EMC & RF Test Report

As per

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

Unlicensed Intentional Radiators

on the

fyrefly
Model: 6626000103

Issued by: **TÜV SÜD Canada Inc.**
11 Gordon Collins Dr,
Gormley, ON, L0H 1G0
Canada
Ph: (905) 883-7255

Amir Emami,
Project Engineer

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 **fyrefly**, Model: **6626000103**, 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.

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:	fyrefly
FCC Certification #, FCC ID:	2AJF76626000103
Industry Canada Certification #, IC:	21812-6626000103
EUT passed all tests performed	Yes
Tests conducted by	Amir Emami

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(a)	6 dB Bandwidth	> 500 kHz	Pass
FCC 15.247(b)2 RSS-247 5.4(d)	Max Output Power	< 1 Watt	Pass
FCC 15.247(b)4 RSS-247 5.4(d)	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(b)	Spectral Density	< 8 dBm (3 kHz BW)	Pass
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:

The unit contains two identical Inverted-F PCB trace antennas. Only one antenna is selected by the software at a time and therefore, these antennas will never receive or transmit simultaneously. For the antenna conducted emission tests, a verification was done at both antenna ports and both produced the same results. Therefore, testing was done at one of these antenna ports only.

For the antenna requirement specified in FCC 15.203 (RSS-247 section 5.4(d)), the antenna has a peak gain of 1.2dBi as specified by the manufacturer, which is less than the 6 dBi gain limit.

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

The EUT is not a hybrid system and FCC 15.247 (f) does not apply to it. However the 15.247 (d) requirement of power density were met and are detailed later in this test report.

The EUT has a fixed (source based) duty cycle of 2.5% (2.5ms on time/100ms). For the average radiated emission measurements of the band edges in the restricted bands, a duty cycle correction factor of 2.5% [20log(2.5%) = -32.04] was applied to the peak measurement to obtain the average measurement.

The EUT was mounted in three orthogonal axis. Worst case results were obtained with the EUT in the X-axis. Worst case results are presented. See Appendix B for axis details.

The EUT also contains a modularly certified Texas Instruments transmitter (FCC ID: Z64-WL18DBMOD, IC: 451I-WL18DBMOD). The software guarantees simultaneous operation of the two radios will not occur and therefore, antenna co-location testing is not applicable.

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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
FCC KDB 558074 v04: 2017	FCC KDB 558074 Digital Transmission Systems, measurements and procedures
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
ISO 17025:2005	General Requirements for the Competence of Testing and Calibration Laboratories

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Document Revision Status

Revision 1 - April 19, 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 a 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)
April 17, 2017	Antenna Conducted Emissions	AE	21	33	99.1
April 11, 2017	Radiated Emissions	AE	22	38	98.9
April 17, 2017	Power Line Conducted Emissions	AE	21	33	99.1

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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 Method

The limit is as specified in FCC Part 15.247(a)2 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 Section 8.1 of FCC KDB 558074 and ANSI C63.10.

Results

The EUT passed. The minimum 6 dB BW measured was 17.05 MHz and the maximum 99% BW at full power setting was 20.06 MHz.

Channel	Frequency (MHz)	6dB Bandwidth (MHz)	99% Bandwidth (MHz)
Low	2412	17.05	19.87
Mid	2437	17.11	19.87
High	2462	17.05	20.06

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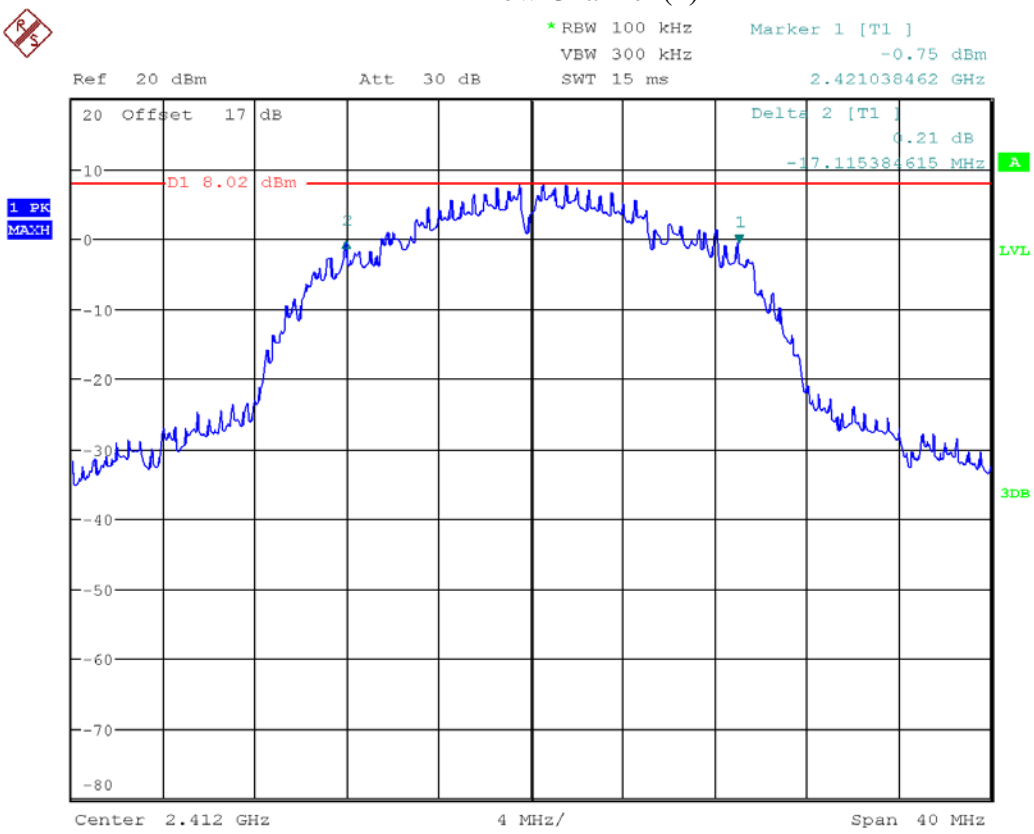
Graphs

The graphs showed 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. Max hold is performed for a duration of not less than 1 minute.

6 dB Bandwidth
Low Channel (1)



Date: 16.APR.2016 10:28:21

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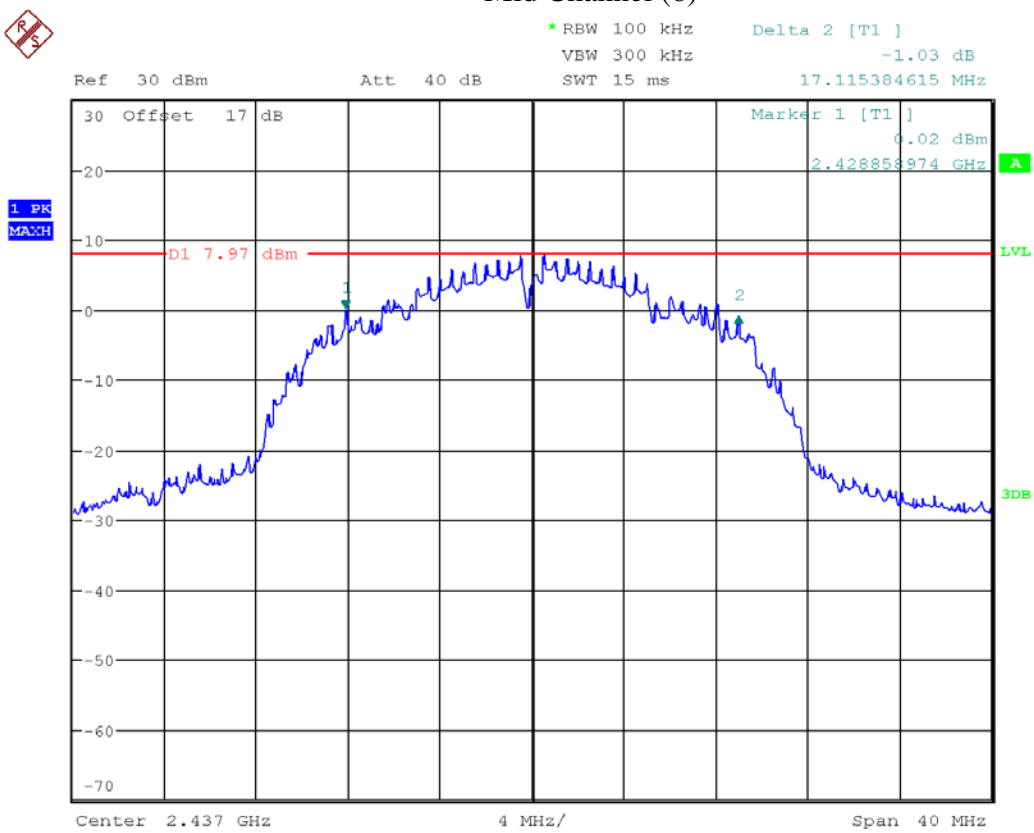
6 dB Bandwidth
Mid Channel (6)



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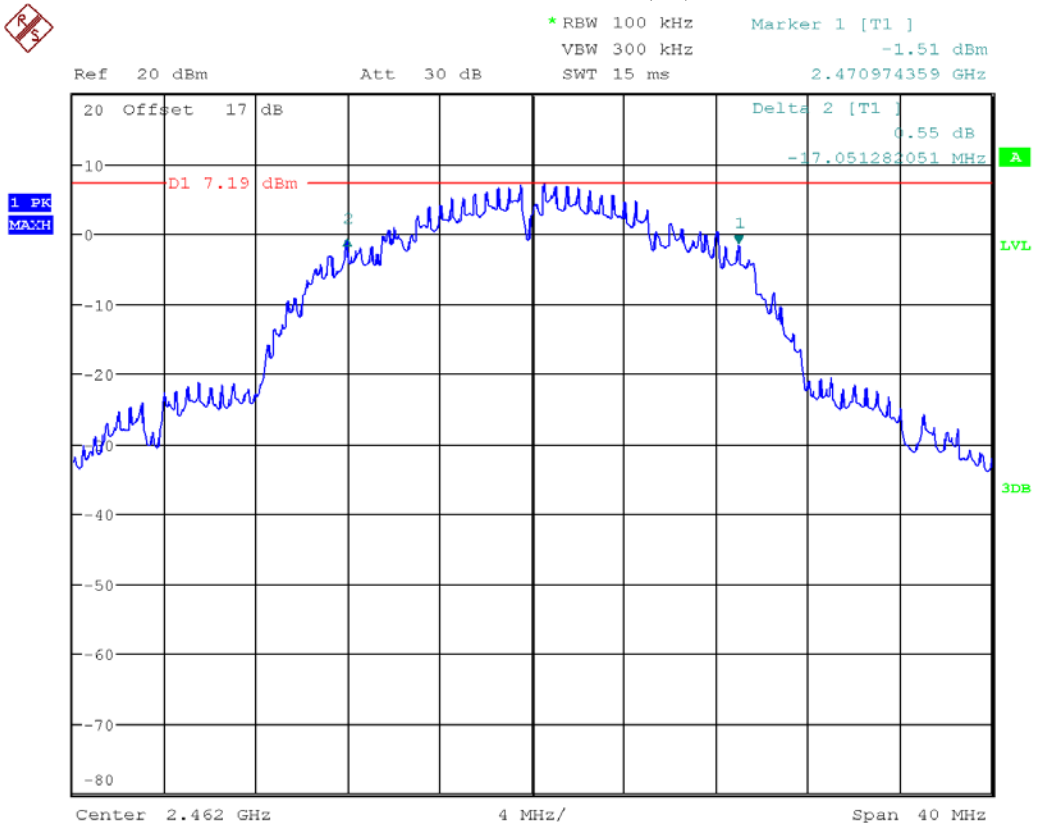
6 dB Bandwidth
Hi Channel (11)



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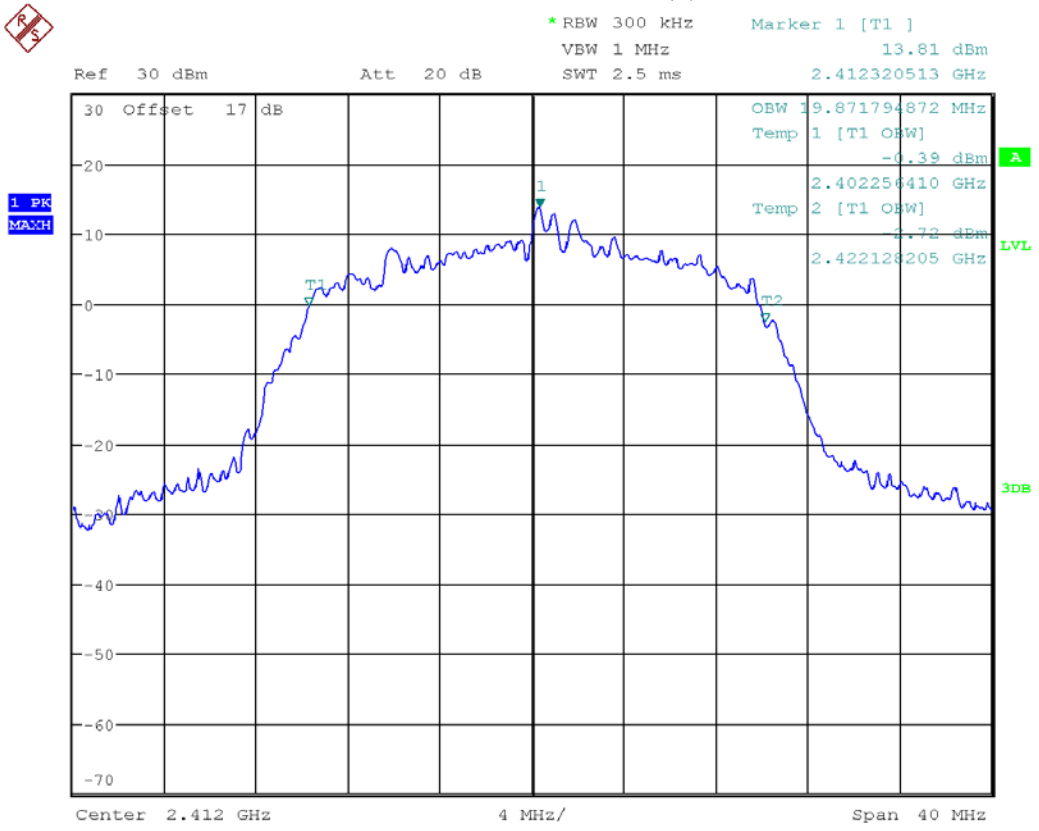
99% Bandwidth
Low Channel (1)



Date: 16.APR.2016 10:45:08

Note: See 'Appendix B – EUT & Test Setup Photos' 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 Date	Asset #
Spectrum Analyzer	FSU 26	Rohde & Schwarz	Feb. 15, 2017	Feb. 15, 2019	GEMC 232
Attenuator 10 dB	8493B	Agilent	Feb. 20, 2017	Feb. 20, 2018	GEMC 133
Attenuator 6 dB	3M-6	Weinschel	Feb. 20, 2017	Feb. 20, 2018	GEMC 278

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Maximum Peak Envelope Conducted 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, the maximum power does not exceed an amount which may create an excessive power level.

Limits and Method

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 (30 dBm).

The method is given in Section 9.1.2 of FCC KDB 558074 and ANSI C63.10.

Results

The EUT passed. The EUT was set to transmit at maximum power (100%). Three channels were measured. The following table show the peak power:

Channel	Frequency (MHz)	Peak Power (dBm)	Peak Power (mW)
Low	2412	25.24	334.20
Mid	2437	25.10	323.59
High	2462	24.23	264.85

Note: The external attenuator and cable loss are accounted for as reference offset in the spectrum analyzer

Graphs

The plots 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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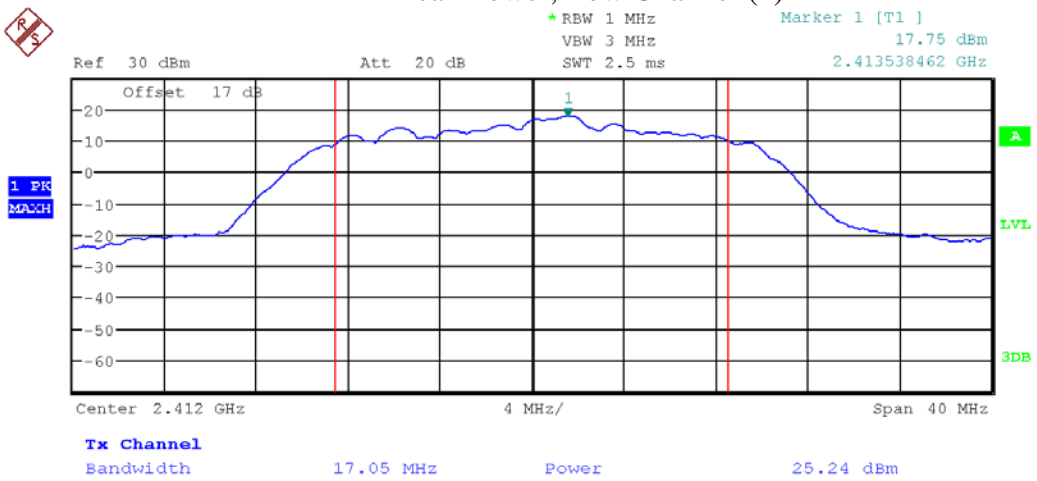
Peak Power, Low Channel (1)



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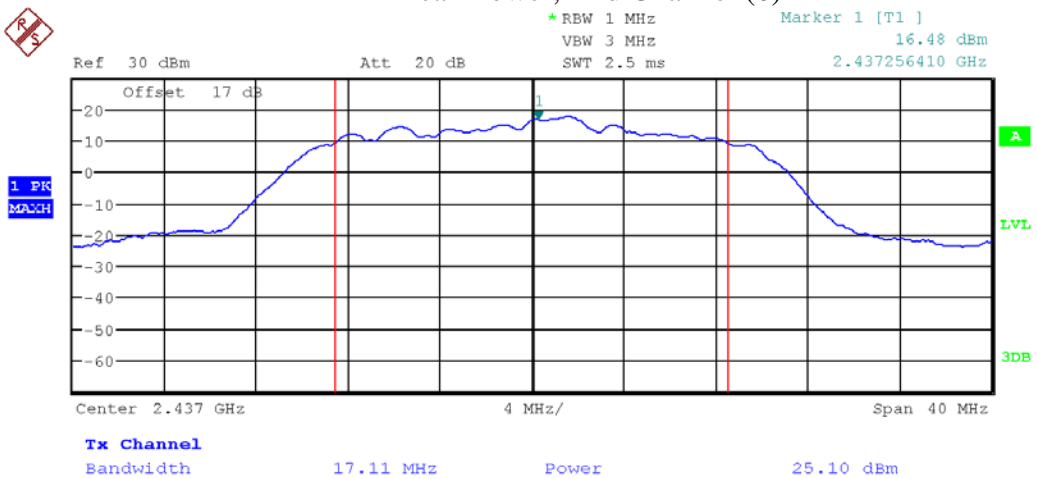
Peak Power, Mid Channel (6)



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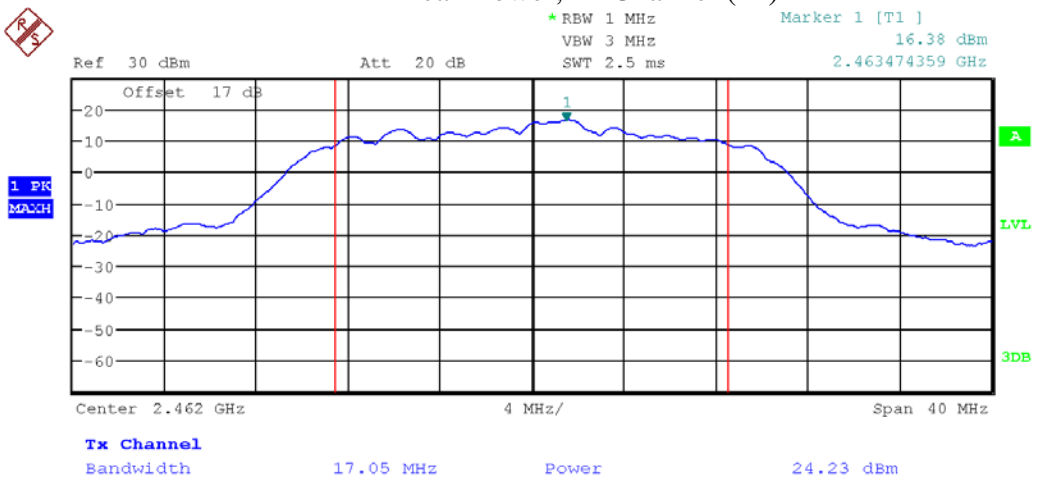
Peak Power, Hi Channel (11)



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See 'Appendix B – EUT and Test Setup Photos' 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 Date	Asset #
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Attenuator 10 dB	8493B	Agilent	Feb. 20, 2017	Feb. 20, 2018	GEMC 133
Attenuator 6 dB	3M-6	Weinschel	Feb. 20, 2017	Feb. 20, 2018	GEMC 278

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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 Method

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 10th harmonic. This -20 dBc requirement also applies at the 'band edge' or 2.4 GHz and 2.4835 GHz.

The method is given in Section 11 of FCC KDB 558074 and ANSI C63.10

Results

The EUT passed. Low, middle and high bands 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 also for the higher band edge at 2.4835 GHz in the high band.

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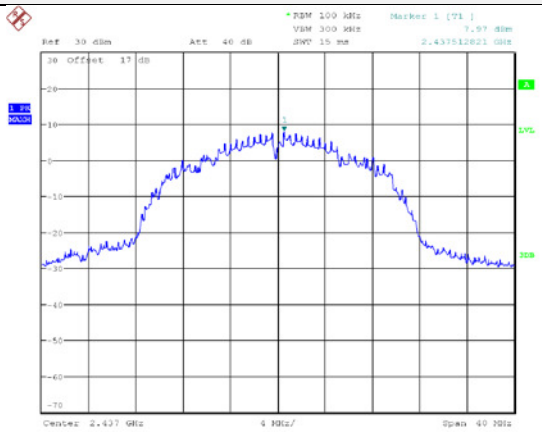
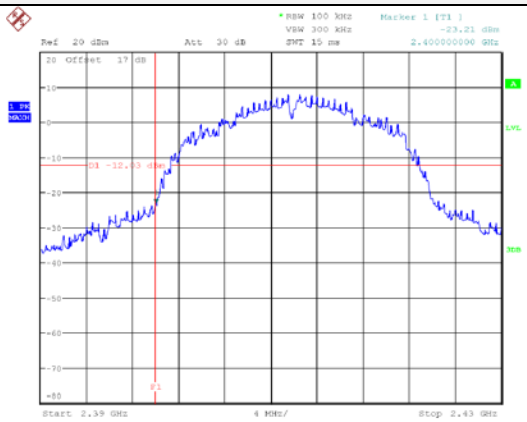
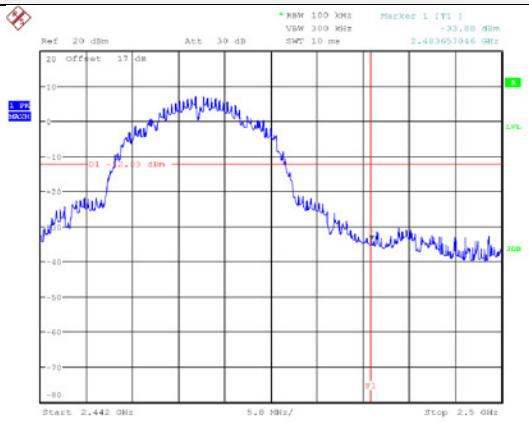
Graphs

The graphs shown below show the peak power output of the device during the antenna conducted measurement during transmit operation of the EUT.

-20dBc	
Reference Level: -12.03 dBm (Channel 6)	
	
2400 MHz Band Edge (Channel 1)	2483.5 MHz Band Edge (Channel 11)
	

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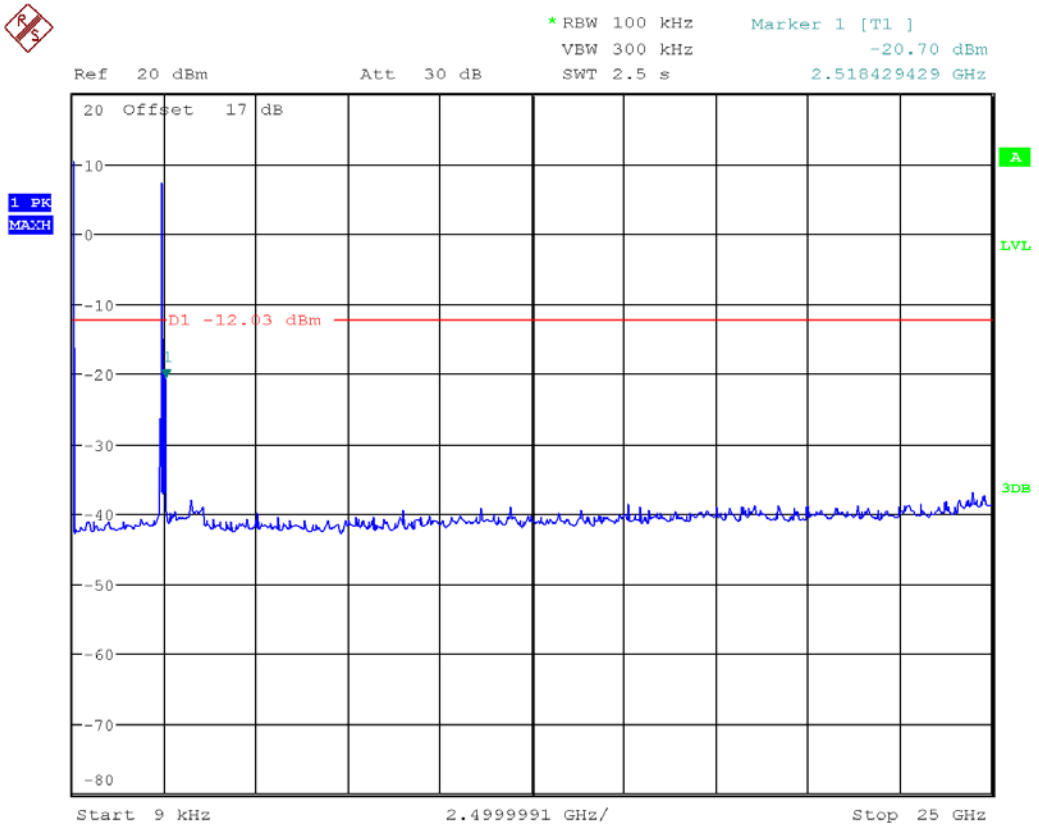
-20dBc
9kHz – 25GHz



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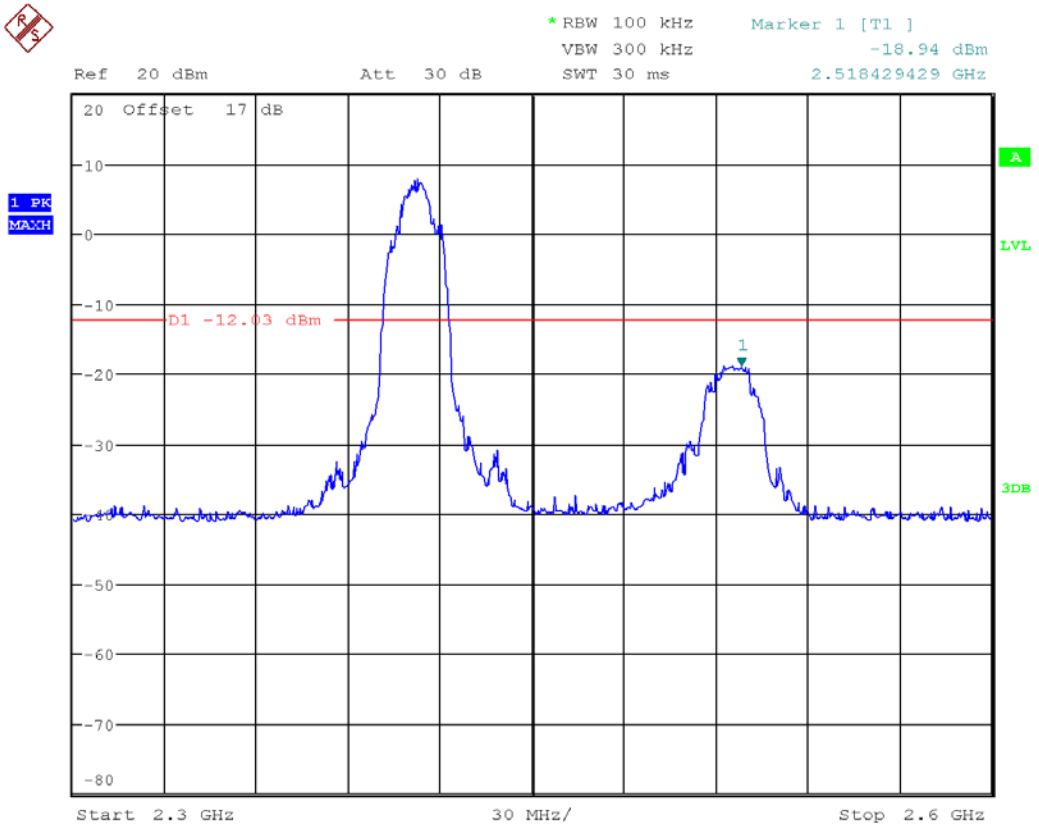
-20dBc
2.3GHz – 2.6GHz



Date: 16.APR.2016 11:54:46

See 'Appendix B – EUT and Test Setup Photos' 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 Date	Asset #
Spectrum Analyzer	FSU 26	Rohde & Schwarz	Feb. 15, 2017	Feb. 15, 2019	GEMC 232
Attenuator 10 dB	8493B	Agilent	Feb. 20, 2017	Feb. 20, 2018	GEMC 133
Attenuator 6 dB	3M-6	Weinschel	Feb. 20, 2017	Feb. 20, 2018	GEMC 278

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Transmitter Spurious Radiated Emissions

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.

Limits and Method

The method is as defined in Section 12.2.7 of FCC KDB 558074 and ANSI C63.10.

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 'Antenna Spurious Conducted Emissions (-20dBc)' for further details.

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

Based on ANSI C63.4 Section 4.2, if the Peak detector measurements do not exceed the Quasi-Peak limits, where defined, then the EUT is deemed to have passed the requirements.

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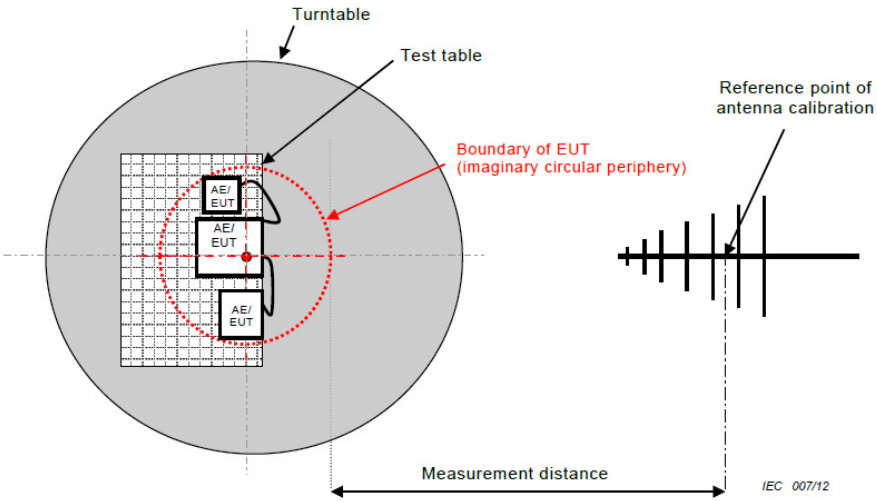
Typical Radiated Emissions Setup



Measurement Uncertainty

The expanded measurement uncertainty is calculated in accordance with CISPR 16-4-2 and is ±4.25dB for 30MHz – 1GHz and ±4.93dB for 1GHz – 18GHz 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 over a full 0-360°. 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.

In accordance with FCC Part 15, Subpart A, Section 15.33, the device was scanned to the 10th harmonic (a minimum of 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.

Low, middle and high channels, each in three orthogonal axis were checked. However, the worst case graphs are presented.

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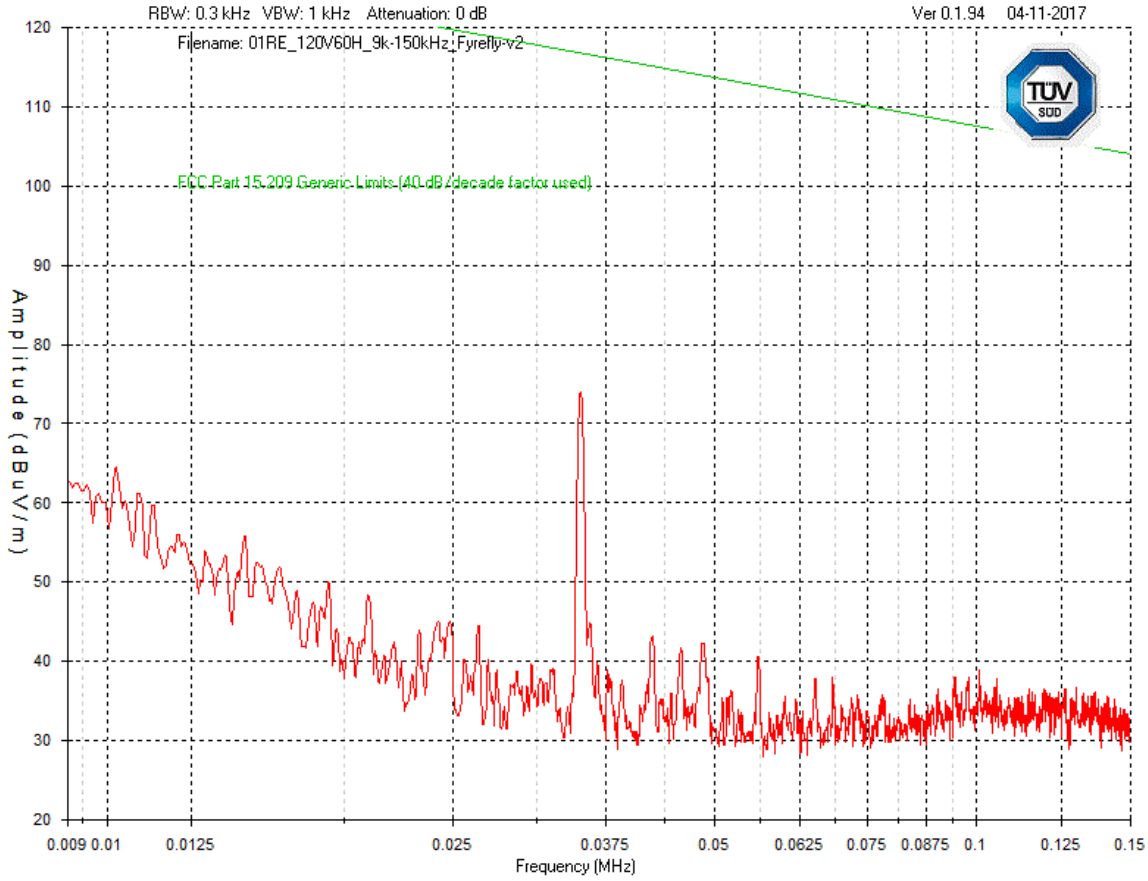
Band-edge measurement graphs are shown for illustration purposes. See final measurement section for all measurements.

Low Channel
9 kHz – 150 kHz
Peak Emission Graph



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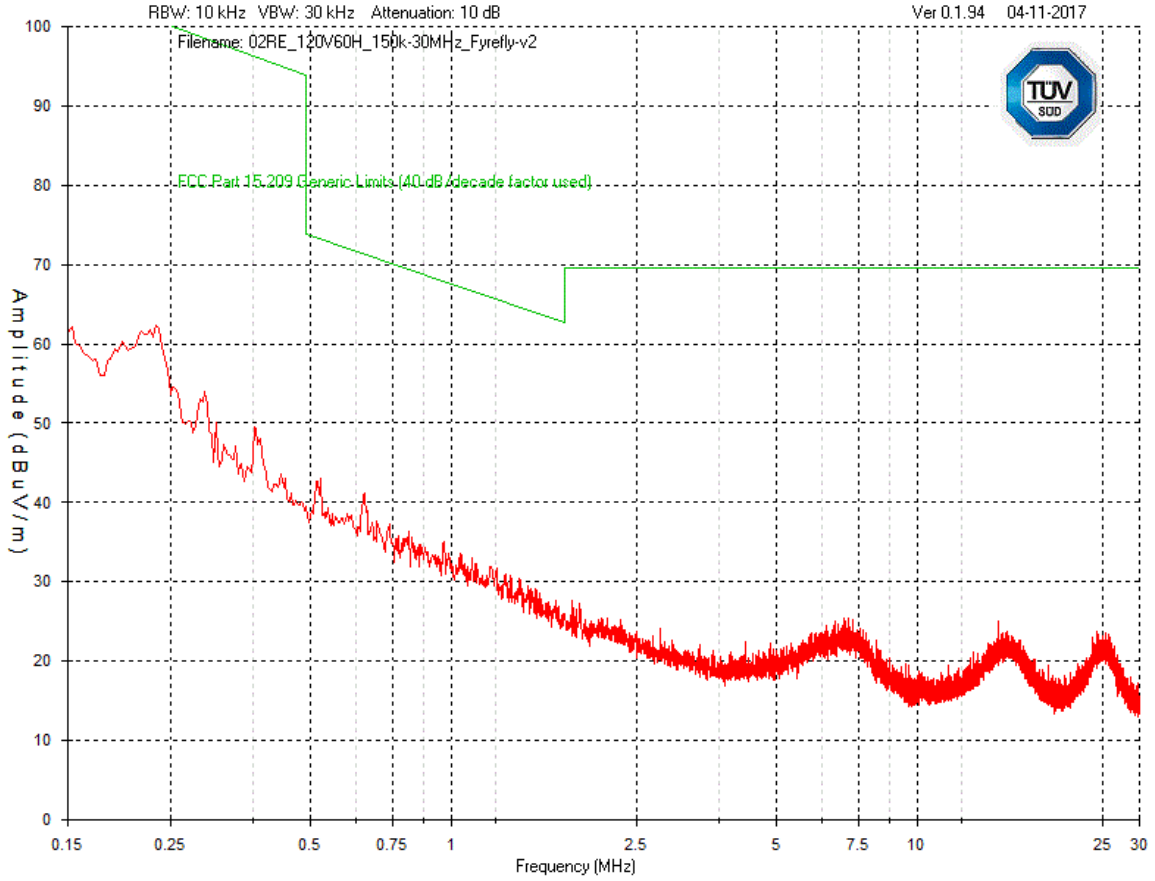
Low Channel
150 kHz – 30 MHz
Peak Emission Graph



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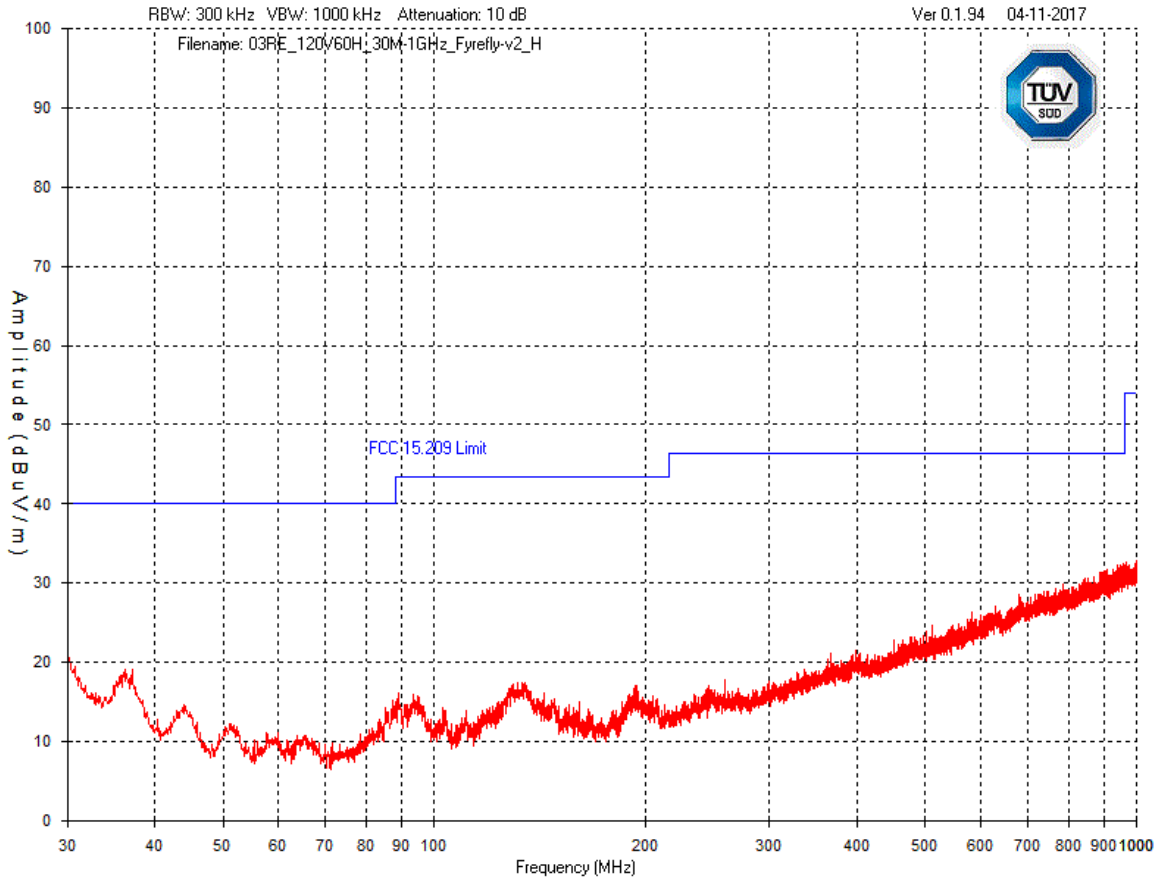
Low Channel – 30 MHz – 1 GHz
Horizontal - Peak Emission Graph



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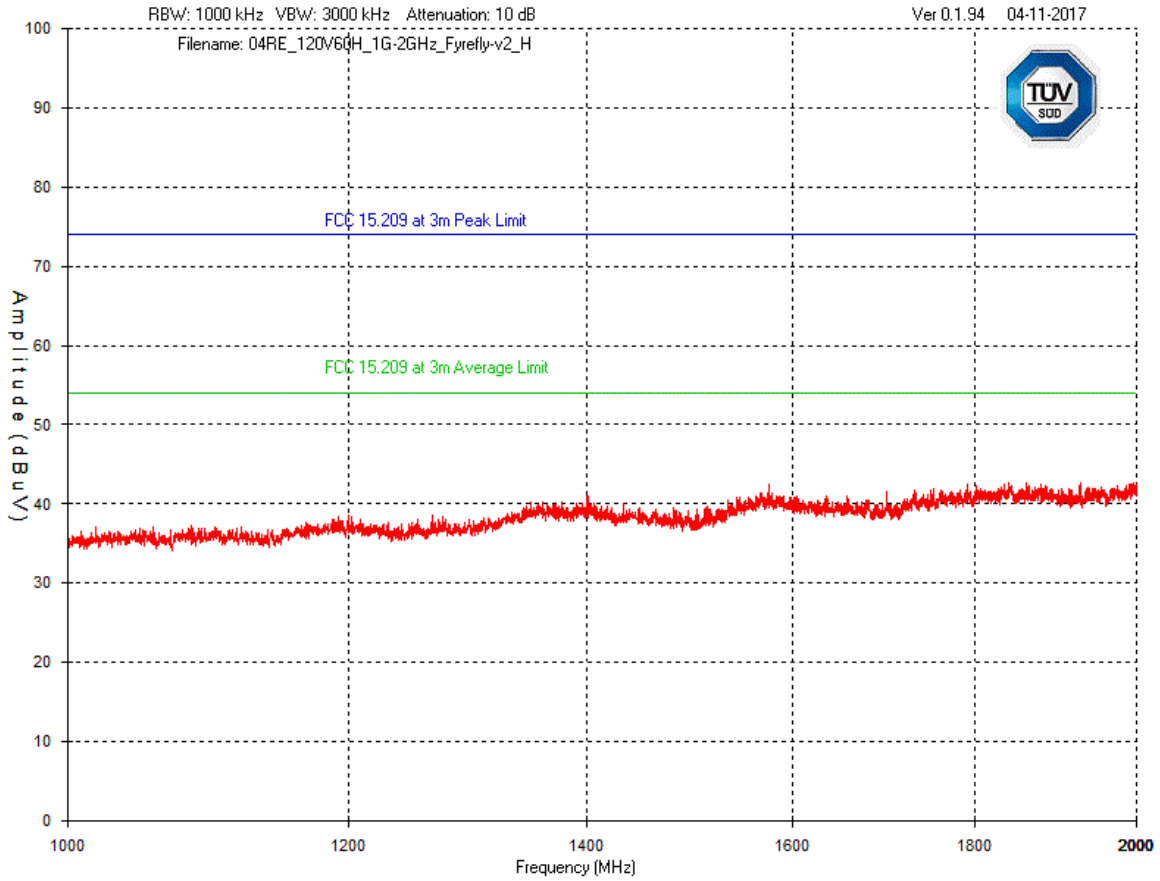
Low Channel – 1 GHz – 2 GHz
Horizontal - Peak Emission Graph



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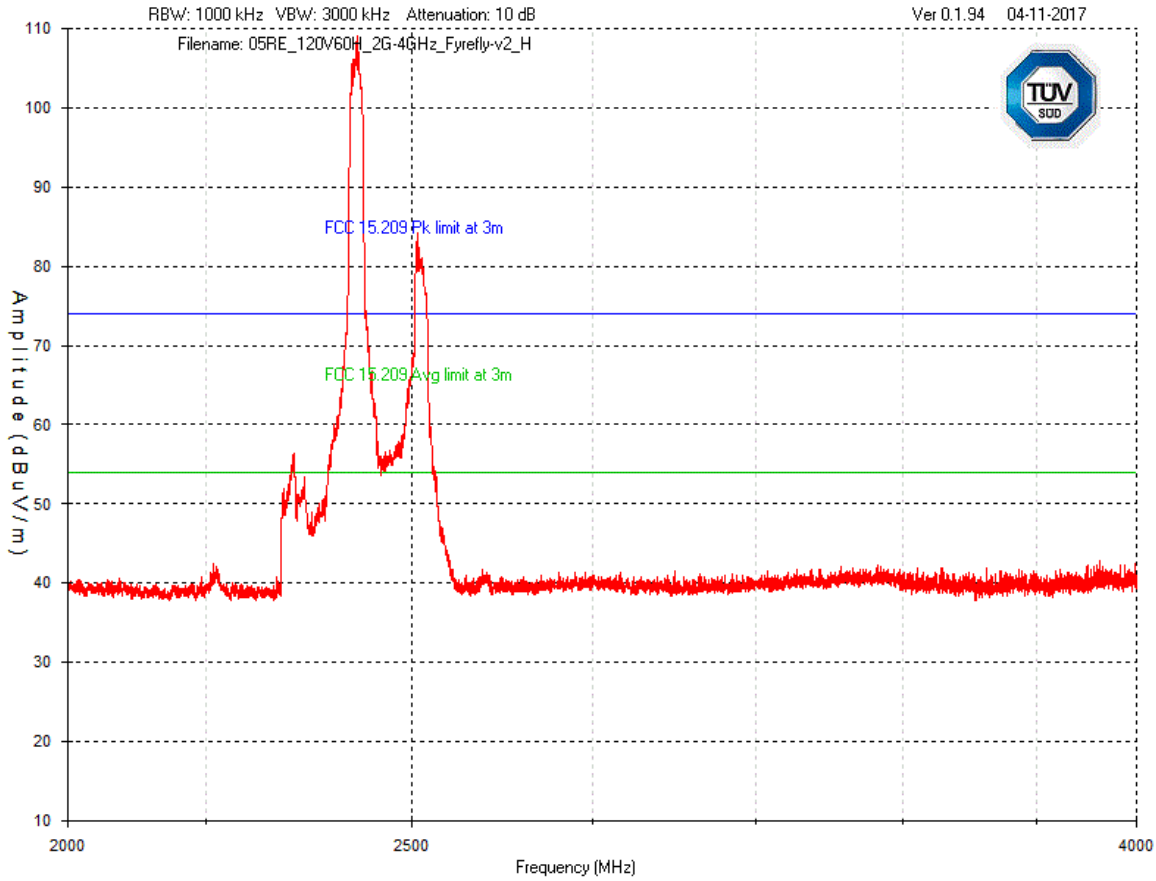
Low Channel – 2 GHz – 4 GHz
Horizontal - Peak Emission Graph



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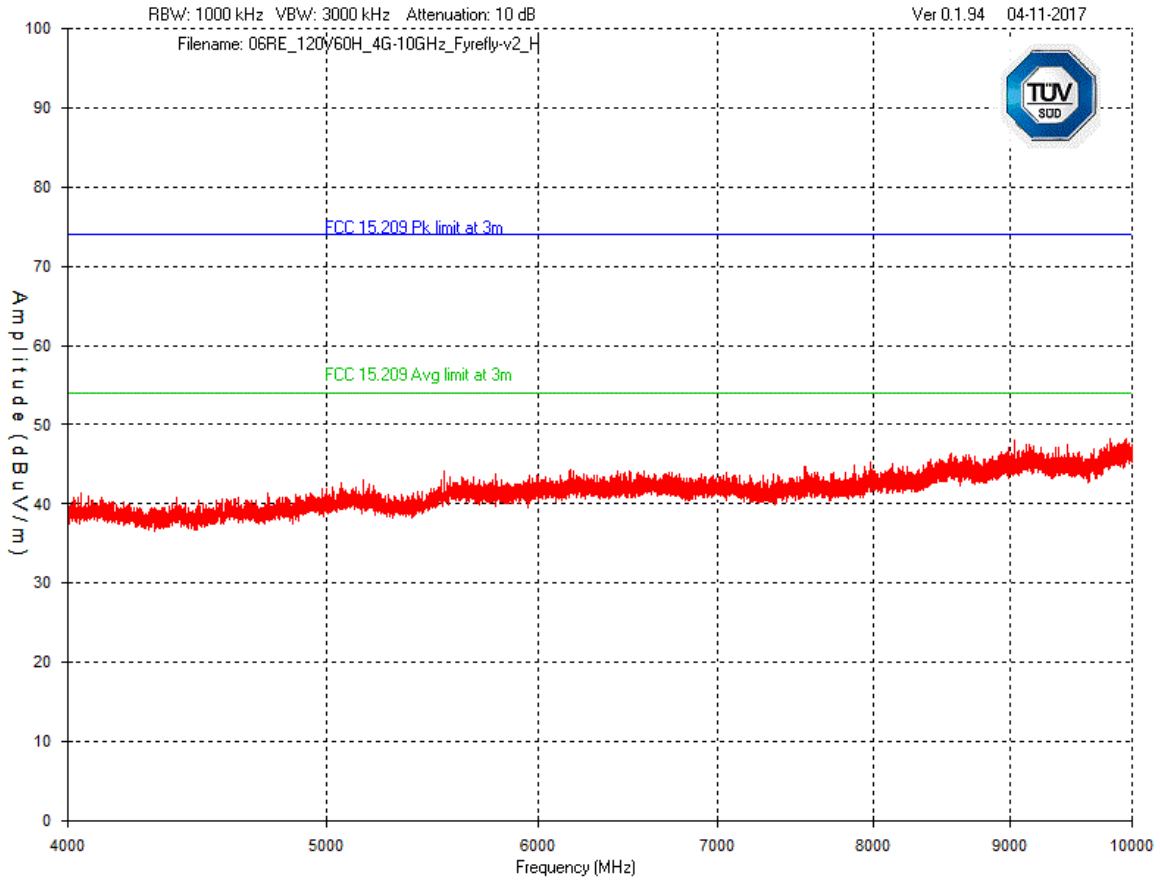
Low Channel – 4 GHz – 10 GHz
Horizontal - Peak Emission Graph



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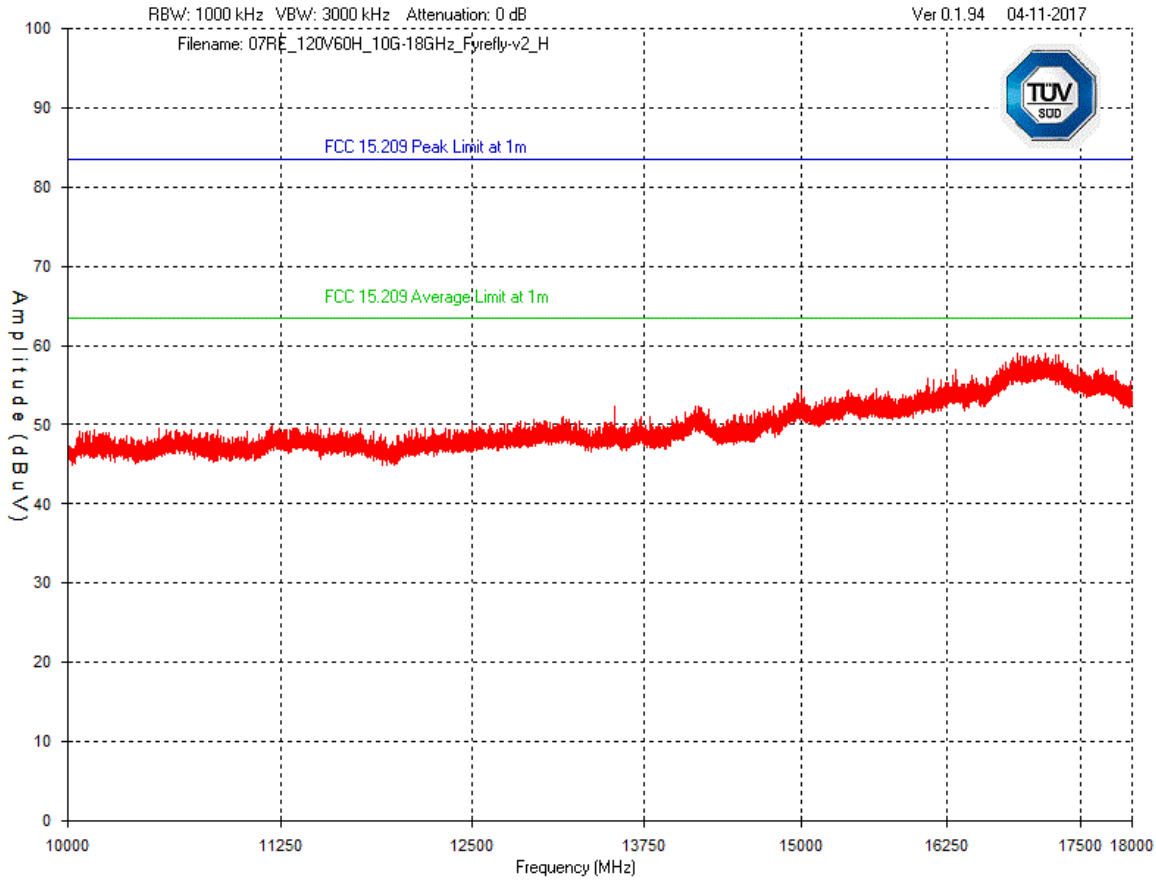
Low Channel – 10 GHz – 18 GHz
Horizontal - Peak Emission Graph



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

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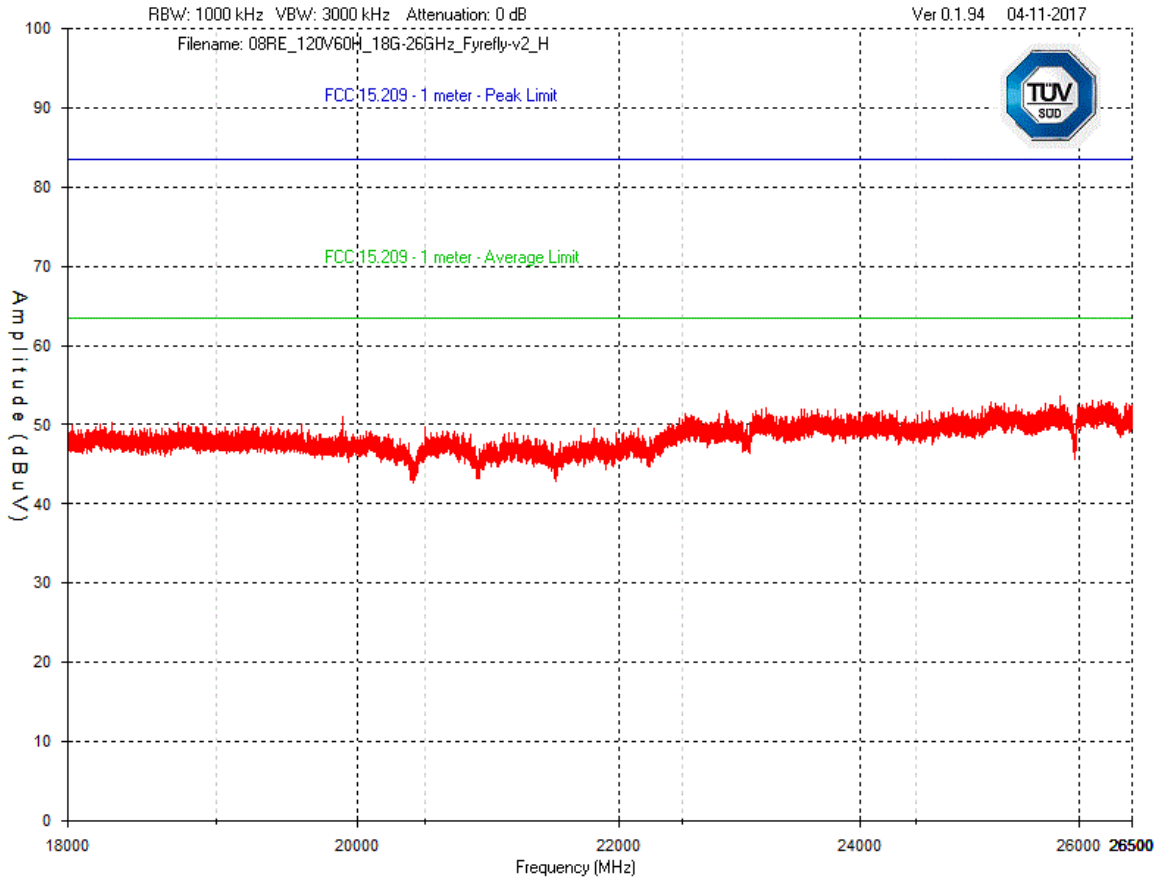
Low Channel – 18 GHz – 26.5 GHz
Horizontal - Peak Emission Graph



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

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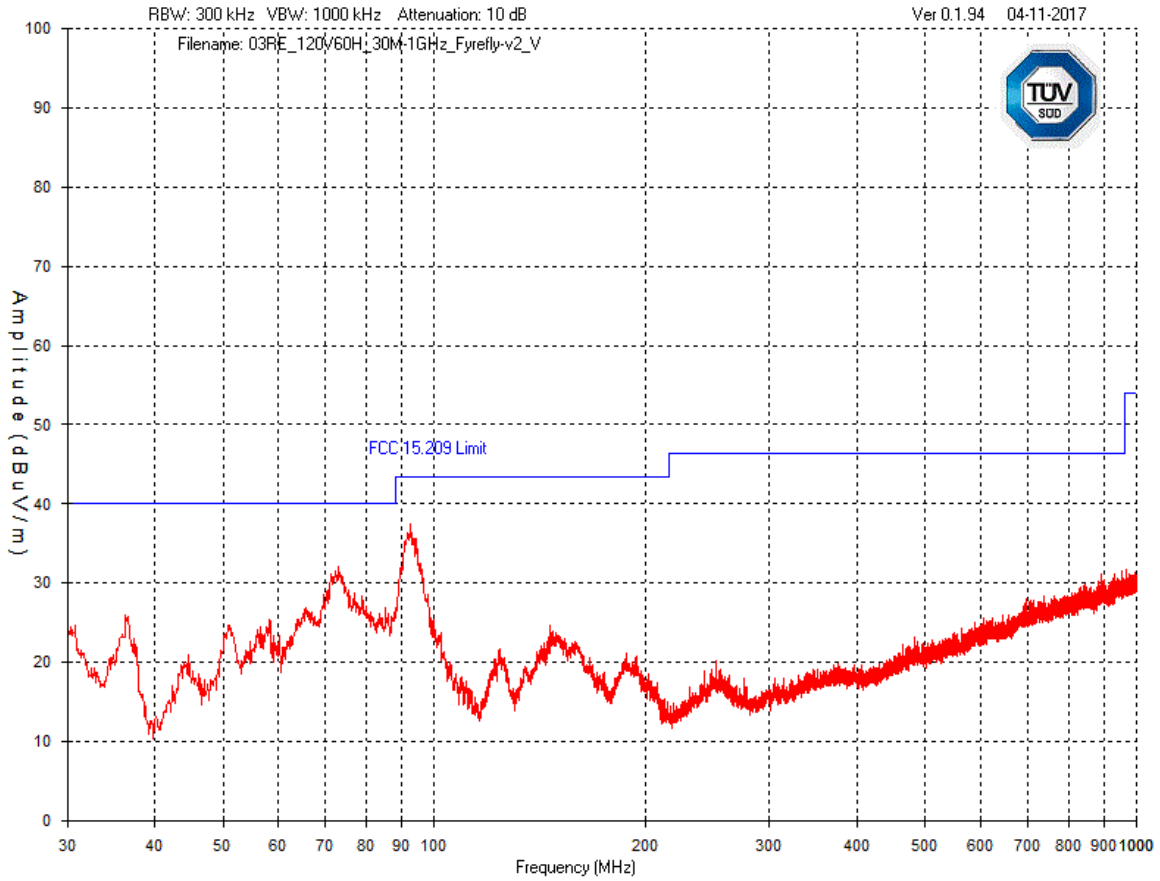
Low Channel – 30 MHz – 1 GHz
Vertical - Peak Emission Graph



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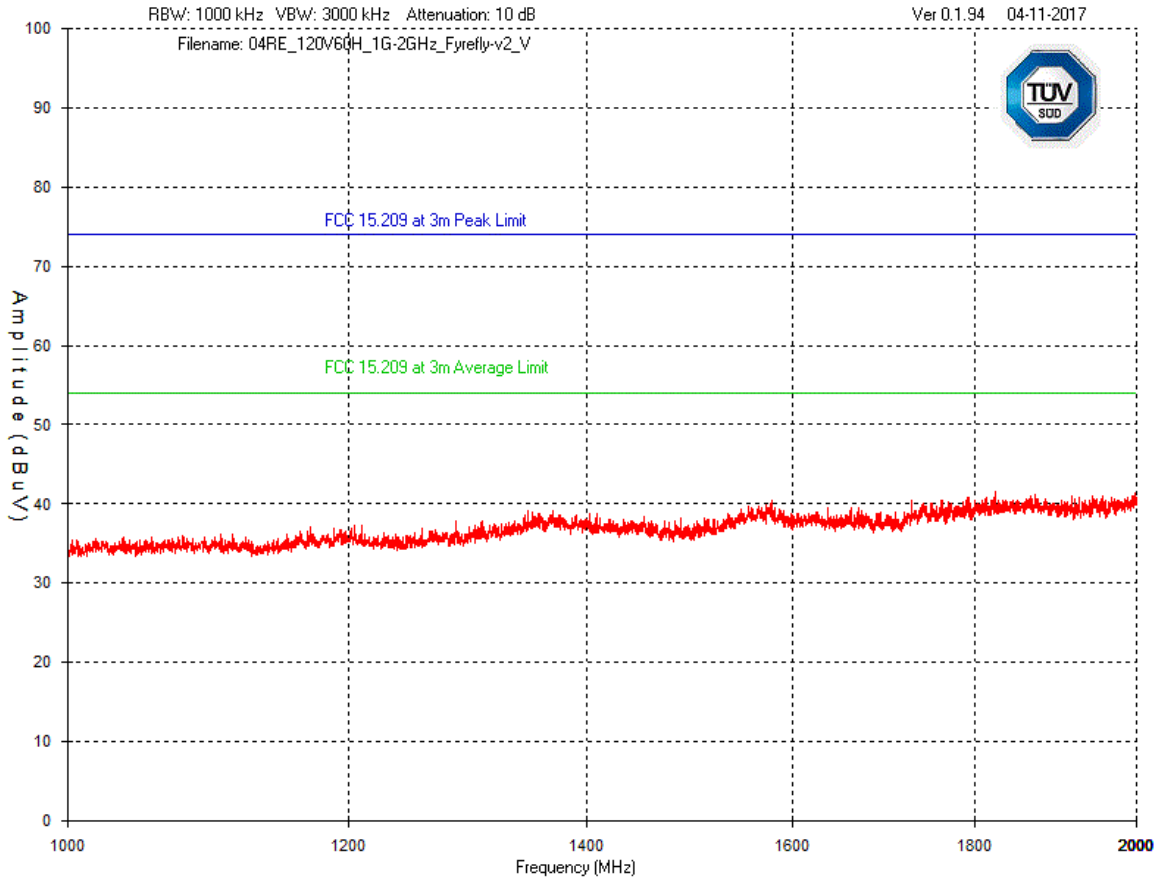
Low Channel – 1 GHz – 2 GHz
Vertical - Peak Emission Graph



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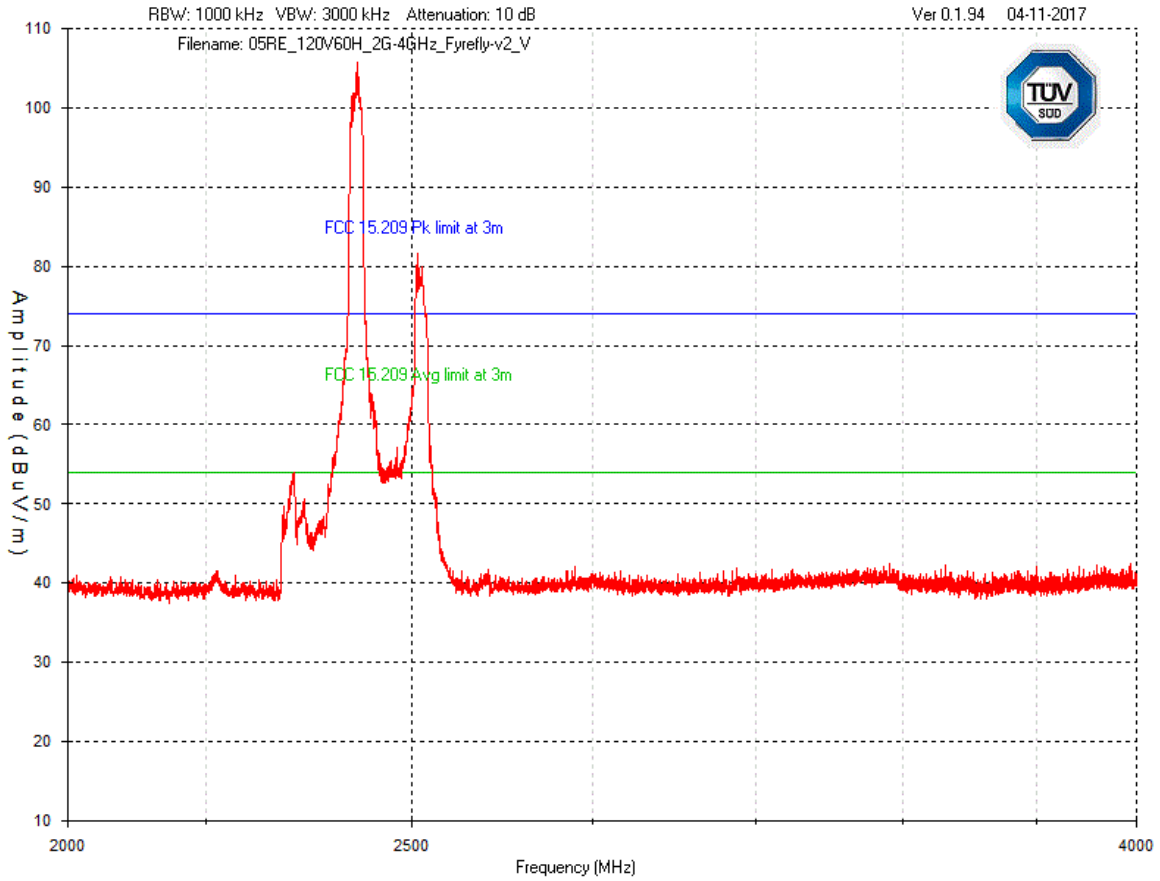
Low Channel – 2 GHz – 4 GHz
Vertical - Peak Emission Graph



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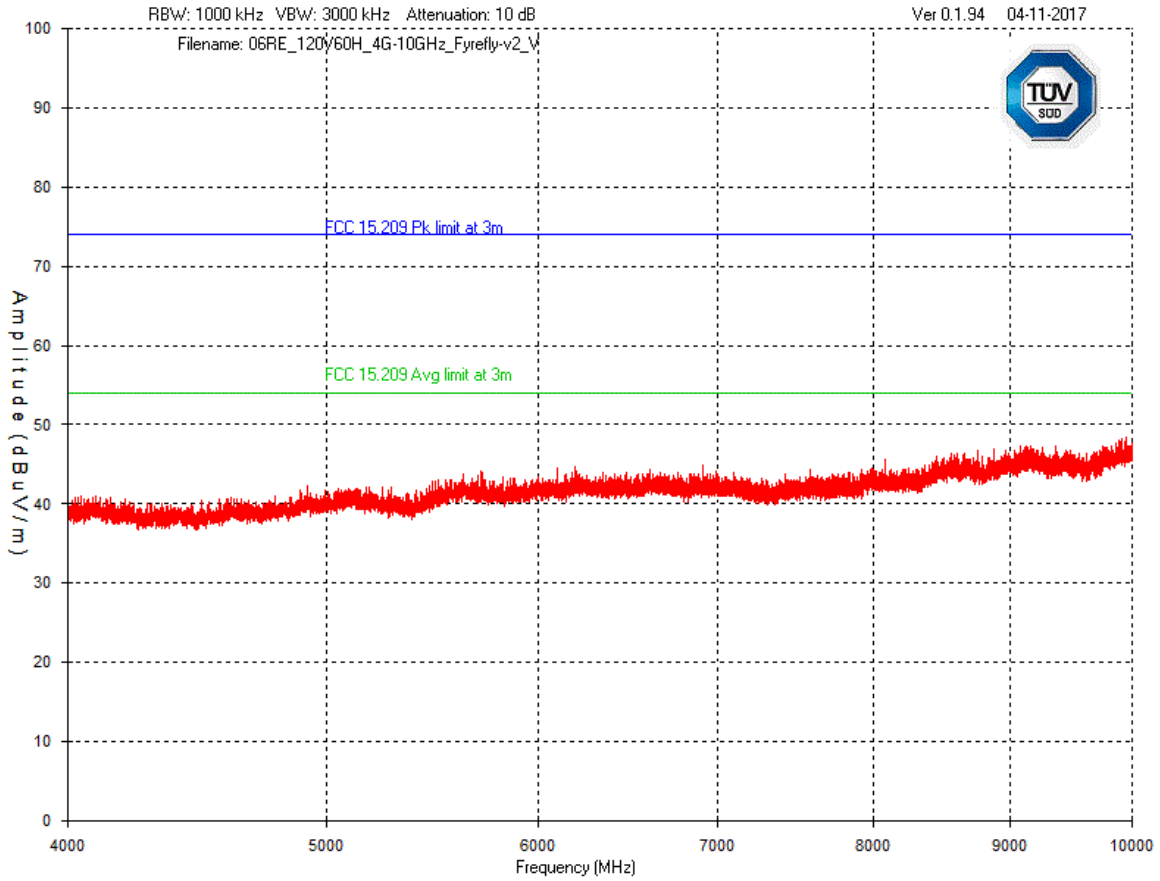
Low Channel – 4 GHz – 10 GHz
Vertical - Peak Emission Graph



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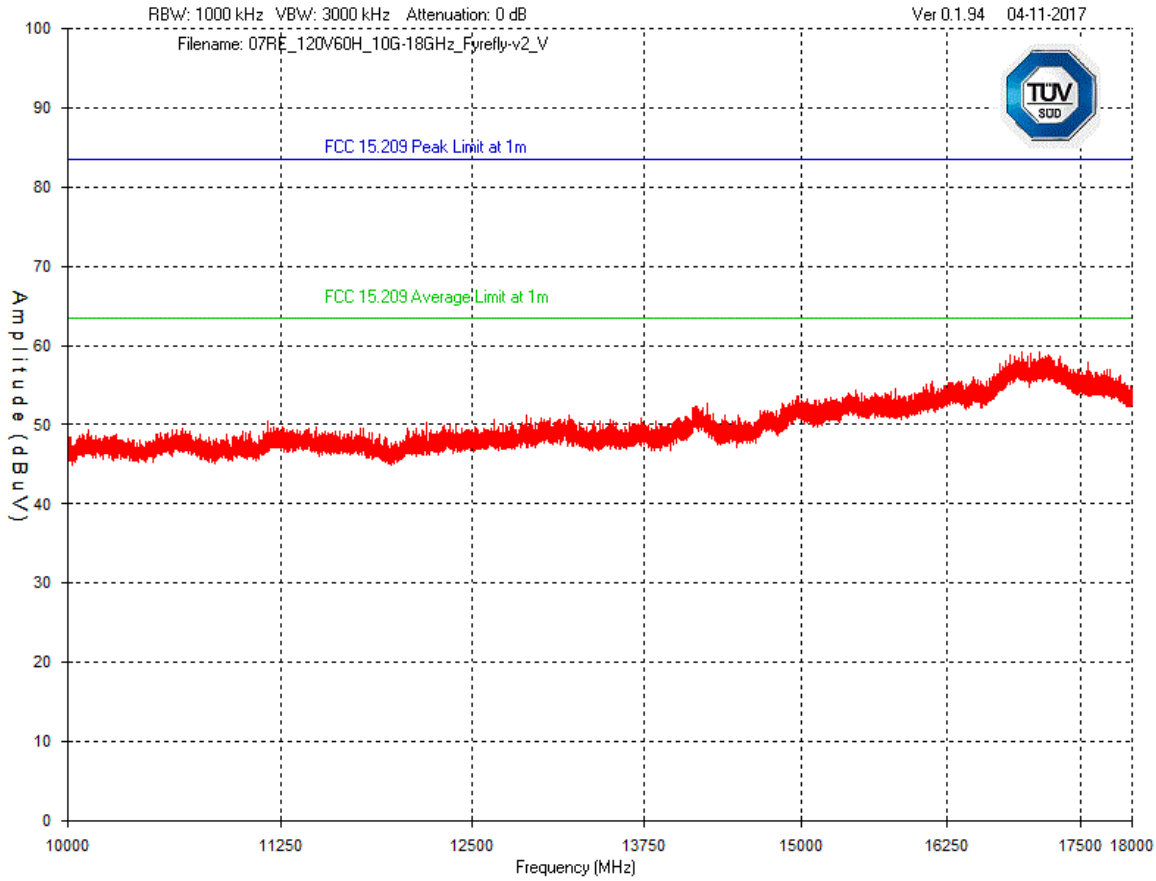
Low Channel – 10 GHz – 18 GHz
Vertical - Peak Emission Graph



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

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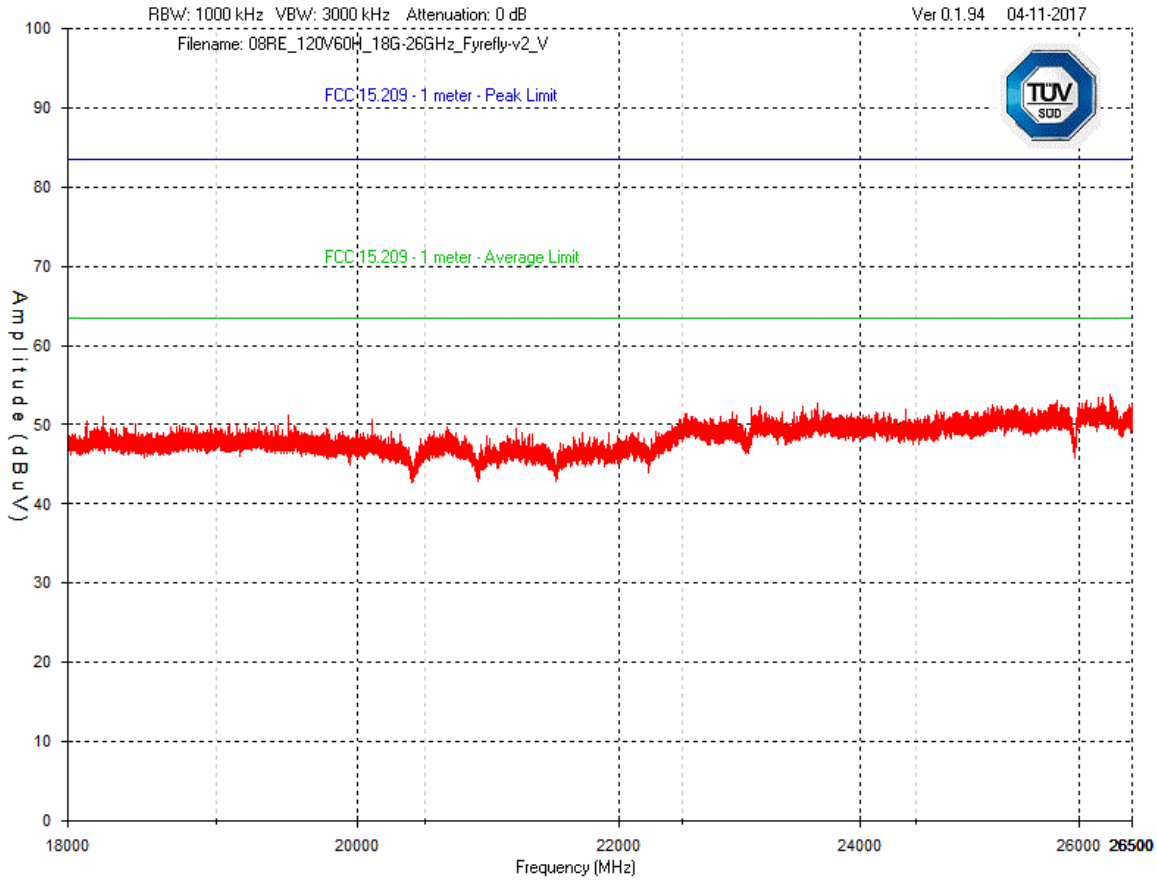
Low Channel – 18 GHz – 26.5 GHz
Vertical - Peak Emission Graph



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

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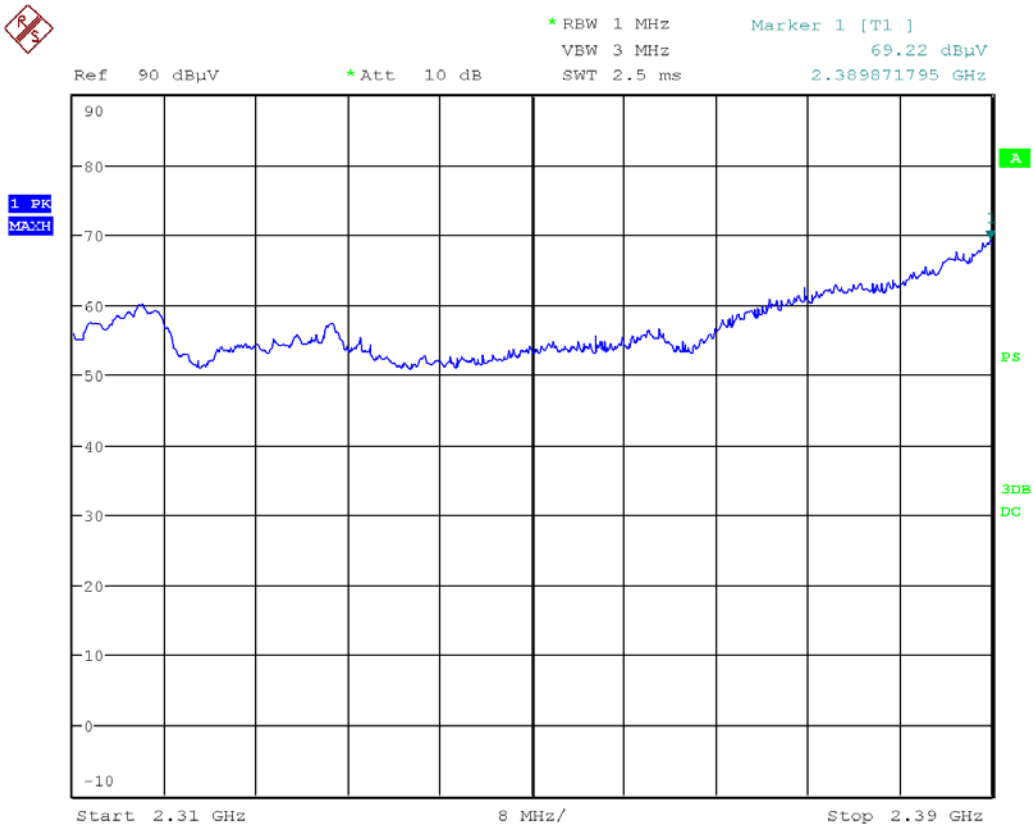
Low Channel (1)
Band Edge – 2310MHz – 2390MHz
Horizontal - Peak Emission



Date: 11.APR.2017 13:55:16

Note: Restricted band Band Edge plot was taken at a 3m measurement distance. The marker shows the raw value. See the Final Measurements and Results section below for correct values.

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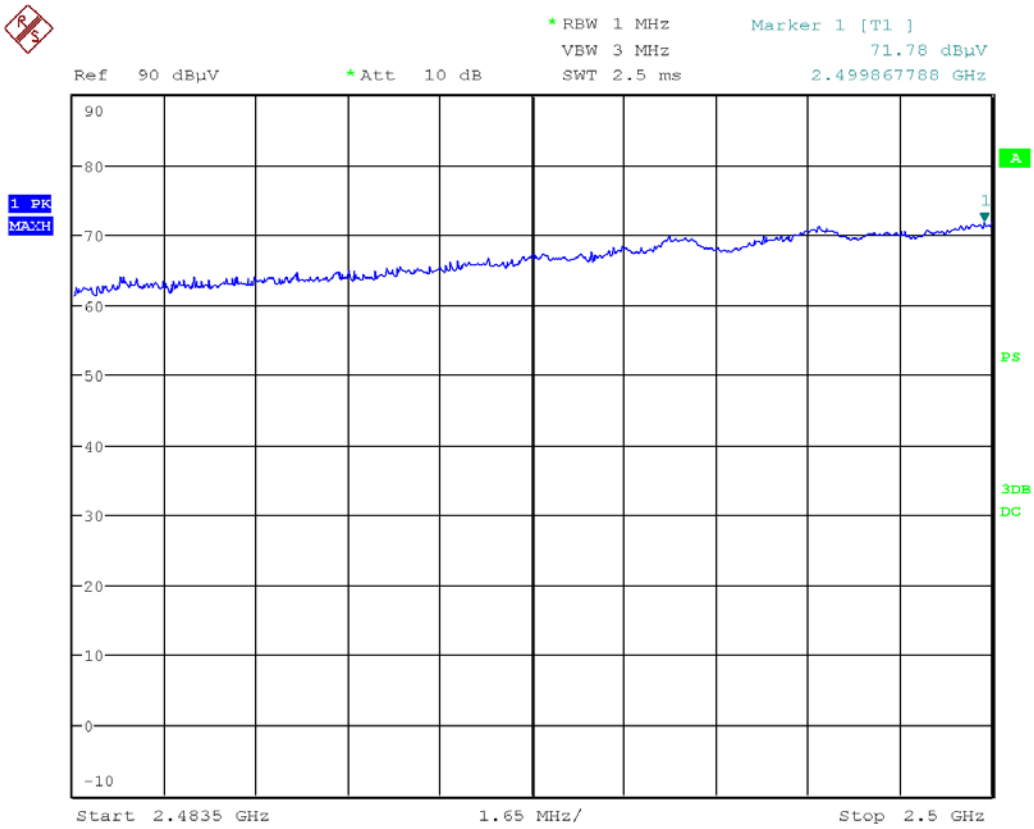
Low Channel (1)
Band Edge – 2483.5MHz – 2500MHz
Horizontal - Peak Emission



Date: 11.APR.2017 13:57:26

Note: Restricted band Band Edge plot was taken at a 3m measurement distance. The marker shows the raw value. See the Final Measurements and Results section below for correct values.

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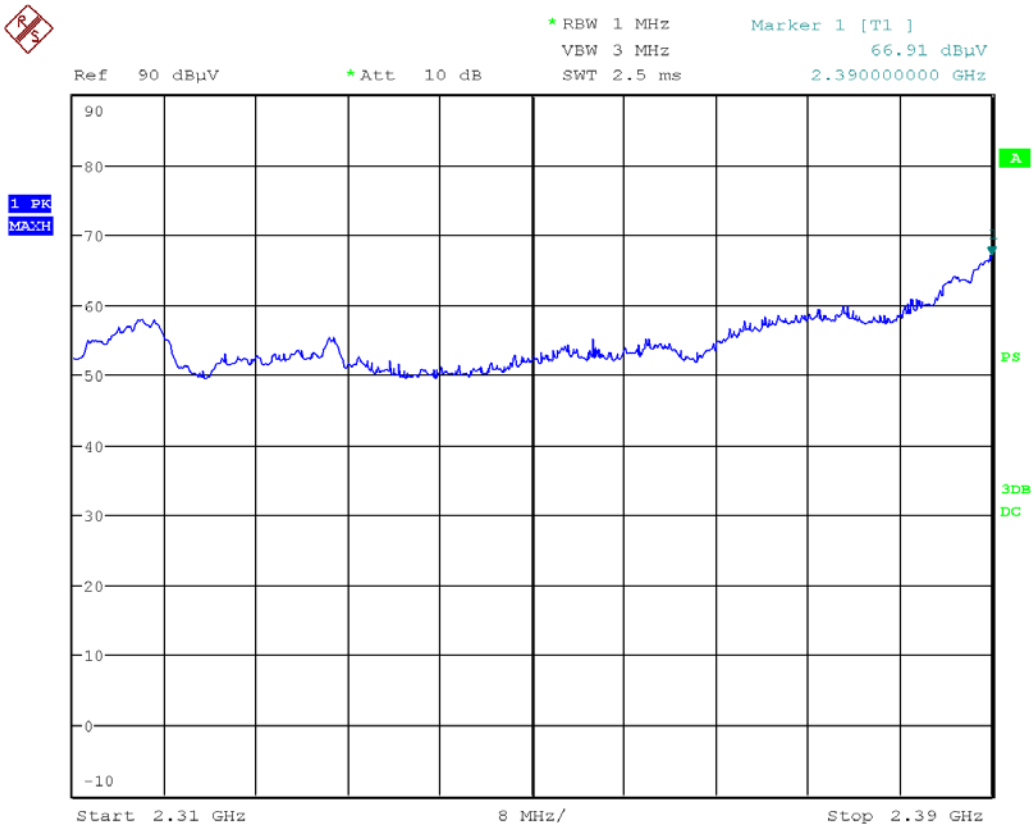
Low Channel (1)
Band Edge – 2310MHz – 2390MHz
Vertical - Peak Emission



Date: 11.APR.2017 13:42:35

Note: Restricted band Band Edge plot was taken at a 3m measurement distance. The marker shows the raw value. See the Final Measurements and Results section below for correct values.

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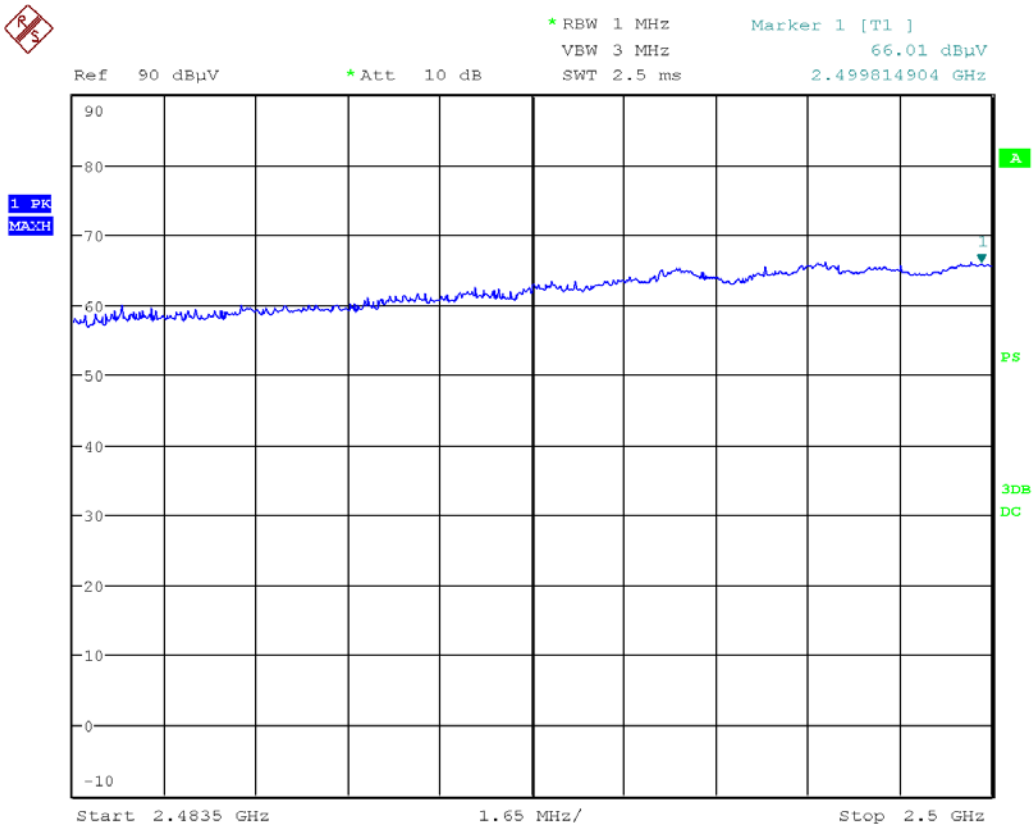
Low Channel (1)
Band Edge – 2483.5MHz – 2500MHz
Vertical - Peak Emission



Date: 11.APR.2017 13:44:22

Note: Restricted band Band Edge plot was taken at a 3m measurement distance. The marker shows the raw value. See the Final Measurements and Results section below for correct values.

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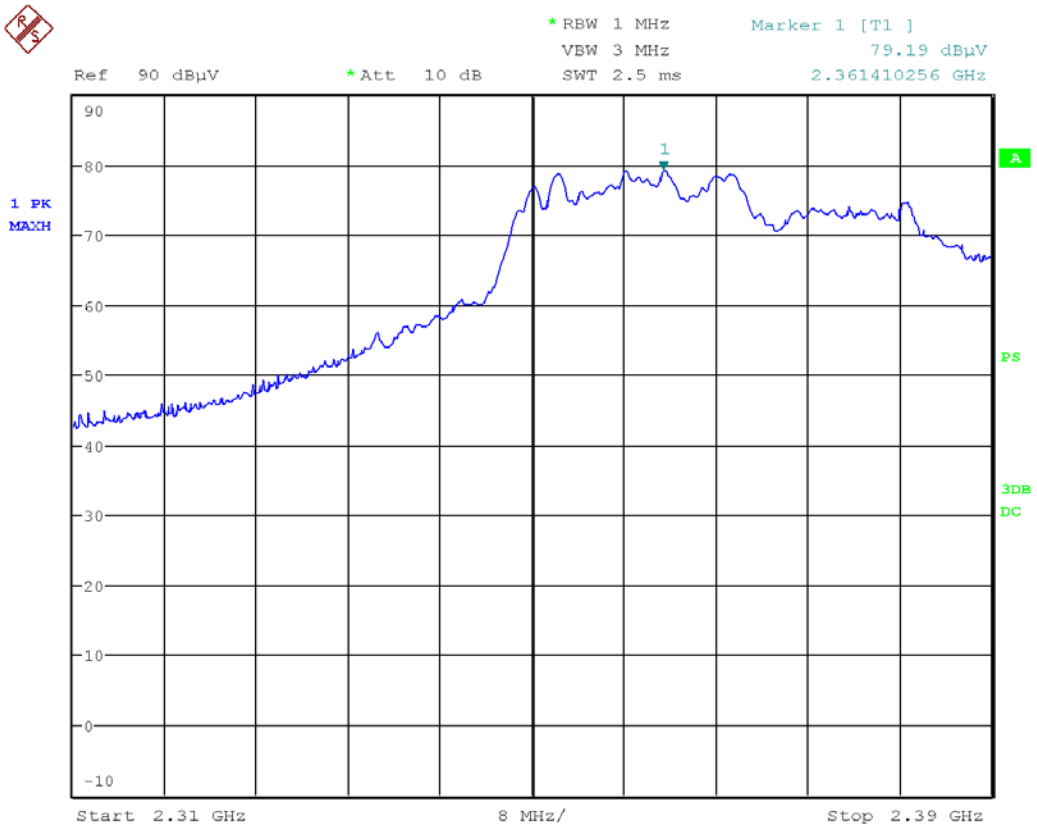
Hi Channel (11)
Band Edge – 2310MHz – 2390MHz
Horizontal - Peak Emission



Date: 11.APR.2017 14:16:32

Note: Restricted band Band Edge plot was taken at a 3m measurement distance. The marker shows the raw value. See the Final Measurements and Results section below for correct values.

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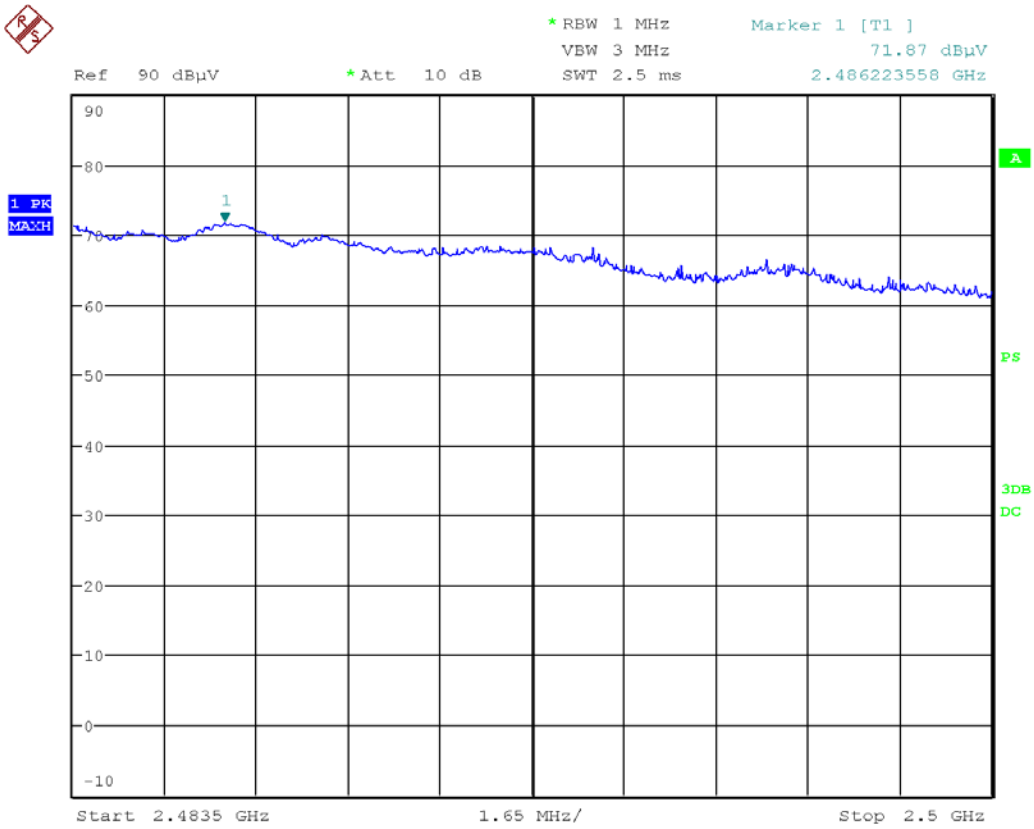
Hi Channel (11)
Band Edge – 2483.5MHz – 2500MHz
Horizontal - Peak Emission



Date: 11.APR.2017 14:14:09

Note: Restricted band Band Edge plot was taken at a 3m measurement distance. The marker shows the raw value. See the Final Measurements and Results section below for correct values.

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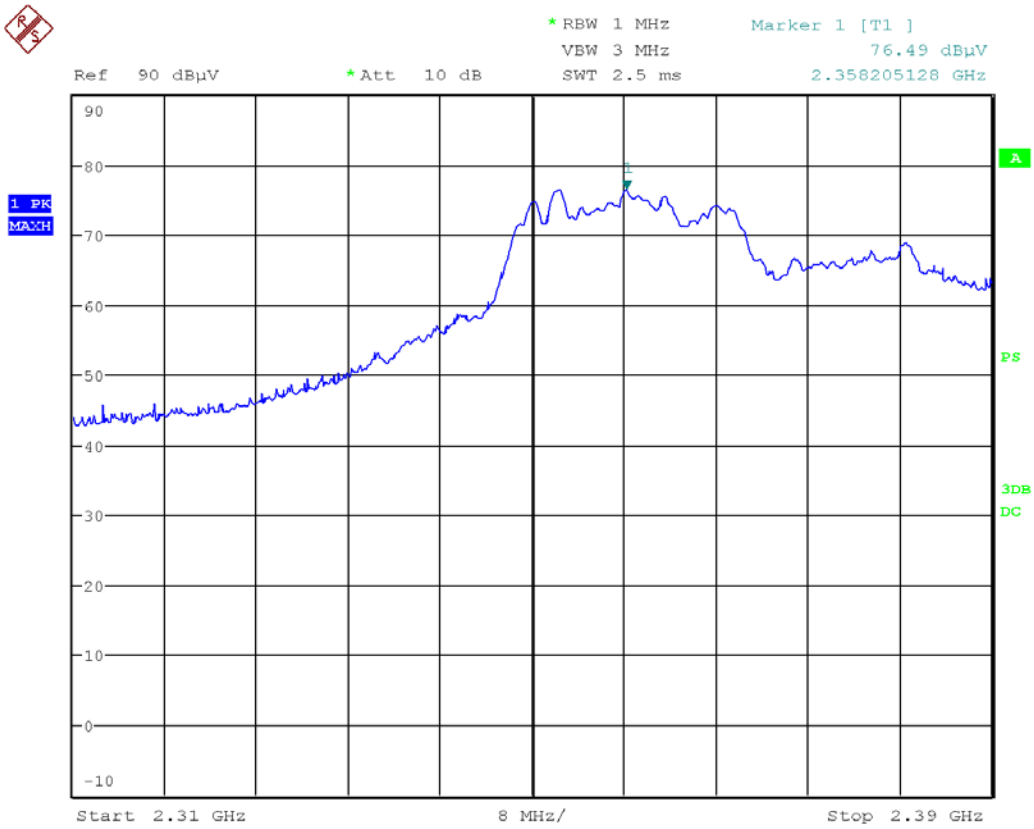
Hi Channel (11)
Band Edge – 2310MHz – 2390MHz
Vertical - Peak Emission



Date: 11.APR.2017 14:27:58

Note: Restricted band Band Edge plot was taken at a 3m measurement distance. The marker shows the raw value. See the Final Measurements and Results section below for correct values.

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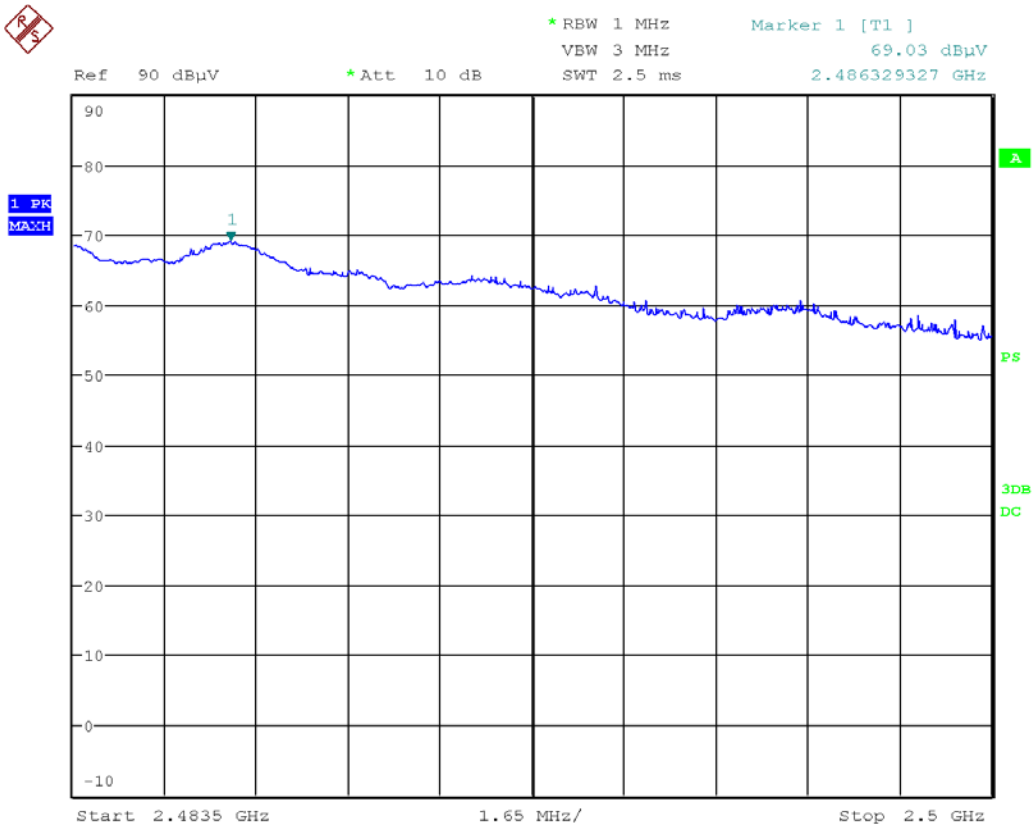
Hi Channel (11)
Band Edge – 2483.5MHz – 2500MHz
Vertical - Peak Emission



Date: 11.APR.2017 14:29:43

Note: Restricted band Band Edge plot was taken at a 3m measurement distance. The marker shows the raw value. See the Final Measurements and Results section below for correct values.

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Final Measurements and Results

The EUT passed. 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. Emissions outside the restricted bands were measured for informational purposes.

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.

Supply			120Vac 60Hz						
Frequency (MHz)	**Detector Peak/QP**	**Received Signal (dBµV)**	**Antenna Factor (dB/m)**	**Cable Factor (dB)**	**Pre-Amp (dB)**	**Level (dBµV/m)**	**QP Limit (dBµV/m)**	**QP Margin (dB)**	**Pass/ Fail**
Horizontal Antenna Polarization									
925.62	PEAK	34.3	23.6	2.6	-29.9	30.6	46.4	15.8	Pass
30.19	PEAK	36.3	18.5	0.4	-34.5	20.7	40.0	19.3	Pass
37.09	PEAK	38.6	14.6	0.5	-34.5	19.2	40.0	20.8	Pass
997.77	PEAK	35.4	23.9	2.8	-29.1	33.0	54.0	21.0	Pass
133.51	PEAK	43.9	7.3	0.9	-34.6	17.5	43.5	26.0	Pass
9039.99	PEAK	43.9	31.0	9.4	-36.2	48.1	54.0	5.9	Pass
Vertical Antenna Polarization									
92.34	QP	47.6	8.6	0.8	-34.6	22.4	43.5	21.1	Pass
73.01	PEAK	60.1	5.9	0.6	-34.5	32.1	40.0	7.9	Pass
36.31	PEAK	47.3	12.8	0.5	-34.5	26.1	40.0	13.9	Pass
58.26	PEAK	50.6	8.9	0.5	-34.5	25.5	40.0	14.5	Pass
51.17	PEAK	51.1	7.7	0.5	-34.5	24.8	40.0	15.2	Pass
9157.89	PEAK	42.6	31.3	9.5	-36.1	47.3	54.0	6.7	Pass

Spurious Emission Measurements

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Test Frequency (MHz)	Detection Mode	Antenna Polarity (Horz/Vert)	Received Signal (dBµV)	Antenna Factor (dB/m)	Cable Factor (dB)	Pre-Amp Gain (dB)	Level (dBµV/m)	Emission Limit (dBµV/m)	Margin (dB)	Result
Low Channel - X axis										
2412	Peak	Horz	114.4	26.4	3.6	-35.8	108.6			PASS
2412	Avg	Horz	100.8	26.4	3.6	-35.8	95.0			PASS
2412	Peak	Vert	111.4	26.4	3.6	-35.8	105.6			PASS
2412	Avg	Vert	97.9	26.4	3.6	-35.8	92.0			PASS
2390	Peak	Horz	69.2	26.4	3.6	-35.8	63.3	74.0	10.7	PASS
2390	Avg	Horz	37.2	26.4	3.6	-35.8	31.3	54.0	22.7	PASS
2390	Peak	Vert	66.9	26.4	3.6	-35.8	61.0	74.0	13.0	PASS
2390	Avg	Vert	34.9	26.4	3.6	-35.8	29.0	54.0	25.0	PASS
2499.8	Peak	Horz	71.8	26.2	3.6	-35.8	65.7	74.0	8.3	PASS
2499.8	Avg	Horz	39.7	26.2	3.6	-35.8	33.7	54.0	20.3	PASS
2500	Peak	Vert	66.0	26.2	3.6	-35.8	60.0	74.0	14.0	PASS
2500	Avg	Vert	34.0	26.2	3.6	-35.8	27.9	54.0	26.1	PASS
Mid Channel - X axis										
2437	Peak	Horz	113.9	26.3	3.6	-35.8	108.0			PASS
2437	Avg	Horz	100.5	26.3	3.6	-35.8	94.6			PASS
2437	Peak	Vert	111.4	26.3	3.6	-35.8	105.5			PASS
2437	Avg	Vert	97.9	26.3	3.6	-35.8	92.0			PASS
High Channel - X axis										
2462	Peak	Horz	114.2	26.3	3.6	-35.8	108.3			PASS
2462	Avg	Horz	100.9	26.3	3.6	-35.8	95.0			PASS
2462	Peak	Vert	110.9	26.3	3.6	-35.8	104.9			PASS
2462	Avg	Vert	97.5	26.3	3.6	-35.8	91.5			PASS
2390	Peak	Horz	79.2	26.4	3.6	-35.8	73.3	74.0	0.7	PASS
2390	Avg	Horz	47.2	26.4	3.6	-35.8	41.3	54.0	12.7	PASS
2358.2	Peak	Vert	76.5	26.4	3.6	-35.8	70.6	74.0	3.4	PASS
2358.2	Avg	Vert	44.4	26.4	3.6	-35.8	38.5	54.0	15.5	PASS
2486.2	Peak	Horz	71.9	26.2	3.6	-35.8	65.9	74.0	8.1	PASS
2486.2	Avg	Horz	39.8	26.2	3.6	-35.8	33.8	54.0	20.2	PASS
2486.3	Peak	Vert	69.0	26.2	3.6	-35.8	63.0	74.0	11.0	PASS
2486.3	Avg	Vert	37.0	26.2	3.6	-35.8	31.0	54.0	23.0	PASS

Peak Power and Band Edge Measurements

Note: The EUT has a fixed (source based) duty cycle of 2.5% (2.5ms on time/100ms). For the average radiated emission measurements of the band edges in the restricted bands, a duty cycle correction factor of 2.5% [20log(2.5%) = -32.04] was applied to the peak measurement to obtain the average measurement.

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Test Equipment List

Equipment	Model No.	Manufacturer	Last Calibration / Verification Date	Next Calibration / Verification Date	Asset #
Spectrum Analyzer	ESU 40	Rohde & Schwarz	Jan. 06, 2016	Jan. 06, 2018	GEMC 233
Horn Antenna 2 – 18 GHz	WBH218HN	Q-par	Feb. 12, 2016	Feb. 12, 2018	GEMC 6375
Pre-Amp 1 – 26.5 GHz	HP 8449B	HP	Oct. 12, 2016	Oct. 12, 2018	GEMC 6351
Horn Antenna 18 – 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
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	3142-C	ETS	Feb. 22, 2017	Feb. 22, 2019	GEMC 137
2.4GHz-2.5GHz Notch Filter	BRM50702	Micro-Tronics	July 11, 2016	July 11, 2017	GEMC 230
RF Cable 10m	LMR-400-10M-50Ω-MN-MN	LexTec	Feb. 20, 2017	Feb. 20, 2018	GEMC 274
RF Cable 2m	Sucoflex 104A	Huber+Suhner	Feb. 20, 2017	Feb. 20, 2018	GEMC 272
Emissions Software	0.1.94	Global EMC	NCR	NCR	GEMC 58

FCC - 15.209 -Radiated Emissions_Rev1

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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 Method

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 Section 10.2 of FCC KDB 558074.

Results

The EUT passed. Low, medium, and high bands were tested. The worst case value is -5.48 dBm as measured with a 3 kHz resolution bandwidth (peak power).

Graphs

The graphs shown below show the power spectral density of the device during the conducted measurement operation of the EUT. Low, middle, and high channel was investigated in each mode, with the worst case being presented. The external attenuator and cable loss are accounted for as reference offset in the spectrum analyzer.

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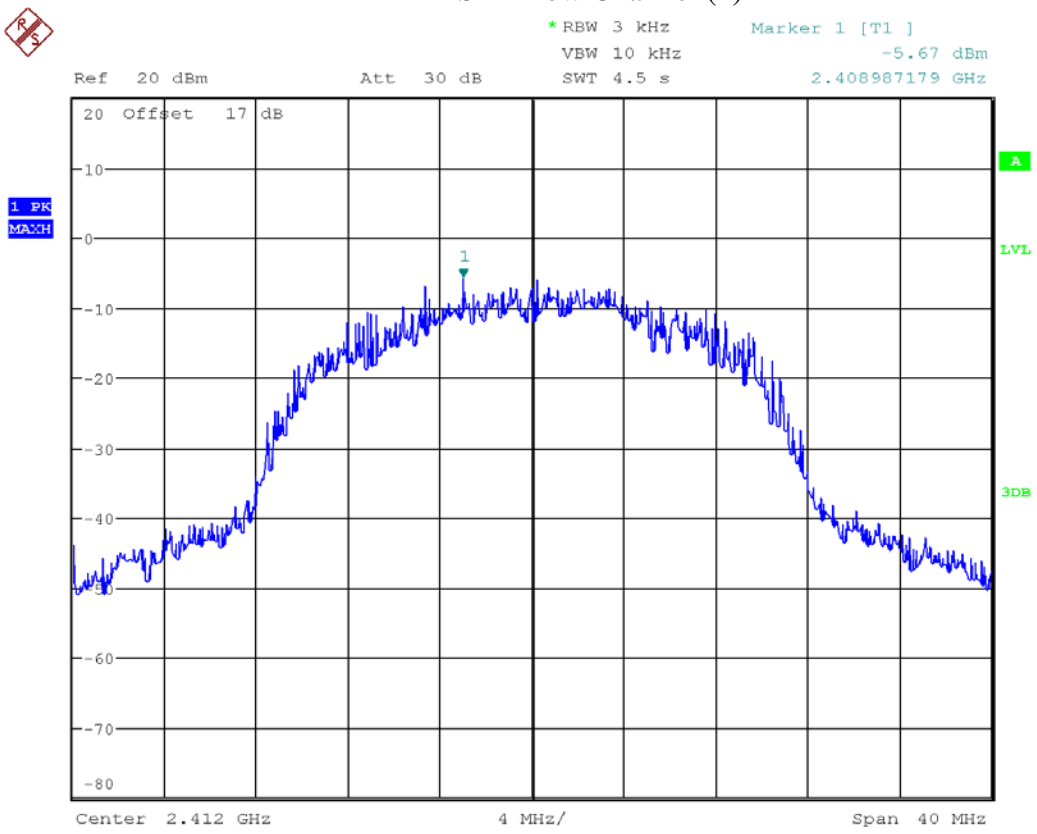
PSD - Low Channel (1)



Date: 16.APR.2016 10:43:27

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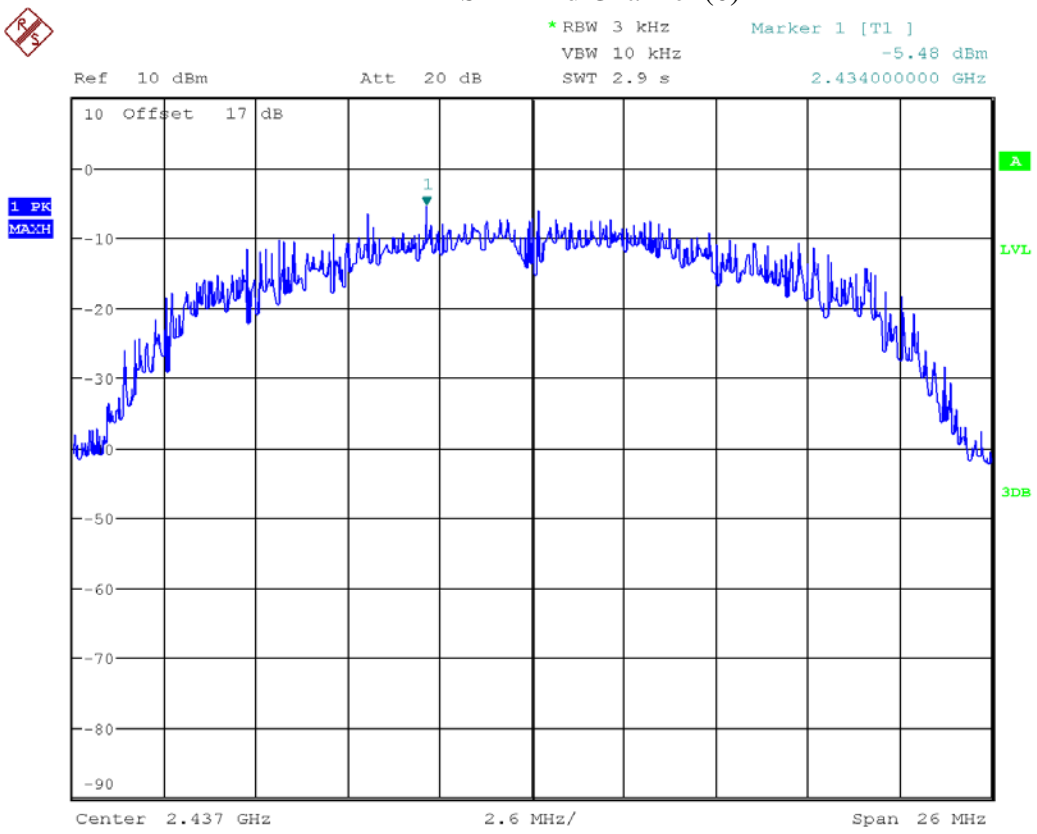
PSD - Mid Channel (6)



Date: 16.APR.2016 11:09:38

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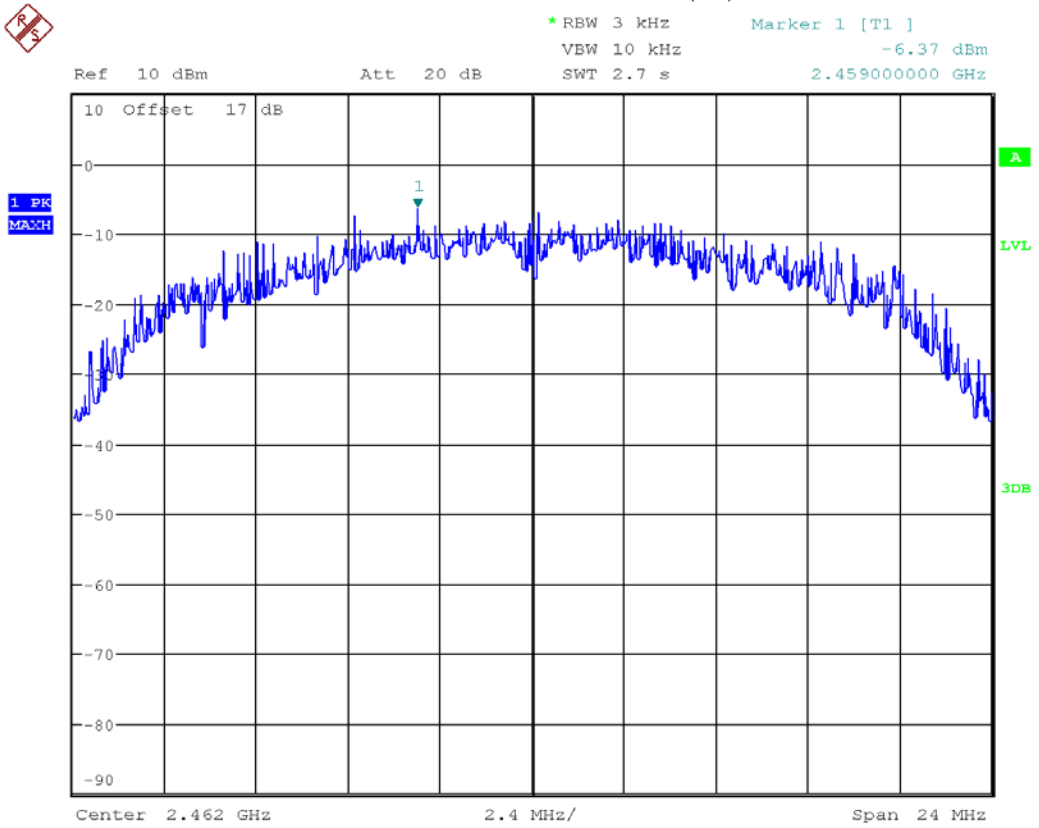
PSD - Hi Channel (11)



Date: 16.APR.2016 11:38:47

See 'Appendix B – EUT and Test Setup Photos' 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 Date	Asset #
Spectrum Analyzer	FSU 26	Rohde & Schwarz	Feb. 15, 2017	Feb. 15, 2019	GEMC 232
Attenuator 10 dB	8493B	Agilent	Feb. 20, 2017	Feb. 20, 2018	GEMC 133
Attenuator 6 dB	3M-6	Weinschel	Feb. 20, 2017	Feb. 20, 2018	GEMC 278

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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, as measured from a LISN. This helps protect lower frequency radio services such as AM radio, shortwave radio, amateur radio operators, maritime radio, CB radio, and so on, from unwanted interference.

Limits and Method

The limits are as defined in 47 CFR FCC Part 15 Section 15.207
Method is as defined in ANSI C63.4

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.

Based on ANSI C63.4 Section 4.2, 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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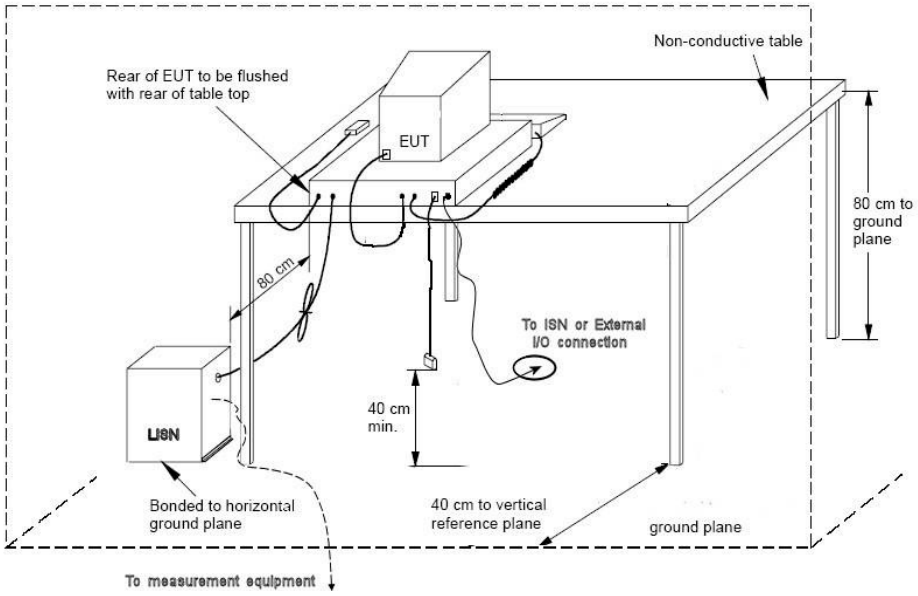
Typical Setup Diagram



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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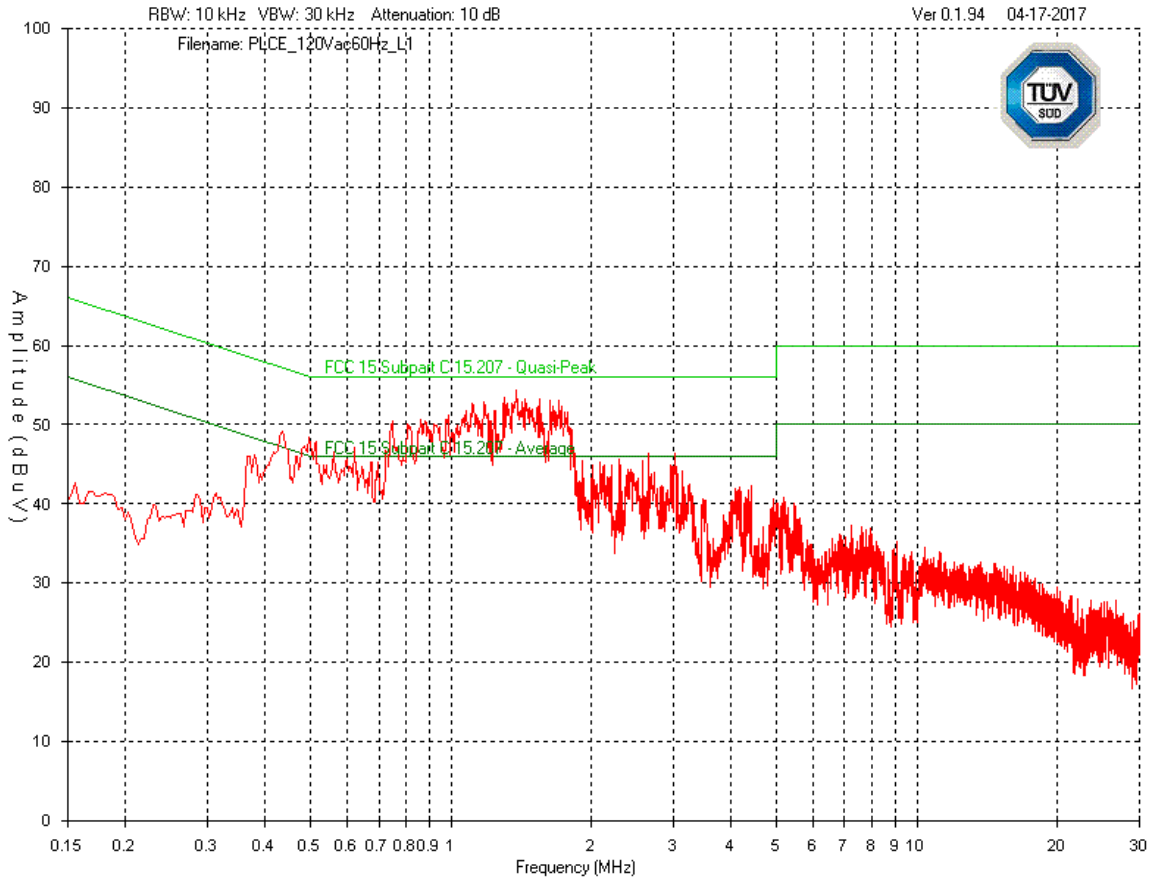
Line 1 (L1) – 120Vac 60Hz
Peak



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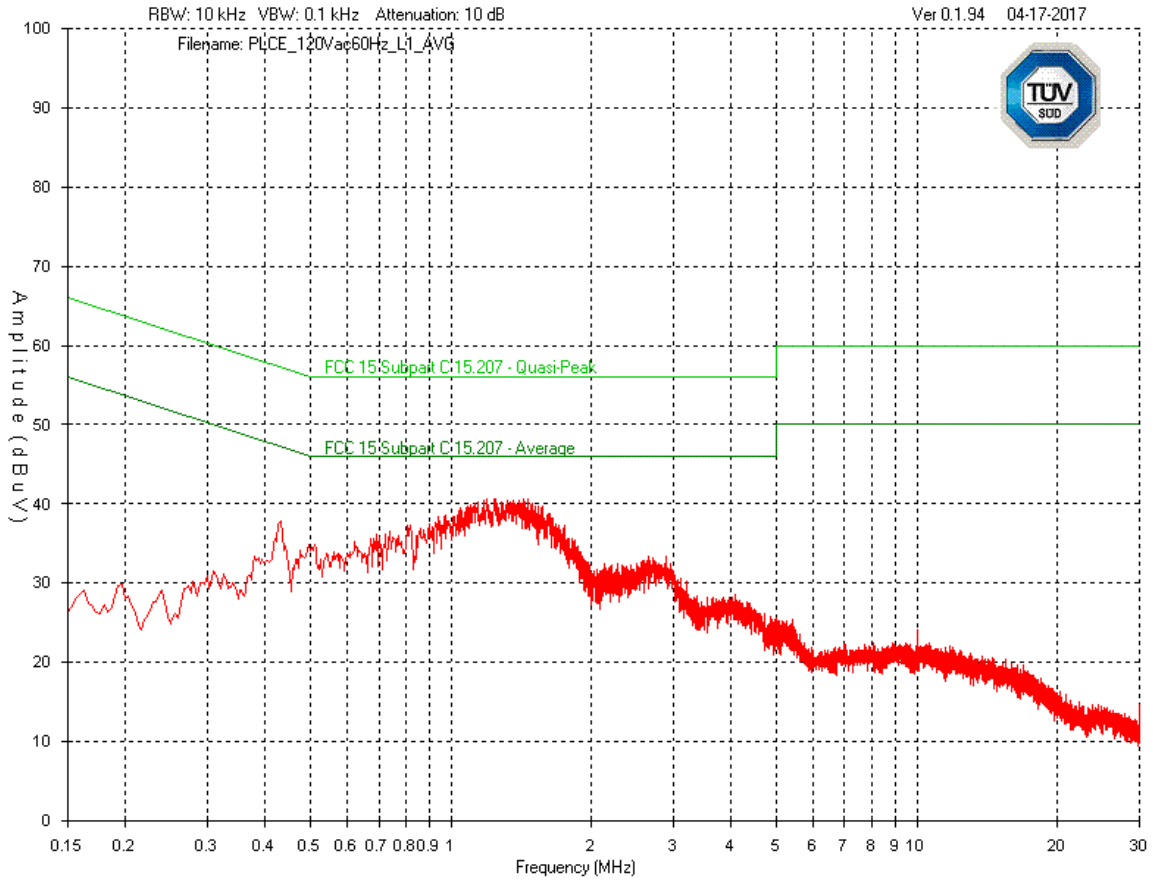
Line 1 (L1) – 120Vac 60Hz
Average



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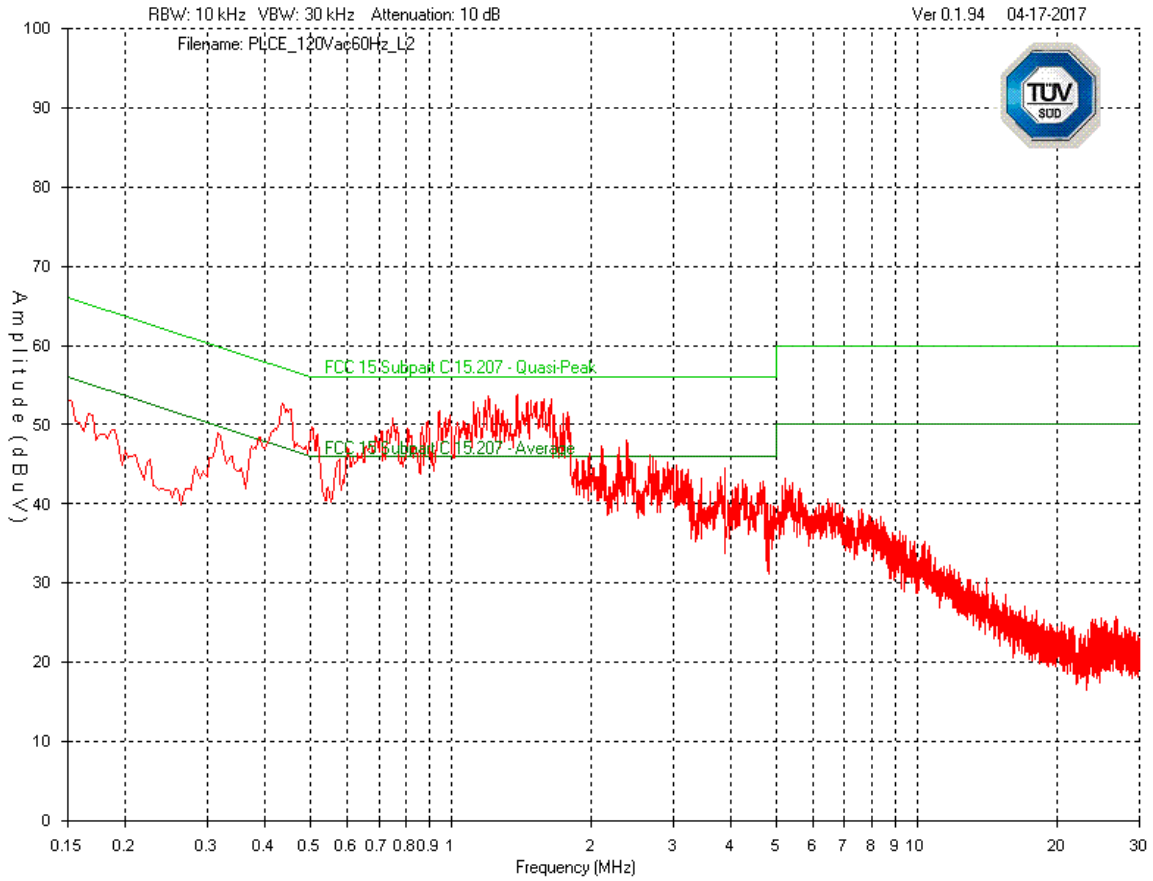
Line 2 (L2) – 120Vac 60Hz
Peak



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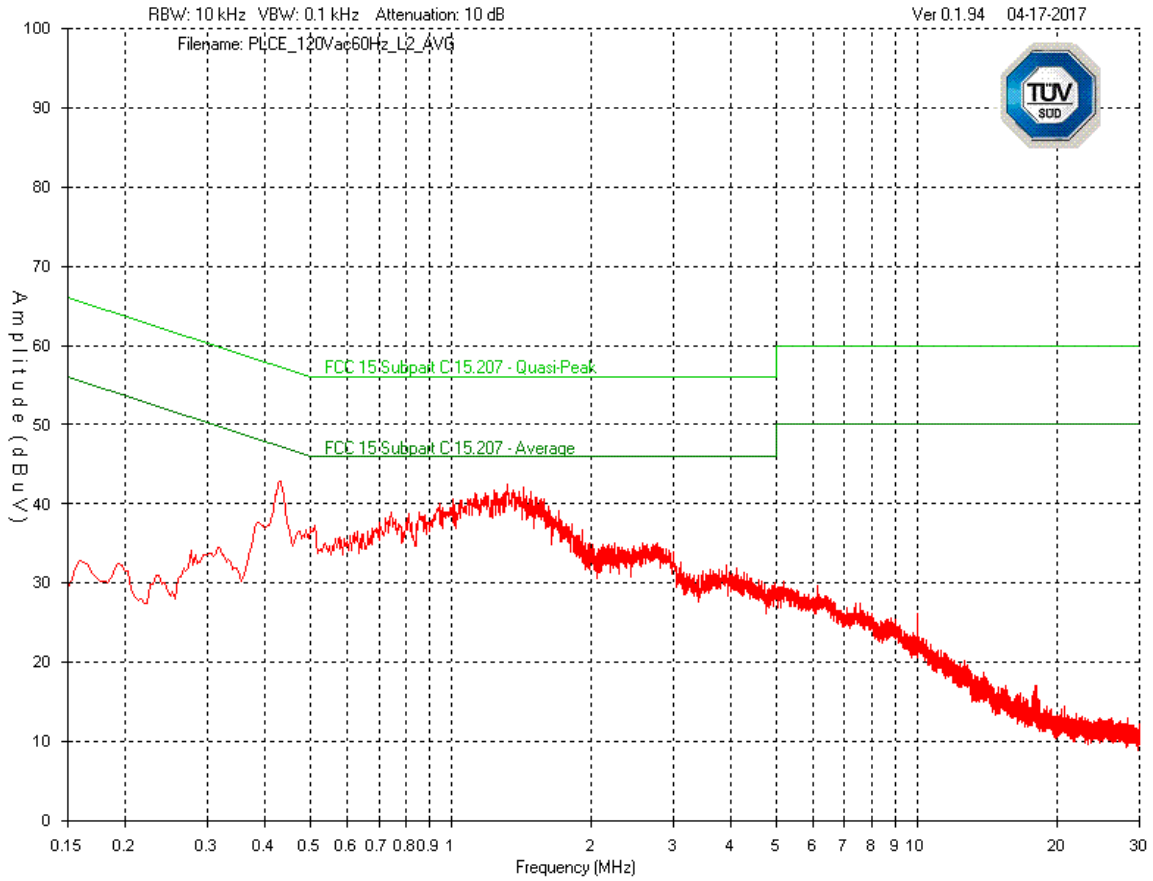
Line 2 (L2) – 120Vac 60Hz
Average



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Final Measurements

Supply			120Vac 60Hz						
Frequency (MHz)	**Detector Peak/QP**	**Received Signal (dBµV)**	**Atten Factor (dB)**	**Cable Factor (dB)**	**LISN Factor (dB)**	**Level (dBµV)**	**QP Limit (dBµV)**	**QP Margin (dB)**	**Pass/ Fail**
Line 1									
1.383	QP	36.0	10	0.1	0.0	46.1	56	9.9	Pass
1.632	QP	34.6	10	0.1	0.0	44.7	56	11.3	Pass
1.177	QP	34.6	10	0.1	0.0	44.7	56	11.3	Pass
0.436	PEAK	39.0	10	0.1	0.0	49.1	57	8.0	Pass
2.659	PEAK	36.3	10	0.1	0.0	46.4	56	9.6	Pass
3.035	PEAK	36.3	10	0.1	0.0	46.4	56	9.6	Pass
Line 2									
1.504	QP	35.1	10	0.1	0.0	45.2	56	10.8	Pass
1.207	QP	35.8	10	0.1	0.0	45.9	56	10.1	Pass
0.400	QP	32.8	10	0.1	0.0	42.9	57	14.2	Pass
0.752	QP	32.3	10	0.1	0.0	42.4	56	13.6	Pass
2.403	PEAK	37.5	10	0.1	0.0	47.6	56	8.4	Pass
2.111	PEAK	37.2	10	0.1	0.0	47.3	56	8.7	Pass

Quasi-Peak Emissions Table

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Supply			120Vac 60Hz						
Frequency (MHz)	**Detector Peak/ AVG**	**Received Signal (dBµV)**	**Atten Factor (dB)**	**Cable Factor (dB)**	**LISN Factor (dB)**	**Level (dBµV)**	**AVG Limit (dBµV)**	**AVG Margin (dB)**	**Pass/ Fail**
Line 1									
1.197	AVG	30.6	10	0.1	0.0	40.7	46.0	5.3	Pass
0.808	AVG	27.2	10	0.1	0.0	37.3	46.0	8.7	Pass
0.433	AVG	27.8	10	0.1	0.0	37.9	47.2	9.3	Pass
2.649	AVG	23.3	10	0.1	0.0	33.4	46.0	12.6	Pass
2.905	AVG	20.8	10	0.1	0.0	30.9	46.0	15.1	Pass
0.150	AVG	16.2	10	0.0	0.1	26.3	56.0	29.7	Pass
Line 2									
1.320	AVG	32.4	10	0.1	0.0	42.5	46.0	3.5	Pass
0.429	AVG	32.8	10	0.1	0.0	42.9	47.3	4.4	Pass
0.160	AVG	22.7	10	0.0	0.1	32.8	55.5	22.7	Pass
10.004	AVG	16.1	10	0.1	0.0	26.2	50.0	23.8	Pass
0.150	AVG	19.2	10	0.0	0.1	29.3	56.0	26.7	Pass
17.970	AVG	6.9	10	0.1	0.1	17.1	50.0	32.9	Pass

Average Emissions Table

Note:

Peak = Peak measurement
AVG = Average measurement
QP = Quasi-Peak measurement

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

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Test Equipment List

Equipment	Model No.	Manufacturer	Last Calibration / Verification Date	Next Calibration / Verification 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 3m	LMR-400-3M-50Ω-MN-MN	LexTec	Feb 20, 2017	Feb 20, 2018	GEMC 276
Attenuator 10 dB	612-10-1	Meca Electronics, Inc	Feb 20, 2017	Feb 20, 2018	GEMC 223
Emissions Software	0.1.94	Global EMC	NCR	NCR	GEMC 58

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Appendix A – EUT Summary

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General EUT Description

Client	
Organization / Address	Cognitive Systems Corp. 560 Westmount Road North Waterloo, ON N2L 0A9
Phone	+1-519-514-0347
EUT Details	
EUT Name	fyrefly
EUT Model	6626000103
Equipment Category	ITE
Basic EUT Functionality	The fyrefly is a cognitive radio sensor product that can receive and analyze radio signals between 2400MHz and 2483.5MHz
Input Voltage and Frequency	120Vac / 60Hz
Rated Input Current	0.15 A
Connectors available on EUT	Micro USB (For Developers use only. Connector location not populated on PCB of final consumer units)
Peripherals Required for Test	Laptop with test software to configure the EUT
Intentional Radiator Frequency	2400 – 2483.5 MHz
EUT Configuration	Wireless configured to transmit at maximum possible 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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Appendix B – EUT and Test Setup Photos

Refer to the files separate from this test report.

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