EMC & RF Test Report

As per

RSS-247 Issue 2:2017
&
FCC Part 15 Subpart 15.247:2015

Unlicensed Intentional Radiators (DTS)

on the

ECB401

Issued by:

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Testing produced for

See Appendix A for full client & EUT details.

Industry Canada
Registration # 6844A-3

Testing Laboratory Certificate #2955.02

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

Registration # CA6844

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Report Scope

This report addresses the EMC verification testing and test results of the **Ecobee Inc.'s ECB401**, and is herein referred to as EUT (Equipment Under Test). The EUT was tested for compliance against the following standards:

RSS-247 Issue 2:2017

FCC Part 15 Subpart C 15.247:2015

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 any government, accreditation agency, or TÜV SÜD Canada Inc.

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

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Summary

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

EUT:	ECB401
FCC Certification #, FCC ID:	WR9116151212151
Industry Canada Certification #, IC:	7981A-11615121215
EUT passed all tests performed	Yes
Tests conducted by	Min Xie

For testing dates, see "Testing Environmental Conditions and Dates".

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Test Results Summary

Standard/Method	Description	Class/Limit	Result
FCC 15.203	Antenna Requirement	Unique	Pass See Justification
FCC 15.205 RSS-GEN (Table 6)	Restricted Bands for intentional operation	QuasiPeak Average	Pass
FCC 15.207 RSS-GEN (Table 3)	Power line conducted emissions	QuasiPeak Average	Pass
FCC 15.209 RSS-GEN (Table 4)	Spurious Radiated emissions	QuasiPeak Average	Pass
FCC 15.247(a)2 RSS-247 5.2 (1)	6 dB Bandwidth	> 500 kHz	Pass
FCC 15.247(b)2 RSS-247 5.4 (4)	Max output power	< 1 Watt	Pass
FCC 15.247(b)(4) RSS-247 5.4 (4)	Antenna Gain	< 6 dBi	Pass See Justifications
FCC 15.247(d) RSS-247 5.5	Antenna conducted spurious	< 20 dBc	Pass
FCC 15.247(e) RSS-247 5.2 (2)	Spectral Density	< 8 dBm (3 kHz BW)	Pass
FCC 15.247(i) RSS-102	Maximum Permissible Exposure	> 20 cm separation.	Pass See justification and calculations
Overall Result			**PASS**

If the product as tested or otherwise complies with the specification, the EUT is deemed to comply with the requirement and is deemed a ‘PASS’ grade. If not ‘FAIL’ grade will be issued. Note that ‘PASS’ / ‘FAIL’ grade is independent of any measurement uncertainties. A ‘PASS’ / ‘FAIL’ grade within measurement uncertainty is marked with a ‘*’.

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Notes, Justifications, or Deviations

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

For the Antenna requirement specified in FCC 15.203 (RSS-247 section 5.5), the unit uses a 2 dBi PCB antenna which is less than 6 dBi gain.

For the Restricted Bands of operation, the EUT is designed to only operate between 2400 – 2483.5 MHz band.

The EUT is not a hybrid system and FCC 15.247 (f) does not apply to it.

For maximum permissible exposure is designed to operate greater than 20 cm from any personnel during normal operation. No testing is required, however worst case calculated exposure compliance follows later in this report.

The EUT contains a 902 – 928 MHz FHSS transmitter and a 2400 – 2483.5 MHz DTS transmitter. The Firmware guarantees simultaneous will not occur. Antenna co-location testing is therefore not applicable.

For maximum permissible exposure, this device operates at less than 1 Watt at 2400 – 2483.5 MHz and is designed to operate greater than 20 cm from any personnel during normal operation. No testing is required, however worst case calculated exposure compliance was shown in the RF Exposure exhibits.

The EUT is an 802.11 complaint transceiver. It have B/G/N protocols. The N protocol operates with 20 MHz bandwidth. Each protocol have multiple modulation schemes and data rates. For each protocol, bandwidth and power were pre-scanned and the worst case results were presented in this report.

Sample Calculation(s)

Radiated Emission Test

Margin = Limit – (Received Signal + Antenna Factor + Cable Loss – Pre-Amp Gain)
Margin = 50.5dBµV/m – (50dBµV + 10dB + 2.5dB – 20dB)
Margin = 8.0 dB (pass)

Power Line Conducted Emission Test

Margin = Limit – (Received Signal + Attenuation Factor + Cable Loss + LISN Factor)
Margin = 73.0dBµV – (50dBµV + 10dB + 2.5dB + 0.5dB)
Margin = 10.0 dB (pass)

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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 Subpart C:2015	Code of Federal Regulations – Radio Frequency Devices, Intentional Radiators
CISPR 22:2008	Information Technology Equipment - Radio Disturbance Characteristics - Limits and Methods of Measurement
ICES-003 Issue 6 2016	Digital Apparatus - Spectrum Management and Telecommunications Policy Interference-Causing Equipment Standard
RSS-GEN Issue 4 2014	General Requirements and Information for the Certification of Radio Apparatus
RSS-247 Issue 2:2017	Issue 2: Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
RSS 102 Issue 5 2015	Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands)
FCC KDB 447498 v06	RF Exposure Procedures And Equipment Authorization Policies For Mobile And Portable Devices
ISO 17025:2005	General Requirements for the Competence of Testing and Calibration Laboratories

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Document Revision Status

Revision 1 - Mar 24, 2017
Initial Release

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Definitions and Acronyms

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

AE – Auxiliary Equipment. A digital accessory that feeds data into or receives data from another device (host) that in turn, controls its operation.

BW – Bandwidth. Unless otherwise stated, this is refers to the 6 dB bandwidth.

EMC – Electro-Magnetic Compatibility. The ability of an equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment.

EMI – Electro-Magnetic Immunity. The ability to maintain a specified performance when the equipment is subjected to disturbance (unwanted) signals of specified levels.

EUT – Equipment Under Test. A device or system being evaluated for compliance that is representative of a product to be marketed.

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

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Testing Facility

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

Calibrations and Accreditations

The 3m semi-anechoic chamber is registered with Federal Communications Commission (FCC, CA6844), Industry Canada (IC, 6844A-3) and Voluntary Control Council for Interference (VCCI, R-4023, G-506, C-4498, and T-1246). This chamber was 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 Inc is accredited to ISO 17025 by A2LA with Testing Certificate #2555.01. The laboratory's 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.

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Testing Environmental Conditions and Dates

Following environmental conditions were recorded in the facility during time of testing

Date	Test	Initials	Temperature (ºC)	Humidity (%)	Pressure (kPa)
2017/2/14-16	Radiated Emissions	MX	20 – 24	40 – 51	98.0 – 102.0
2017/2/29	Antenna Conducted Emissions	MX	20 – 24	40 – 51	98.0 – 102.0
2017/3/2	Power Line Conducted Emissions	MX	20 – 24	40 – 51	98.0 – 102.0

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Detailed Test Results Section

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6dB Bandwidth of Digitally Modulated Systems

Purpose

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

Limits and Methods

The Limit is as specified in FCC Part 15.247 and RSS 247.

Systems using digital modulation techniques may operate in the 902 - 928 MHz, 2400 - 2483.5 MHz and 5725 - 5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz. This should be measured with a 100 kHz RBW and a 300 kHz VBW.

The method is given in ANSI C63.10 Clause 11.8 DTS bandwidth.

Results

The EUT passed. The minimum measured 6 dB BW was of all modulations were greater than 500 kHz.

Additional 99% bandwidth were measured for information purpose. There is no requirement on 99% bandwidth.

The EUT supports three modes of operation, 802.11 b/g/n. The n-mode only support 20 MHz nominal bandwidth. Three Channels for each mode were measured. The following tables show the 6 dB and 99% bandwidth: The external attenuator and cable loss were accounted for as reference offset in the spectrum analyzer.

Bandwidth - B-Mode					
Channel	Frequency (MHz)	6 dB BW (MHz)	99% BW (MHz)	6 dB BW Limit (kHz)	Pass/Fail
1	2412	10.96	13.72	500	Pass
6	2437	11.03	13.72	500	Pass
11	2462	11.03	13.65	500	Pass

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Bandwidth G-Mode					
Channel	Frequency (MHz)	6 dB BW (MHz)	99% BW (MHz)	6 dB BW Limit (kHz)	Pass/Fail
1	2412	16.75	16.90	500	Pass
6	2437	16.74	16.90	500	Pass
11	2462	16.74	16.90	500	Pass

Bandwidth N-Mode					
Channel	Frequency (MHz)	6 dB BW (MHz)	99% BW (MHz)	6 dB Limit (kHz)	Pass/Fail
1	2412	17.89	18.11	500	Pass
6	2437	17.87	18.19	500	Pass
11	2462	17.87	18.11	500	Pass

Graph(s)

The graphs shown below show the OBW during the operation of the device. This is measured by a max hold on the spectrum analyzer and the highest resolution bandwidth that is sufficiently low to exhibit the 6 dB bandwidth of a channel during operation of the EUT. This measurement is a peak measurement. Max hold is performed for a duration of not less than 1 minute.

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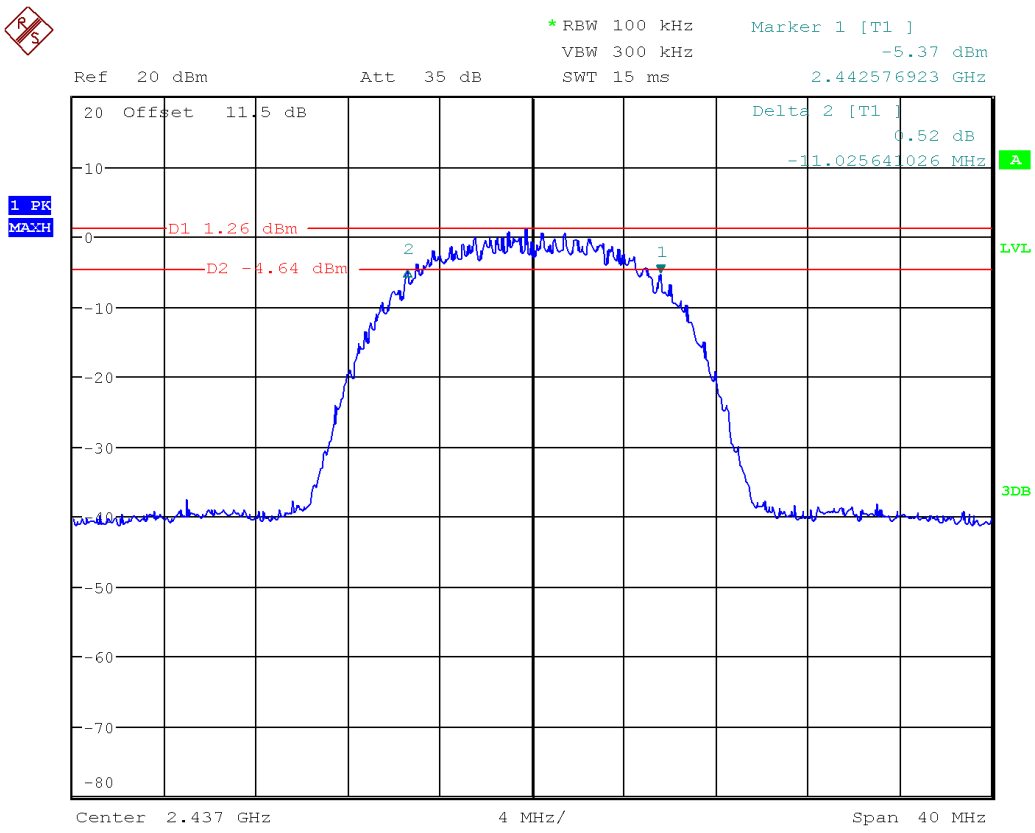
6 dB Bandwidth B- Mode
Mid Channel



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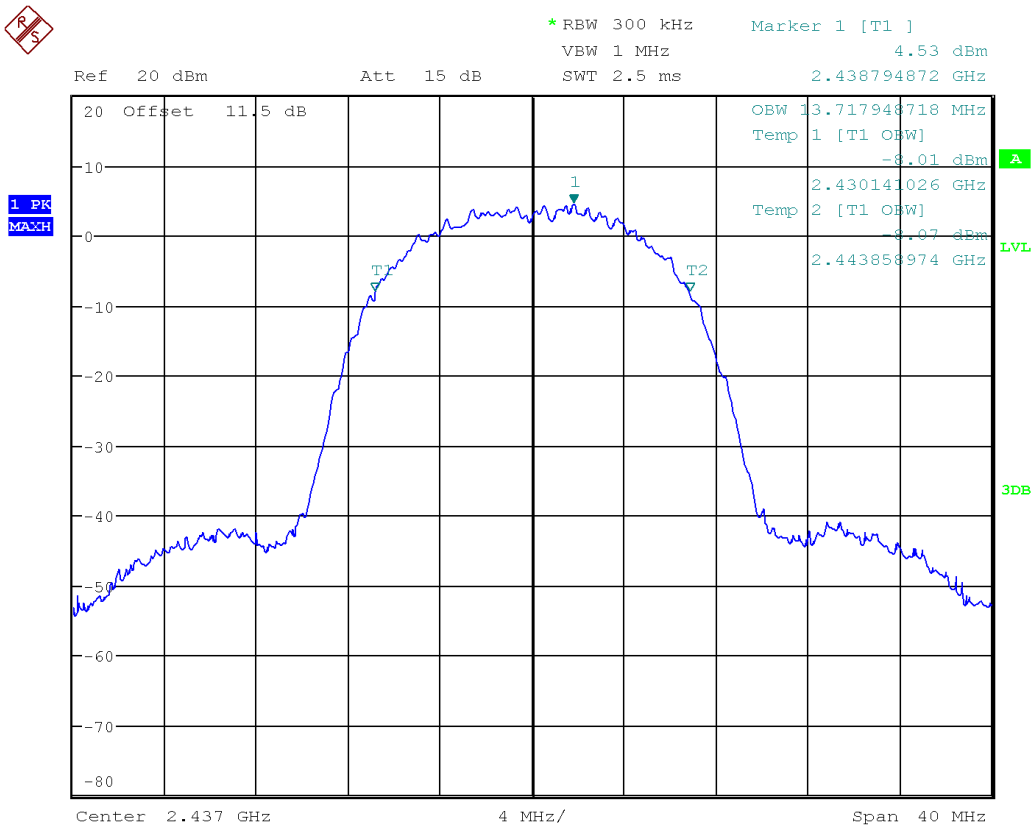
99%Bandwidth B- Mode
Mid Channel



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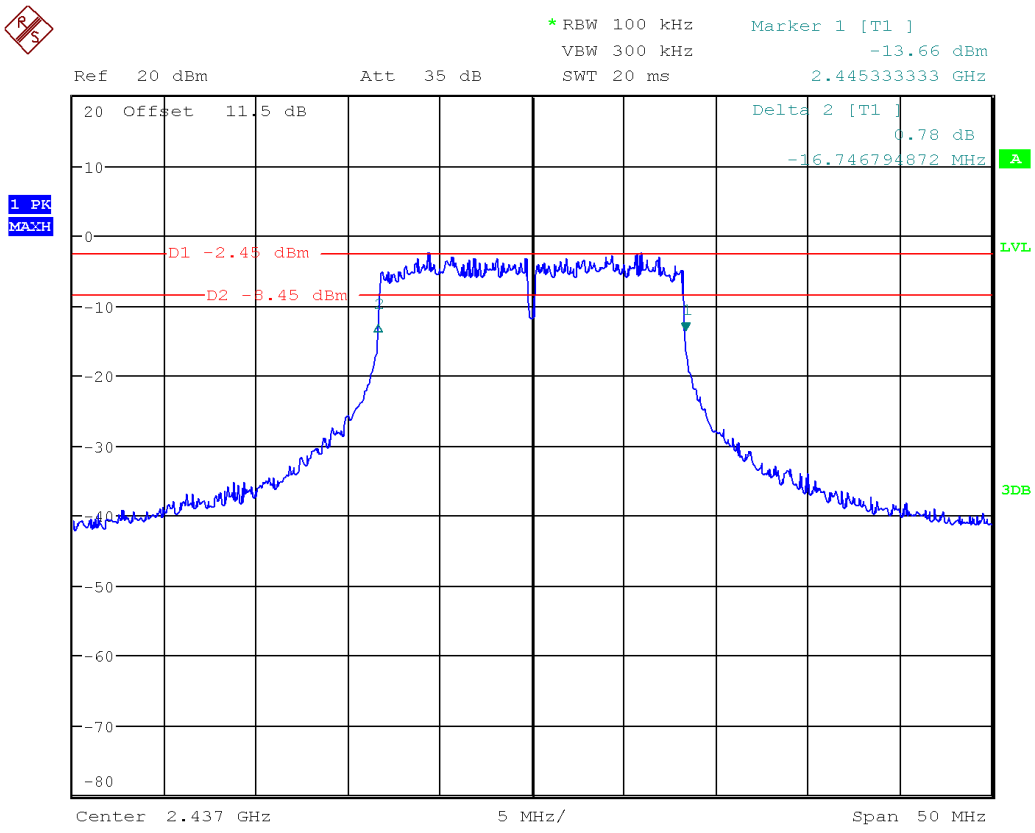
6 dB Bandwidth, G - Mode
Mid Channel



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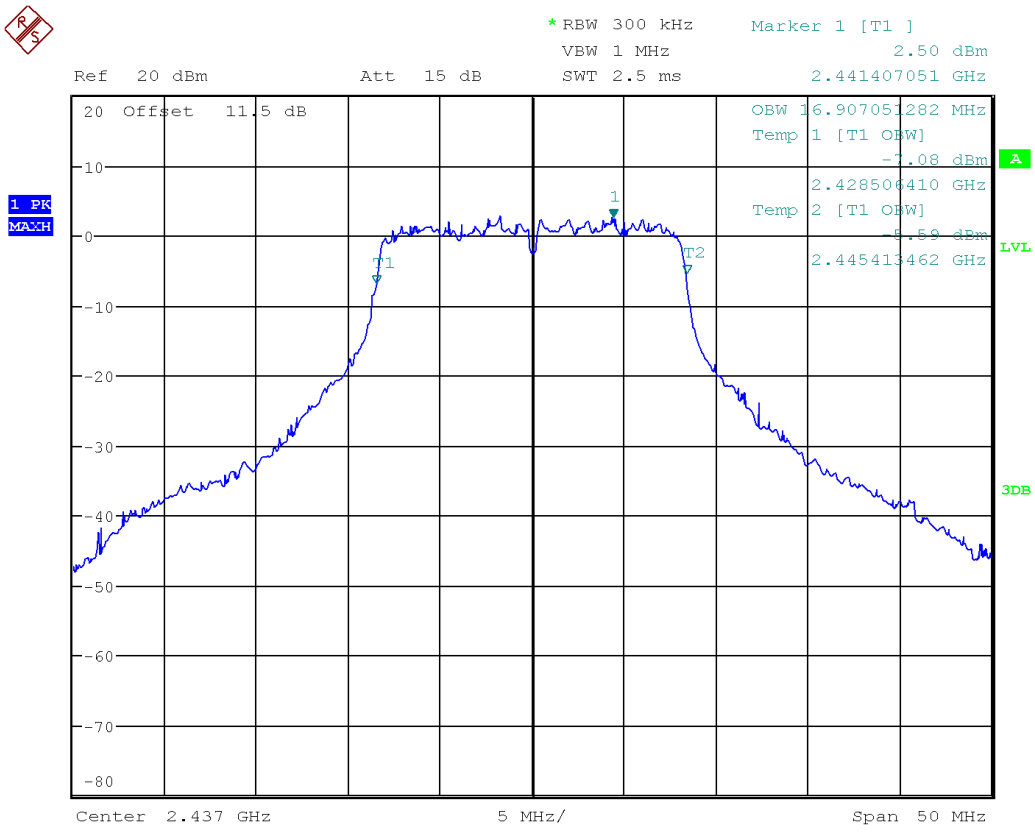
99%Bandwidth, G - Mode
Mid Channel



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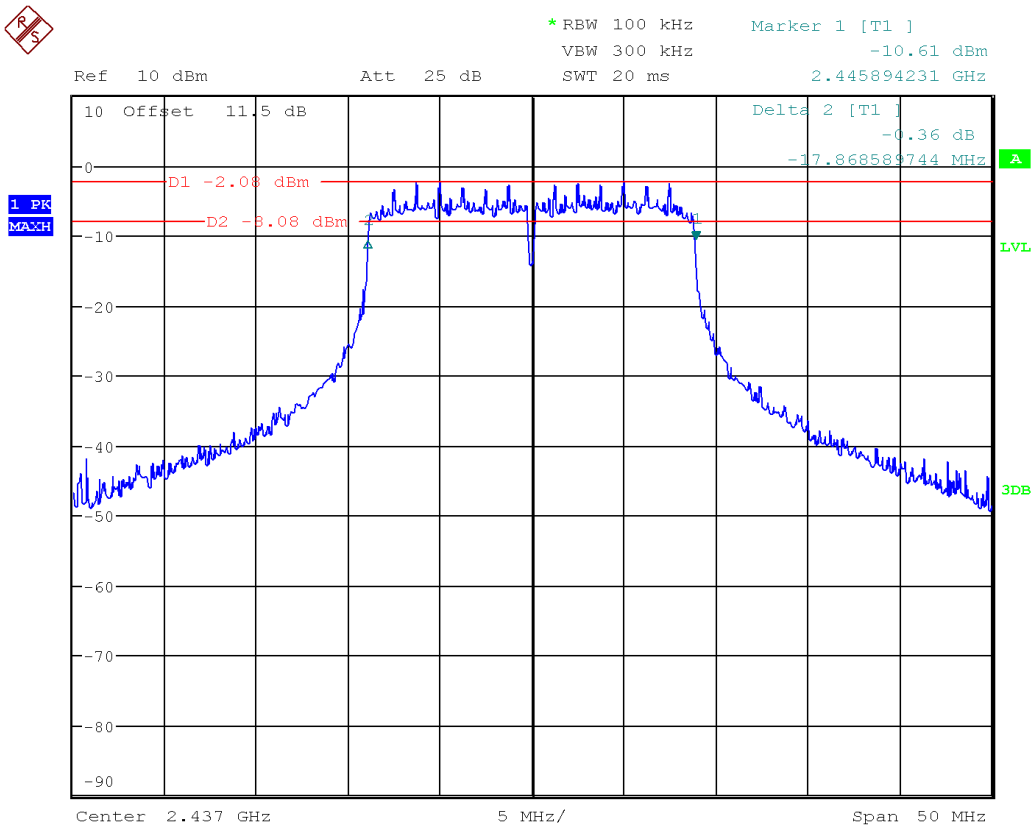
6 dB Bandwidth, N-Mode
Mid Channel



Date: 29.FEB.2016 18:04:05

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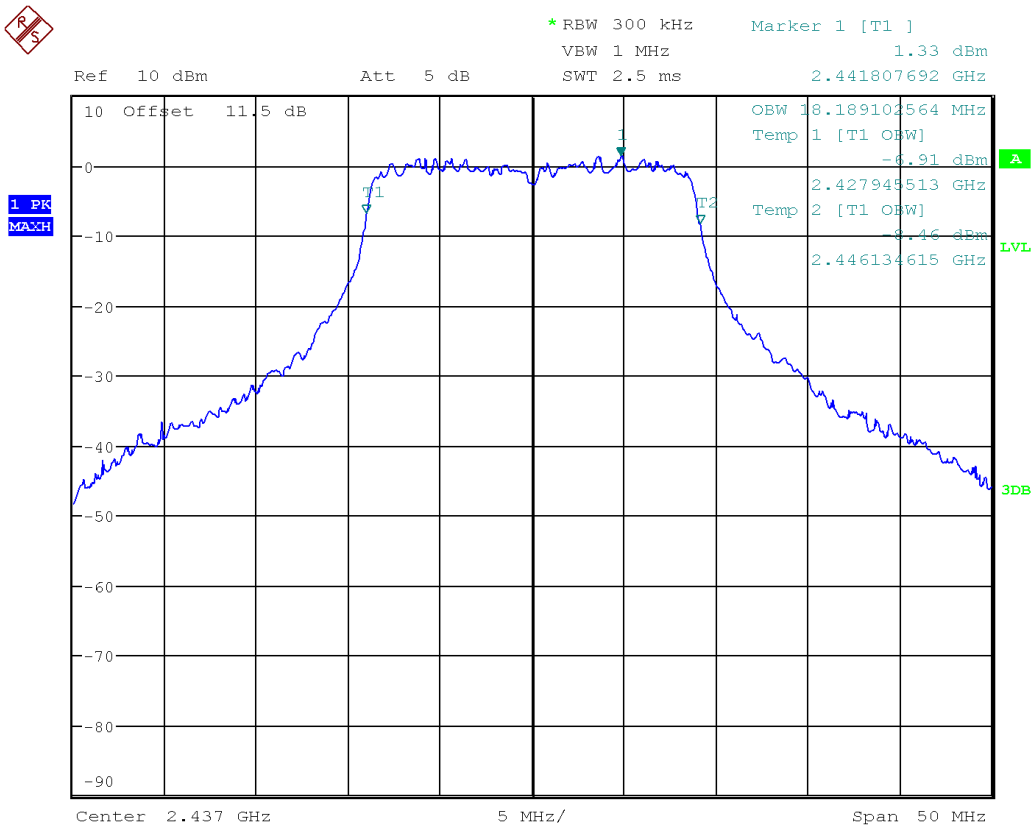
99%Bandwidth, N-Mode
Mid Channel



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

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Test Equipment List

Equipment	Model No.	Manufacturer	Last calibration / Verification date	Next calibration/ Verification due date	Asset #
26.5GHz Spectrum Analyzer	FSU26	Rohde & Schwarz	Feb-15, 2017	Feb-15, 2019	GEMC 232
10 dB attenuator	605-10-1F18	Meca Electronics, Inc.	Feb-15, 2017	Feb-15, 2018	GEMC225

This report module is based on GEMC template "FCC – Power Line Conducted Emissions Class B_Rev1"

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Maximum Peak Envelope Conducted Power - DM

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 and Methods

The limits are defined in FCC Part 15.247(b) and RSS 247.
For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands, the peak limit is 1 watt.

The method is given in ANSI C63.10 Clause 11.9.1.2 Integrated band power method.

Results

The EUT passed. The EUT was set to transmit at maximum power. The EUT supports three modes of operation, 802.11 b/g/n. The n-mode only support 20 MHz nominal bandwidth. Three Channels for each mode were measured. The following tables show the peak power: The external attenuator and cable loss were accounted for as reference offset in the spectrum analyzer.

Power B-Mode					
Channel	Frequency (MHz)	Power (dBm)	Power (mW)	Limit (mW)	Pass/Fail
1	2412	15.01	31.70	1000	Pass
6	2437	16.26	42.27	1000	Pass
11	2462	16.26	42.27	1000	Pass

Power G-Mode					
Channel	Frequency (MHz)	Power (dBm)	Power (mW)	Limit (mW)	Pass/Fail
1	2412	17.42	55.21	1000	Pass
6	2437	19.03	79.98	1000	Pass
11	2462	18.91	77.80	1000	Pass

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Power N-Mode					
Channel	Frequency (MHz)	Power (dBm)	Power (mW)	Limit (mW)	Pass/Fail
1	2412	16.33	42.95	1000	Pass
6	2437	17.71	59.02	1000	Pass
11	2462	17.46	55.72	1000	Pass

Readings

The graphs shown below show the peak power output of the device. This is measured by a max hold on the spectrum analyzer using a RBW of 1MHz. This measurement is a peak measurement. Max hold is performed for a duration of not less than 1 minute.

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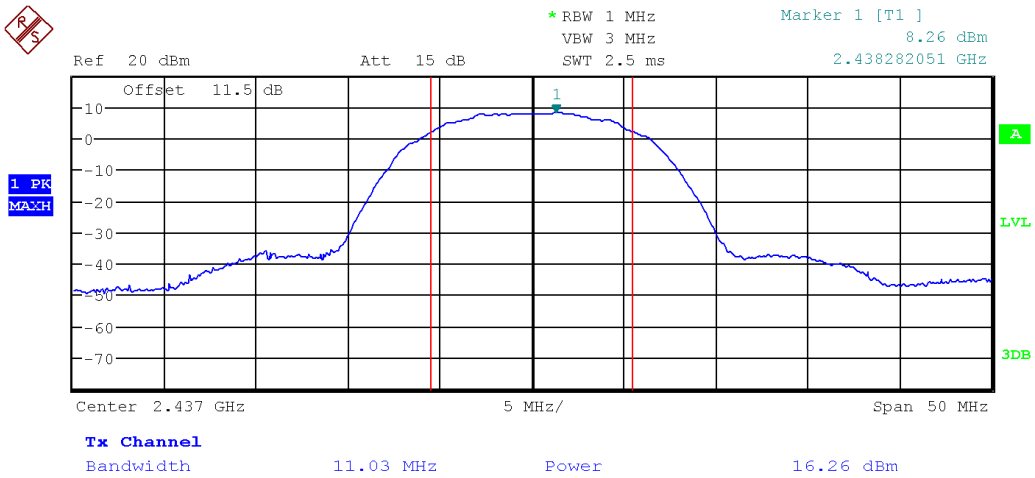
Peak Power: B-Mode
Mid Channel



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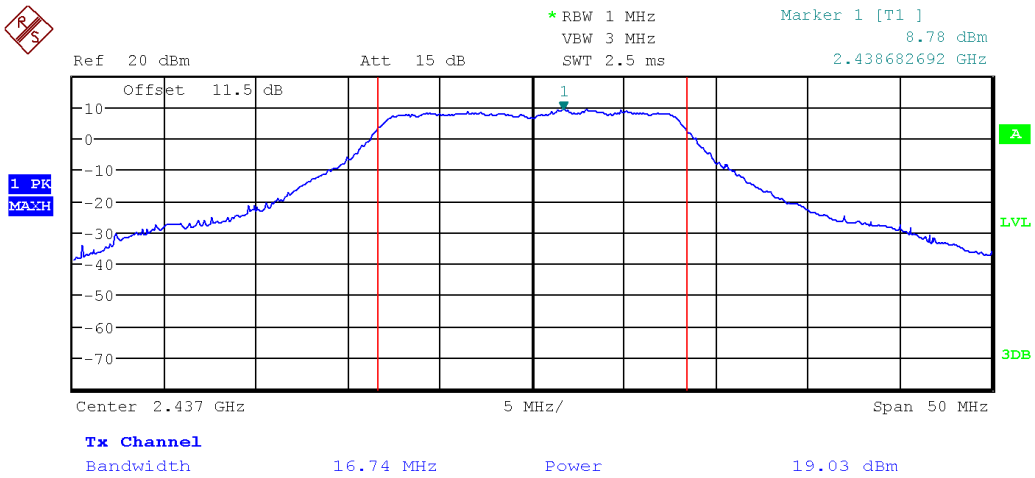
Peak Power: G-Mode
Mid Channel



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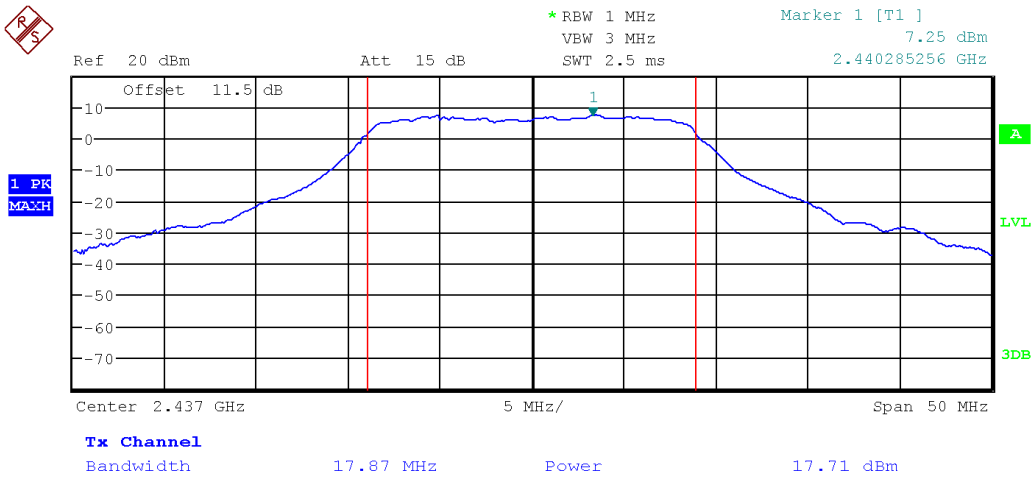
Peak Power: N-Mode
Mid Channel



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

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Test Equipment List

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10 dB attenuator	605-10-1F18	Meca Electronics, Inc.	Feb-15, 2017	Feb-15, 2018	GEMC225

This report module is based on GEMC template "FCC – Power Line Conducted Emissions Class B_Rev1"

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Antenna Spurious Conducted Emissions (-20 dBc Requirement)

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 and Methods

The limits are defined in 15.247(d). In any 100 kHz band, 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.

The method is given in ANSI C63.10 Clause 11.11 Emissions in nonrestricted frequency bands

Results

The EUT passed.

The EUT was set to transmit at maximum power. The EUT supports three modes of operation, 802.11 b/g/n. The n-mode only support 20 MHz nominal bandwidth. Three Channels for each mode were measured.

Low, middle and high channels were measured. The worst case was 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. The -20 dBc requirement is also shown for the higher band edge at 2.4835 GHz in the high band.

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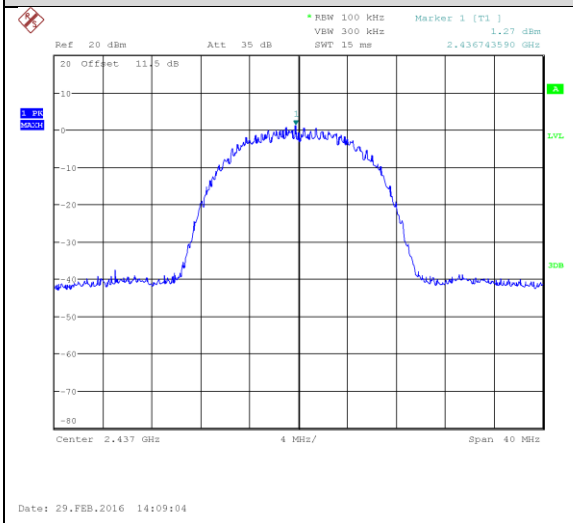
Graph(s)

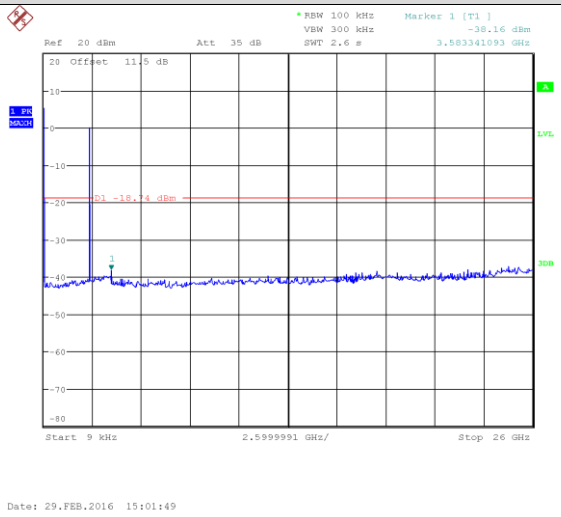
The graphs shown below shows the peak power spectral density of the device. This is measured by a max hold on the spectrum analyzer using a RBW of 100 kHz. This measurement is a peak measurement. Max hold is performed for a duration of not less than 1 minute.

-20 dBc: B-Mode

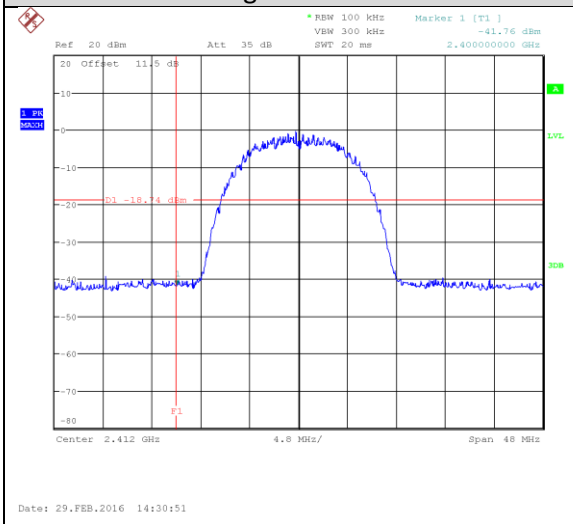
Reference level: -18.74 dBm



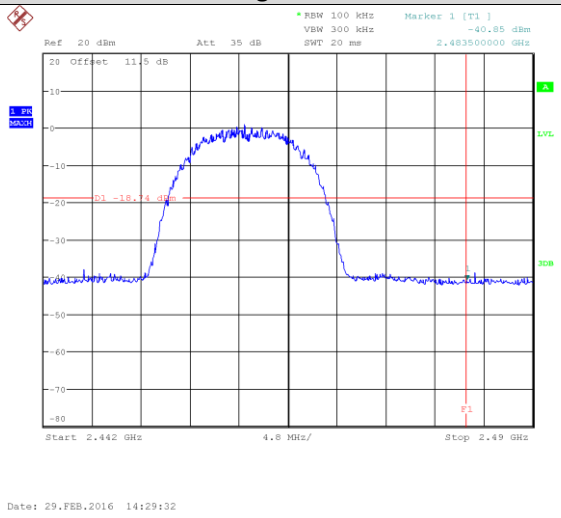
9 kHz – 26 GHz



2400 MHz Band edge



2483.5 MHz Band edge



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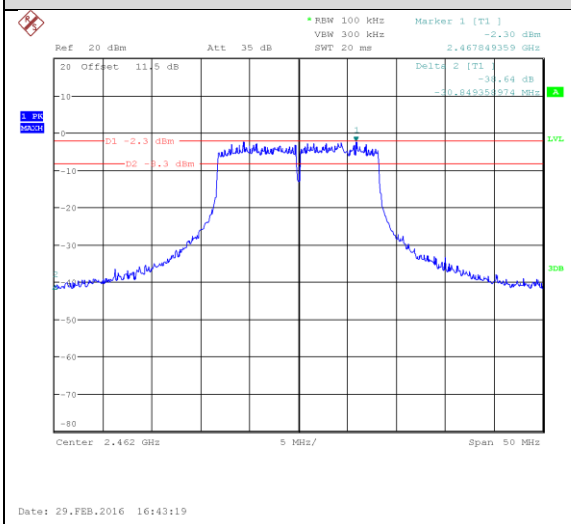
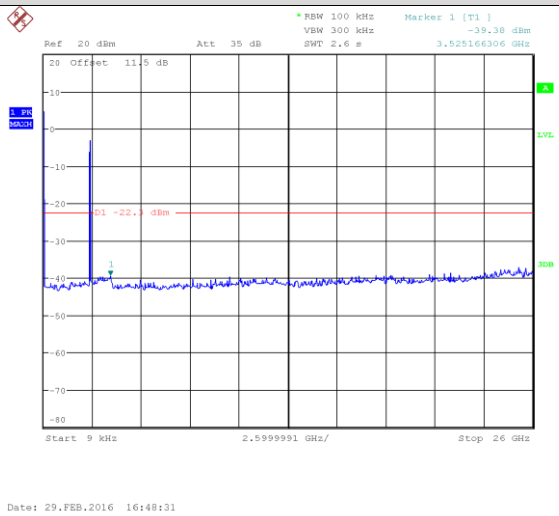
-20 dBc: G-Mode

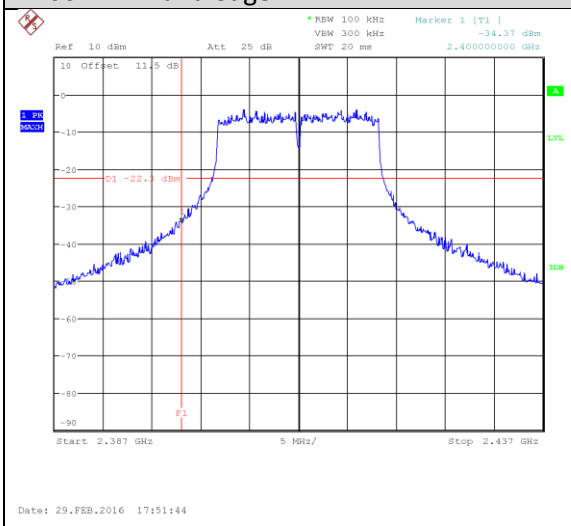
Reference level: -22.3 dBm



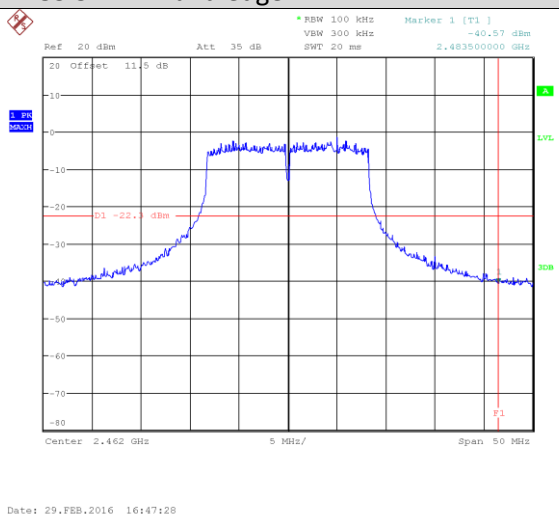
9 kHz – 26 GHz



2400 MHz Band edge



2483.5 MHz Band edge



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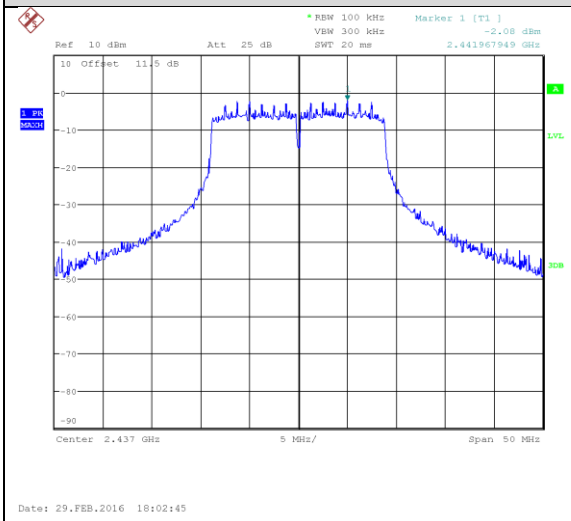
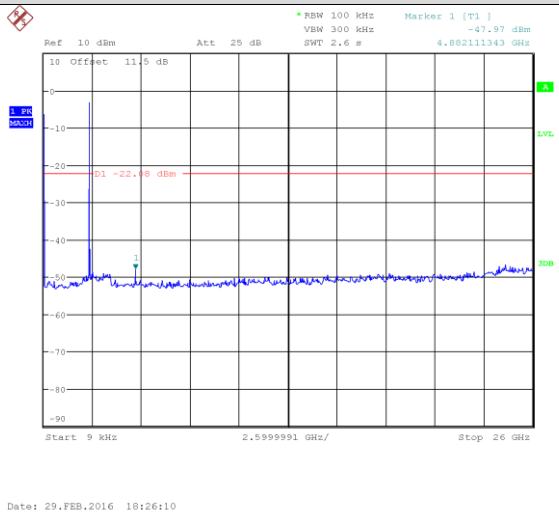
-20 dBc: N-Mode

Reference level: -22.08 dBm

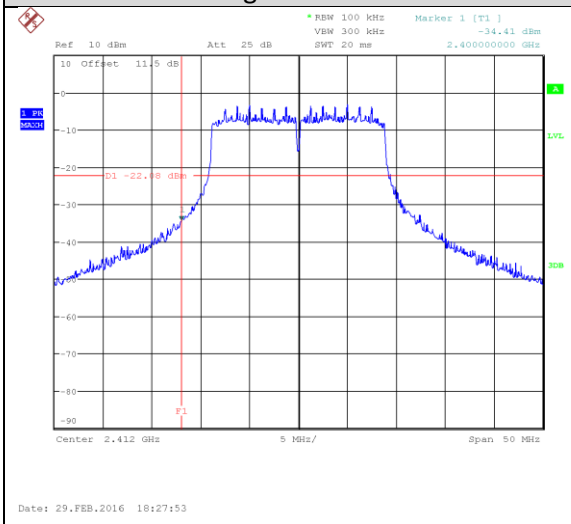
9 kHz – 26 GHz

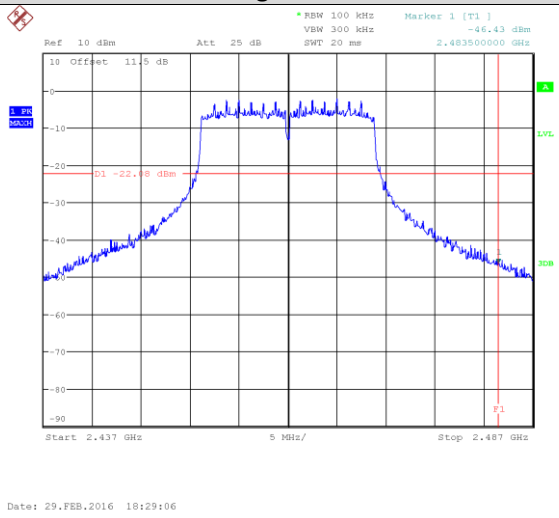




2400 MHz Band edge

2483.5 MHz Band edge





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

Test Equipment List

Equipment	Model No.	Manufacturer	Last calibration / Verification date	Next calibration/ Verification due date	Asset #
26.5GHz Spectrum Analyzer	FSU26	Rohde & Schwarz	Feb-15, 2017	Feb-15, 2019	GEMC 232
10 dB attenuator	605-10-1F18	Meca Electronics, Inc.	Feb-15, 2017	Feb-15, 2018	GEMC225

This report module is based on GEMC template "FCC – Power Line Conducted Emissions Class B_Rev1"

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Radiated Emissions in Restricted Band

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 and Method

The method is given in ANSI C 63.10
The limits are as defined in FCC Part 15, Section 15.209 and RSS GEN:

The limits, as defined in 15.247(d) for unintentional radiated emissions apply for those emissions that fall in the restricted bands, as defined in Section 15.205(a). These emissions must comply with the radiated emission limits specified in Section 15.209(a).

All unintentional emissions must also meet the 'Spurious Conducted Emissions' requirements of -20 dBc or greater. See also 'Spurious Conducted Emissions' for further details.

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, 500 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

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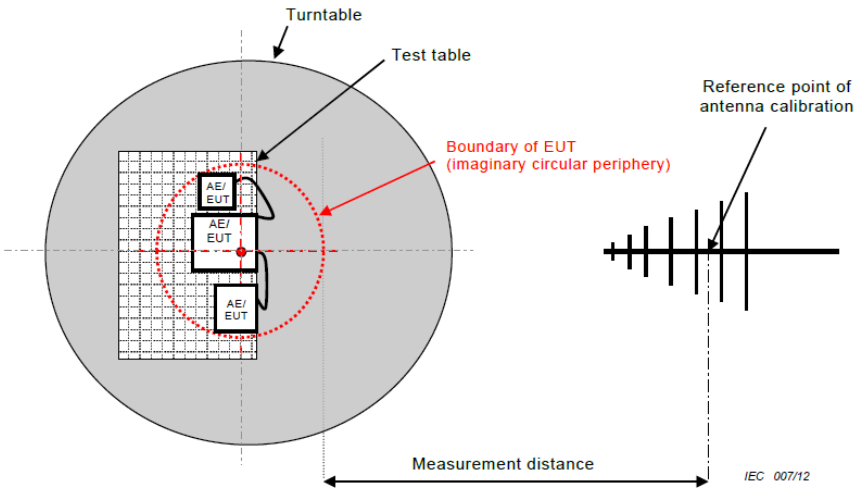
Typical Radiated Emissions Setup



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 graph shown below is a maximized peak measurement graph, measured with a resolution bandwidth greater than 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 (a minimum of a 24.835 GHz).

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.

The EUT was set to transmit at maximum power. The EUT supports three modes of operation, 802.11 b/g/n. Low, middle and high channels in each mode were measured; however the worst case graphs are presented.

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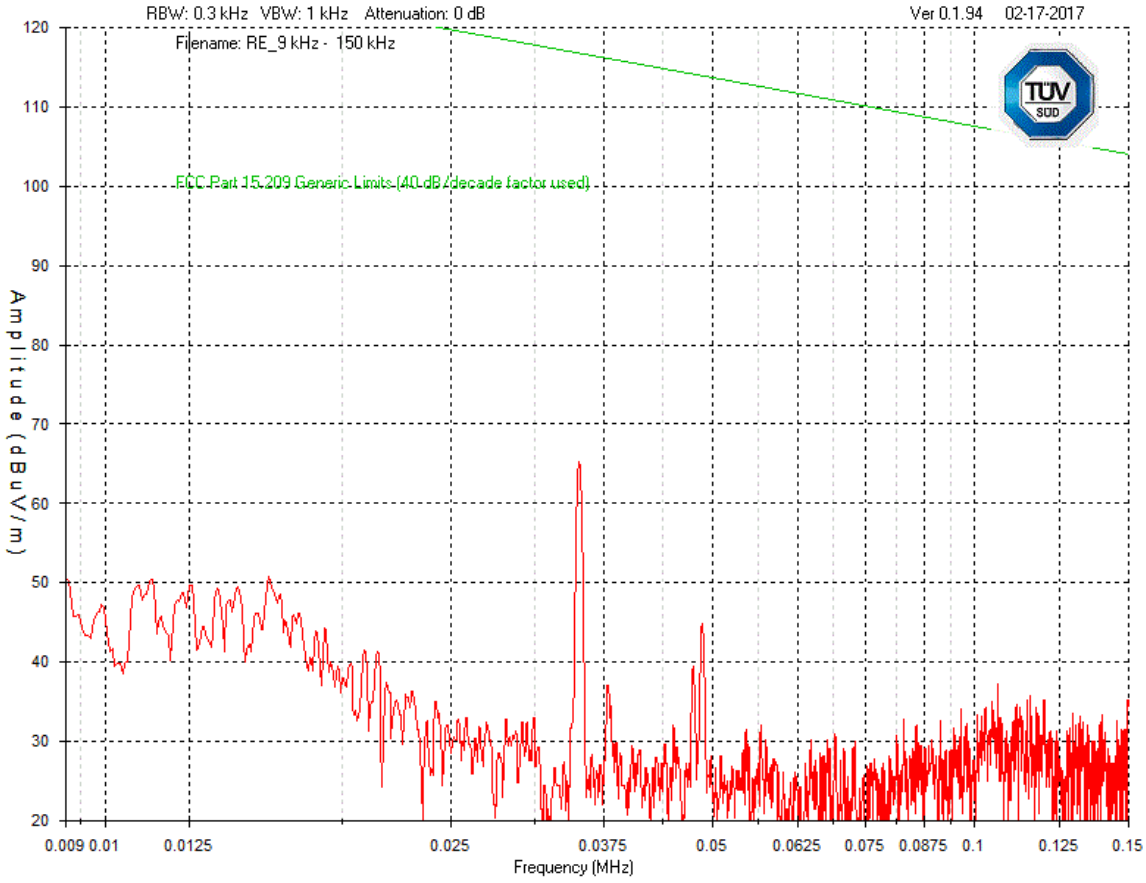
Band edge measure graphs were shown for illustrations purpose. See final measurement section for all measurements.

9 kHz – 150 kHz



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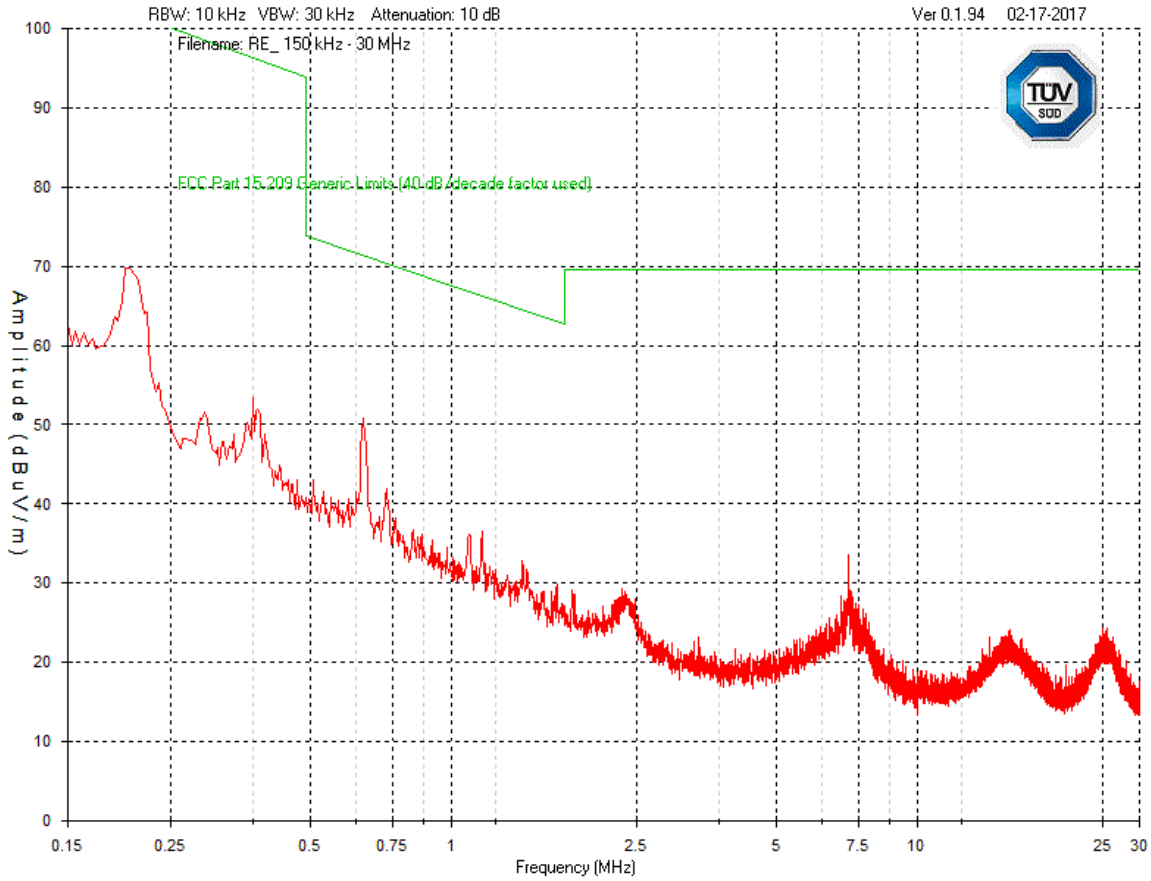
150 kHz – 30 MHz



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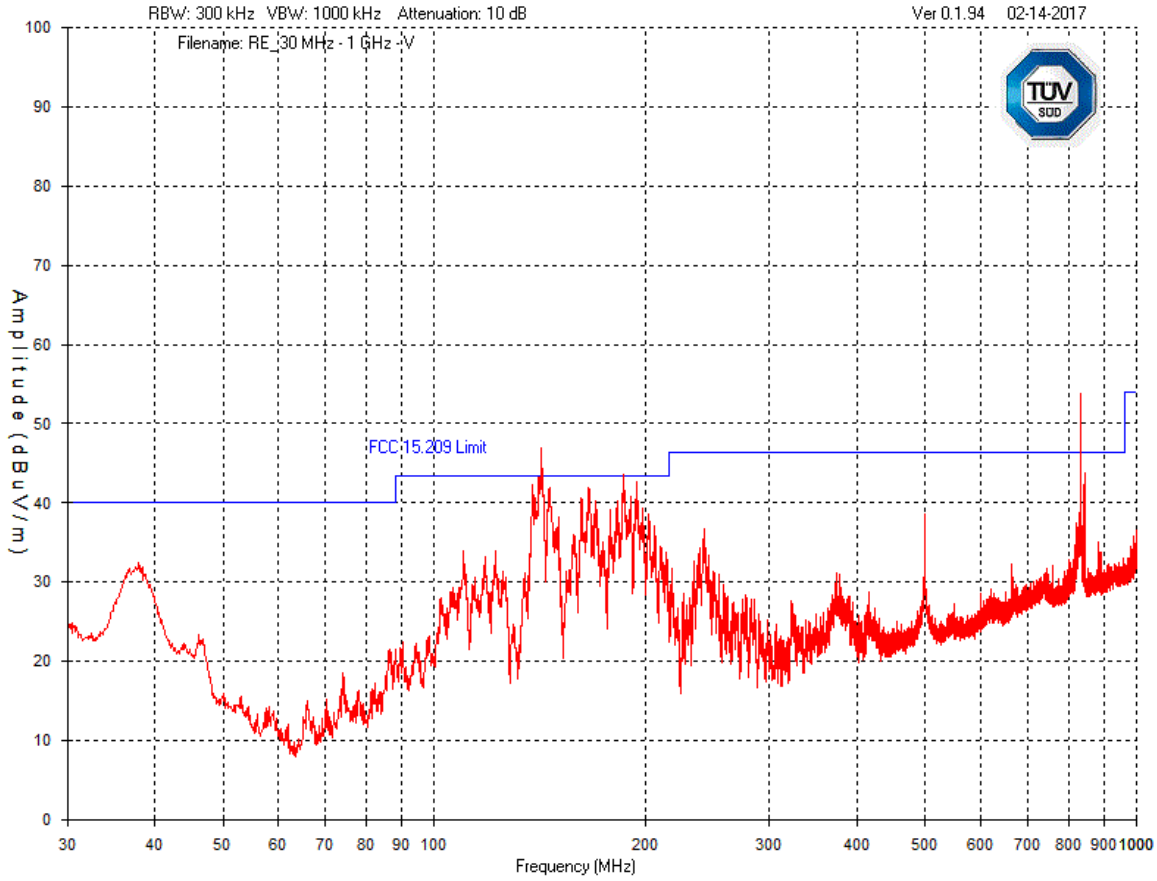
Mid Channel - 30 MHz – 1 GHz
Vertical – Peak Emission Graph



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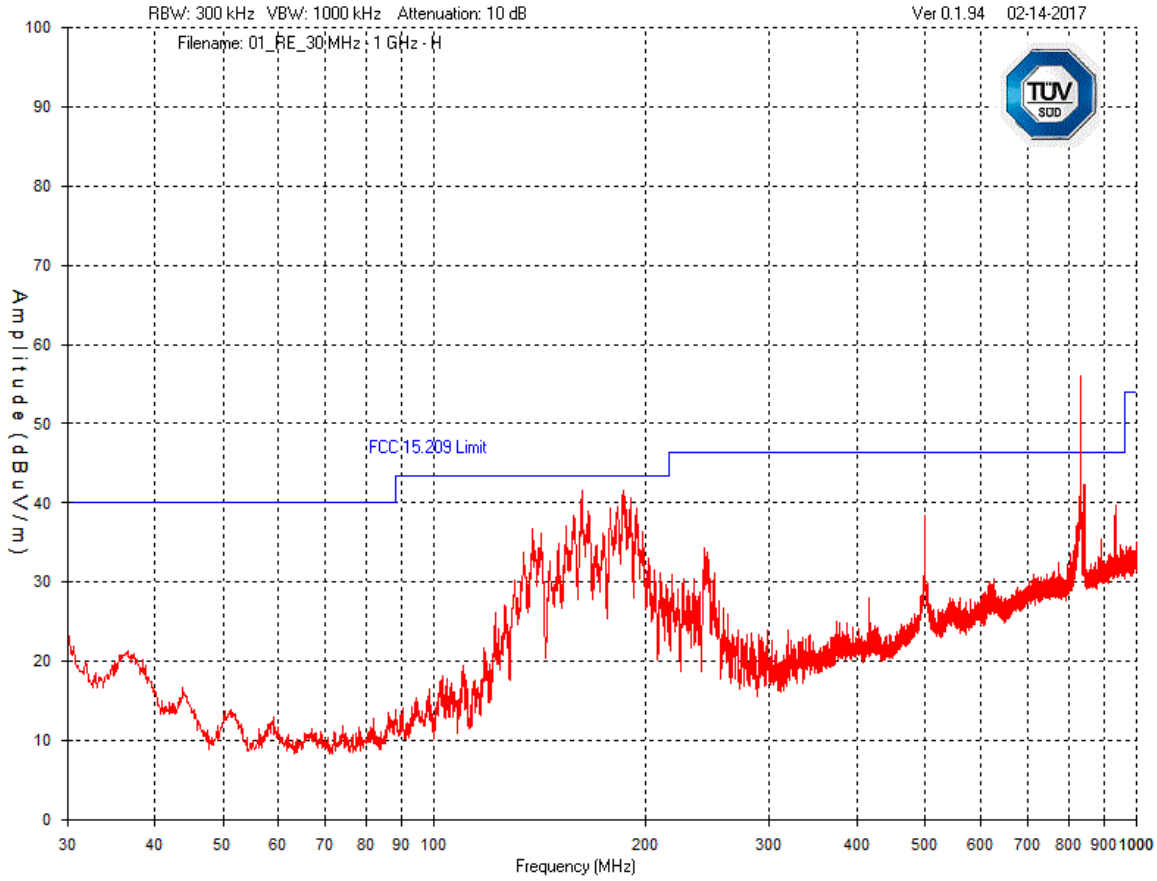
Mid Channel – 30 MHz – 1 GHz
Horizontal - Peak Emission Graph



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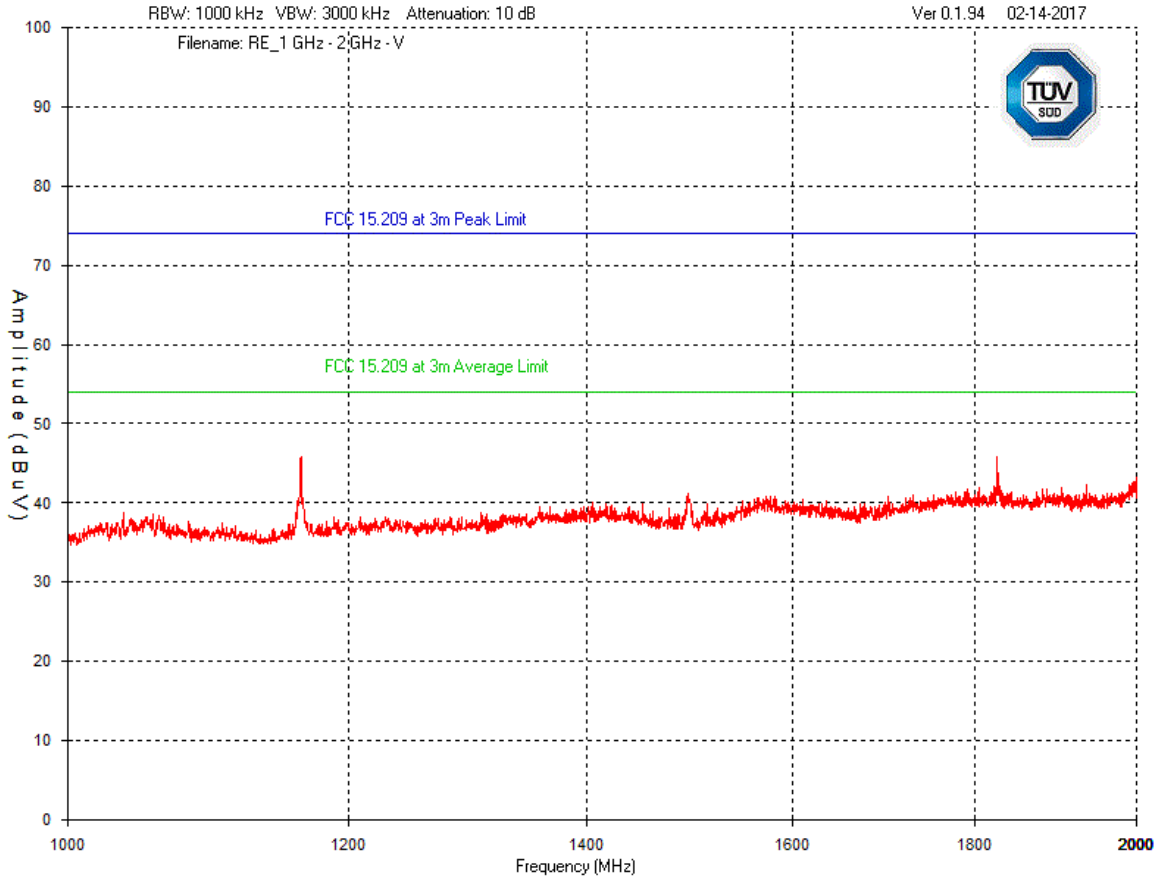
Mid Channel – 1 GHz – 2 GHz
Vertical - Peak Emission Graph



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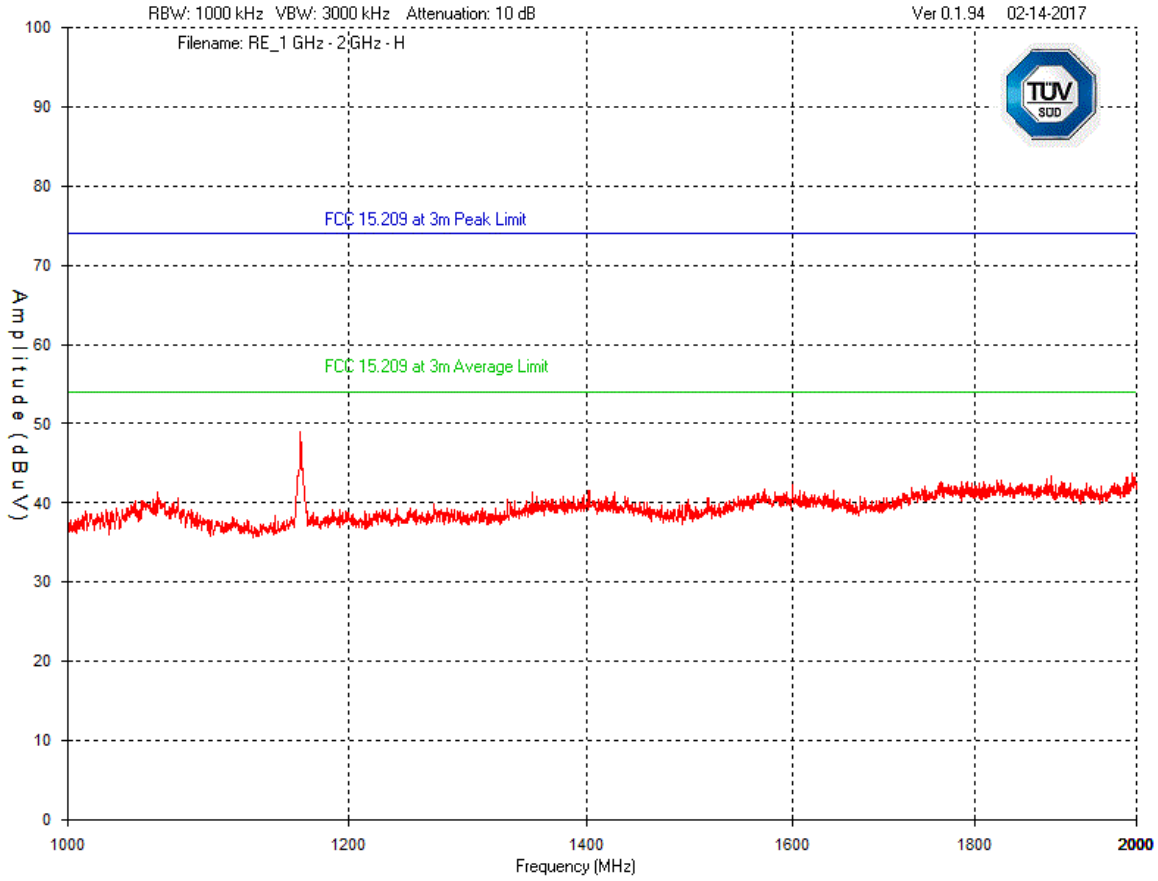
Mid Channel – 1 GHz – 2 GHz
Horizontal - Peak Emission Graph



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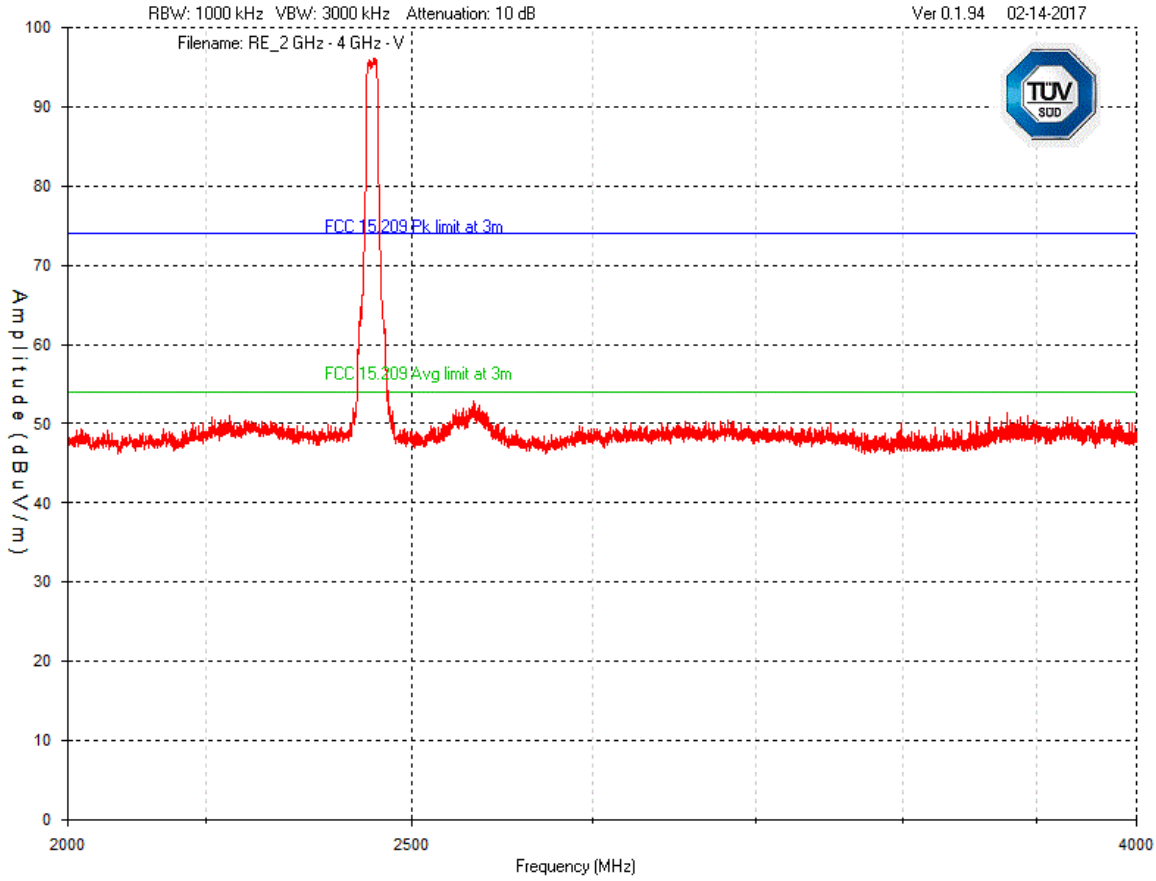
Mid Channel – 2 GHz – 4 GHz
Vertical - Peak Emission Graph



Note: See Final Measurements and Results section starting on page 72 for measurements.

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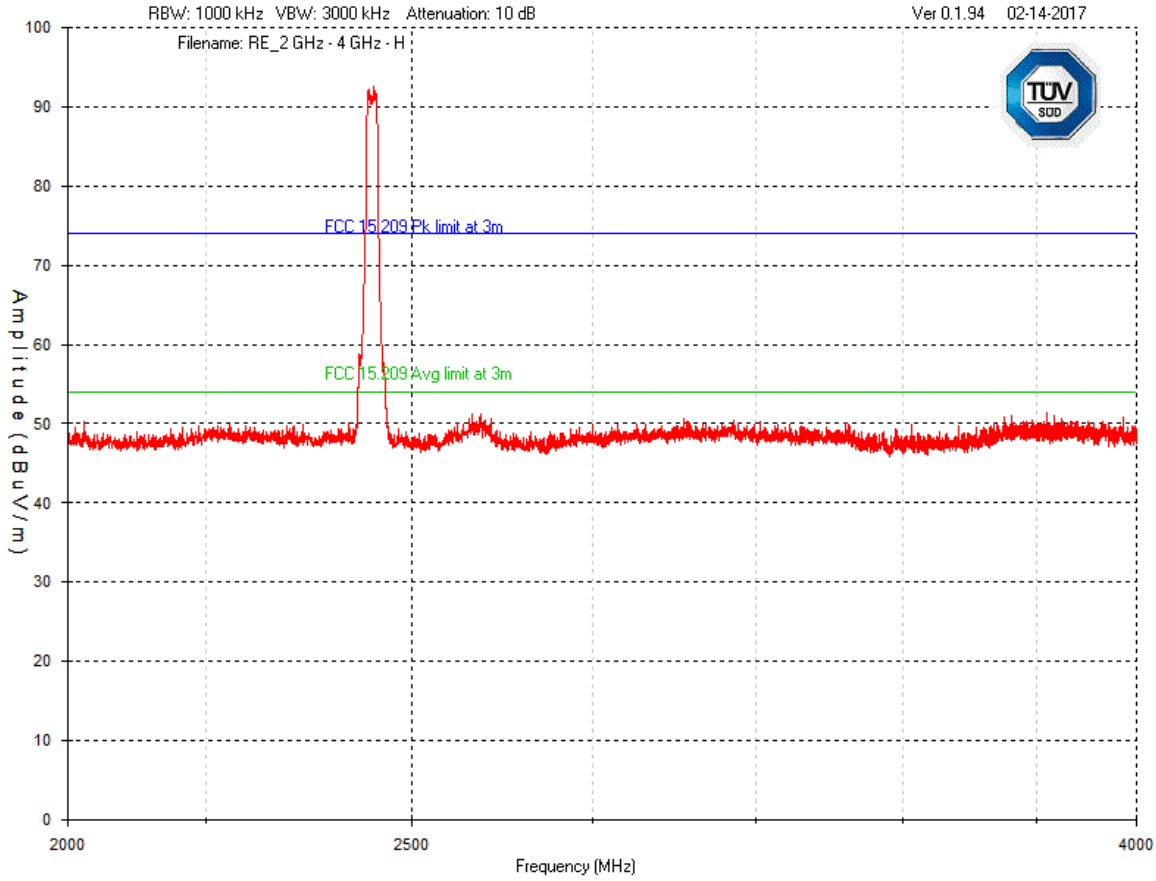
Mid Channel – 2 GHz – 4 GHz
Horizontal - Peak Emission Graph



Note: See Final Measurements and Results section starting on page 72 for measurements.

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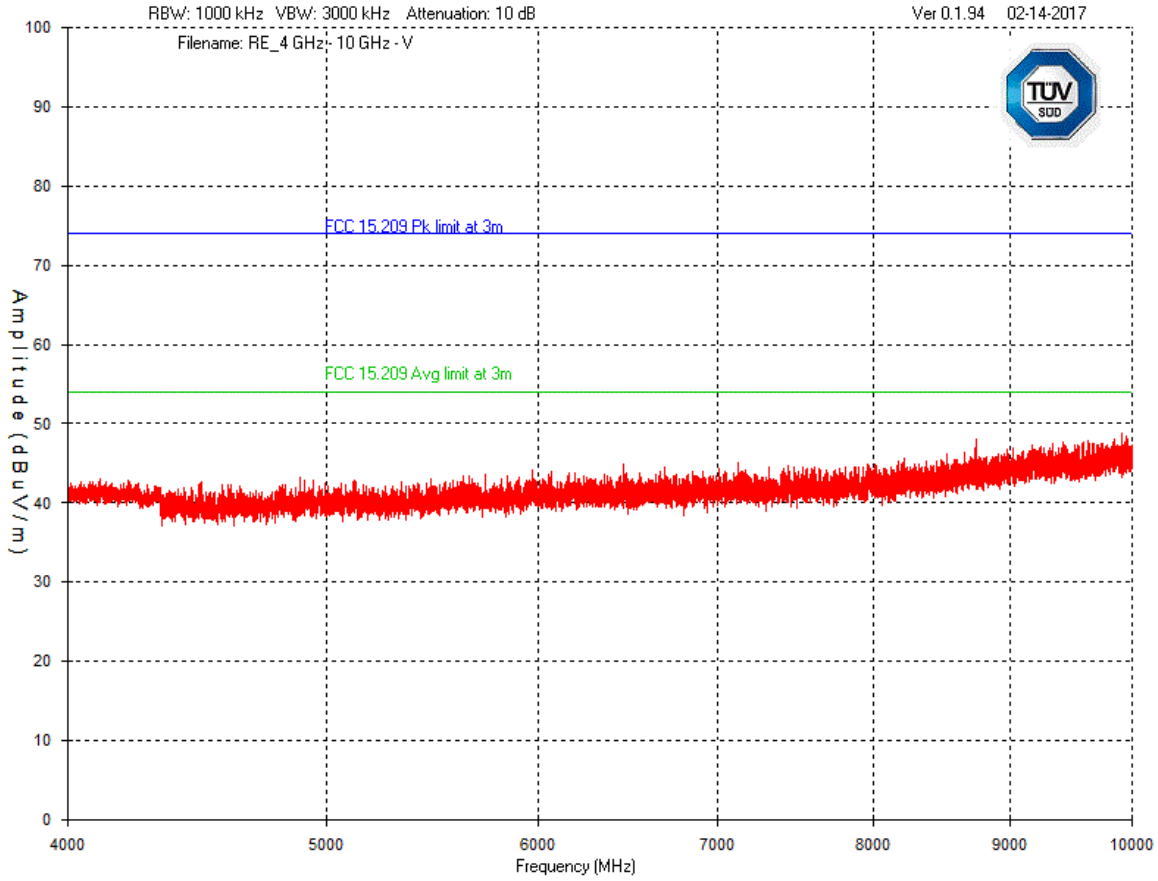
Mid Channel – 4 GHz – 10 GHz
Vertical - Peak Emission Graph



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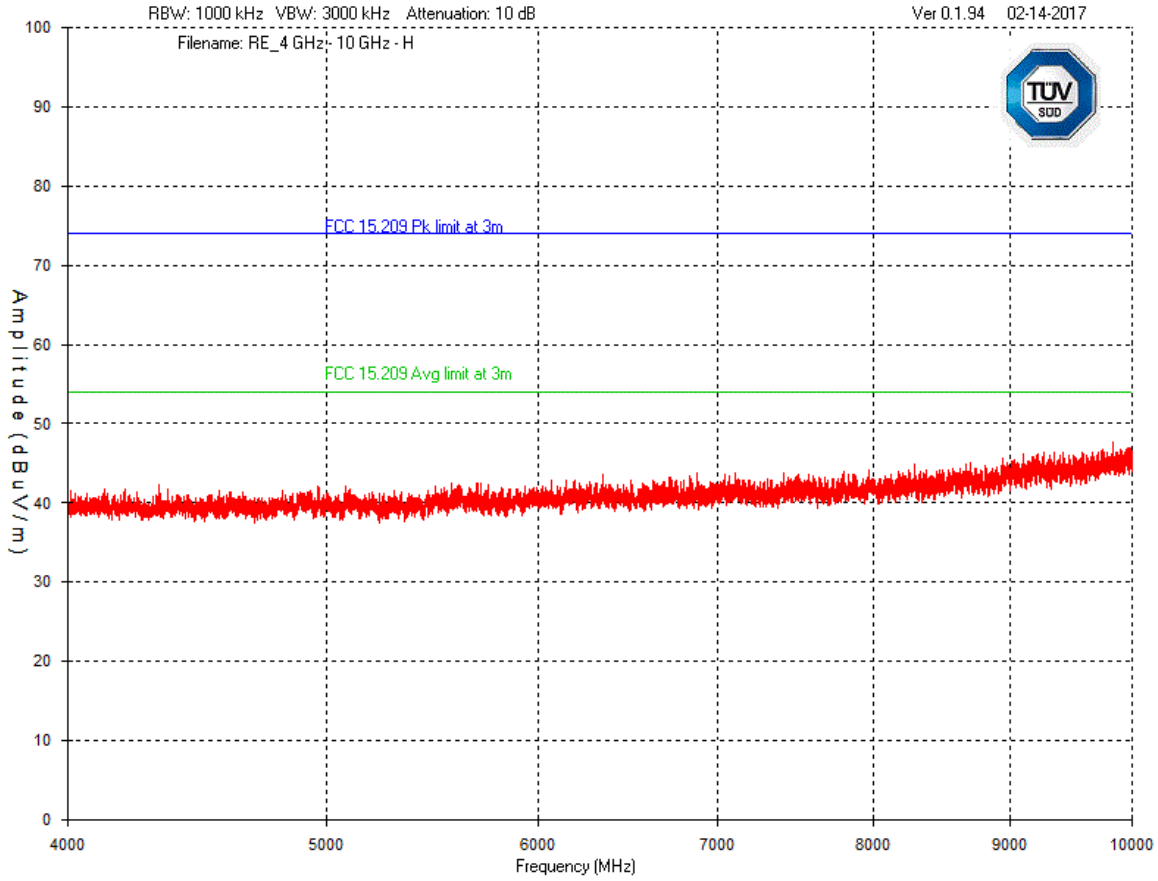
Mid Channel – 4 GHz – 10 GHz
Horizontal - Peak Emission Graph



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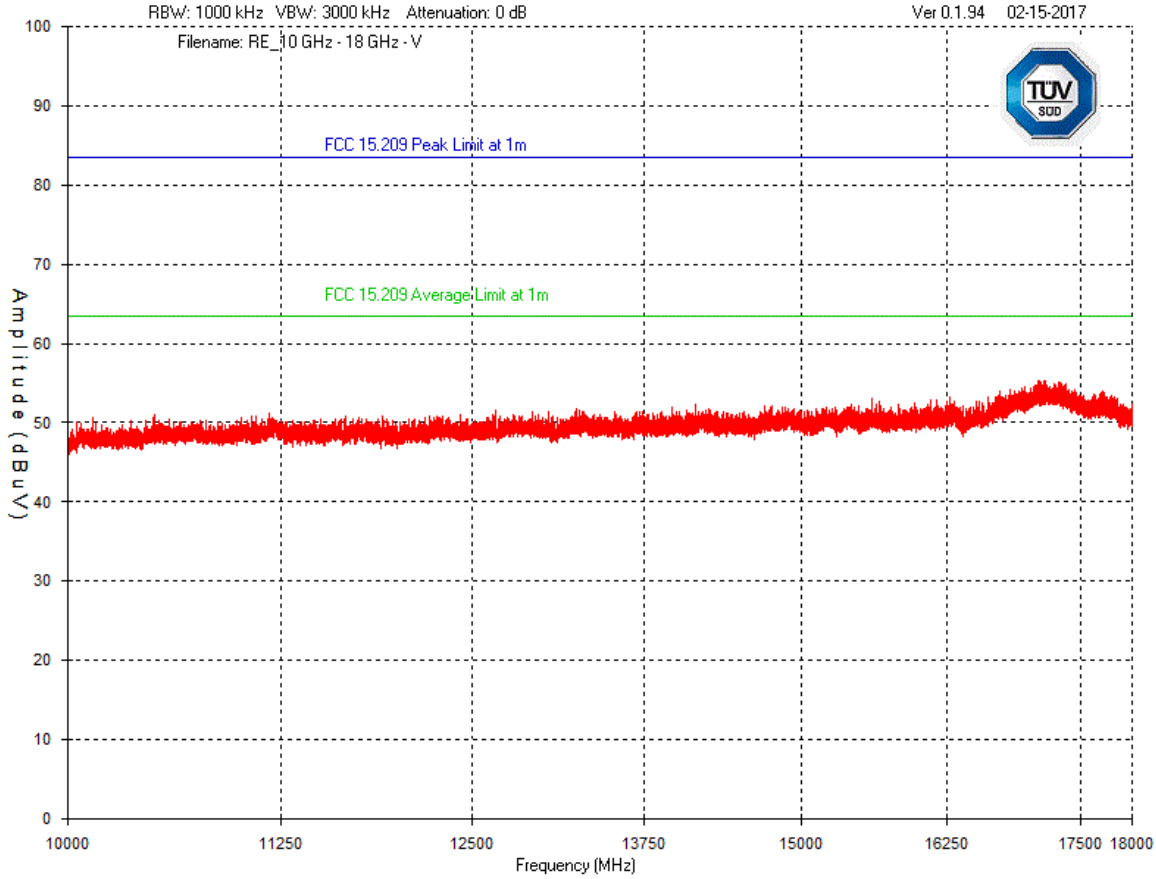
Mid Channel – 10 GHz – 18 GHz
Vertical - Peak Emission Graph



Note: See Final Measurements and Results section starting on page 72 for measurements.

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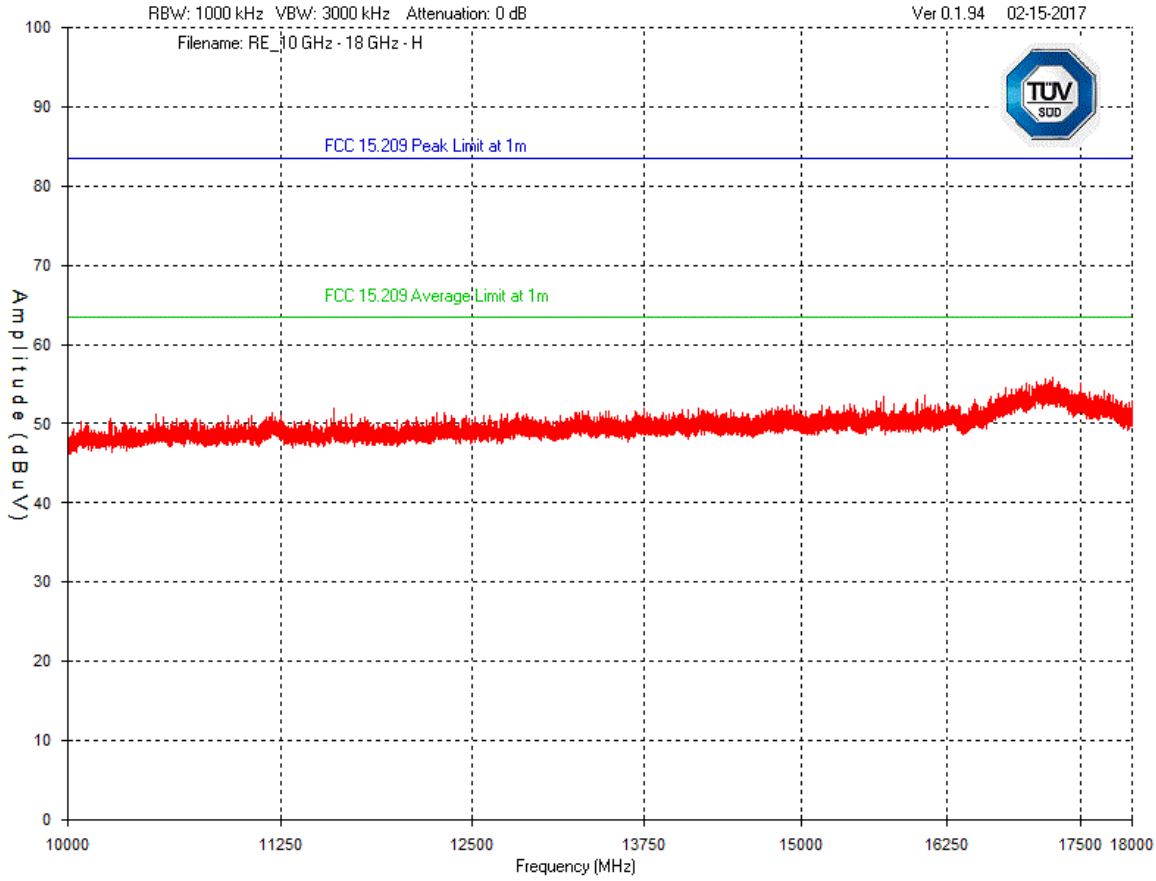
Mid Channel – 10 GHz – 18 GHz
Horizontal - Peak Emission Graph



Note: See Final Measurements and Results section starting on page 72 for measurements.

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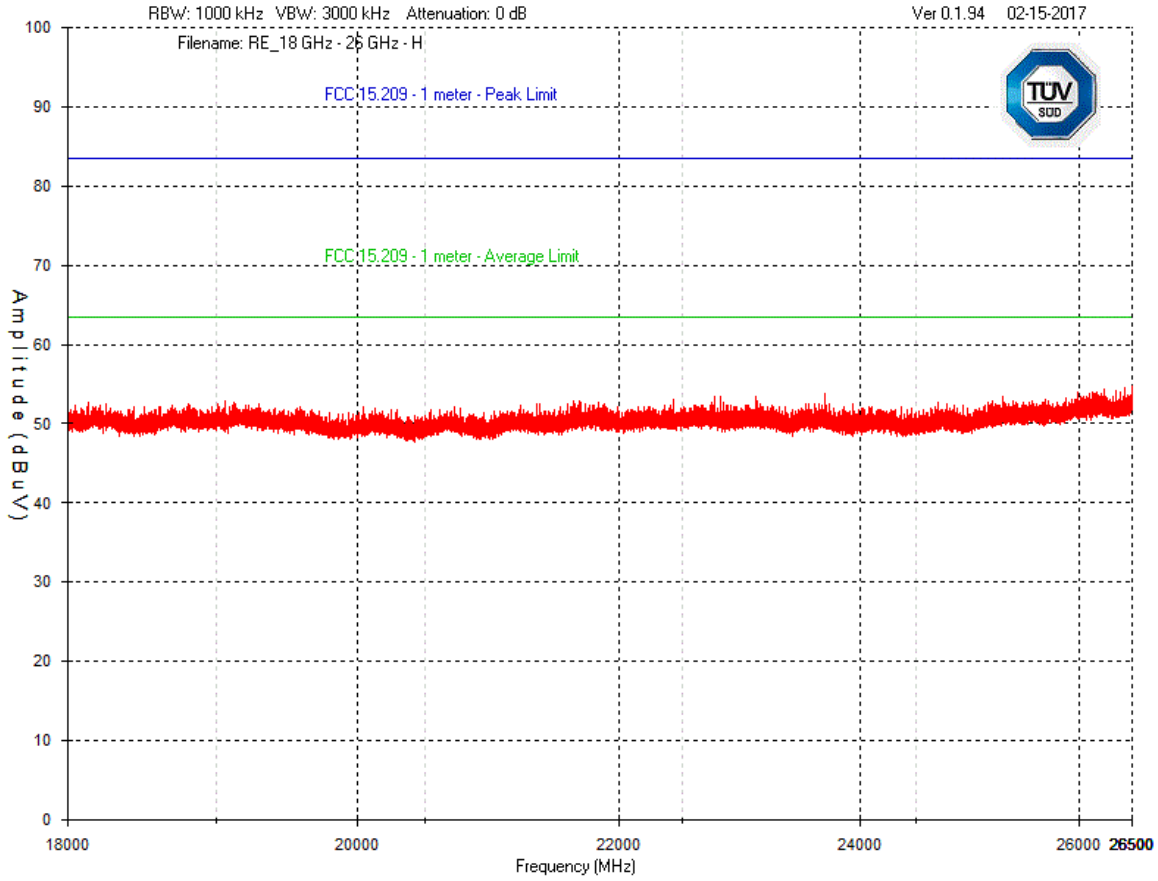
Mid Channel – 18 GHz – 26 GHz
Horizontal - Peak Emission Graph



Plot was taken at 1 meter distances. All emissions shown were instrument noise floor of measurement instrument. No emissions were found in this frequency range.

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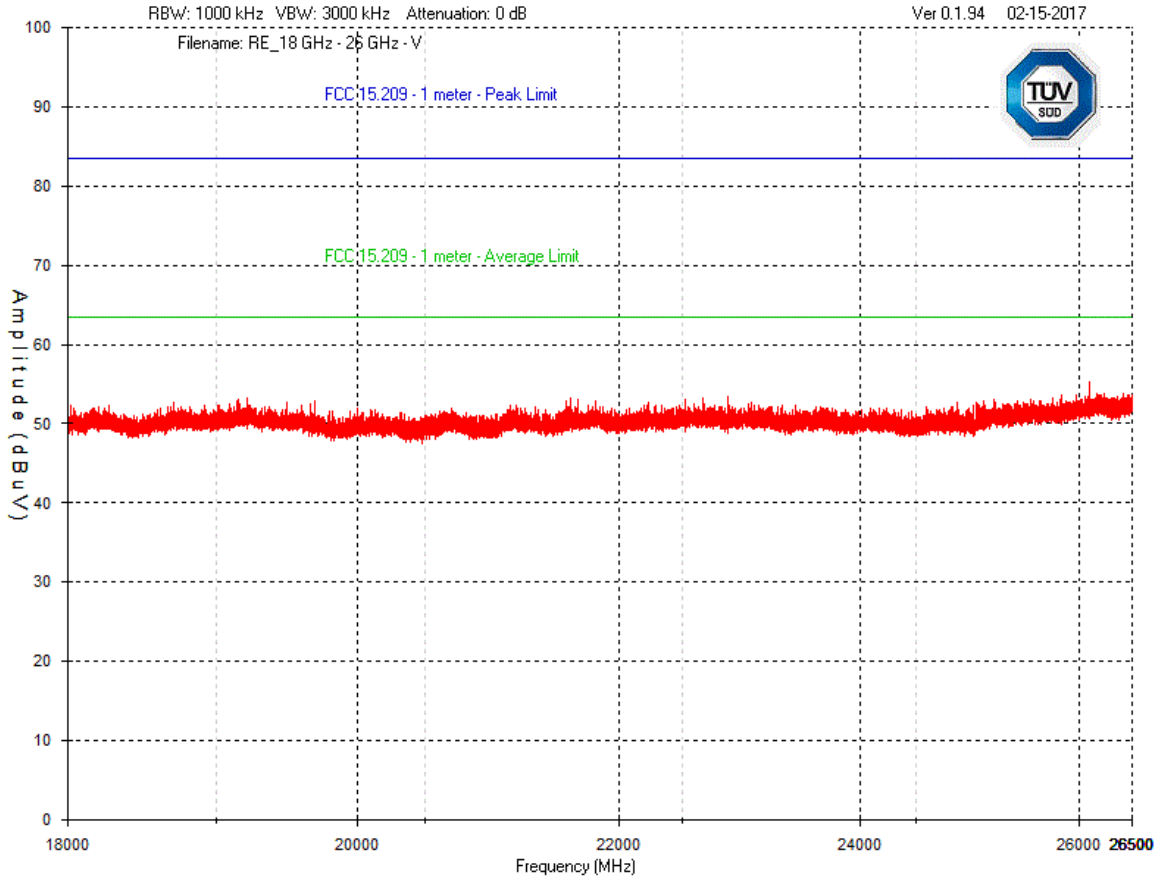
Mid Channel – 18 GHz – 26 GHz
Vertical - Peak Emission Graph



Plot was taken at 1 meter distances. All emissions shown were instrument noise floor of measurement instrument. No emissions were found in this frequency range.

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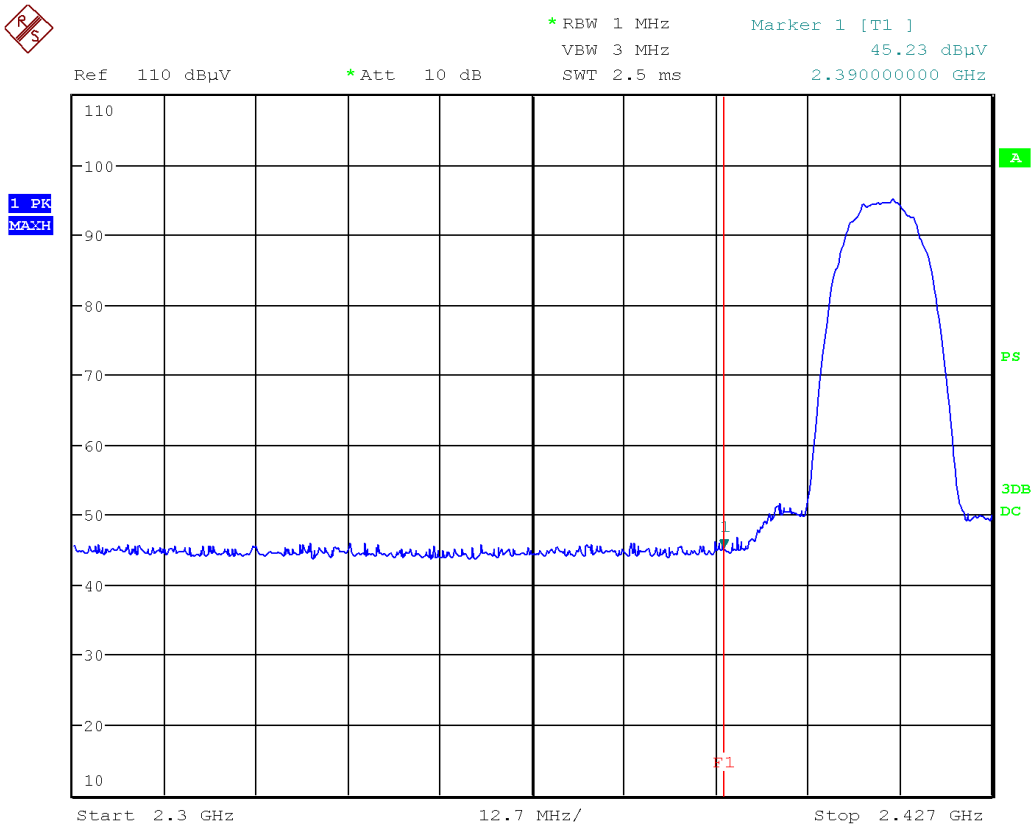
Band edge measurements – B-Mode

Band Edge – Low Channel
Vertical - Peak Emission



Date: 16.FEB.2017 10:33:19

Note: Band edge plots were taken with 3 m measurements distance. The marker shows the raw value; see Final Measurements and Results section starting on page 72 for corrected values.

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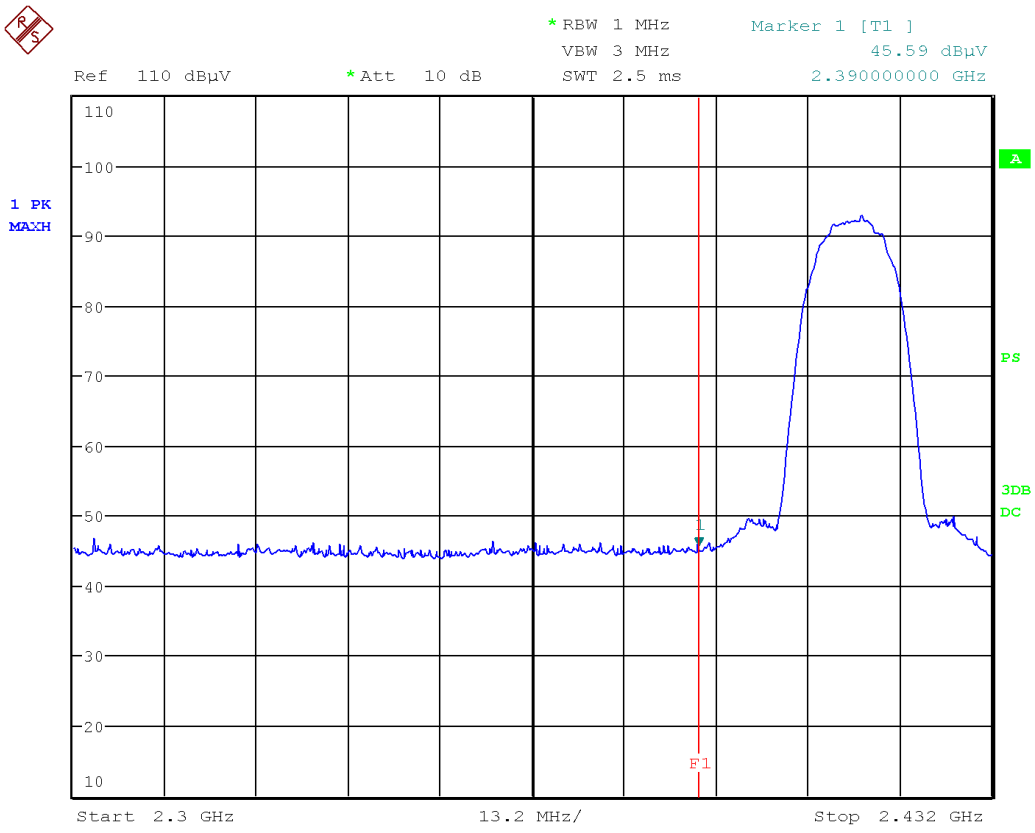
Band Edge – Low Channel
Horizontal - Peak Emission



Date: 16.FEB.2017 10:56:56

Note: Band edge plots were taken with 3 m measurements distance. The marker shows the raw value; see Final Measurements and Results section starting on page 72for corrected values.

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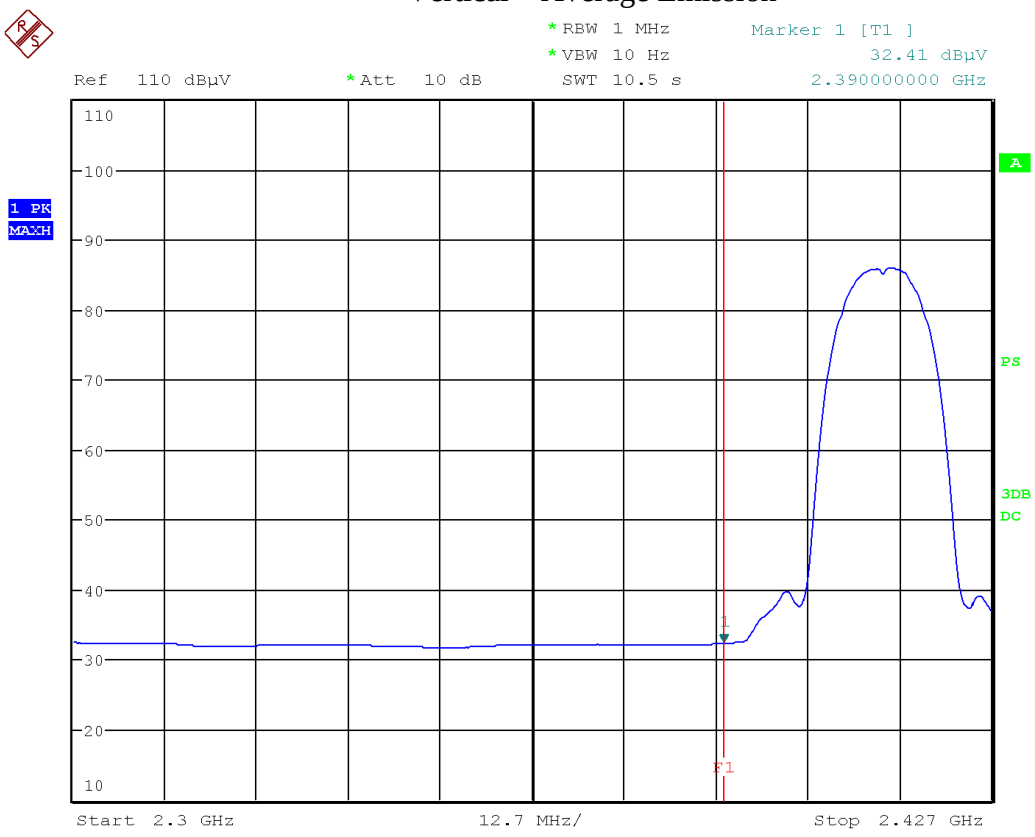
Band Edge – Low Channel
Vertical – Average Emission



Date: 16.FEB.2017 10:32:08

Note: Band edge plots were taken with 3 m measurements distance. The marker shows the raw value; see Final Measurements and Results section starting on page 72 for corrected values.

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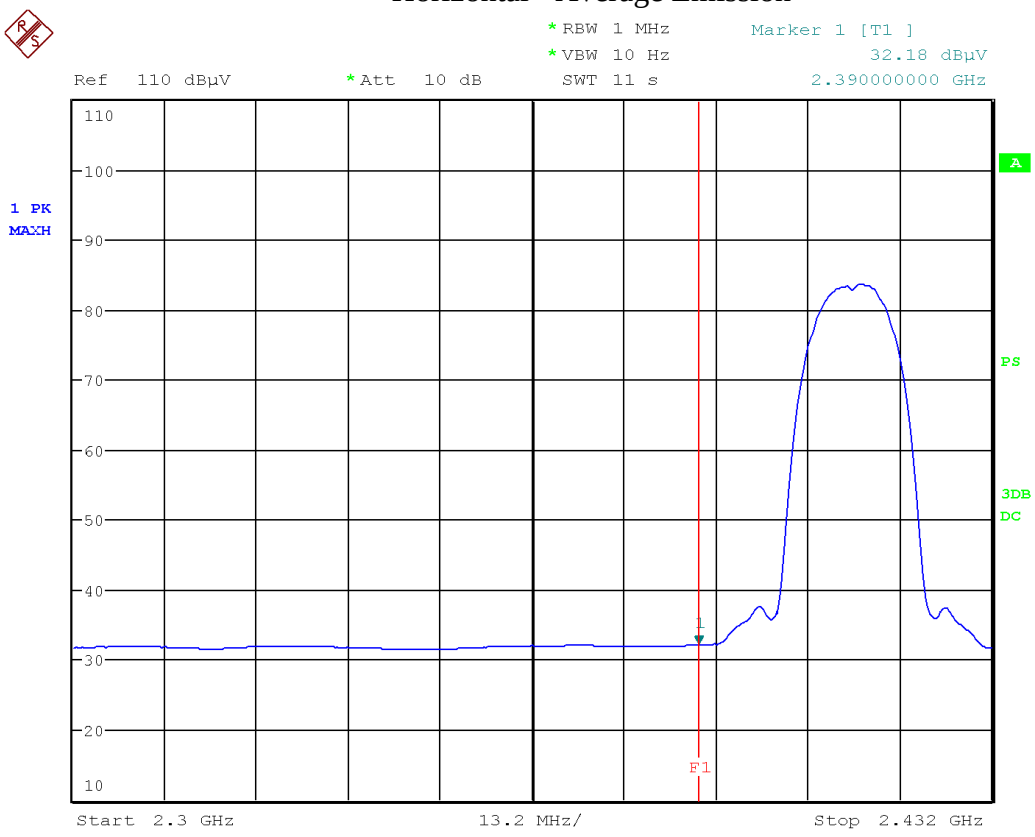
Band Edge – Low Channel
Horizontal - Average Emission



Date: 16.FEB.2017 10:54:08

Note: Band edge plots were taken with 3 m measurements distance. The marker shows the raw value; see Final Measurements and Results section starting on page 72 for corrected values.

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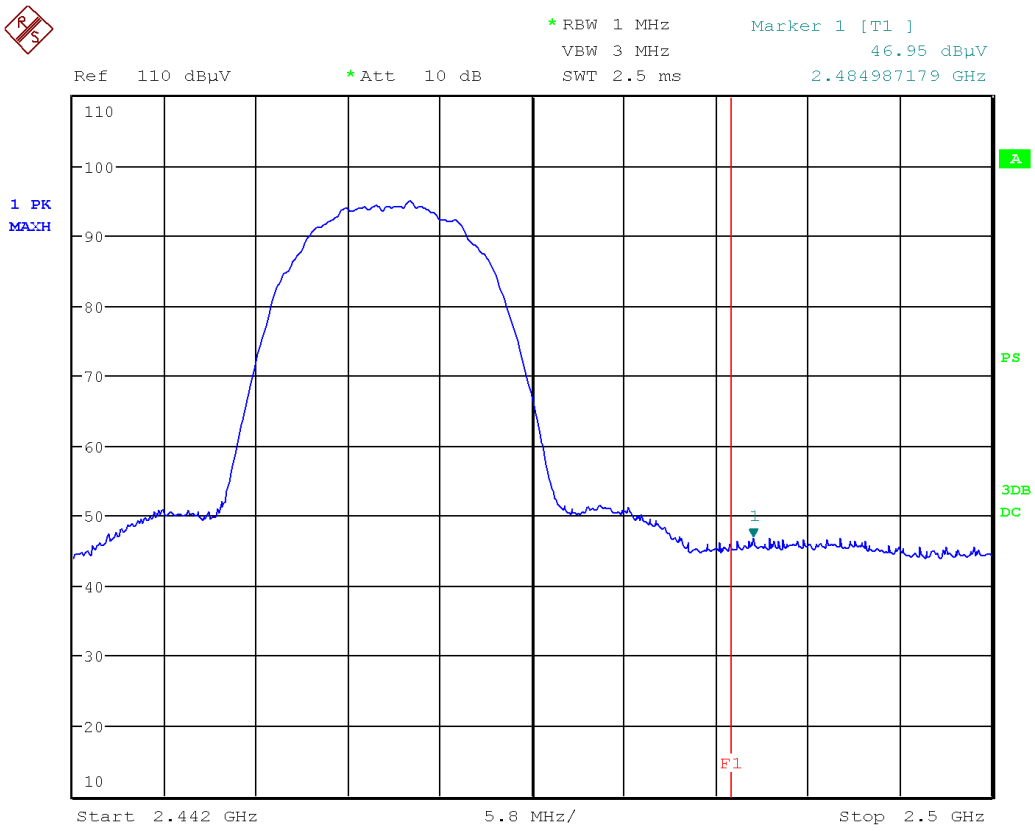
Band Edge – Hi Channel
Horizontal - Peak Emission



Date: 16.FEB.2017 11:22:22

Note: Band edge plots were taken with 3 m measurements distance. The marker shows the raw value; see Final Measurements and Results section starting on page 72 for corrected values.

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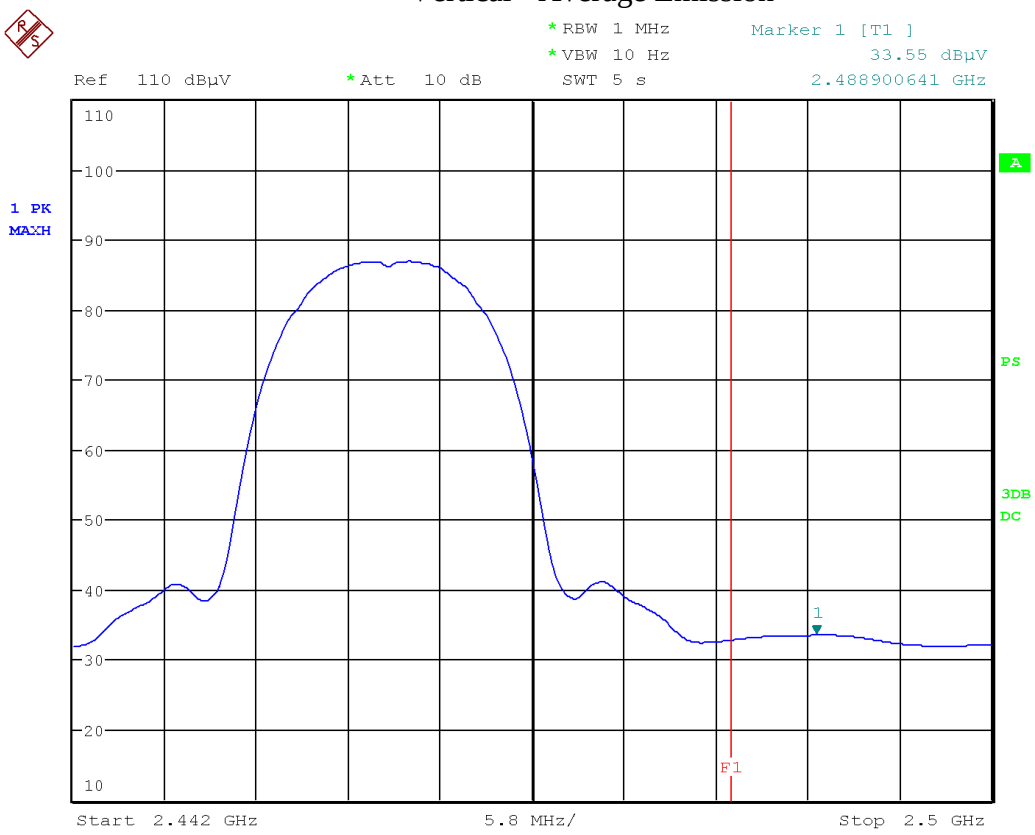
Band Edge – Hi Channel
Vertical - Average Emission



Date: 16.FEB.2017 11:30:11

Note: Band edge plots were taken with 3 m measurements distance. The marker shows the raw value; see Final Measurements and Results section starting on page 72 for corrected values.

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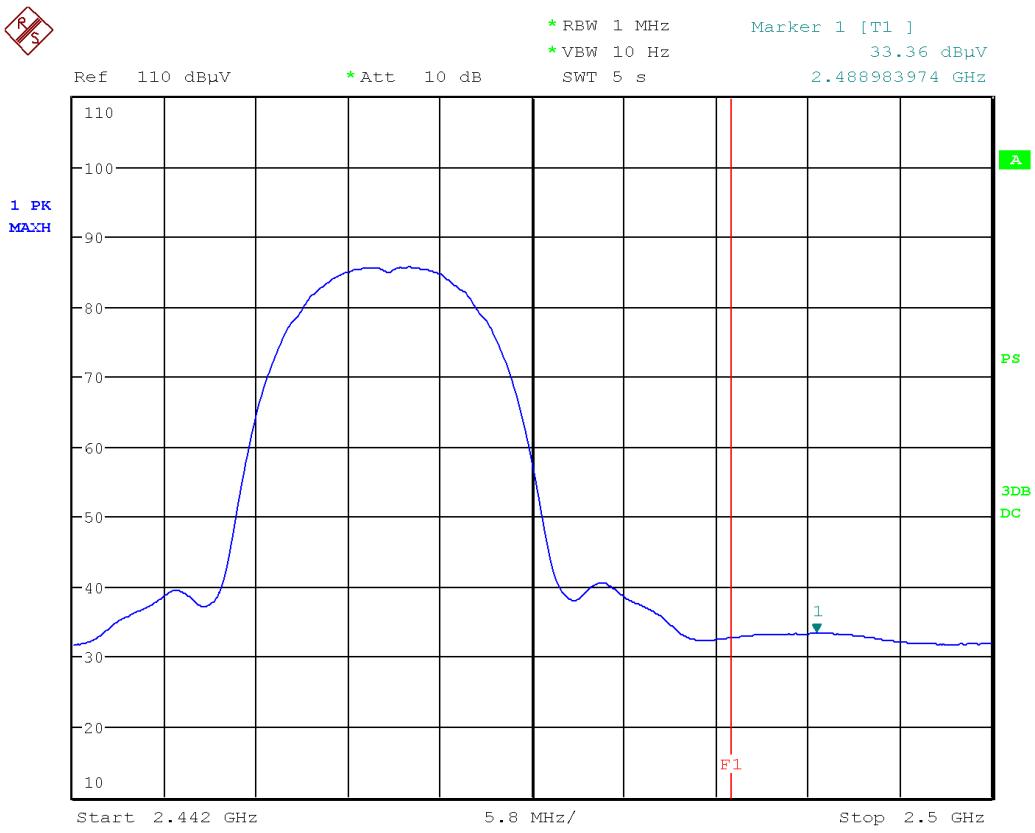
Band Edge – Hi Channel
Horizontal - Average Emission



Date: 16.FEB.2017 11:20:50

Note: Band edge plots were taken with 3 m measurements distance. The marker shows the raw value; see Final Measurements and Results section starting on page 72 for corrected values.

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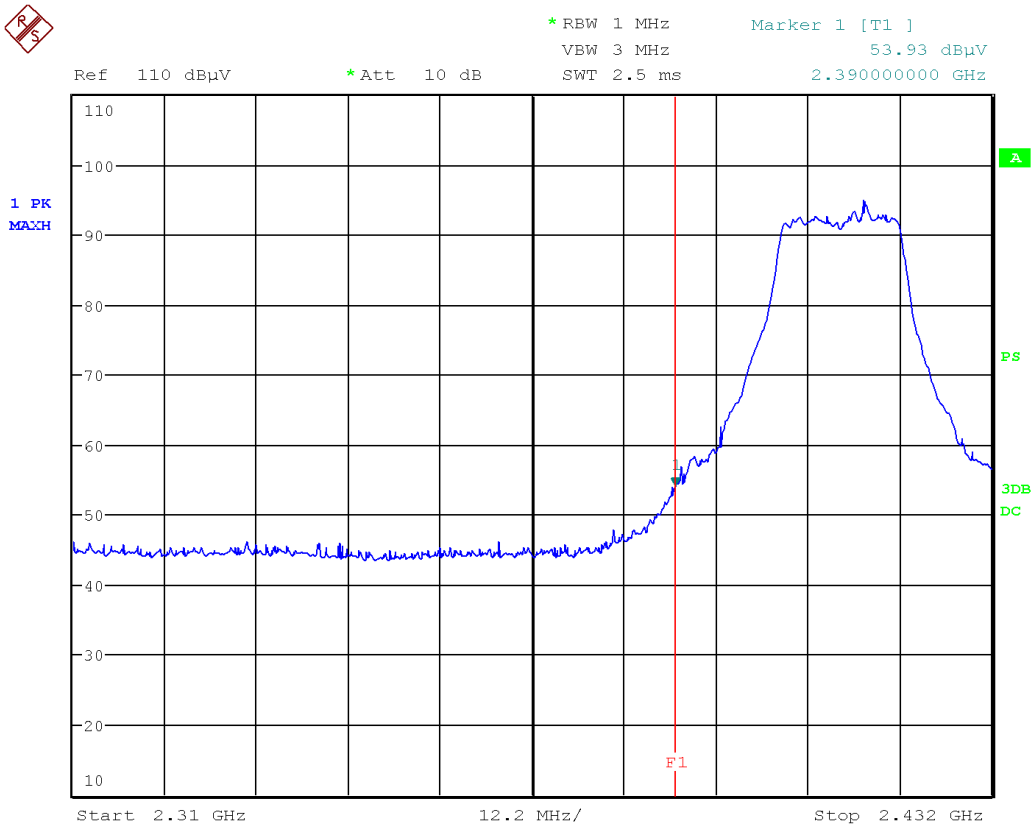
Band edge measurements – G-Mode

Band Edge – Low Channel
Vertical - Peak Emission



Date: 16.FEB.2017 15:02:57

Note: Band edge plots were taken with 3 m measurements distance. The marker shows the raw value; see Final Measurements and Results section starting on page 72 for corrected values.

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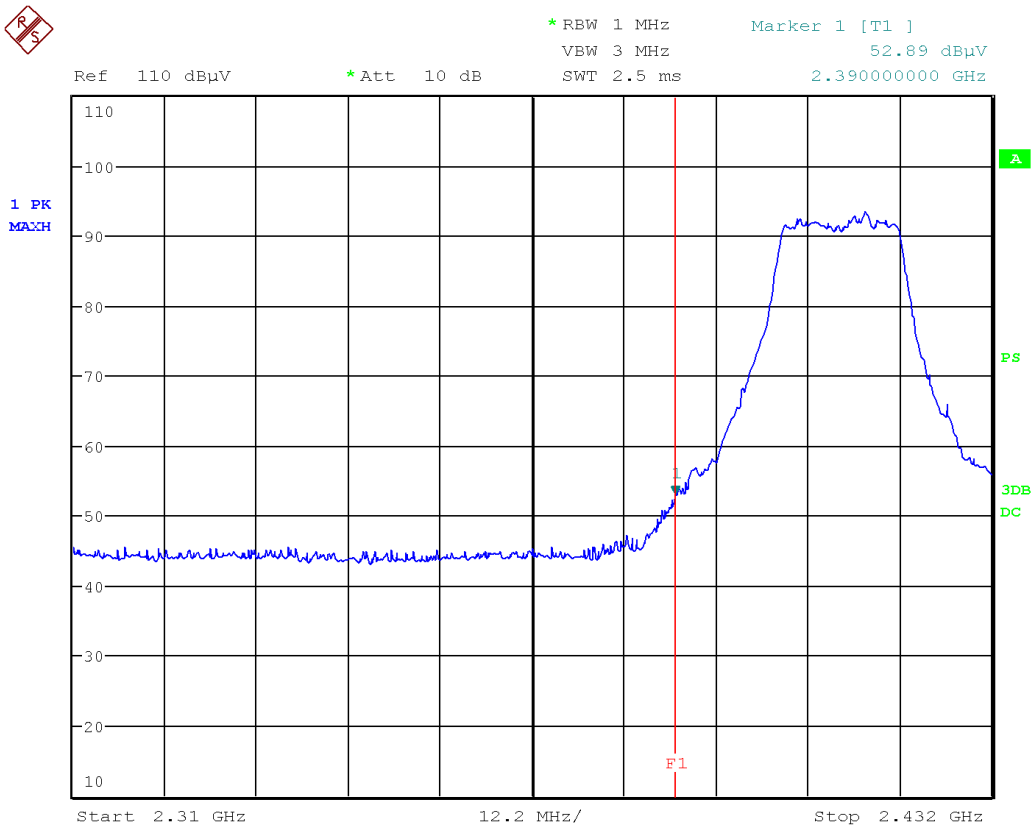
Band Edge – Low Channel
Horizontal - Peak Emission



Date: 16.FEB.2017 14:58:56

Note: Band edge plots were taken with 3 m measurements distance. The marker shows the raw value; see Final Measurements and Results section starting on page 72for corrected values.

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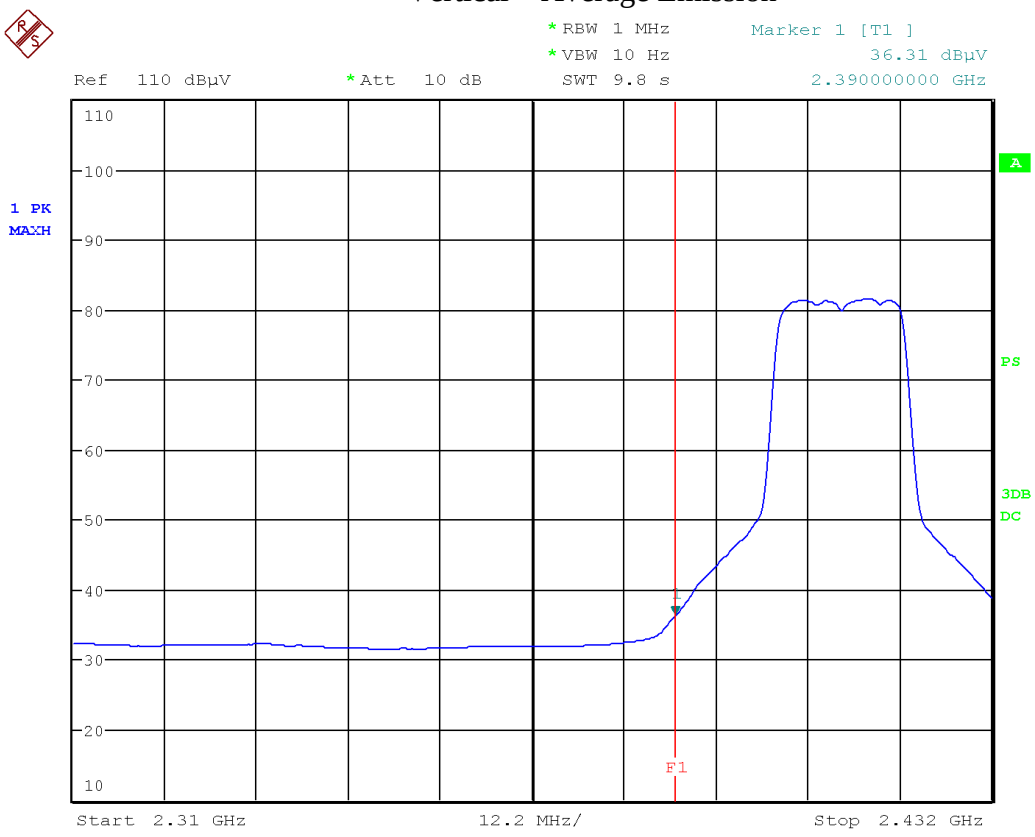
Band Edge – Low Channel
Vertical – Average Emission



Date: 16.FEB.2017 15:03:59

Note: Band edge plots were taken with 3 m measurements distance. The marker shows the raw value; see Final Measurements and Results section starting on page 72 for corrected values.

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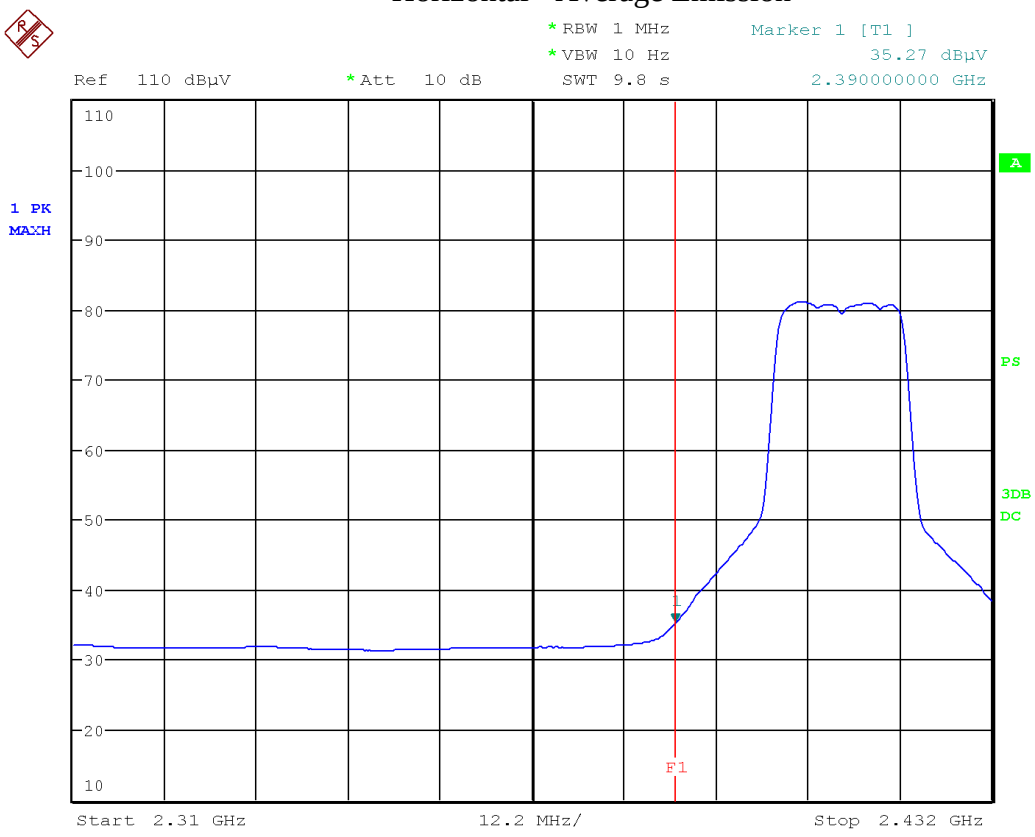
Band Edge – Low Channel
Horizontal - Average Emission



Date: 16.FEB.2017 14:58:05

Note: Band edge plots were taken with 3 m measurements distance. The marker shows the raw value; see Final Measurements and Results section starting on page 72 for corrected values.

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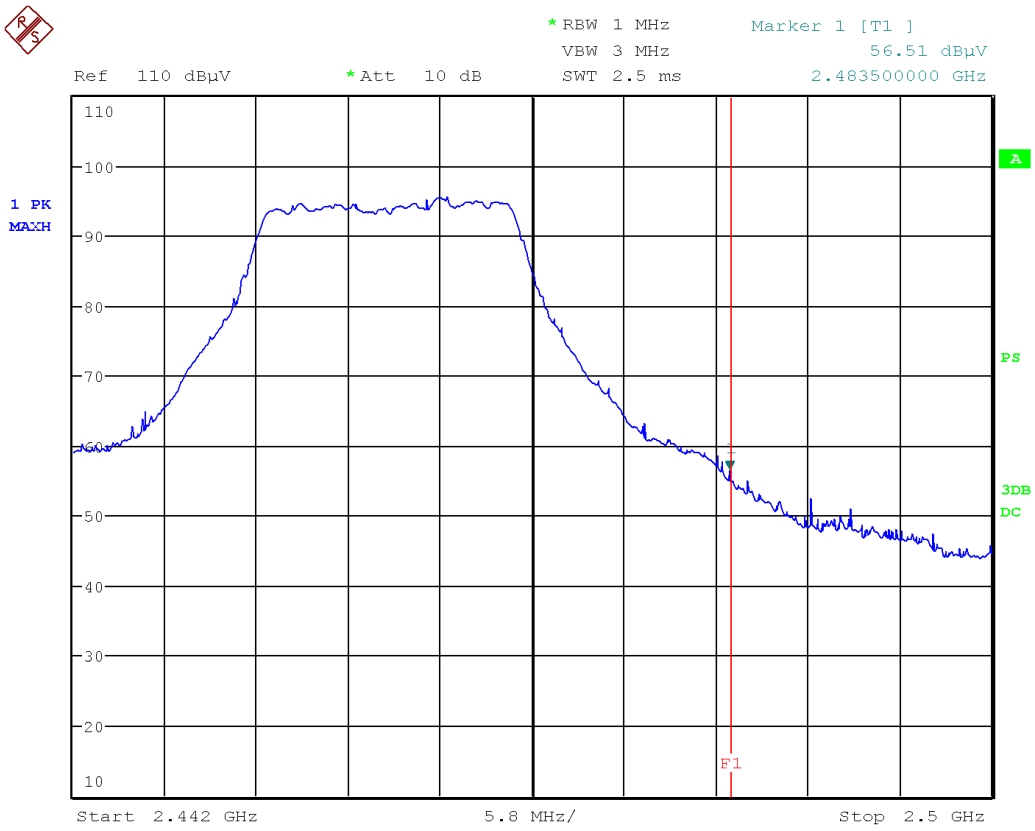
Band Edge – Hi Channel
Vertical - Peak Emission



Date: 16.FEB.2017 14:36:21

Note: Band edge plots were taken with 3 m measurements distance. The marker shows the raw value; see Final Measurements and Results section starting on page 72 for corrected values.

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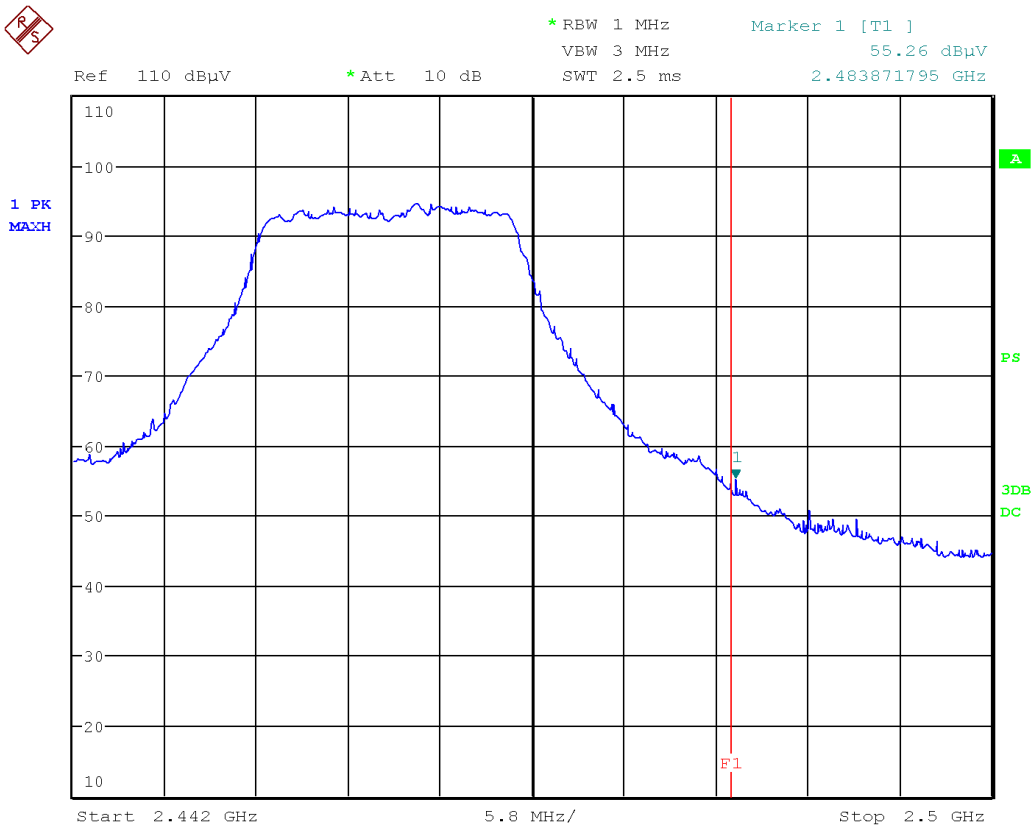
Band Edge – Hi Channel
Horizontal - Peak Emission



Date: 16.FEB.2017 14:29:56

Note: Band edge plots were taken with 3 m measurements distance. The marker shows the raw value; see Final Measurements and Results section starting on page 72 for corrected values.

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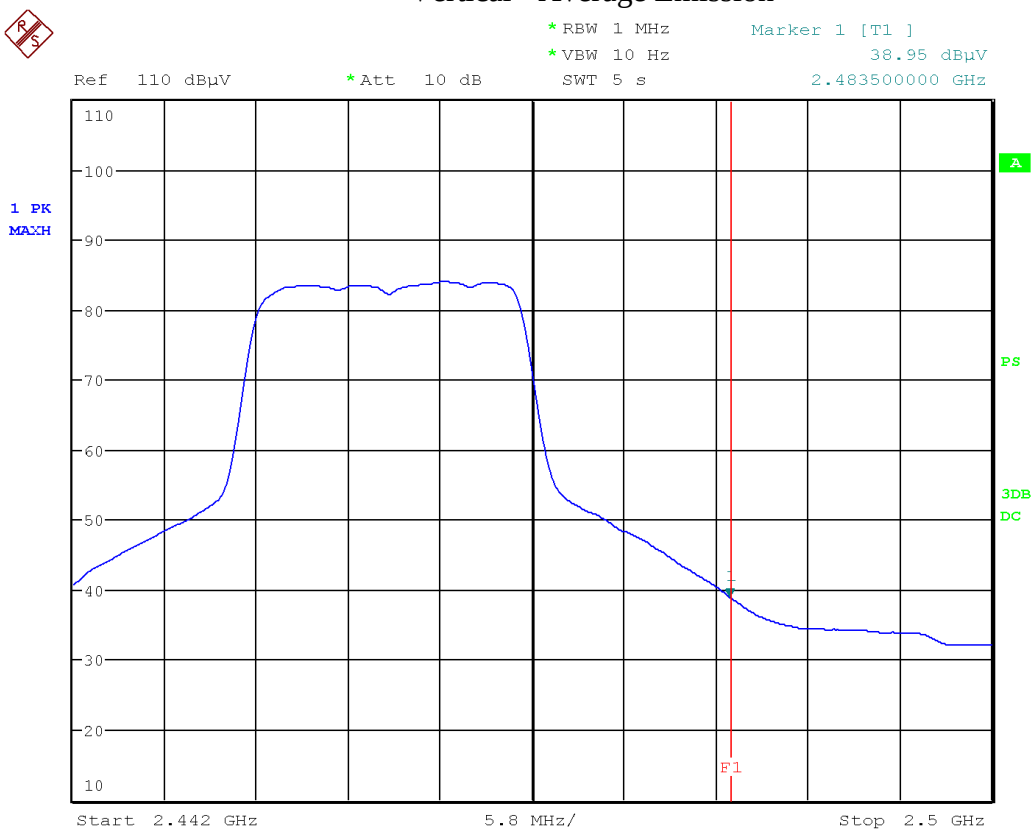
Band Edge – Hi Channel
Vertical - Average Emission



Date: 16.FEB.2017 14:35:20

Note: Band edge plots were taken with 3 m measurements distance. The marker shows the raw value; see Final Measurements and Results section starting on page 72 for corrected values.

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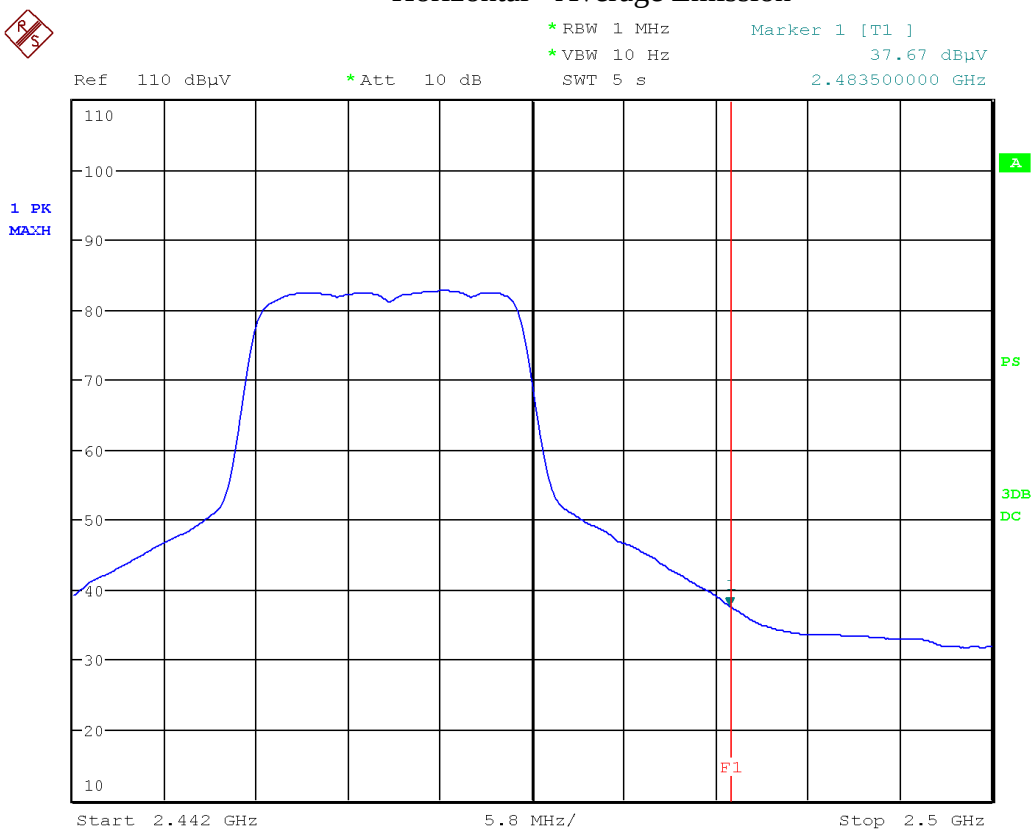
Band Edge – Hi Channel
Horizontal - Average Emission



Date: 16.FEB.2017 14:28:19

Note: Band edge plots were taken with 3 m measurements distance. The marker shows the raw value; see Final Measurements and Results section starting on page 72 for corrected values.

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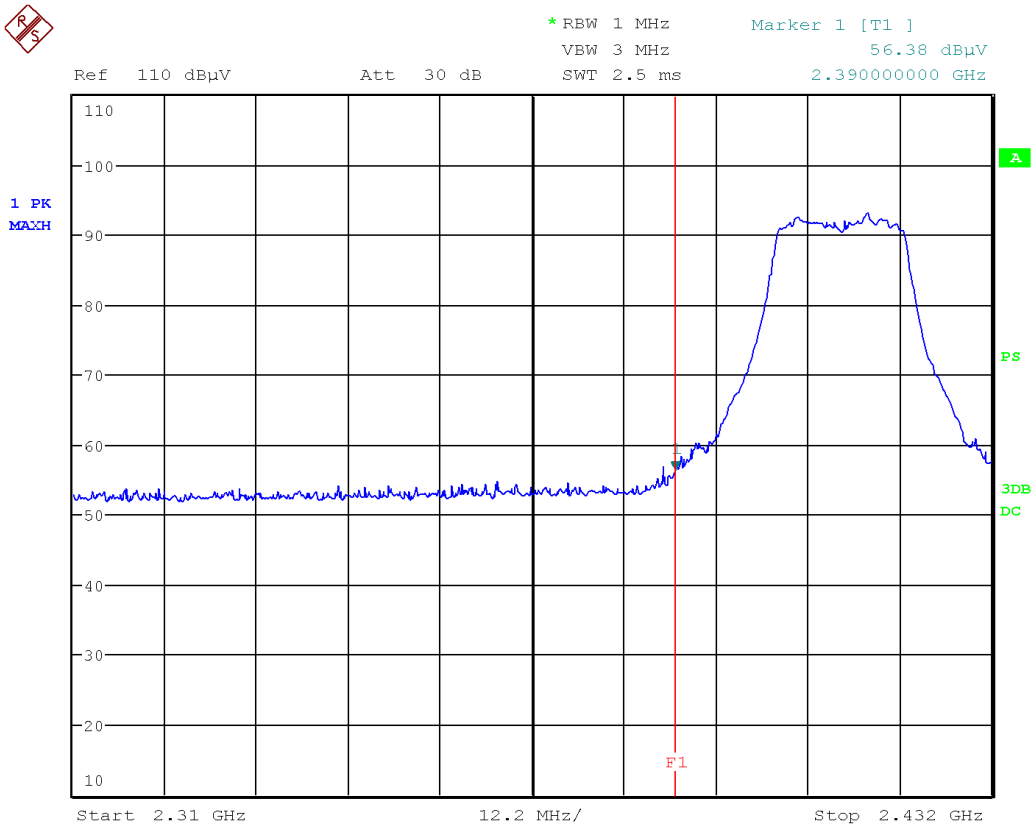
Band edge measurements – N-Mode

Band Edge – Low Channel
Vertical - Peak Emission



Date: 16.FEB.2017 16:57:16

Note: Band edge plots were taken with 3 m measurements distance. The marker shows the raw value; see Final Measurements and Results section starting on page 72 for corrected values.

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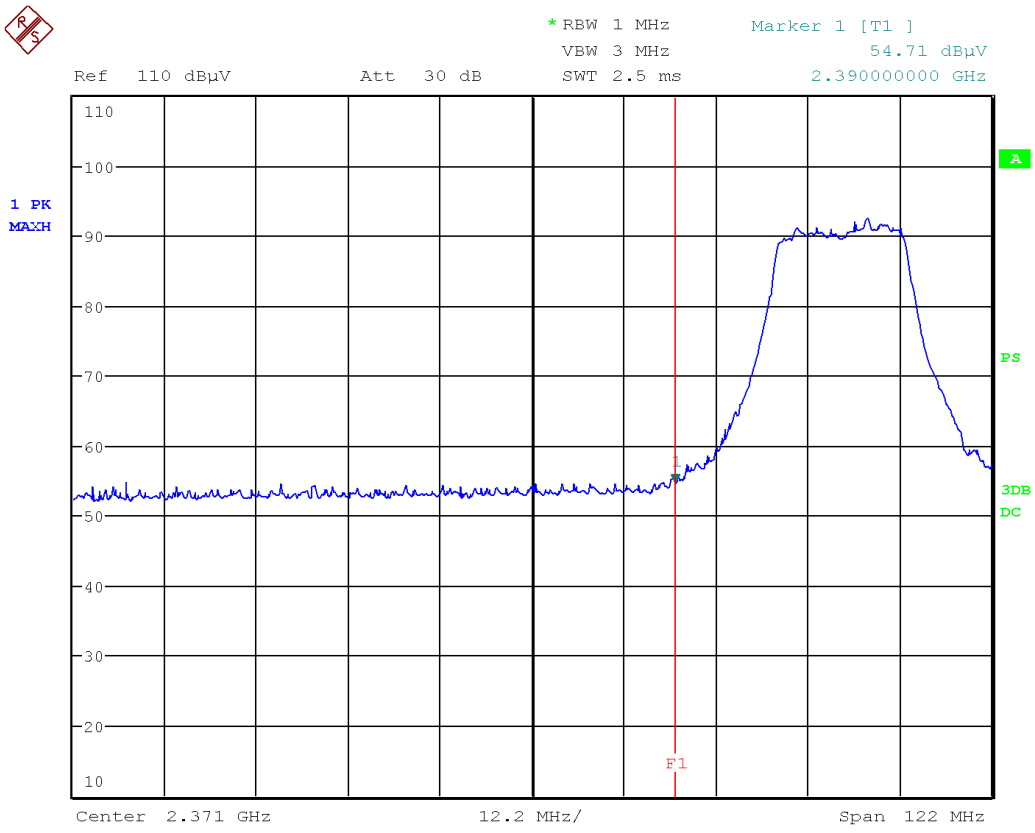
Band Edge – Low Channel
Horizontal - Peak Emission



Date: 16.FEB.2017 16:59:19

Note: Band edge plots were taken with 3 m measurements distance. The marker shows the raw value; see Final Measurements and Results section starting on page 72for corrected values.

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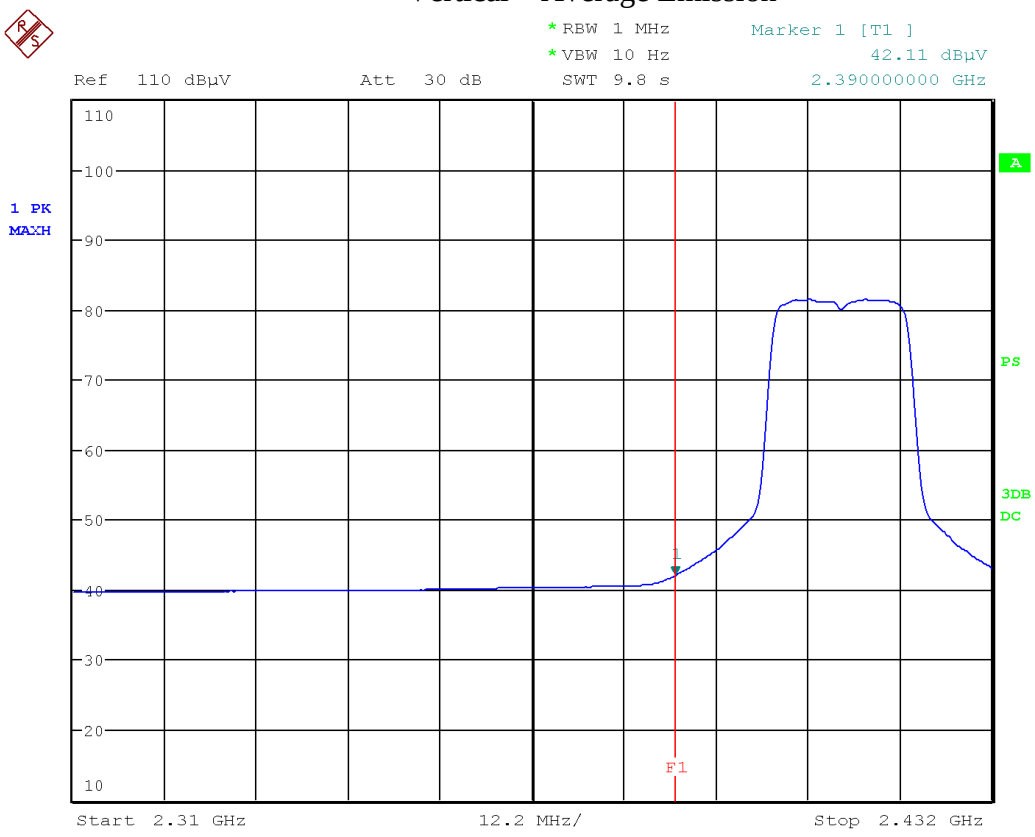
Band Edge – Low Channel
Vertical – Average Emission



Date: 16.FEB.2017 16:56:33

Note: Band edge plots were taken with 3 m measurements distance. The marker shows the raw value; see Final Measurements and Results section starting on page 72 for corrected values.

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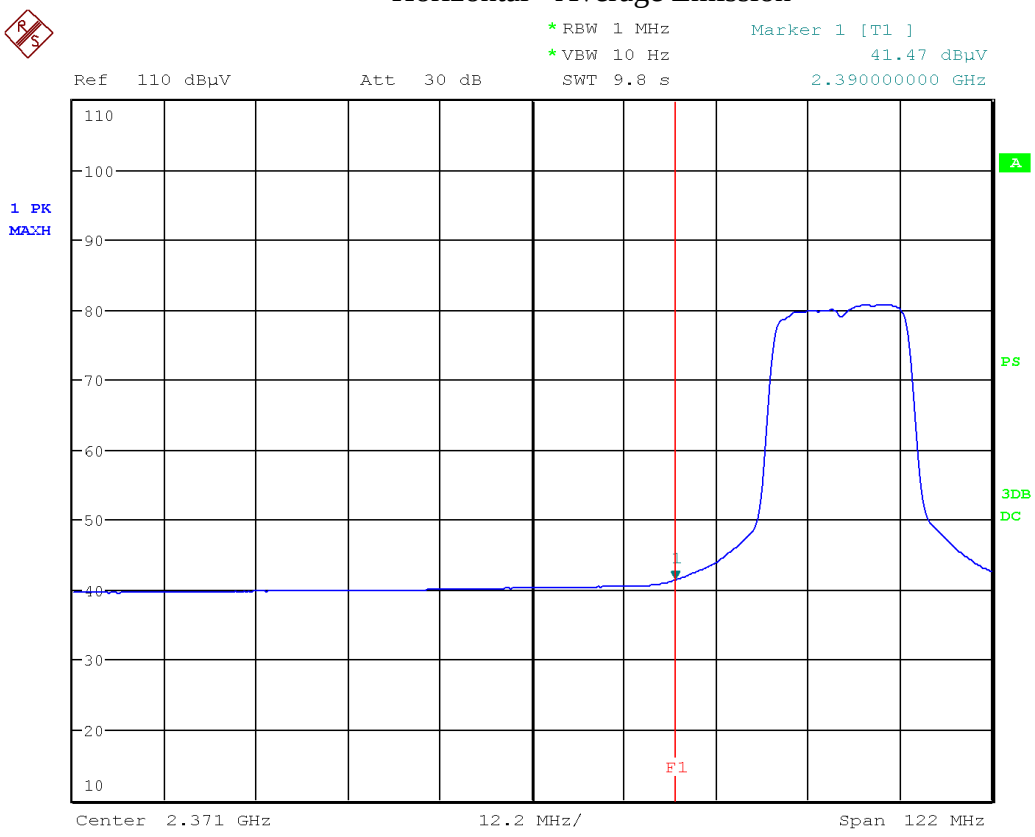
Band Edge – Low Channel
Horizontal - Average Emission



Date: 16.FEB.2017 17:00:10

Note: Band edge plots were taken with 3 m measurements distance. The marker shows the raw value; see Final Measurements and Results section starting on page 72 for corrected values.

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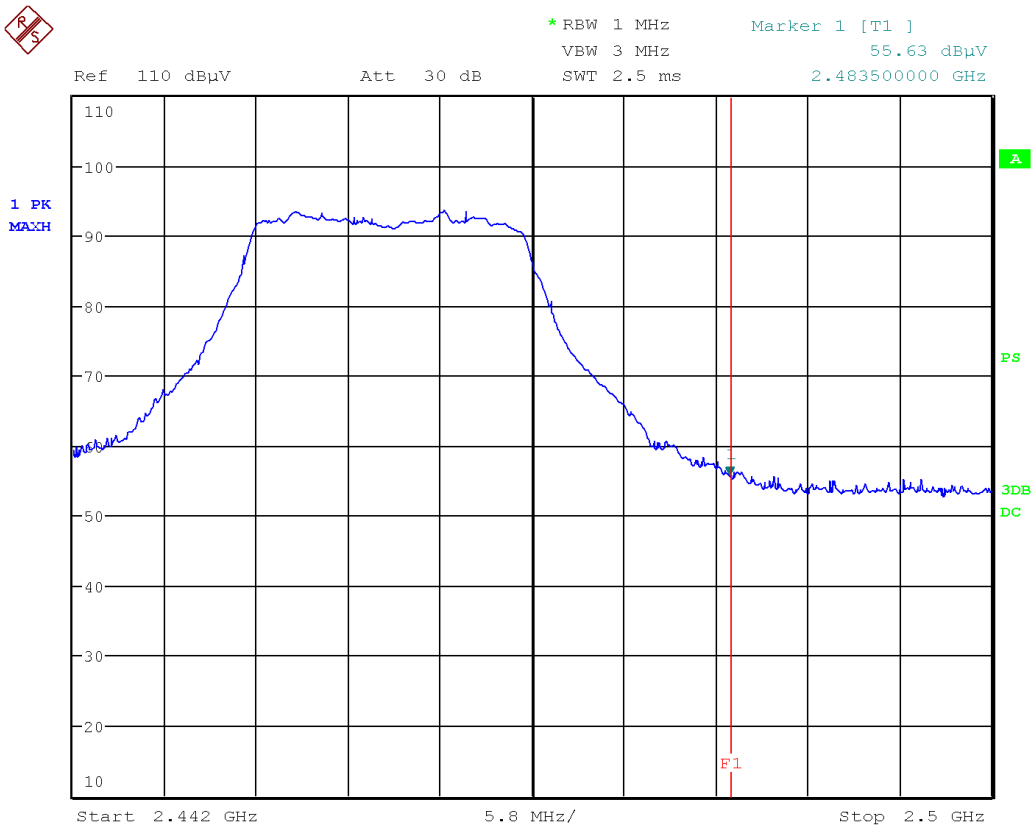
Band Edge – Hi Channel
Vertical - Peak Emission



Date: 16.FEB.2017 17:11:00

Note: Band edge plots were taken with 3 m measurements distance. The marker shows the raw value; see Final Measurements and Results section starting on page 72 for corrected values.

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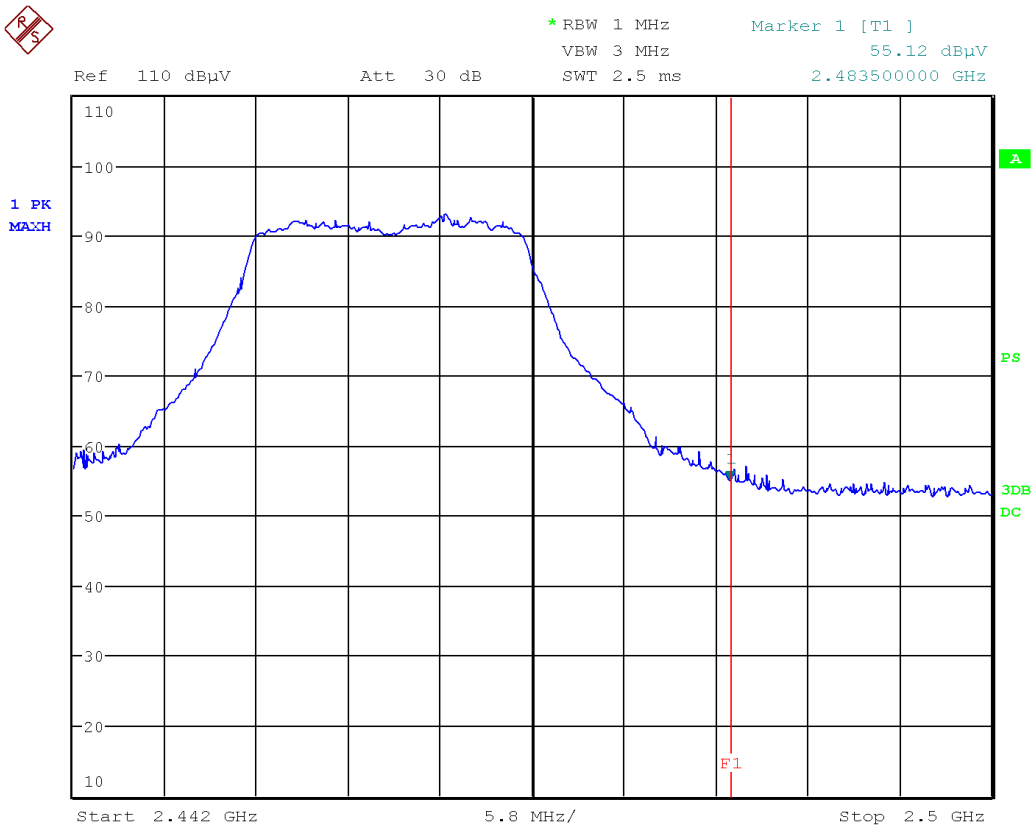
Band Edge – Hi Channel
Horizontal - Peak Emission



Date: 16.FEB.2017 17:06:43

Note: Band edge plots were taken with 3 m measurements distance. The marker shows the raw value; see Final Measurements and Results section starting on page 72 for corrected values.

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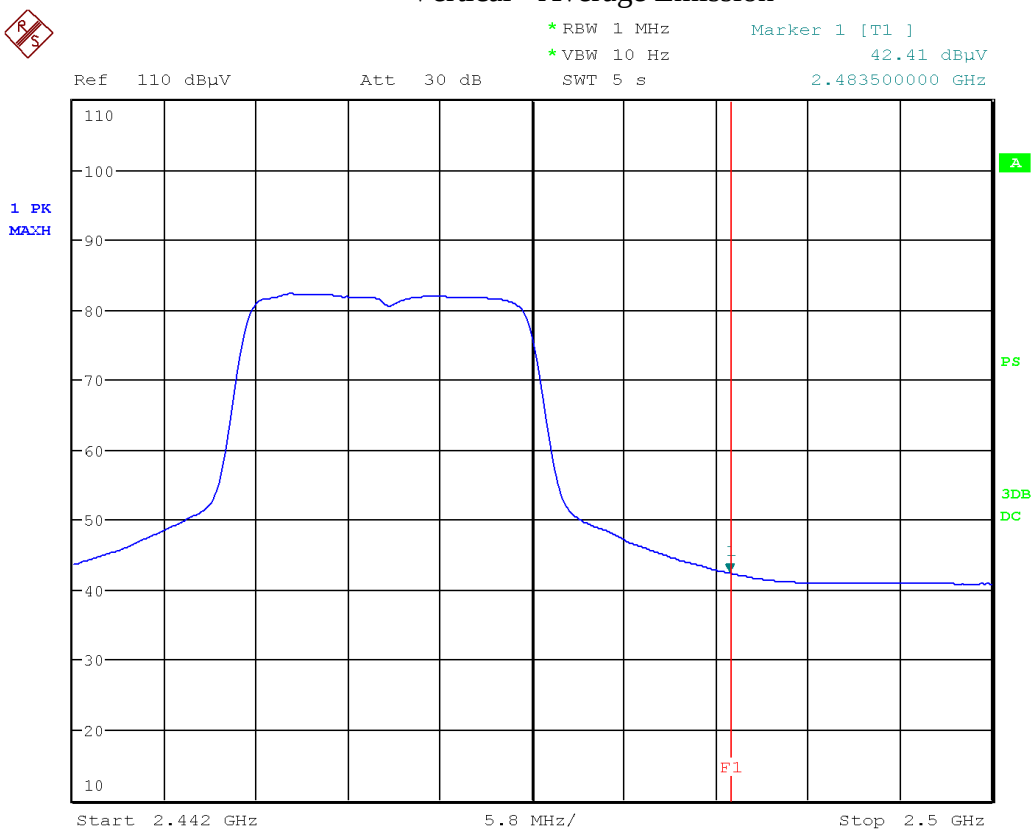
Band Edge – Hi Channel
Vertical - Average Emission



Date: 16.FEB.2017 17:10:18

Note: Band edge plots were taken with 3 m measurements distance. The marker shows the raw value; see Final Measurements and Results section starting on page 72 for corrected values.

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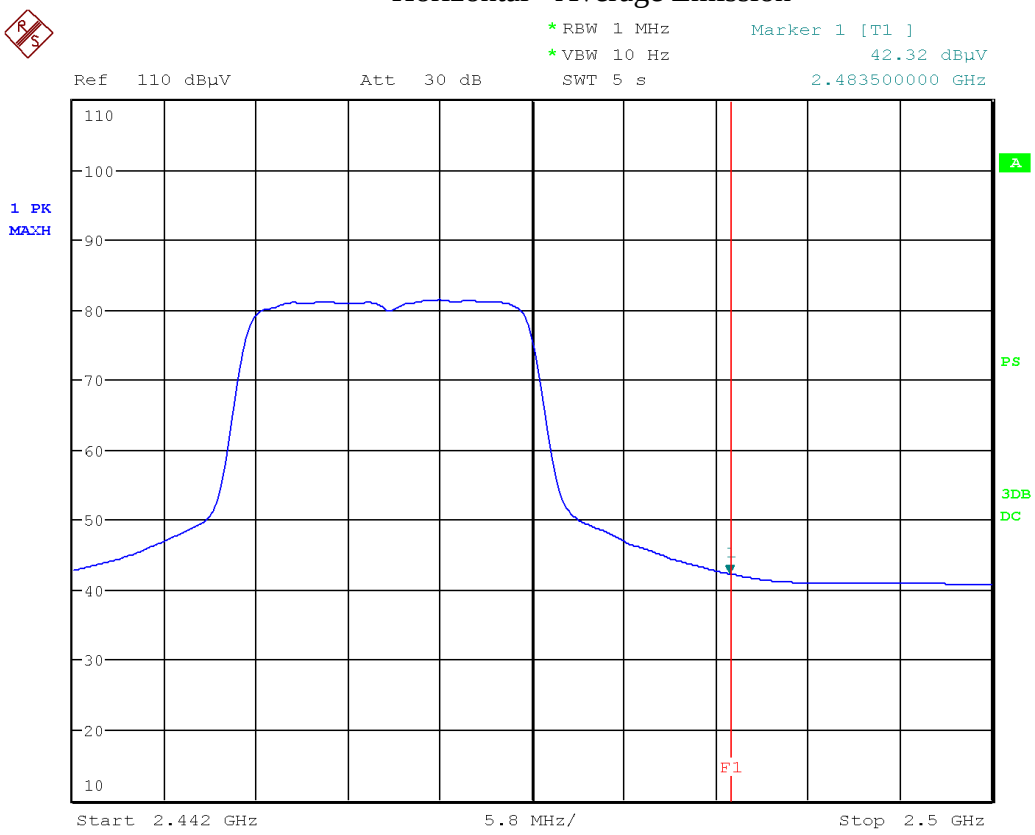
Band Edge – Hi Channel
Horizontal - Average Emission



Date: 16.FEB.2017 17:06:14

Note: Band edge plots were taken with 3 m measurements distance. The marker shows the raw value; see Final Measurements and Results section starting on page 72 for corrected values.

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Final Measurements and Results

The EUT passed the limits. Low, middle and high bands were measured.

In accordance with 15.247(d), only frequencies exceeding the 15.209 limit that occur within the bands listed in 15.205, need to be verified with a final detector. Emission outside the restricted bands were measured for information purpose.

The measurements were maximized by rotating the turn table over a full 0-360 rotation and the antenna height was varied from 1 m to 4 m.

Product Category	Class B						
Product	ECB401						
Supply	120 Vac 60 Hz						
Vertical Emission Table							
Frequency (MHz)	Detector	Raw (dBuV)	Correction Factors (dB)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Pass/Fail
830.929	QP	49.2	-5.5	43.7	46.4	2.7	Pass
141.938	QP	63.6	-24.1	39.5	43.5	4.0	Pass
186.17	QP	60.2	-22.2	38.0	43.5	5.5	Pass
193.93	QP	59.2	-22.5	36.7	43.5	6.8	Pass
146.109	QP	59.0	-23.9	35.1	43.5	8.4	Pass
165.897	QP	61.6	-22.6	39.0	43.5	4.5	Pass
842.569	QP	25.6	-5.3	20.3	46.4	26.1	Pass
162.017	QP	59.8	-22.9	36.9	43.5	6.6	Pass
Horizontal Emission Table							
830.735	QP	44.9	-4.3	40.6	46.4	5.8	Pass
831.123	QP	38.5	-4.3	34.2	46.4	12.2	Pass
186.073	QP	57.2	-22.1	35.1	43.5	8.4	Pass
162.114	QP	56.5	-23.4	33.1	43.5	10.4	Pass
190.05	QP	53.8	-21.9	31.9	43.5	11.6	Pass
182.484	QP	55.0	-22.6	32.4	43.5	11.1	Pass
840.92	QP	31.9	-4.1	27.8	46.4	18.6	Pass

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Project Name / Number	Ecobee WCB401 B-Mode

Test Frequency (MHz)	Detection mode	Antenna polarity (Horz/Vert)	Raw signal dB(µV)	Antenna factor dB	Cable loss dB + Preselecor	Attenuator dB	Pre-Amp Gain dB	Received signal dB(µV/m)	Emission limit dB(µV/m)	Margin dB(µV)	Result
Low Channel (1)											
2412	Peak	Horz	93.3	26.4	3.6	9.0	36.1	96.2			PASS
2412	Avg	Horz	83.5	26.4	3.6	9.0	36.1	86.4			PASS
2412	Peak	Vert	95.8	26.4	3.6	9.0	36.1	98.7			PASS
2412	Avg	Vert	85.8	26.4	3.6	9.0	36.1	88.7			PASS
2390	Peak	Horz	45.6	26.4	3.6	9.0	36.1	48.5	74.0	25.5	PASS
2390	Avg	Horz	32.2	26.4	3.6	9.0	36.1	35.1	54.0	18.9	PASS
2390	Peak	Vert	45.2	26.4	3.6	9.0	36.1	48.1	74.0	25.9	PASS
2390	Avg	Vert	32.4	26.4	3.6	9.0	36.1	35.3	54.0	18.7	PASS
Mid Channel (6)											
2437	Peak	Horz	93.9	26.4	3.6	9.0	36.1	96.8			PASS
2437	Avg	Horz	84.2	26.4	3.6	9.0	36.1	87.1			PASS
2437	Peak	Vert	95.7	26.4	3.6	9.0	36.1	98.6			PASS
2437	Avg	Vert	86.0	26.4	3.6	9.0	36.1	88.9			PASS
High Channel (11)											
2462	Peak	Horz	95.3	26.4	3.6	9.0	36.1	98.2			PASS
2462	Avg	Horz	85.5	26.4	3.6	9.0	36.1	88.4			PASS
2462	Peak	Vert	96.2	26.4	3.6	9.0	36.1	99.1			PASS
2462	Avg	Vert	86.7	26.4	3.6	9.0	36.1	89.6			PASS
2483.5	Peak	Horz	47.0	26.4	3.6	9.0	36.1	49.9	74.0	24.1	PASS
2483.5	Avg	Horz	33.4	26.4	3.6	9.0	36.1	36.3	54.0	17.7	PASS
2483.5	Peak	Vert	47.0	26.4	3.6	9.0	36.1	49.9	74.0	24.1	PASS
2483.5	Avg	Vert	33.6	26.4	3.6	9.0	36.1	36.5	54.0	17.5	PASS

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Project Name / Number	Ecobee ECB401 G-Mode

Test Frequency (MHz)	Detection mode	Antenna polarity (Horz/Vert)	Raw signal dB(µV)	Antenna factor dB	Cable loss dB + Preselecor	Attenuator dB	Pre-Amp Gain dB	Received signal dB(µV/m)	Emission limit dB(µV/m)	Margin dB(µV)	Result
Low Channel (1)											
2412	Peak	Horz	93.4	26.4	3.6	9.0	36.1	96.3			PASS
2412	Avg	Horz	80.9	26.4	3.6	9.0	36.1	83.8			PASS
2412	Peak	Vert	94.8	26.4	3.6	9.0	36.1	97.7			PASS
2412	Avg	Vert	82.0	26.4	3.6	9.0	36.1	84.9			PASS
2390	Peak	Horz	52.9	26.4	3.6	9.0	36.1	55.8	74.0	18.2	PASS
2390	Avg	Horz	35.3	26.4	3.6	9.0	36.1	38.2	54.0	15.8	PASS
2390	Peak	Vert	53.9	26.4	3.6	9.0	36.1	56.8	74.0	17.2	PASS
2390	Avg	Vert	36.3	26.4	3.6	9.0	36.1	39.2	54.0	14.8	PASS
Mid Channel (6)											
2437	Peak	Horz	94.3	26.4	3.6	9.0	36.1	97.2			PASS
2437	Avg	Horz	82.3	26.4	3.6	9.0	36.1	85.2			PASS
2437	Peak	Vert	96.0	26.4	3.6	9.0	36.1	98.9			PASS
2437	Avg	Vert	83.7	26.4	3.6	9.0	36.1	86.6			PASS
High Channel (11)											
2462	Peak	Horz	95.4	26.4	3.6	9.0	36.1	98.3			PASS
2462	Avg	Horz	82.5	26.4	3.6	9.0	36.1	85.4			PASS
2462	Peak	Vert	95.6	26.4	3.6	9.0	36.1	98.5			PASS
2462	Avg	Vert	83.8	26.4	3.6	9.0	36.1	86.7			PASS
2483.5	Peak	Horz	55.3	26.4	3.6	9.0	36.1	58.2	74.0	15.8	PASS
2483.5	Avg	Horz	37.6	26.4	3.6	9.0	36.1	40.5	54.0	13.5	PASS
2483.5	Peak	Vert	56.5	26.4	3.6	9.0	36.1	59.4	74.0	14.6	PASS
2483.5	Avg	Vert	39.0	26.4	3.6	9.0	36.1	41.9	54.0	12.2	PASS

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Project Name / Number	Ecobee ECB401 N-Mode

Test Frequency (MHz)	Detection mode	Antenna polarity (Horz/Vert)	Raw signal dB(µV)	Antenna factor dB	Cable loss dB + Preselecor	Attenuator dB	Pre-Amp Gain dB	Received signal dB(µV/m)	Emission limit dB(µV/m)	Margin dB(µV)	Result
Low Channel (1)											
2412	Peak	Horz	93.0	26.4	3.6	9.0	36.1	95.9			PASS
2412	Avg	Horz	80.9	26.4	3.6	9.0	36.1	83.8			PASS
2412	Peak	Vert	93.5	26.4	3.6	9.0	36.1	96.4			PASS
2412	Avg	Vert	81.3	26.4	3.6	9.0	36.1	84.2			PASS
2390	Peak	Horz	54.7	26.4	3.6	9.0	36.1	57.6	74.0	16.4	PASS
2390	Avg	Horz	41.5	26.4	3.6	9.0	36.1	44.4	54.0	9.7	PASS
2390	Peak	Vert	56.4	26.4	3.6	9.0	36.1	59.3	74.0	14.7	PASS
2390	Avg	Vert	42.1	26.4	3.6	9.0	36.1	45.0	54.0	9.0	PASS
Mid Channel (6)											
2437	Peak	Horz	92.6	26.4	3.6	9.0	36.1	95.5			PASS
2437	Avg	Horz	80.9	26.4	3.6	9.0	36.1	83.8			PASS
2437	Peak	Vert	94.5	26.4	3.6	9.0	36.1	97.4			PASS
2437	Avg	Vert	82.7	26.4	3.6	9.0	36.1	85.6			PASS
High Channel (11)											
2462	Peak	Horz	93.0	26.4	3.6	9.0	36.1	95.9			PASS
2462	Avg	Horz	81.2	26.4	3.6	9.0	36.1	84.1			PASS
2462	Peak	Vert	93.9	26.4	3.6	9.0	36.1	96.8			PASS
2462	Avg	Vert	82.1	26.4	3.6	9.0	36.1	85.0			PASS
2483.5	Peak	Horz	55.3	26.4	3.6	9.0	36.1	58.2	74.0	15.8	PASS
2483.5	Avg	Horz	42.3	26.4	3.6	9.0	36.1	45.2	54.0	8.8	PASS
2483.5	Peak	Vert	55.4	26.4	3.6	9.0	36.1	58.3	74.0	15.7	PASS
2483.5	Avg	Vert	42.4	26.4	3.6	9.0	36.1	45.3	54.0	8.7	PASS

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Test Equipment List

Equipment	Model No.	Manufacturer	Last Calibration Date	Next Calibration Date	Asset #
Spectrum Analyzer	ESU 40	Rohde & Schwarz	Jan. 6, 2016	Jan. 6, 2018	GEMC 233
Loop Antenna	EM 6871	Electro-Metrics	Feb 13, 2017	Feb 13, 2019	GEMC 70
Loop Antenna	EM 6872	Electro-Metrics	Feb 13, 2017	Feb 13, 2019	GEMC 71
BiLog Antenna	HLP-3003C	TDK RF Solutions	Oct. 12, 2016	Oct. 12, 2018	GEMC 231
Horn Antenna 2 – 18 GHz	WBH218HN	Q-par	Feb. 12, 2016	Feb. 12, 2018	GEMC 6375
Horn Antenna 18 GHz - 26.5 GHz	SAS-572	A.H. Systems	Oct 11, 2016	Oct 11, 2018	GEMC 6371
Pre-Amp 9 kHz – 1 GHz	CPA9231A	Chase	Oct 12, 2016	Oct 12, 2018	GEMC 6403
Pre-Amp 1 – 26.5 GHz	HP 8449B	HP	Nov. 27, 2015	Nov. 27, 2017	GEMC 189
2.4Ghz-2.5GHz Notch Filter	BRM50702	Micro-Tronics	Jul 16, 2016	Jul 16, 2017	GEMC 230
Attenuator 3 dB	612-03-1	Meca Electronics, Inc	Feb 13, 2017	Feb 13, 2018	GEMC 222
Attenuator 6 dB	FP-50-6	Trilithic	Feb 13, 2017	Feb 13, 2018	GEMC 41
RF Cable 7m	LMR-400-7M-50Ω-MN-MN	LexTec	Feb 13, 2017	Feb 13, 2018	GEMC 28
RF Cable 10m	LMR-400-10M-50Ω-MN-MN	LexTec	Feb 13, 2017	Feb 13, 2018	GEMC 27
RF Cable 0.5m	LMR-400-0.5M-50Ω-MN-MN	LexTec	Feb 13, 2017	Feb 13, 2018	GEMC 31
RF Cable 1m	LMR-400-1M-50OHM-MN-MN	LexTec	Feb 13, 2017	Feb 13, 2018	GEMC 29
Emissions Software	0.1.94	Global EMC	NCR	NCR	GEMC 58

This report module is based on GEMC template "FCC - 15.209 - Radiated Emissions_Rev1.doc"

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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 and Methods

The limits are defined in 15.247(e).

For digitally modulated systems, the power spectral density 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.

The method is given in ANSI 63.10 11.10.2 Method PKPSD.

Results

The EUT passed. The EUT was set to transmit at maximum power. The EUT supports three modes of operation, 802.11 b/g/n. The n-mode only support 20 MHz nominal bandwidth. Three Channels for each mode were measured. The following tables show the peak power spectral density: External attenuator and cable loss were accounted for as reference offset in the spectrum analyzer.

PSD: B-Mode				
Channel	Frequency (MHz)	PSD/3kHz (dBm)	Limit (dBm/3kHz)	Pass/Fail
1	2412	-14.68	8	Pass
6	2437	-13.22	8	Pass
11	2462	-13.30	8	Pass

PSD: G-Mode				
Channel	Frequency (MHz)	PSD/3kHz (dBm)	Limit (dBm/3kHz)	Pass/Fail
1	2412	-17.78	8	Pass
6	2437	-16.30	8	Pass
11	2462	-16.31	8	Pass

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PSD: N-Mode				
Channel	Frequency (MHz)	PSD/3kHz (dBm)	Limit (dBm/3kHz)	Pass/Fail
1	2412	-18.81	8	Pass
6	2437	-15.50	8	Pass
11	2462	-16.20	8	Pass

Graph(s)

The graphs shown below show the power spectral density of the device. This is measured by a max hold on the spectrum analyzer using a RBW of 3 kHz. This measurement is a peak measurement. Max hold is performed for a duration of not less than 1 minute.

Low, middle, and high channel for each mode was investigated in each mode, with the worst case being presented.

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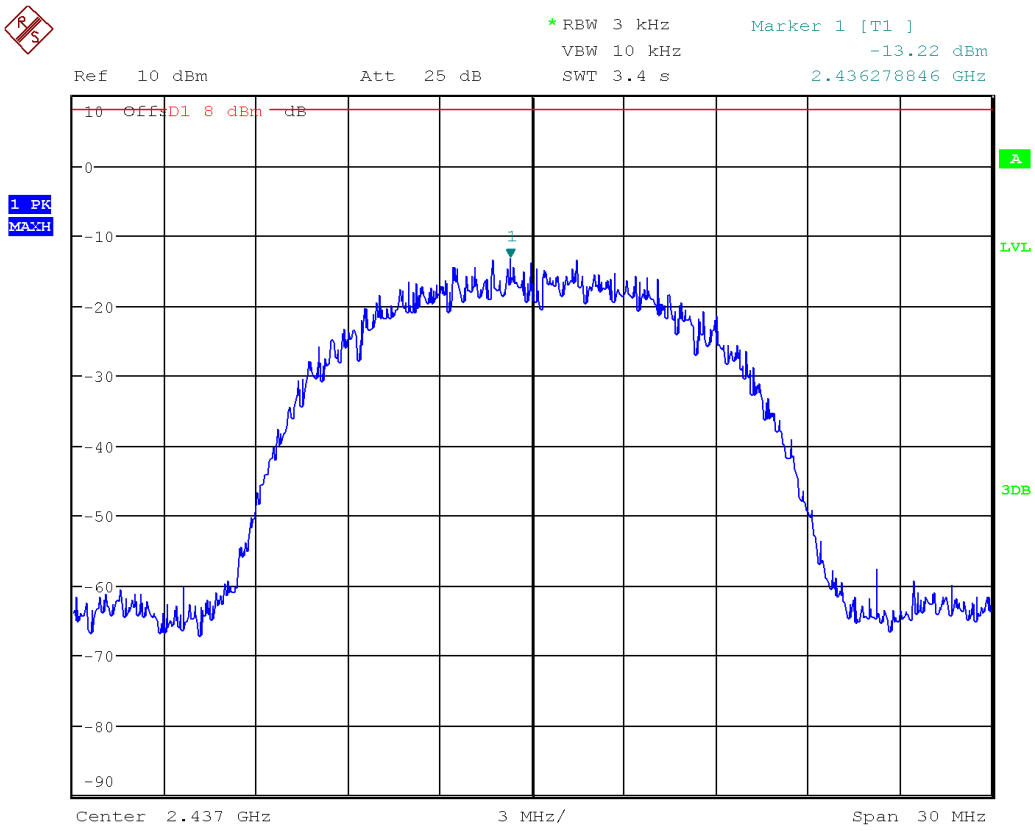
Peak Power Spectral Density: B-Mode
Mid Channel



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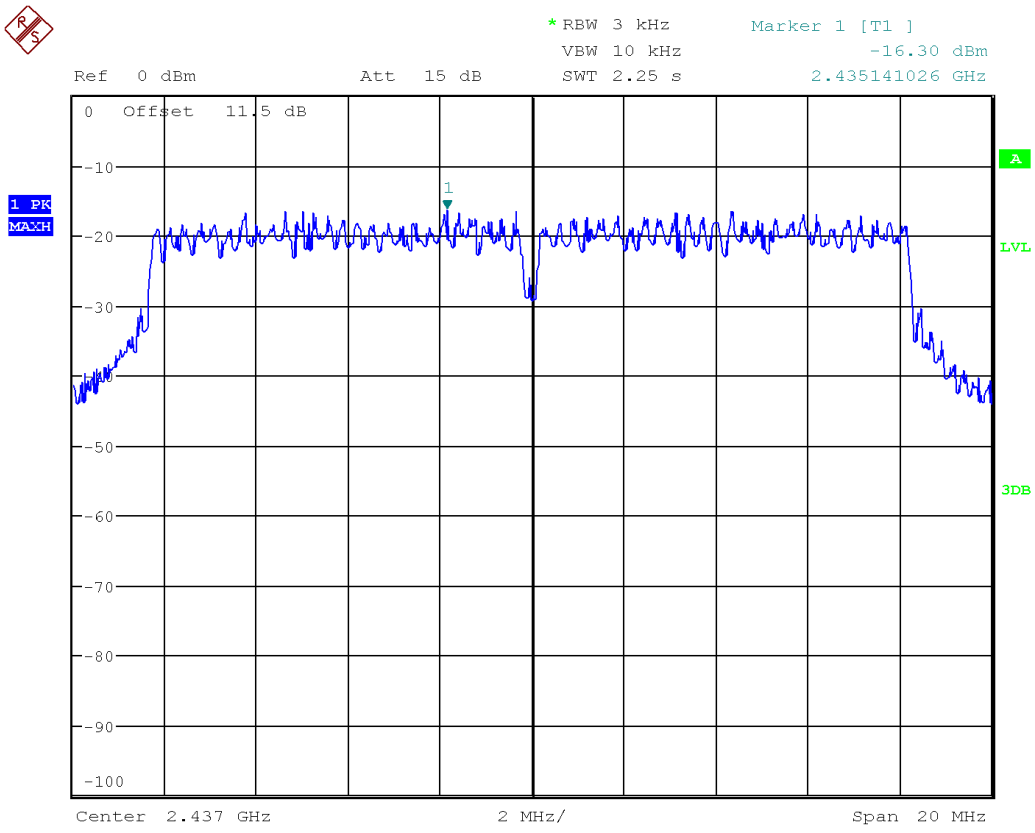
Peak Power Spectral Density: G-Mode
Mid Channel



Date: 29.FEB.2016 17:25:26

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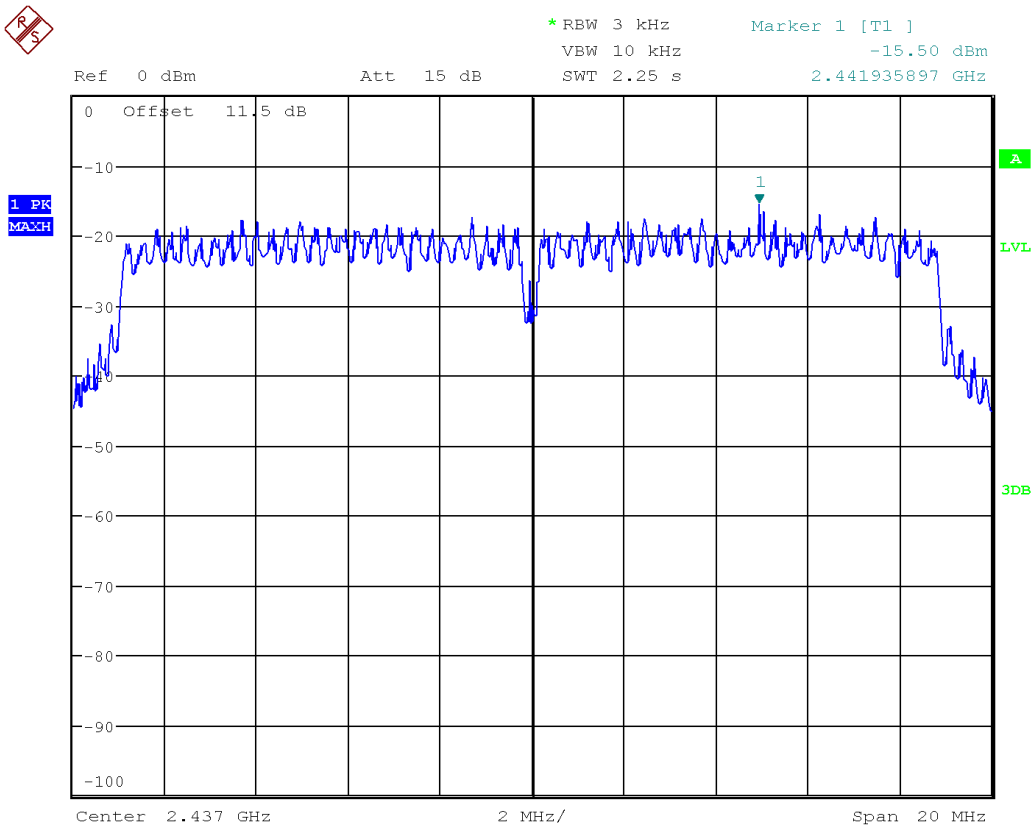
Peak Power Spectral Density: N-Mode
Mid Channel



Date: 29.FEB.2016 18:05:49

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

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Test Equipment List

Equipment	Model No.	Manufacturer	Last calibration / Verification date	Next calibration/ Verification due date	Asset #
26.5GHz Spectrum Analyzer	FSU26	Rohde & Schwarz	Feb-15, 2017	Feb-15, 2019	GEMC 232
10 dB attenuator	605-10-1F18	Meca Electronics, Inc.	Feb-15, 2017	Feb-15, 2018	GEMC225

This report module is based on GEMC template "FCC – Power Line Conducted Emissions Class B_Rev1"

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Power Line Conducted Emissions

Purpose

The purpose of this test is to ensure that the RF energy unintentionally emitted from the EUT's power line does not exceed the limits listed below as defined in the applicable test standard and measured from a LISN. This helps protect lower frequency radio services such as AM radio, shortwave radio, amateur radio, maritime radio, CB radio, and so on, from unwanted interference.

Limits & Method

The method is as defined in ANSI C63.10. The limits are as defined in FCC Part 15 Section 15.207 and RSS-GEN:

Average Limits		Quasi-Peak Limits	
150 kHz – 500 kHz	56 to 46* dBµV	150 kHz – 500 kHz	66 to 56* dBµV
500 kHz – 5 MHz	46 dBµV	500 kHz – 5 MHz	56 dBµV
5 MHz – 30 MHz	50 dBµV	5 MHz – 30 MHz	60 dBµV

* Decreases linearly with the logarithm of the frequency

Both Quasi-Peak and Average limits are applicable and each is specified as being measured with a resolution bandwidth of 9 kHz. For Quasi-Peak, a video bandwidth at least three times greater than the resolution bandwidth is used.

If the Peak or Quasi-Peak detector measurements do not exceed the Average limits, then the EUT is deemed to have passed the requirements.

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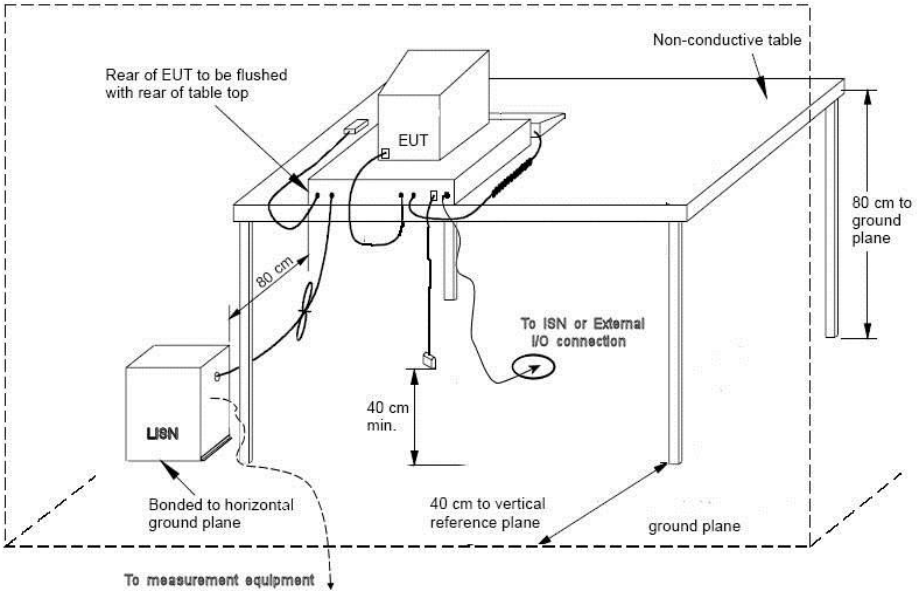
Typical Setup Diagram



Measurement Uncertainty

The expanded measurement uncertainty is calculated in accordance with CISPR 16-4-2 and is ±2.91dB with a 'k=2' coverage factor and a 95% confidence level.

Preliminary Graphs

The graphs shown below are maximized peak measurement graphs measured with a resolution bandwidth greater than or equal to the final required detector. This peaking process is done as a worst case measurement and enables the detection of frequencies of concern for final measurement. For final measurements with the appropriate detector, where applicable, please refer to the tables under Final Measurements.

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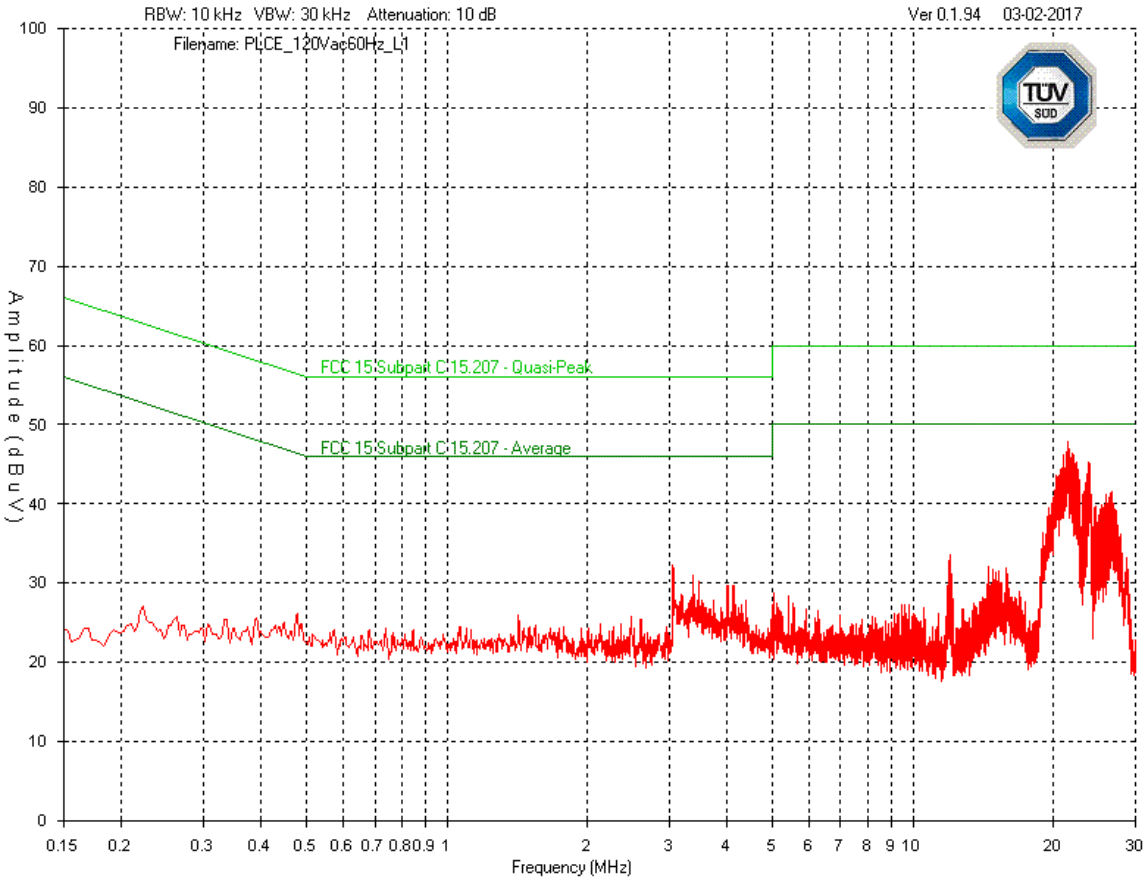
Line (L1) – 120Vac 60Hz



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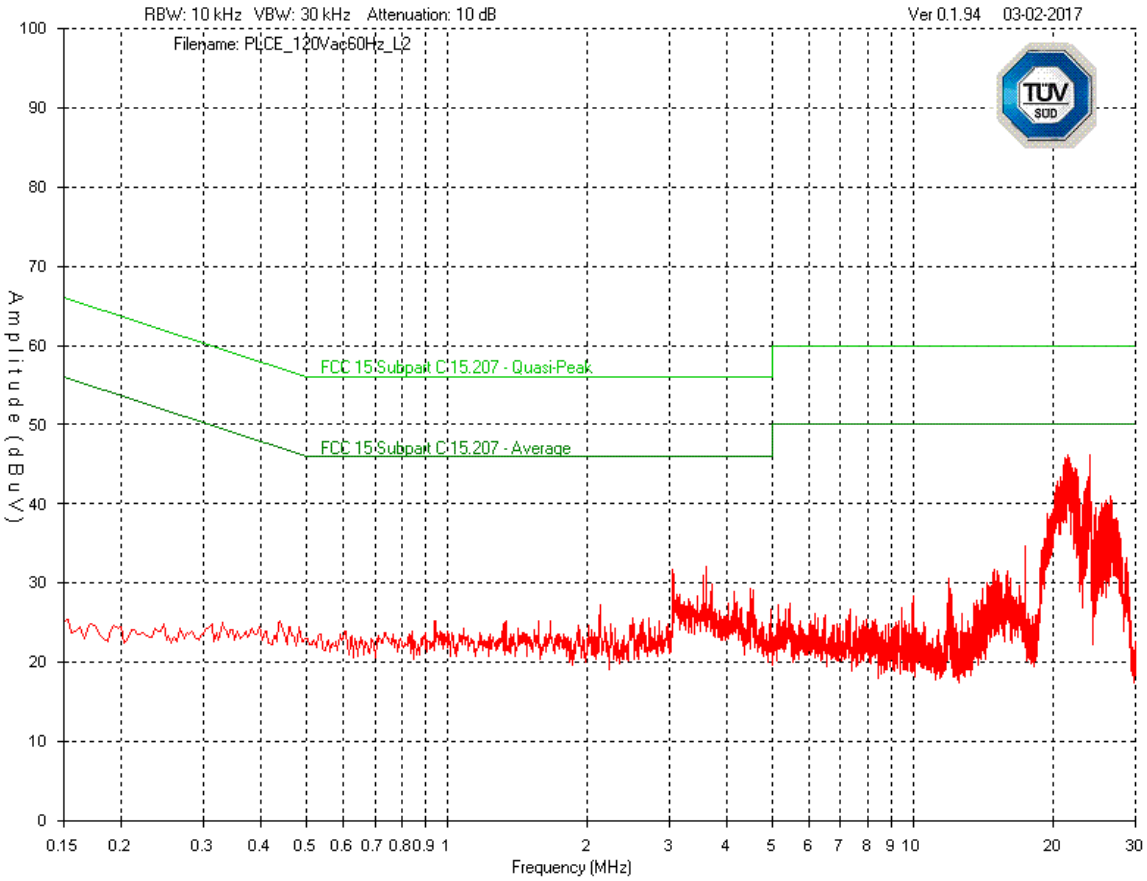
Neutral (L2) – 120Vac 60Hz



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Final Measurements

All peak emission were below the average limit thus the EUT was deemed to meet power line conducted emission limits based on peak emission.

See 'Appendix B – EUT, Peripherals and Test Setup Photos' for photos showing the test set-up for the highest line conducted emission

Test Equipment List

Equipment	Model No.	Manufacturer	Last Calibration Date	Next Calibration Date	Asset #
Spectrum Analyzer	ESL 6	Rohde & Schwarz	Nov. 25, 2015	Nov. 25, 2017	GEMC 160
LISN	FCC-LISN-50/250-16-2-01	FCC	Feb 1, 2017	Feb 1, 2019	GEMC 65
RF Cable 7m	LMR-400-7M-50Ω-MN-MN	LexTec	NCR	NCR	GEMC 28
10dB Attenuator	FP-50-10	Trilithic	NCR	NCR	GEMC 42
Emissions Software	0.1.94	TUV SUD Canada	NCR	NCR	GEMC 58

This report module is based on report template 'FCC_ICES003_CE_Rev1'

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Appendix A – EUT Summary

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

General EUT Description

Client	
Organization / Address	Ecobee Inc 250 University Avenue, Suite 400 Toronto, ON M5H 3E5
Contact	Kashif Ahmed
Phone	416 987 1048
Email	kashif@ecobee.com
EUT Details	
EUT Name	ECB401
FCC ID	WR9116151212151
Industry Canada #	7981A-11615121215
Equipment Category	Low power wireless thermostat
Basic EUT Functionality	EUT is a smart thermostat that have a 2400 – 2483.5 MHz DTS (802.11 b/g/n) transmitter and a 902 – 928 MHz FHSS transmitter.
Input Voltage and Frequency	24 Vac 60 Hz
Rated Input Current	2 A
Connectors available on EUT	1 (terminals for HVAC control)
Peripherals Required for Test	None
Release type	Final
Intentional Radiator Frequency	2400 – 2483.5 MHz for 802.11 b/g/n DTS 902 – 928 MHz FHSS
EUT Configuration	Wireless configured to transmit continuously at 100% duty cycle

Note the EUT is considered to have been received the date of the commencement of the first test, unless otherwise stated. For a close-up picture of the EUT, see 'Appendix B – EUT and Test Setup Photos'.

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EUT Configuration

Please see Appendix B for a picture of the unit running in normal conditions.

- Wireless were configured to transmit at maximum possible duty cycle
- The following commands were used to set the chipset for duty cycle /channel/power/data rate (modulation):
  B mode transmission: "xxxxxxxxx --tx tx99 --txfreq 11 --txpwr 20 --txrate 3"
  G mode transmission: "xxxxxxxxx --tx tx100 --txfreq 11 --txpwr 20 --txrate 11"
  N mode transmission: "xxxxxxxxx --tx tx100 --txfreq 11 --txpwr 20 --txrate 16"

  Where xxxxxxxxx is the low level chipset command line program.

Operational Setup

These devices are required to be attached to the EUT for its normal operation.

- A debug board was connected to the EUT to issue test commands.

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