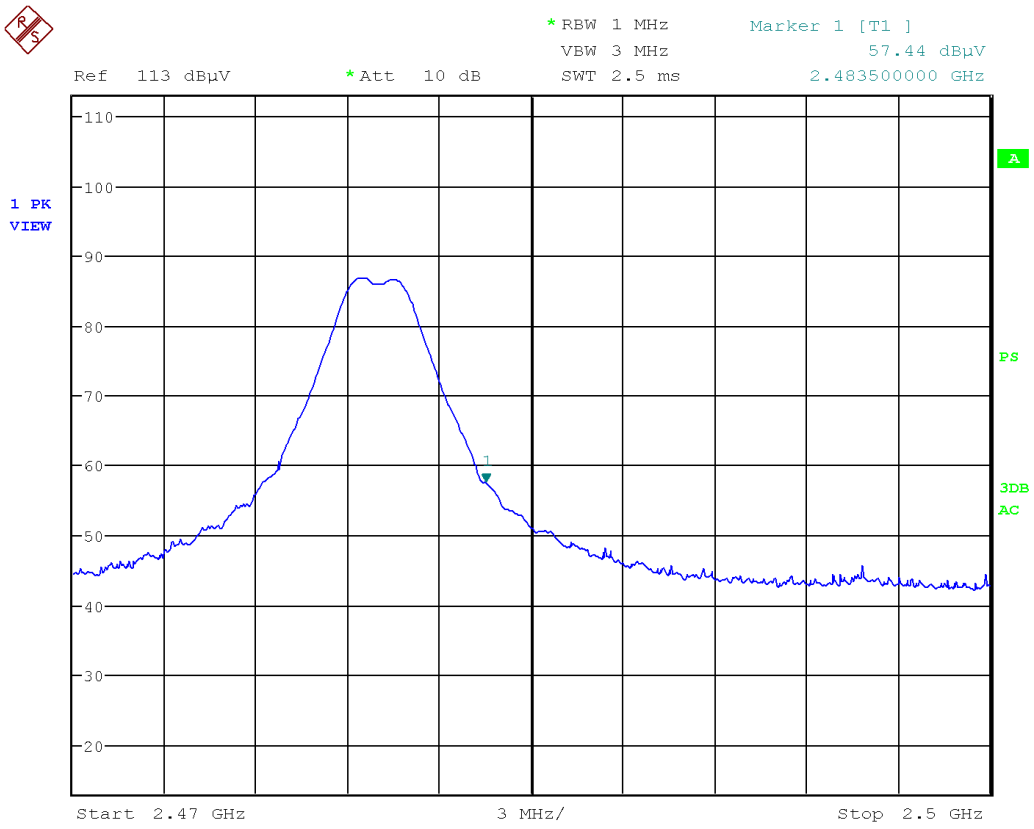
Restricted Band Edges Emissions Graph (Average)
At 2.4835 GHz, Vertical Antenna Polarity
High Channel (Ch. 26), Power set to 23

Notes:
Factors not incorporated. See table in *Final Measurements* for final factored values.



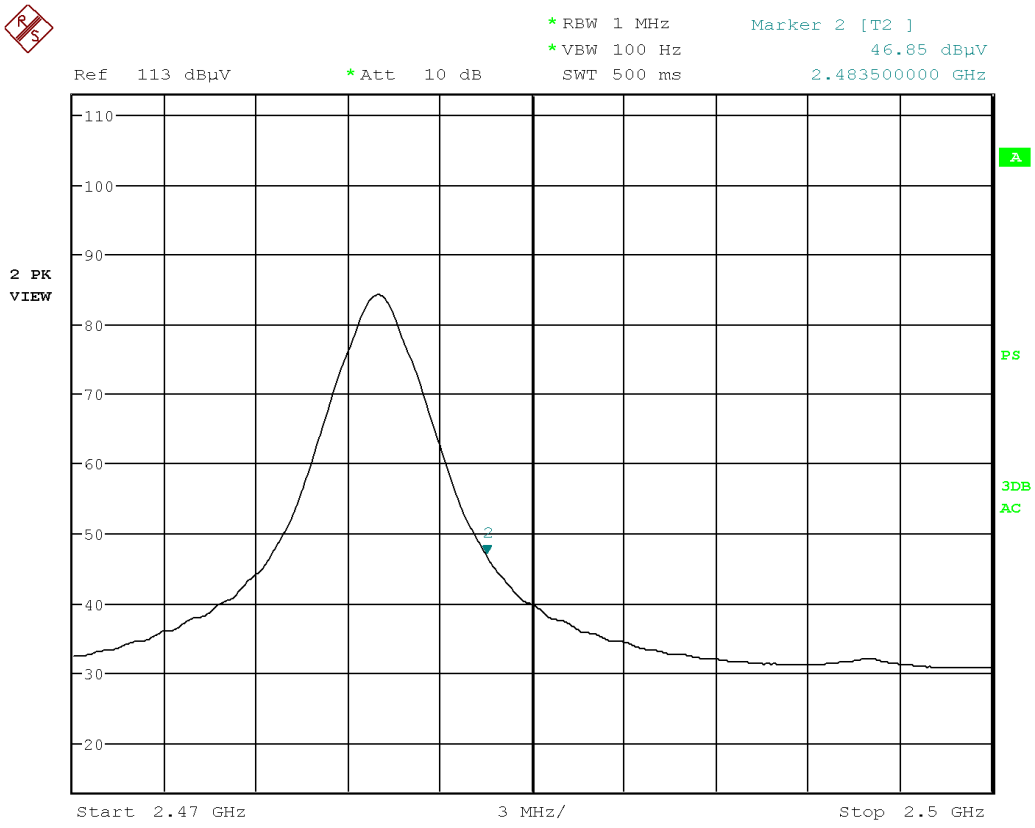
Restricted Band Edges Emissions Graph (Peak)
At 2.4835 GHz, Horizontal Antenna Polarity
High Channel (Ch. 26), Power set to 23

Notes:
Factors not incorporated. See table in *Final Measurements* for final factored values.



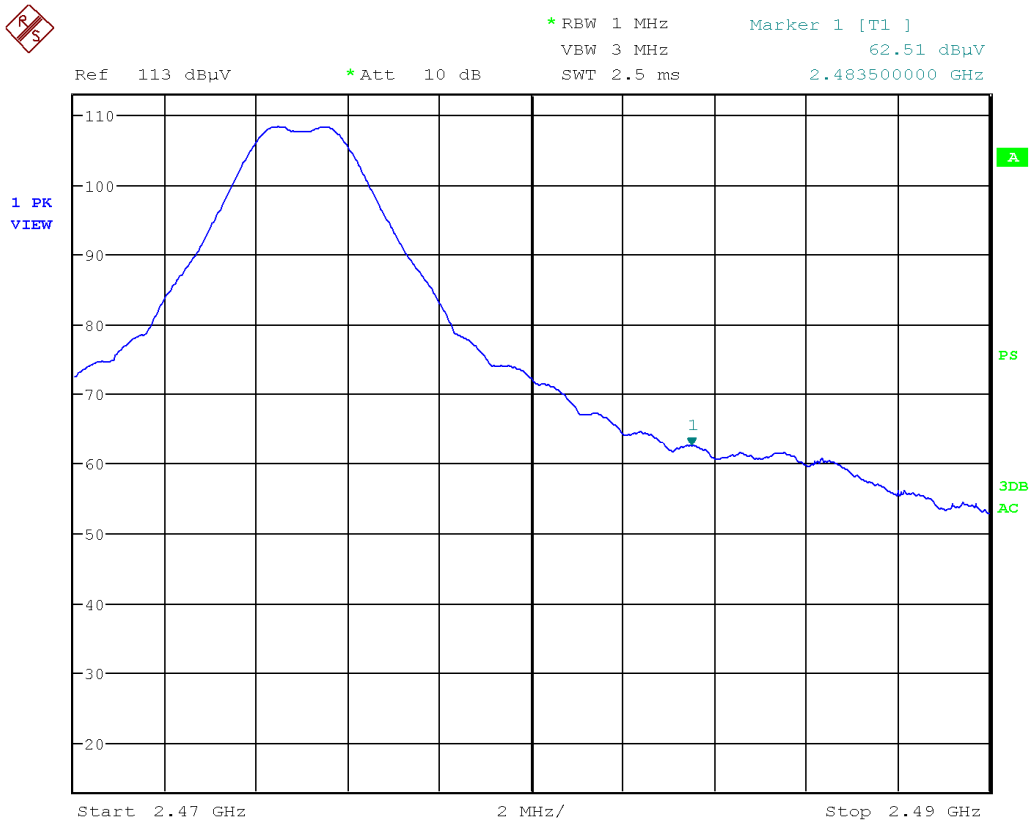
Restricted Band Edges Emissions Graph (Average)
At 2.4835 GHz, Horizontal Antenna Polarity
High Channel (Ch. 26), Power set to 23

Notes:
Factors not incorporated. See table in *Final Measurements* for final factored values.



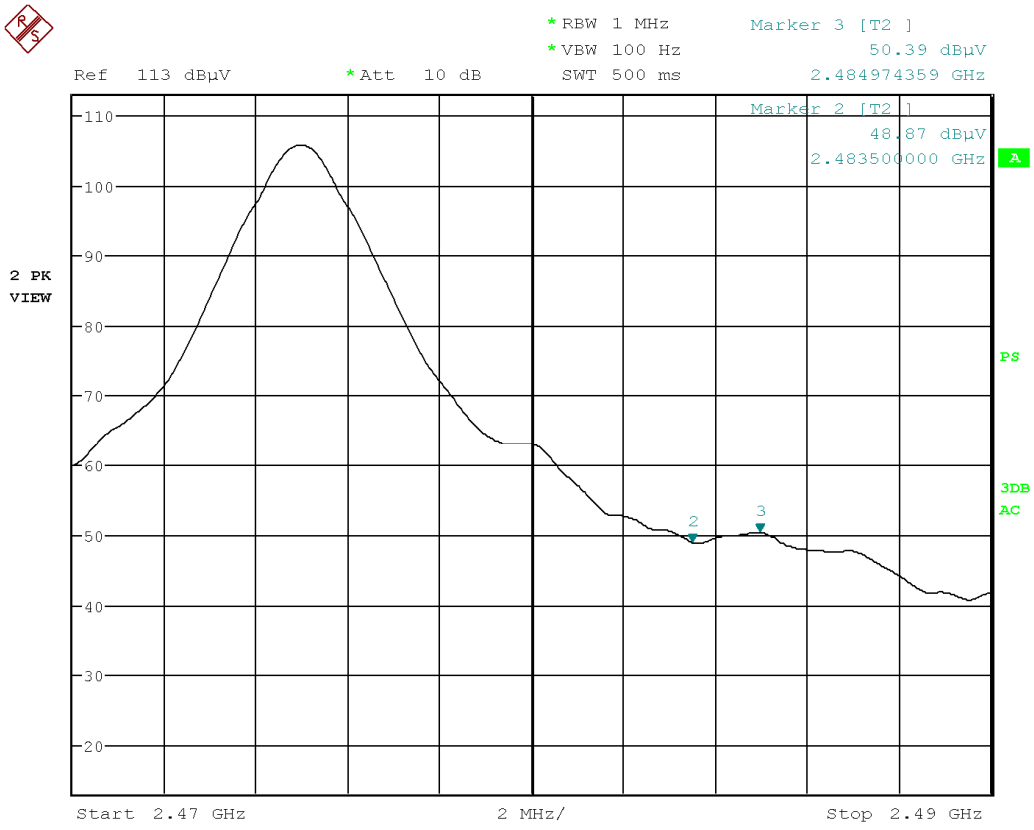
Restricted Band Edges Emissions Graph (Peak)
At 2.4835 GHz, Vertical Antenna Polarity
2nd Highest Channel (Ch. 25), Power set to 31 (max)

Notes:
Factors not incorporated. See table in *Final Measurements* for final factored values.



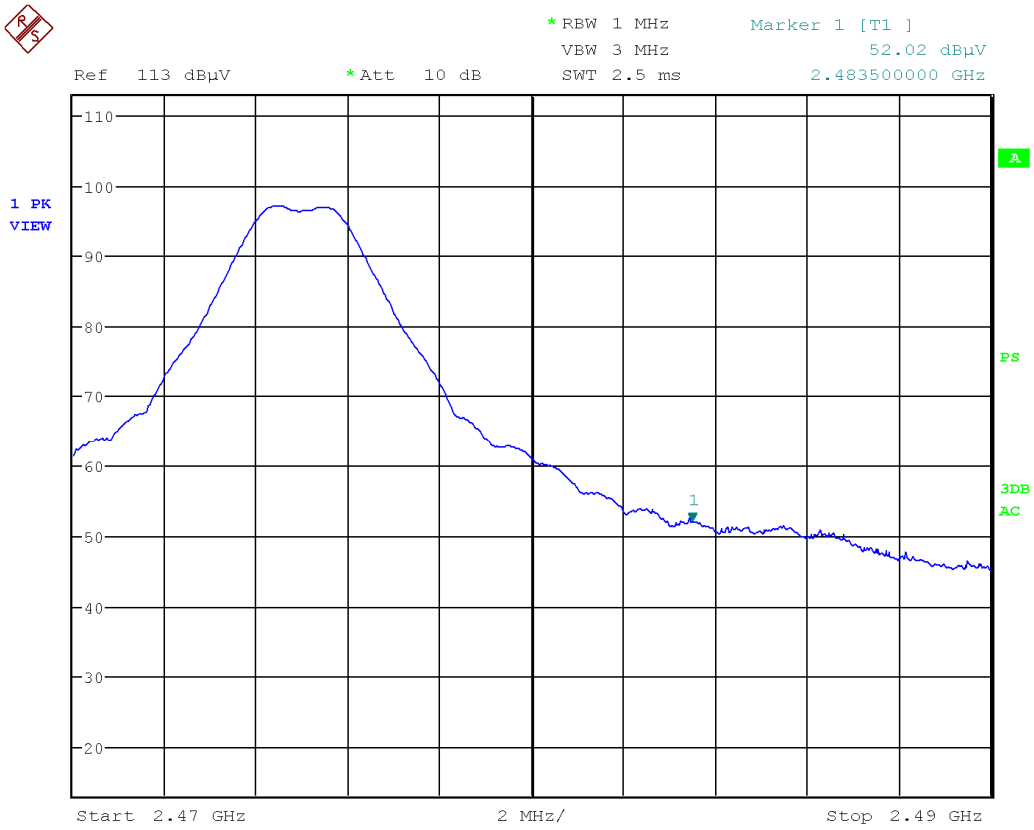
Restricted Band Edges Emissions Graph (Average)
At 2.4835 GHz, Vertical Antenna Polarity
2nd Highest Channel (Ch. 25), Power set to 31 (max)

Notes:
Factors not incorporated. See table in *Final Measurements* for final factored values.



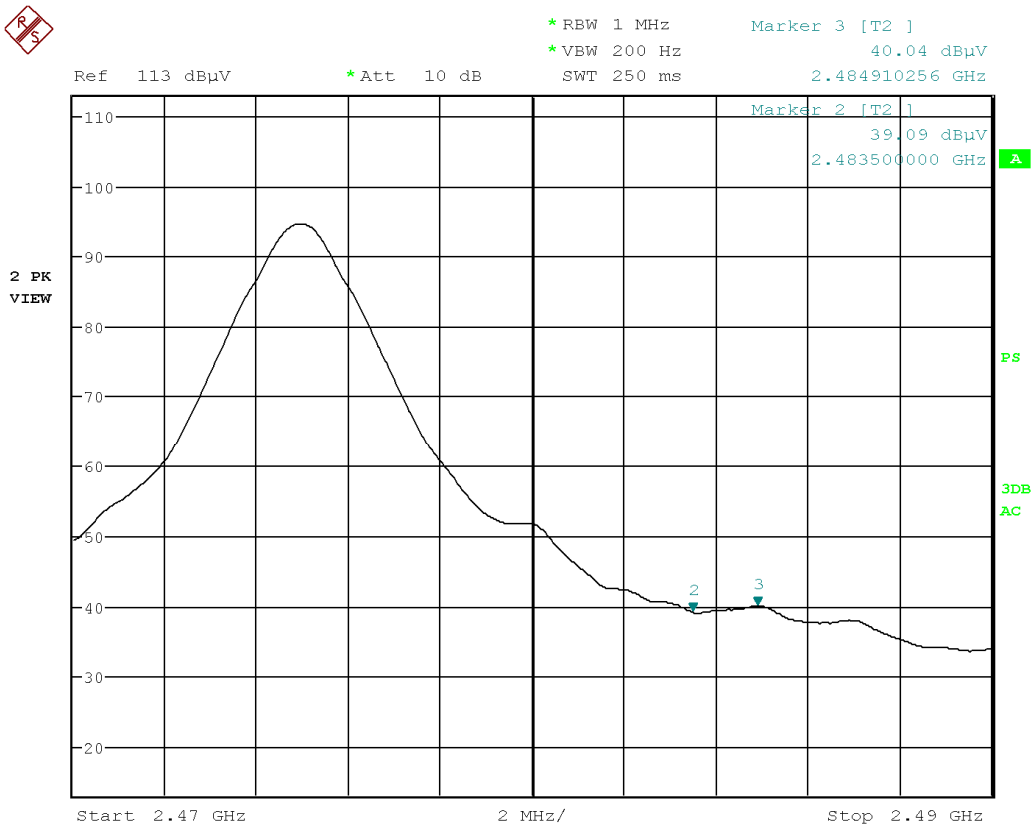
Restricted Band Edges Emissions Graph (Peak)
At 2.4835 GHz, Horizontal Antenna Polarity
2nd Highest Channel (Ch. 25), Power set to 31 (max)

Notes:
Factors not incorporated. See table in *Final Measurements* for final factored values.



Restricted Band Edges Emissions Graph (Average)
At 2.4835 GHz, Horizontal Antenna Polarity
2nd Highest Channel (Ch. 25), Power set to 31 (max)

Notes:
Factors not incorporated. See table in *Final Measurements* for final factored values.



Final Measurements

Table 4: Spurious Radiated Emissions

Test Frequency (MHz)	Detection mode	Measured signal (dBµV)	Antenna factor (dB)	Attenuator (dB)	Cable loss + Pre-selector (dB)	Pre-Amp Gain (dB)	Received signal (dBµV/m)	Emission limit (dBµV/m)	Emission margin (dB)	Result
Vertical Antenna Polarity										
917.1	Peak	39.2	23.4	6	2.3	-33.2	37.7	46.4	8.7	Pass
884.5	Peak	38.8	23.5	6	2.2	-33.3	37.2	46.4	9.2	Pass
783.7	Peak	38.8	22.4	6	2.2	-33.4	36	46.4	10.4	Pass
30.4	Peak	36.4	17.7	6	0.3	-30.9	29.5	40	10.5	Pass
670.9	Peak	39.5	21.1	6	1.7	-33.4	34.9	46.4	11.5	Pass
125.1	Peak	46.4	6.9	6	0.6	-33.3	26.6	43.5	16.9	Pass
Horizontal Antenna Polarity										
928.3	Peak	39.1	23.4	6	2.3	-33.2	37.6	46.4	8.8	Pass
897.1	Peak	38.6	23.7	6	2.2	-33.2	37.3	46.4	9.1	Pass
774.1	Peak	39.4	22.5	6	2.1	-33.4	36.6	46.4	9.8	Pass
801.4	Peak	39.4	21.9	6	2.2	-33.3	36.2	46.4	10.2	Pass
30.4	Peak	36	17.7	6	0.3	-30.9	29.1	40	10.9	Pass
594.6	Peak	39.4	20	6	1.9	-33.4	33.9	46.4	12.5	Pass

Table 5: Restricted Band Edges Emissions

Test Frequency (MHz)	Antenna polarity	Detection mode	Measured signal (dBµV)	Antenna factor (dB)	Cable loss + Pre-selector (dB)	Pre-Amp Gain (dB)	Received signal (dBµV/m)	Average Emission limit (dBµV/m)	Peak Emission limit (dBµV/m)	Average margin (dB)	Peak margin (dB)	EUT Channel Setting	EUT Output Setting	Result
2400.0 α	Vertical	Peak	67.8	26.4	3.6	-33.5	64.3	---	74	---	9.7	11	31 (max)	Pass
2390.0	Vertical	Avg.	39.41	26.4	3.6	-33.3	36.11	54	---	17.89	---	11	31 (max)	Pass
2383.9	Vertical	Avg.	40.87	26.4	3.6	-33.5	37.37	54	---	16.63	---	11	31 (max)	Pass
2400.0	Horizontal	Peak	60.15	26.4	3.6	-33.5	56.65	---	74	---	17.35	11	31 (max)	Pass
2390	Horizontal	Avg.	33.41	26.4	3.6	-33.5	29.91	54	---	24.09	---	11	31 (max)	Pass
2388.9	Horizontal	Avg.	33.78	26.4	3.6	-33.5	30.28	54	---	23.72	---	11	31 (max)	Pass
2483.5	Vertical	Peak	66.99	26.2	3.6	-33.3	63.49	---	74	---	10.51	26	23	Pass
2483.5	Vertical	Avg.	56.11	26.2	3.6	-33.3	52.61	54	---	1.39	---	26	23	Pass
2483.5	Horizontal	Peak	57.44	26.2	3.6	-33.3	53.94	---	74	---	20.06	26	23	Pass
2483.5	Horizontal	Avg.	46.85	26.2	3.6	-33.3	43.35	54	---	10.65	---	26	23	Pass
2483.5	Vertical	Peak	62.51	26.2	3.6	-33.3	59.01	---	74	---	14.99	25	31 (max)	Pass
2483.5	Vertical	Avg.	48.87	26.2	3.6	-33.3	45.37	54	---	8.63	---	25	31 (max)	Pass
2485.0	Vertical	Avg.	50.39	26.2	3.6	-33.3	46.89	54	---	7.11	---	25	31 (max)	Pass
2483.5	Horizontal	Peak	52.02	26.2	3.6	-33.3	48.52	---	74	---	25.48	25	31 (max)	Pass

2483.5	Horizontal	Avg.	39.09	26.2	3.6	-33.3	35.59	54	---	18.41	---	25	31 (max)	Pass
2484.9	Horizontal	Avg.	40.04	26.2	3.6	-33.3	36.54	54	---	17.46	---	25	31 (max)	Pass

Notes:

[α] Emission already passes at 2.4 GHz, and emission at 2.39 GHz is < that at 2.4 GHz.

All harmonics are under the limits defined in FCC 15.209.

Peak = Peak measurement
QP = Quasi-Peak measurement
Avg. = Average measurement

Where peak values are under the quasi-peak and/or average limit, the emission passes the corresponding limit, and no measurement with the respective detector is required.

Test Equipment List

Equipment	Model No.	Manufacturer	Last calibration date	Next calibration due date	Asset #
Spectrum Analyzer	ESU 40	Rohde & Schwarz	Jan. 12, 2018	Jan. 12, 2020	GEMC 233
Loop Antenna 9 – 150 kHz	EM 6871	Electro-Metrics	Feb. 13, 2017	Feb. 13, 2019	GEMC 70
Loop Antenna 150 kHz – 30 MHz	EM 6872	Electro-Metrics	Feb. 13, 2017	Feb. 13, 2019	GEMC 71
BiLog Antenna 30 MHz – 2 GHz	3142-C	ETS	Feb. 22, 2017	Feb. 22, 2019	GEMC 137
Horn Antenna 2 – 18 GHz	WBH218HN	Q-par	Feb. 27, 2018	Feb. 27, 2020	GEMC 6375
Horn Antenna 18 GHz – 26 GHz	SAS-572	A.H. Systems	Oct. 11, 2016	Oct. 11, 2018	GEMC 6371
Pre-Amp 9 – 150 kHz	CPA9231A	Chase	Oct 12, 2016	Oct 12, 2018	GEMC 6403
Pre-Amp 150 kHz – 1 GHz	LNA-10-20	RF Bay Inc.	Feb. 2, 2017	Feb. 2, 2019	GEMC 244
Pre-Amp 1 – 26 GHz	HP 8449B	HP	Nov. 15, 2017	Nov. 15, 2019	GEMC 189
RF Cable 3m	LMR-400-3M-50Ω-MN-MN	LexTec	NCR	NCR	GEMC 273
RF Cable 10m	LMR-400-10M-50Ω-MN-MN	LexTec	NCR	NCR	GEMC 27
Emissions Software	0.1.94	TUV SUD Canada, Inc	NCR	NCR	GEMC 58

Appendix A – EUT Summary

Client	Mircom	
Product	MD-1150 Zigbee module	
Standard(s)	RSS 247 Issue 2 / FCC Part 15 Subpart C 15.247	

For further details for filing purposes, refer to filing package.

General EUT Description

Client / Manufacturer Details	
Organization / Address	Mircom group 25 Interchange Way Vaughan, Ontario Canada, L4K 5W3
Contact	Michael Sugerman
Phone	905.660.4655 ext. 7250
Email	msugarman@mircomgroup.com
EUT (Equipment Under Test) Details	
EUT Name	Zigbee module
EUT Model	MD-1150
FCC ID	2ABFD-MD1150
Industry Canada #	1156A-MD1150
EUT is powered using	5 VDC
Input voltage range(s) (V)	4.5-5.4 VDC
Rated input current (A)	30mA
Nominal power consumption (W)	0.15W
Basic EUT functionality description	Wireless communication module to be used in Mircom ZC or WIO line of products.
Available connectors on EUT	PCI Express
Peripherals required to exercise EUT	Programming interface board PC
Dimensions of product (approx.)	L: 32 mm, W: 31 mm, H: 5 mm

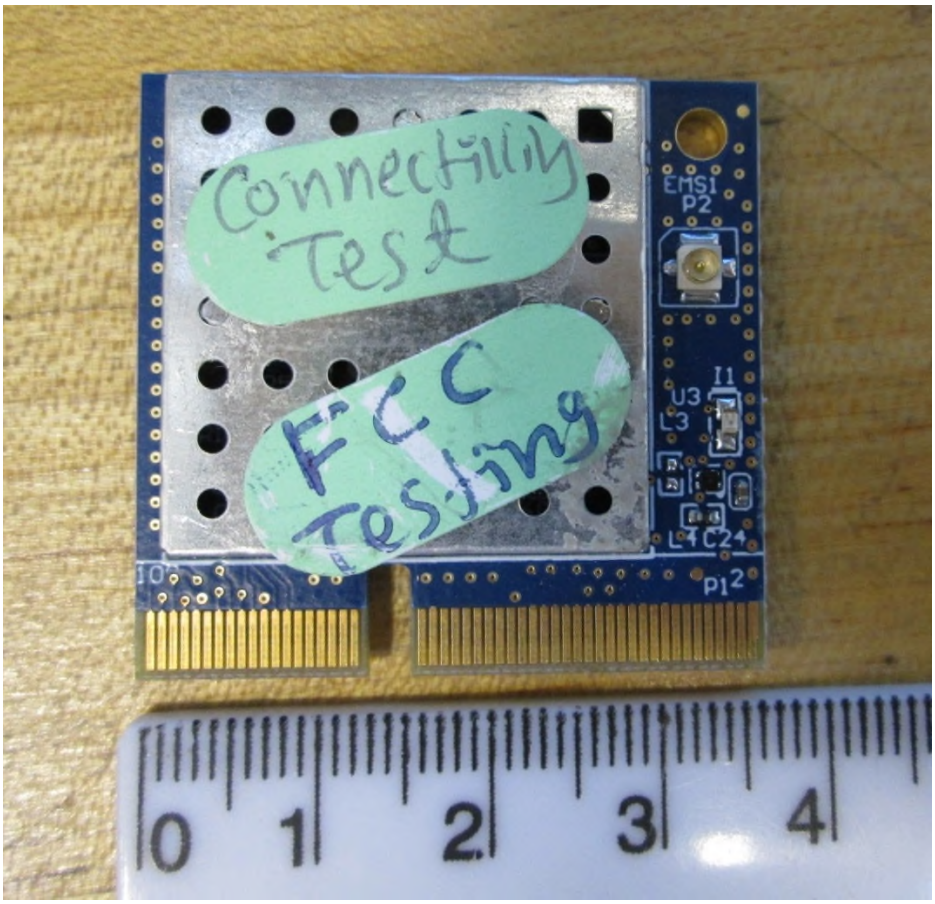
Note the EUT is considered to have been received the date of the commencement of the first test, unless otherwise stated.

Appendix B – EUT and Test Setup Photographs

Note: These photos are for information purposes only.
Also refer to submitted files that are separate from this test report.

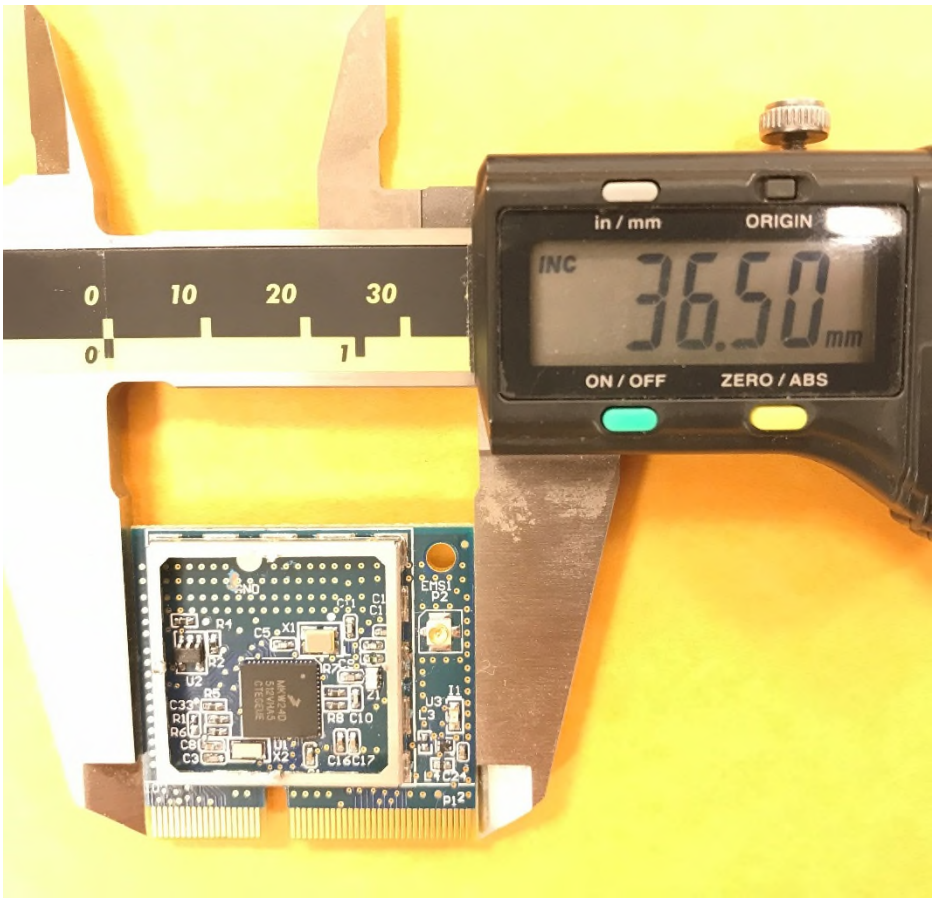
EUT – External view 1

EUT – External view 2

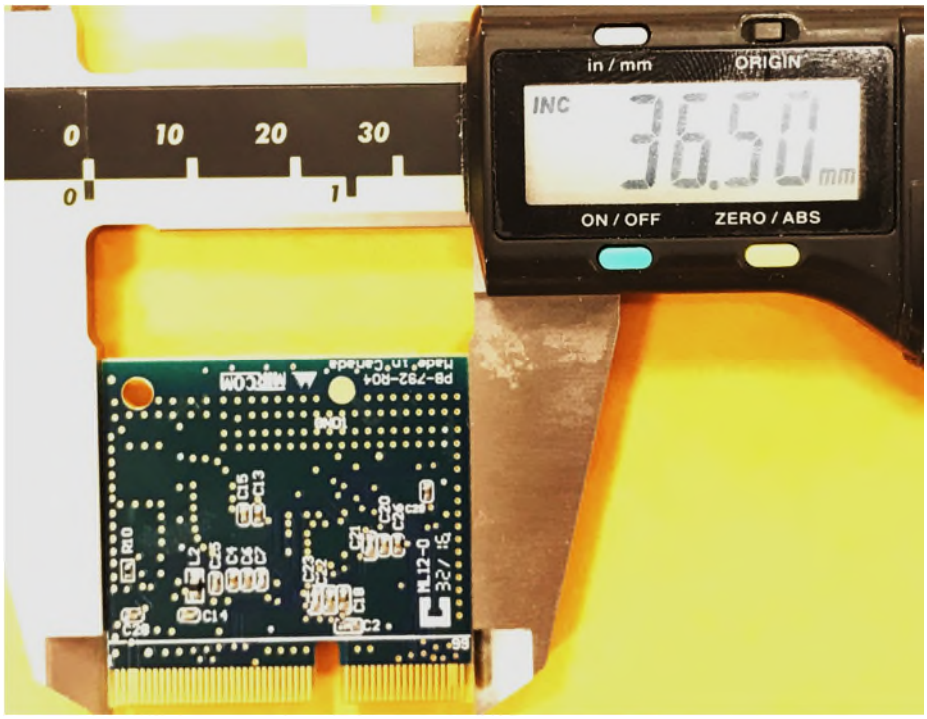


EUT – External, Close-up, view 1

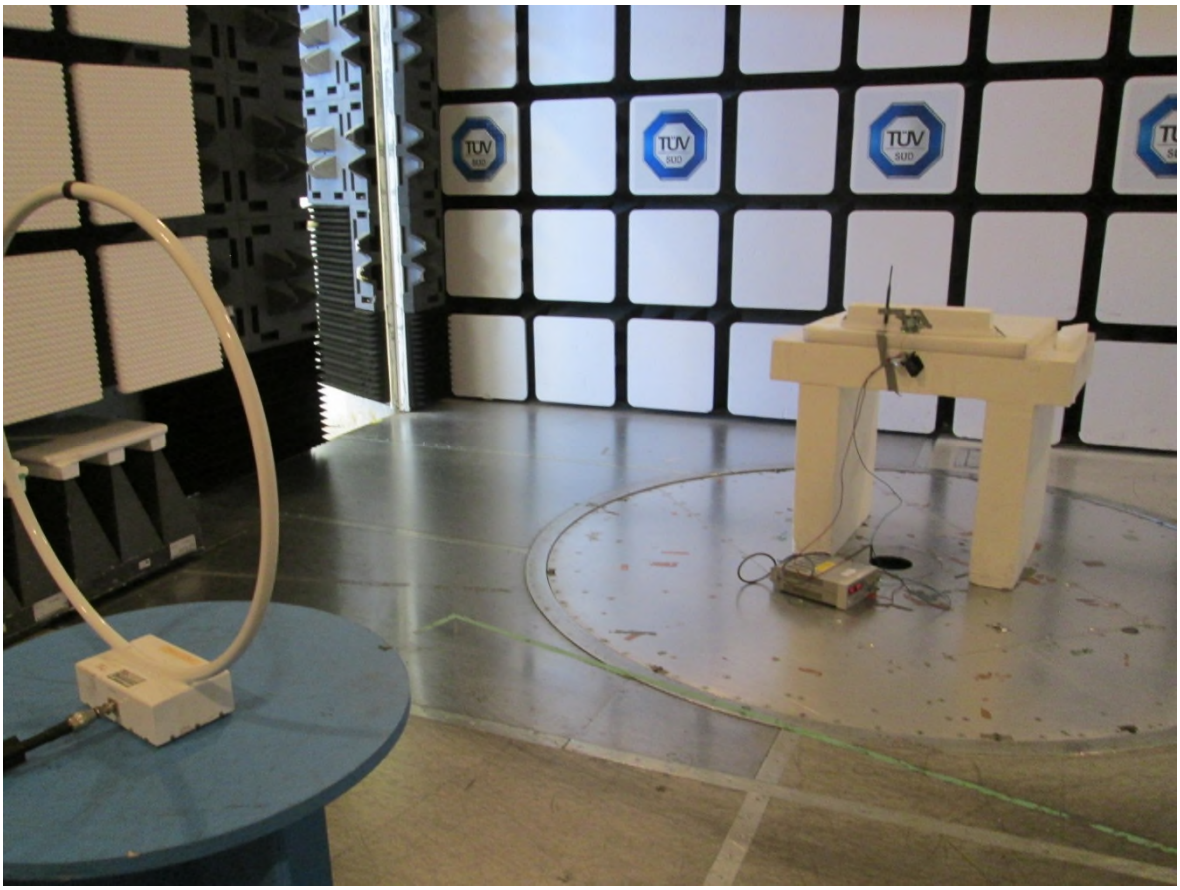
EUT – External, Close-up, view 2



EUT – Internal view 1

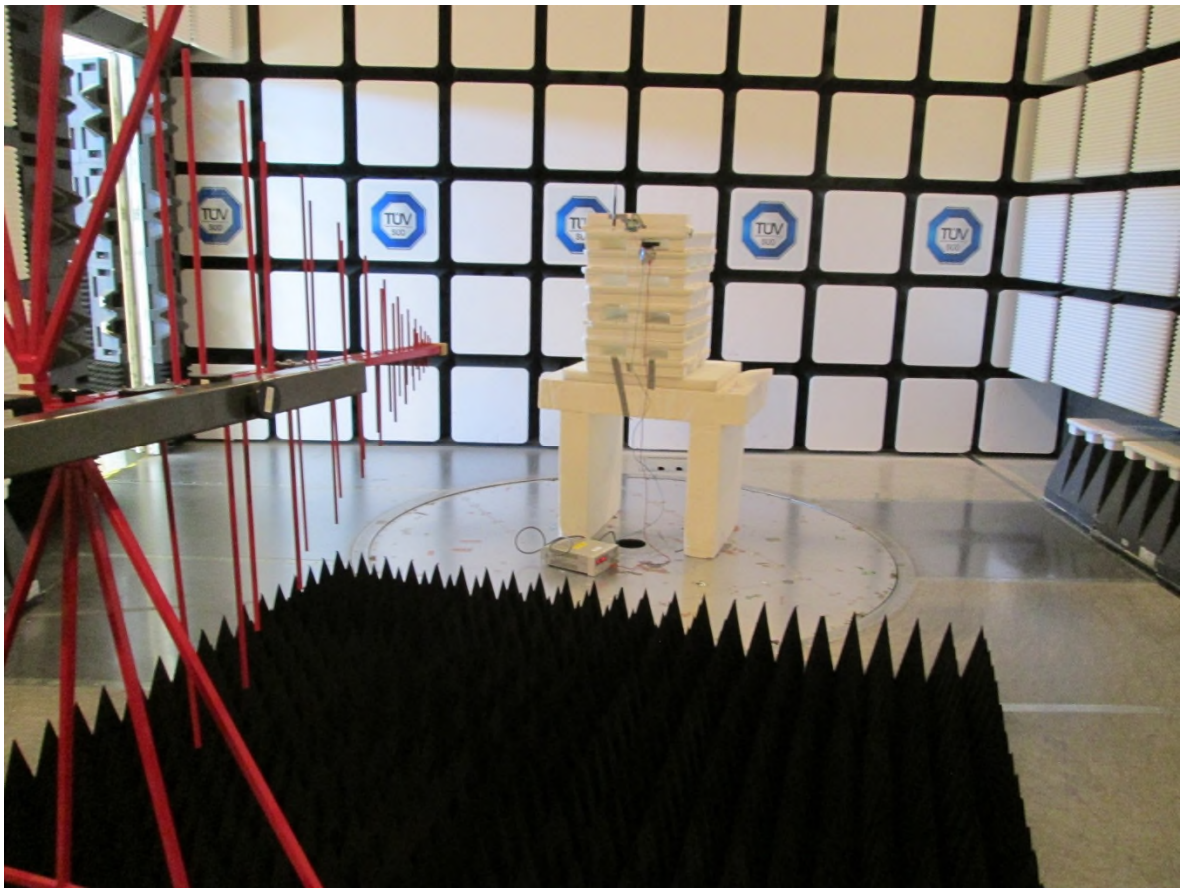


EUT – Internal view 2

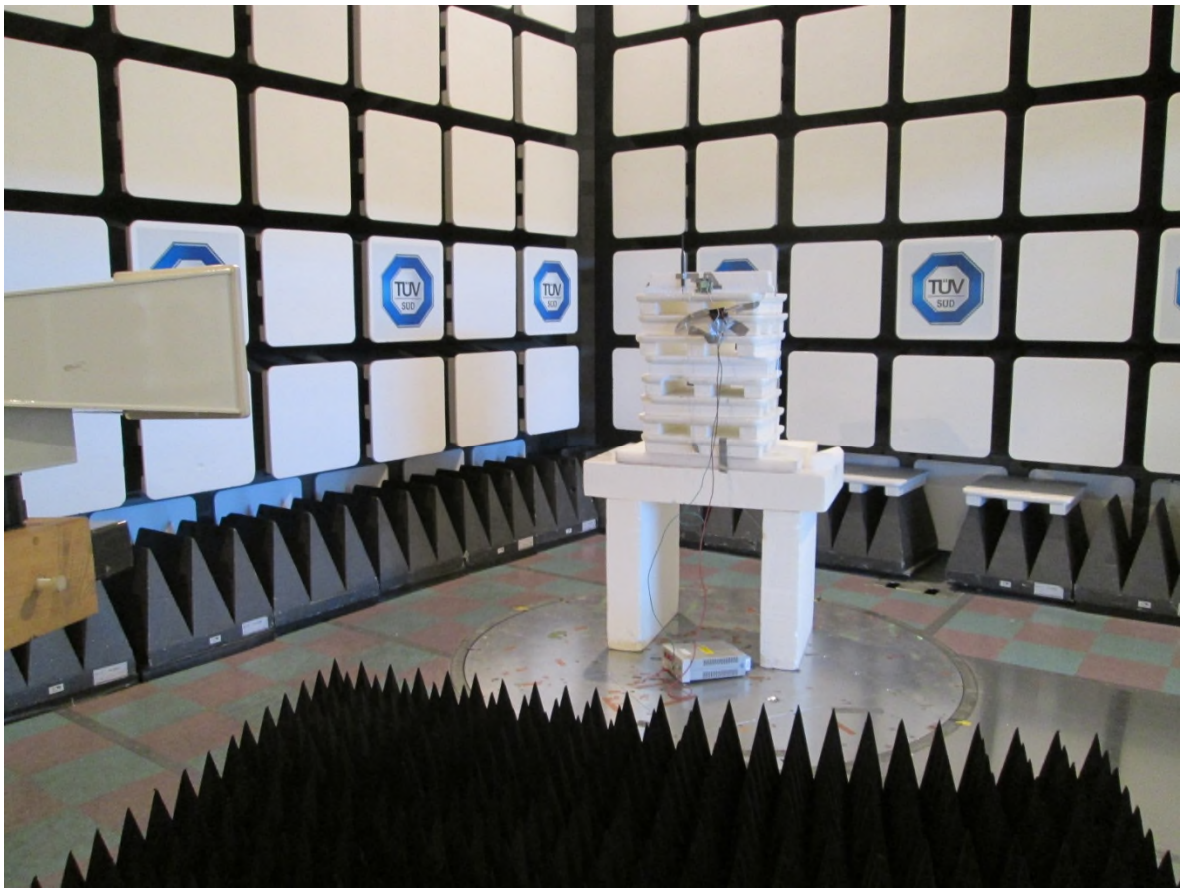


Test setup photo 1
Radiated measurements, 9 kHz – 30 MHz

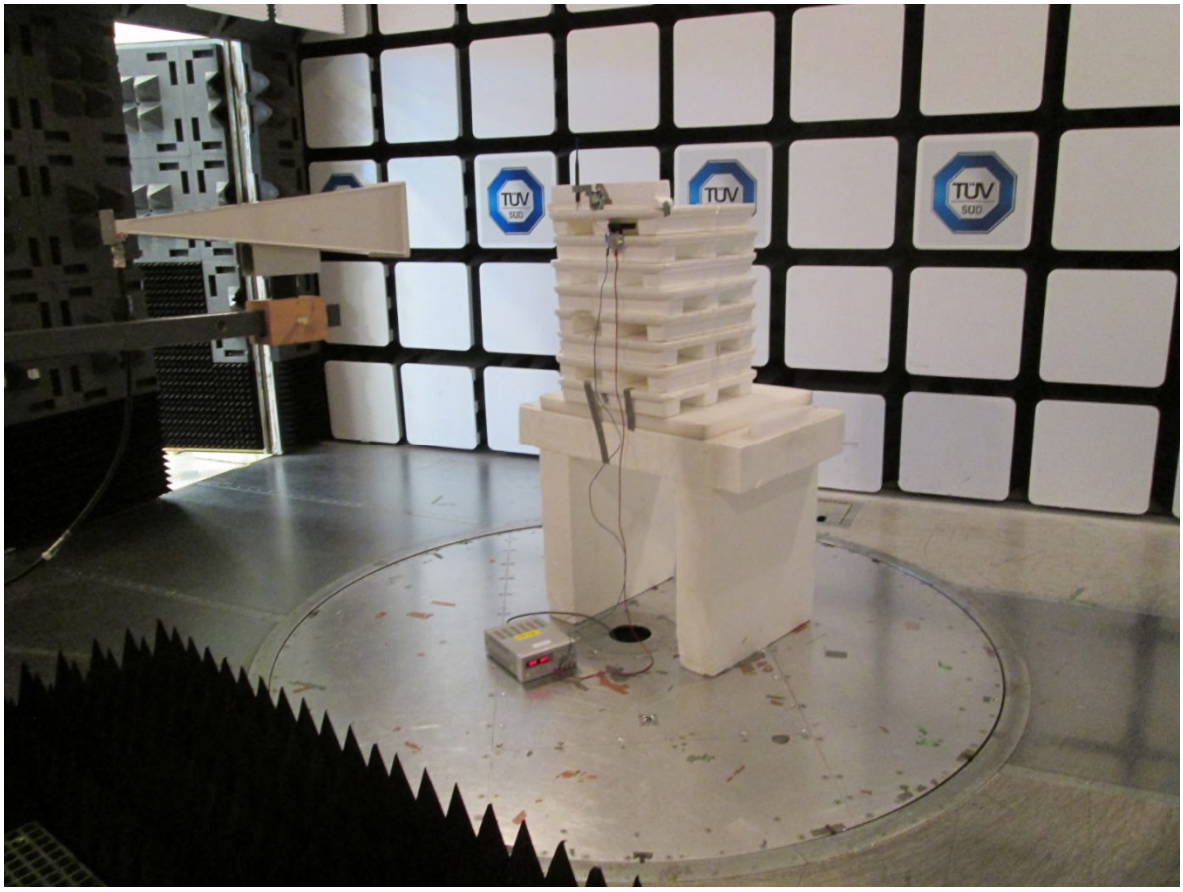
Test setup photo 2
Radiated measurements, 30 MHz – 1 GHz



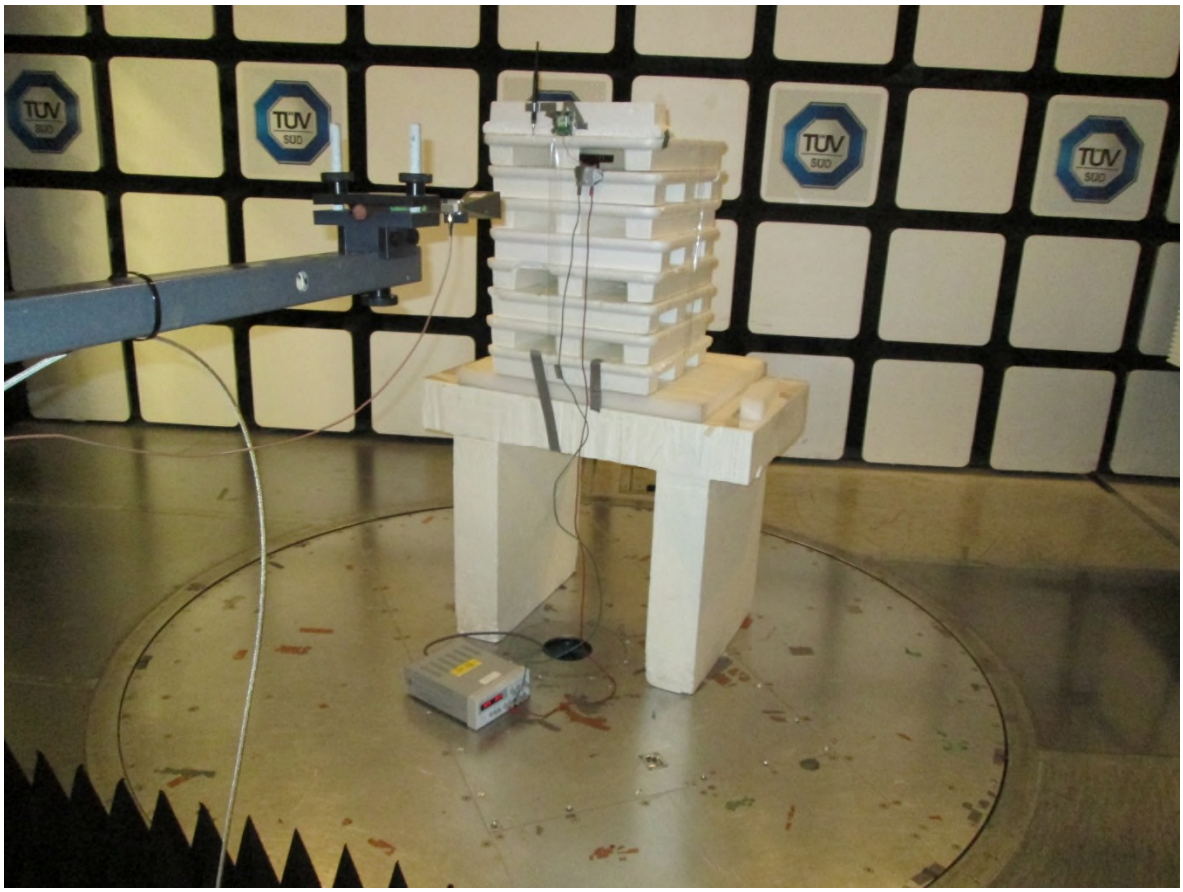
Test setup photo 3
Radiated measurements, 1 GHz – 2 GHz



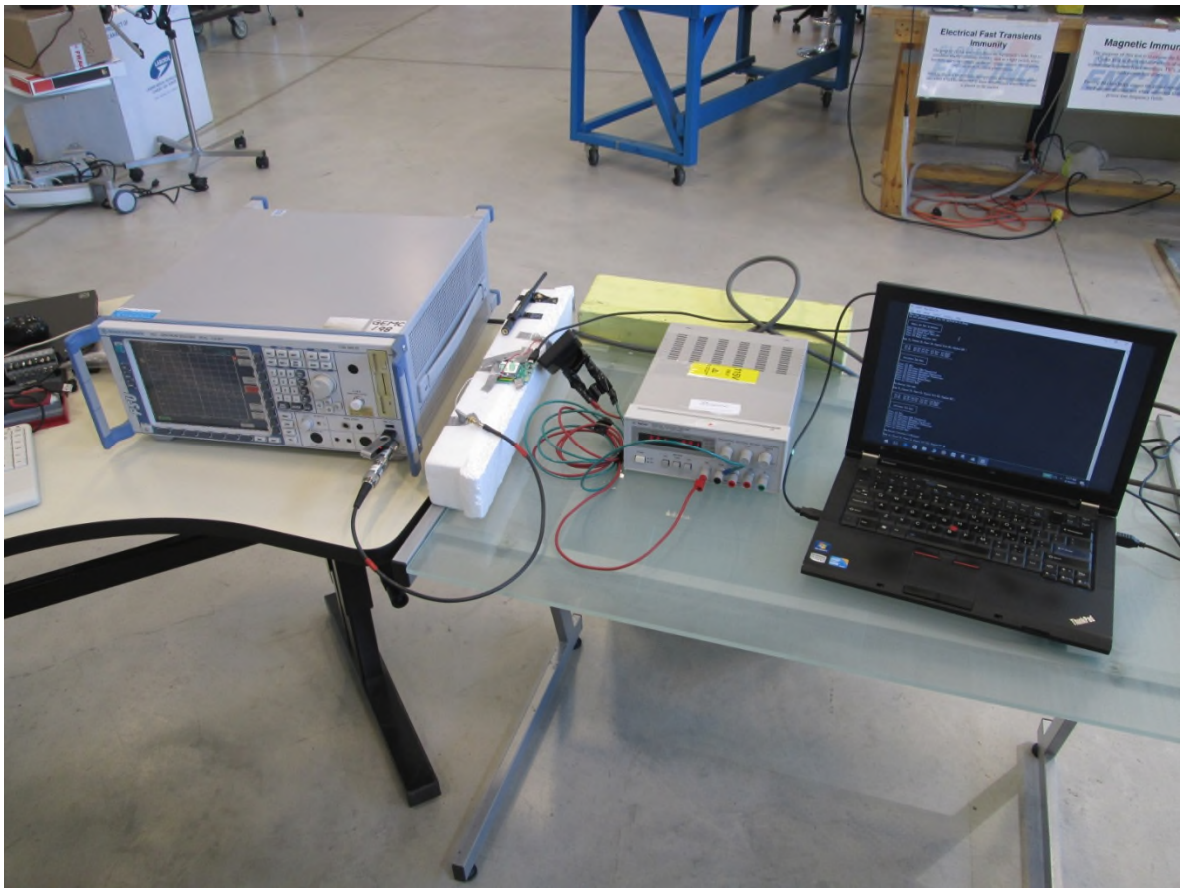
Test setup photo 4
Radiated measurements, 2 GHz – 10 GHz



Test setup photo 5
Radiated measurements, 10 GHz – 18 GHz



Test setup photo 6
Radiated measurements, 18 GHz – 26 GHz



Test setup photo 7
Conducted measurements