FCC Test Report

FOR:

HAP Innovations

Model Name:

Spencer

Product Description:

Smart In-Home Medication Dispenser

FCC ID: 2AIA7-SPN01

Per:

47 CFR Part 15.247 (DTS)

Report #: EMC_HAPIN-001-16501_15.247_WLAN_rev3
DATE: September 1, 2016

CETECOM **Inc.**
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1 Assessment

The following device was evaluated against the applicable criteria specified in FCC rules Parts 15.247 of Title 47 of the Code of Federal Regulations.

No deviations were ascertained during the course of testing performed.

Company	Description	Model #
HAP Innovations	Smart In-Home Medication Dispenser	sp.01

Responsible for Testing Laboratory:

Date	Section	Name	Signature
September 1, 2016	Compliance	Franz Engert (Compliance Manager)	Digitally signed by Franz Engert DN: cn=Franz Engert, c=US, o=CETECOM, ou=Complience, email=franz.engert@cetecom.com

Responsible for the Report:

Date	Section	Name	Signature
September 1, 2016	Compliance	Douglas Antioco (EMC Engineer)	Douglas Antioco 2016.09.01 15:16:43 -07'00'

The test results of this test report relate exclusively to the test item specified in Section3.
CETECOM Inc. USA does not assume responsibility for any conclusions and generalizations drawn from the test results with regard to other specimens or samples of the type of the equipment represented by the test item. The test report may only be reproduced or published in full. Reproduction or publication of extracts from the report requires the prior written approval of CETECOM Inc. USA.

2 Administrative Data

2.1 Identification of the Testing Laboratory Issuing the EMC Test Report

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Department:	Compliance
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Telephone:	+1 (408) 586 6200
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Manager Compliance Services:	Franz Engert
Project Engineer:	Douglas Antioco

2.2 Identification of the Client

Clients Name:	Device Solutions
Clients Address:	1004 Copeland Oaks Dr.
City/Zip Code	Morrisville, NC 27560
Country	USA

2.3 Identification of the Manufacturer

Manufacturer's Name:	HAP Innovations
Manufacturers Address:	4220 Apex Highway, Suite 200
City/Zip Code	Durham, NC 27713
Country	USA

3 Equipment Under Test (EUT)

3.1 EUT Specifications

Model #:	sp.01
HW Version :	1.0
SW Version :	1.0
FCC-ID :	2AIA7-SPN01
HVIN:	Sp.01
PMN:	spencer
Product Description:	Smart In-Home Medication Dispenser
Regulatory Band:	Nominal band: 2400 – 2483.5 MHz
Channels Used:	2412 MHz (Ch. 1) – 2462 (Ch.11), 11 channels
Type(s) of Modulation:	802.11b/g/n with CCK, DQPSK, DBPSK + DSSS QBSK, BPSK, 16 QAM, 64 QAM + OFDM
Modes of Operation:	802.11b/g/n Client only
Integrated Module Info:	TI WL1835MOD WiLink™ 8 single band combo 2x2 MIMO Wi-Fi®, Bluetooth® & Bluetooth Smart (Low energy) module (FCC ID: Z64-WL18SBMOD / IC ID: 451I-WL18SBMO) • Bluetooth Low Energy with GFSK modulation • Bluetooth EDR/BDR with GFSK, π/4 DPSK, and 8 DPSK Modulations • 802.11 b/g/n (2.4GHz)
Antenna Type:	Single internal antenna.
Max. Declared Antenna Gain:	Documented max antenna gain: 2.4GHz = 3.6 dBi
Maximum Conducted Output Power: (Measured)	Conducted Power: 15.9 dBm RMS (802.11b mode), 23.9 dBm Peak (802.11g mode)
Power Supply:	Dedicated Battery Pack
Rated Operating Voltage Range:	Vmin: 11.5V dc/ Vnom: 12.0V dc / Vmax: 16.8V dc
Operating Temperature Range:	Tlow: 5° C/Tnom: 25° C/ Tmax: 40° C

Other Radios included in the Device:	BTLE 4.0 Bluetooth EDR/BDR LTE (Band 4 and 13)
Sample Revision:	■Prototype; ☐Production; ☐Pre-Production

Note: Obtained from Sections 3.2.5 and 3.2.6 of the referenced module report. Please see Section 6.4 of this report.

3.2 EUT Sample details

EUT #	Serial Number	HW Version	SW Version	Notes/Comments
1	010C0319160300002E	1.0	1.0	Radiated and Conducted Sample

3.3 Accessory Equipment (AE) details

AE #	Type	Model	Manufacturer	Serial Number
1	N/A	N/A	N/A	N/A

3.4 EUT Sample Configuration

EUT Set-Up #	Combination of AE used for test set up	Comments
1	EUT#1	The radio of the EUT was stimulated directly in a test mode not accessible by the end user via RS323 with a laptop utilizing a terminal emulator such as Tera Term. The EUT transmitted a modulated WLAN signal on a specified channel.

3.5 Environmental conditions during Test:

The following environmental conditions were maintained during the course of testing:
Ambient Temperature: 20-25°C
Relative humidity: 40-60%

4 Subject of Investigation

The objective of the measurements done by CETECOM Inc. was to assess the performance of the EUT per the relevant requirements specified in FCC rules Part 15.247 of Title 47 of the Code of Federal Regulations..

This test report is to support a request for new equipment authorization under the FCC ID: 2AIA7-SPN01

Testing procedures are based on ANSI 63.10 (2013) and "GUIDANCE FOR PERFORMING COMPLIANCE MEASUREMENTS ON DIGITAL TRANSMISSION SYSTEMS (DTS) OPERATING UNDER §15.247; April 8, 2016" by the Federal Communications Commission, Office of Engineering and Technology, Laboratory Division.

5 Measurement Results Summary

Test Specification	Test Case	Temperature and Voltage Conditions	Mode	Pass	Fail	NA	NP	Result
§15.247(e)	Power Spectral Density	Nominal	802.11g	☐	☐	☐	■	Complies, See Note 1
§15.247(a)(1)	Emission Bandwidth	Nominal	802.11g	☐	☐	☐	■	Complies, See Note 1
§15.247(b)(1)	Maximum Conducted Output Power and EIRP	Nominal	802.11g	☐	☐	☐	■	Complies, See Note 1
§15.247/15.209/ 15.205	Band edge compliance-Restricted Band Edges	Nominal	802.11g	☐	☐	☐	■	Complies, See Note 1
§15.247(d)	Band edge compliance-Unrestricted Band Edges	Nominal	802.11g	☐	☐	☐	■	Complies, See Note 1
§15.247(d) §15.209	TX Spurious emissions-Radiated	Nominal	802.11b/g	■	☐	☐	☐	Complies
§15.207(a)	AC Conducted Emissions	Nominal	802.11b/g	■	☐	☐	☐	Complies

Note: NA= Not Applicable; NP= Not Performed.
Note 1: 802.11b mode Leveraged from module certification. See Section 6.4.

6 Measurements

6.1 Measurement Uncertainty

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus, with 95% confidence interval (in dB delta to result), based on a coverage factor k=1.

	Uncertainty in dB radiated <30MHz	Uncertainty in dB radiated 30MHz - 1GHz	Uncertainty in dB radiated > 1GHz	Uncertainty in dB Conducted measurement
standard deviation k=1	2.48	1.94	2.16	0.64
95% confidence interval in dB	4.86	3.79	4.24	1.25
95% confidence interval in dB in delta to Result (rounded up to next decimal point)	+/- 2.5 dB	+/- 2.0 dB	+/- 2.3dB	+/- 0.7dB

6.2 Environmental Conditions During Testing:

The following environmental conditions were maintained during the course of testing:

- Ambient Temperature: 20-25˚C
- Relative humidity: 40-60%

6.3 Dates of Testing:

May 9, 2016 – August 29, 2016

6.4 Inheriting Test Results from Incorporated Module Certification:

The EUT integrates the certified module TI WL1835MOD (details see EUT spec in section 3.1)

Taking into account guidance from FCC KDB 996369 (modular approval) and where relevant test procedures did not change conducted test results are leveraged from the conducted test report for the TI WL1835MOD given by Sporton International Inc., dated January 27, 2014 with Report Reference Number: FR3N2752-01C; FCC ID: Z64-WL18SBMOD.

This test report contains full radiated testing as per FCC 15.247.

6.5 Additional Test Information

Testing is performed according to the guidelines provided in FCC publication (KDB) FCC KDB 558074 D01 V03R05, GUIDANCE FOR PERFORMING COMPLIANCE MEASUREMENTS ON DIGITAL TRANSMISSION SYSTEMS (DTS) OPERATING UNDER §15.247 and according to relevant parts of ANSI 63.10 as detailed below.

Due to the discrepancy of the conducted peak output power from the measurements and the module report (section 8.4), full testing was done on 802.11g mode.

7 Measurement Procedures

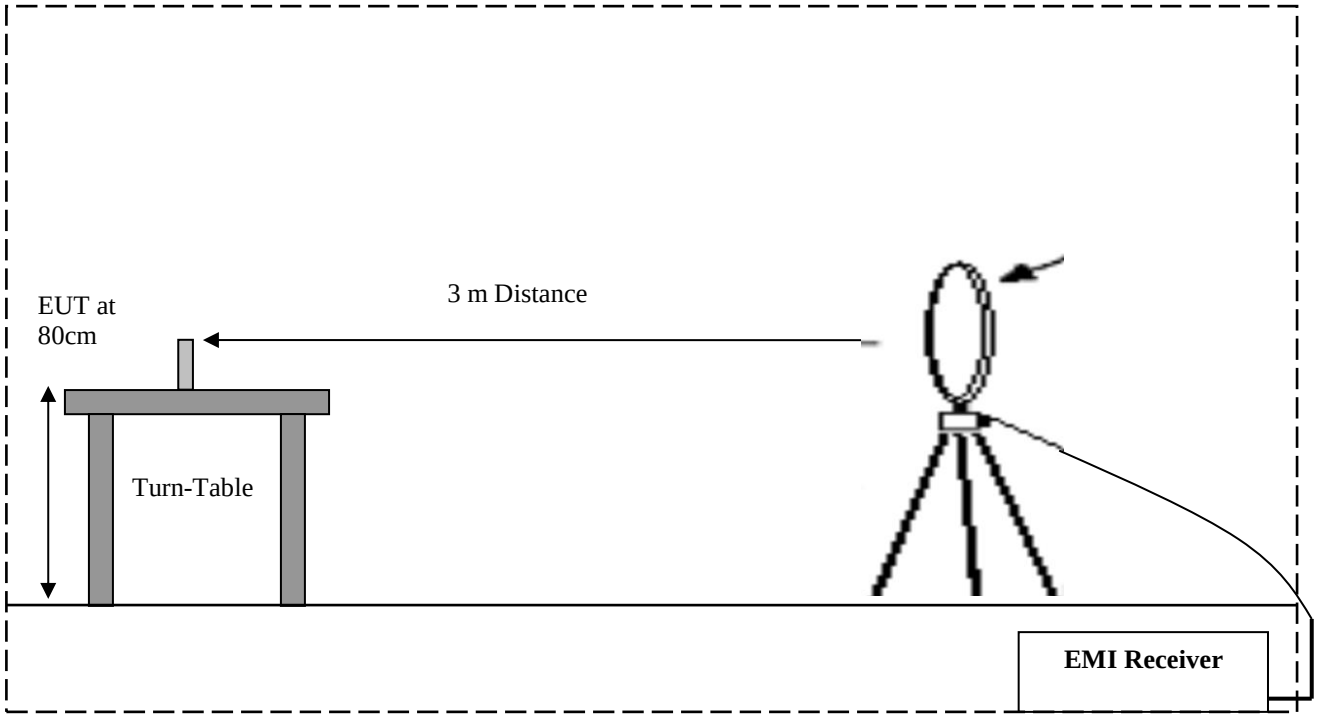
7.1 Radiated Measurement

The radiated measurement is performed according to:

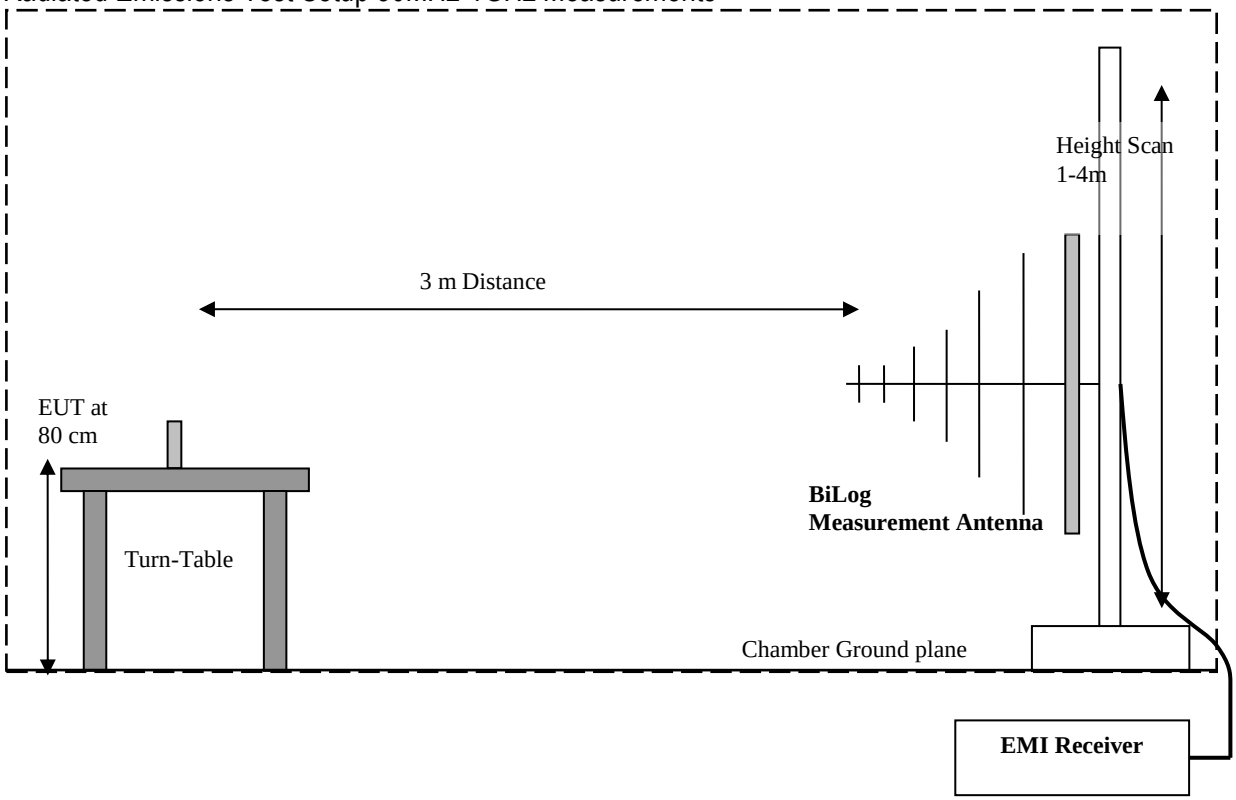
ANSI C63.10 (2013)

- The exploratory measurement is accomplished by running sweeps at 1 and 4m antenna heights over the required frequency range with R&S Test-SW EMC32 for both antenna polarizations. During each frequency scan the turntable rotates by no more than10deg.
- The 10 highest emissions are selected with an automatic algorithm of EMC32 searching for peaks in the noise floor and ensuring that broadband signals are not selected multiple times.
- The maxima are then again maximized through a fine search in frequency domain, maximized in the 360deg range of the turntable, and maximized over antenna height between 1m and 4m and for positioning of the EUT.
- The above procedure is repeated for transmission low mid and high channel.
- In case there are no emissions above noise floor level only the maximum trace is reported as described above.
- The results are split up into up to 4 frequency ranges due to antenna bandwidth restrictions. A magnetic loop is used from 9 kHz to 30 MHz, a Biconilog antenna is used from 30 MHz to 1 GHz, and two different horn antennas are used to cover frequencies up to 40 GHz.

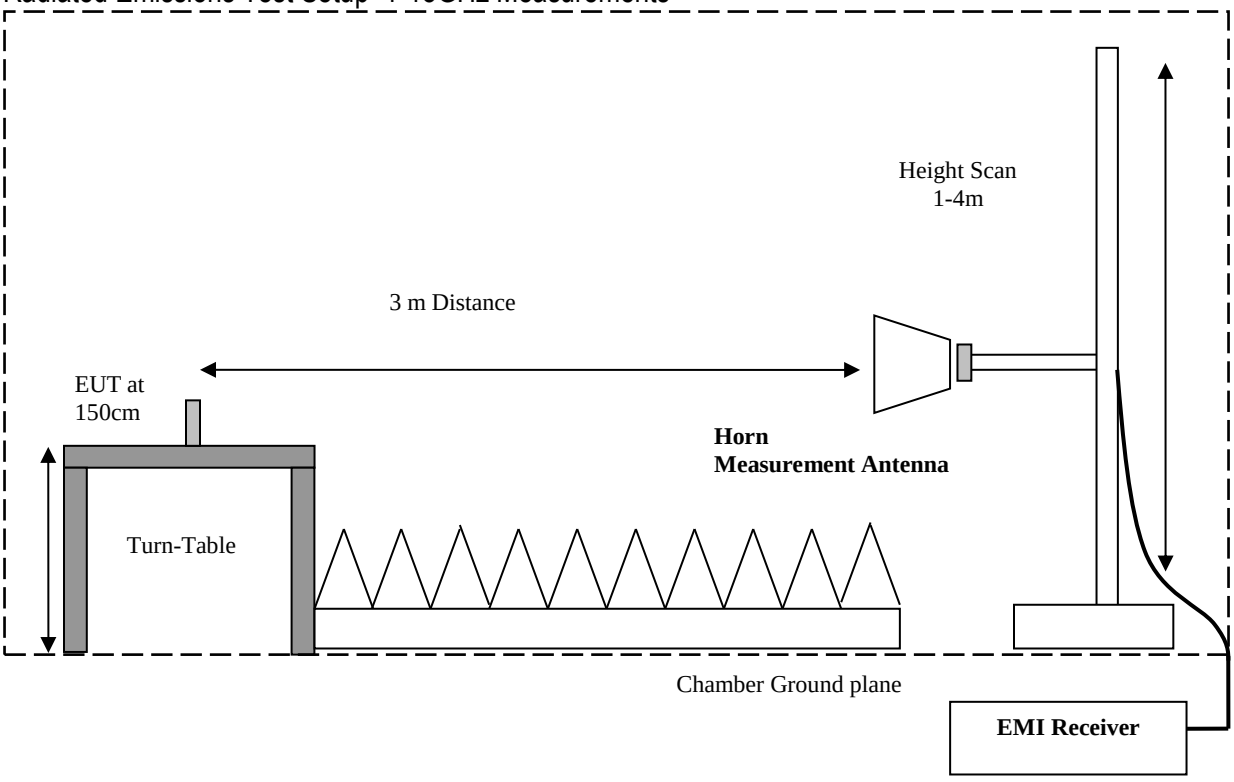
Radiated Emissions Test Setup Below 30MHz Measurements



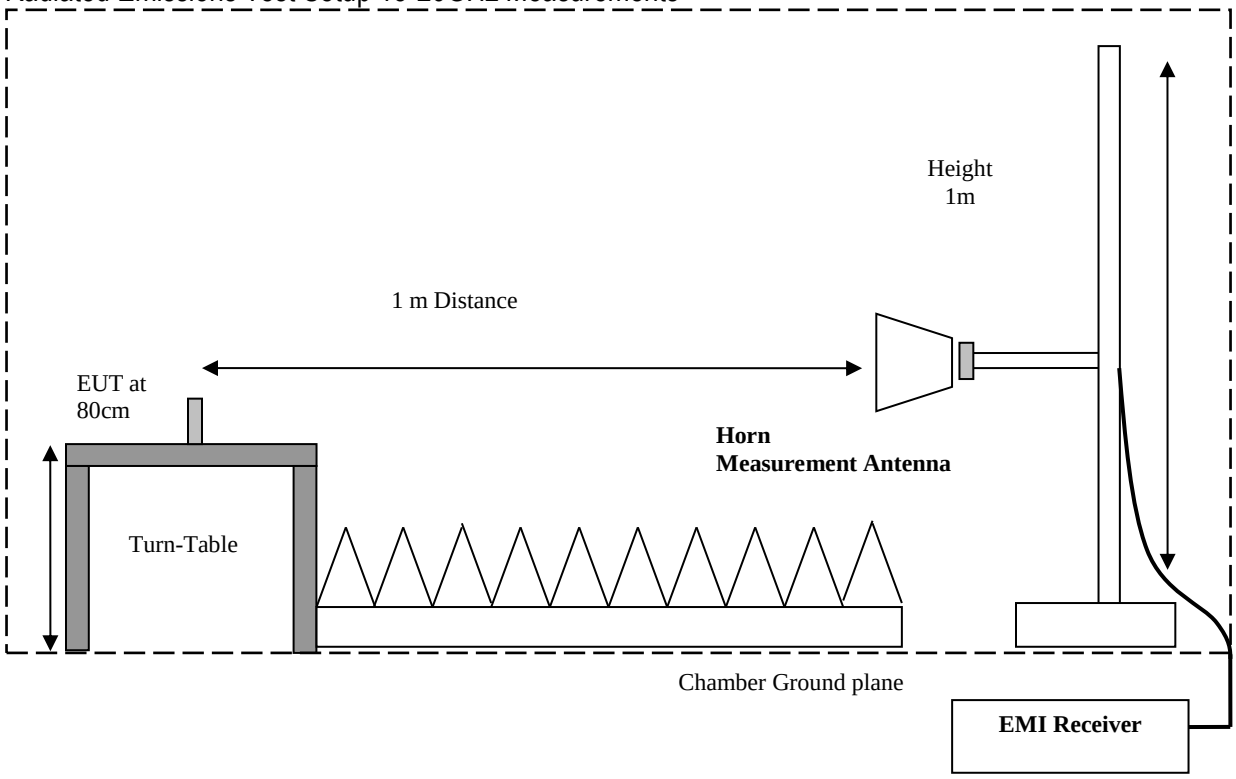
Radiated Emissions Test Setup 30MHz-1GHz Measurements



Radiated Emissions Test Setup 1-18GHz Measurements



Radiated Emissions Test Setup 18-26GHz Measurements



7.2 Sample Calculations for Field Strength Measurements

Field Strength is calculated from the Spectrum Analyzer/ Receiver readings, taking into account the following parameters:

1. Measured reading in dBµV
2. Cable Loss between the receiving antenna and SA in dB and
3. Antenna Factor in dB/m

All radiated measurement plots in this report are taken from a test SW that calculates the Field Strength based on the following equation:

FS (dBµV/m) = Measured Value on SA (dBµV)- Cable Loss (dB)+ Antenna Factor (dB/m)

Example:

Frequency (MHz)	Measured SA (dBµV)	Cable Loss (dB)	Antenna Factor Correction (dB)	Field Strength Result (dBµV/m)
1000	80.5	3.5	14	98.0

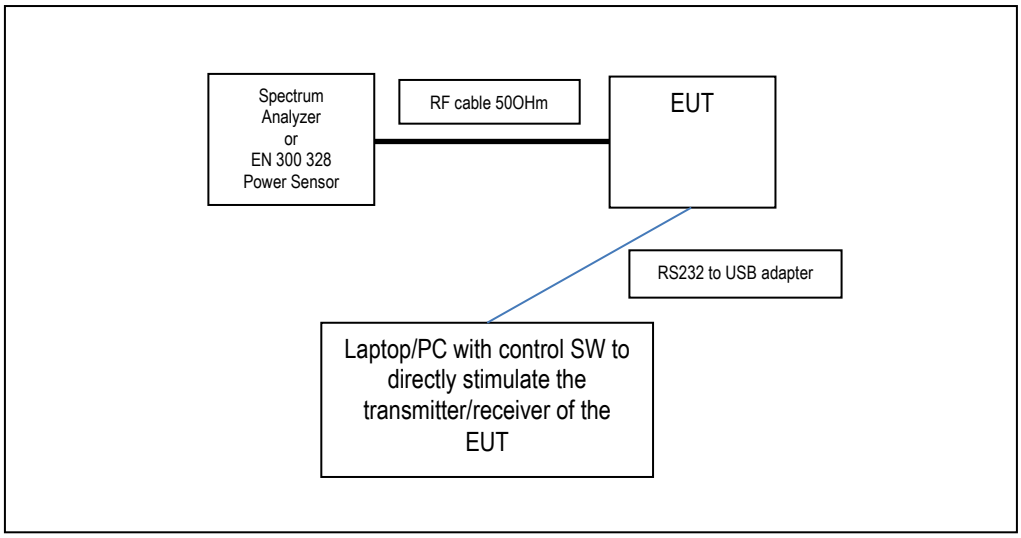
7.3 Power Line Conducted Measurement Procedure

AC Power Line conducted emissions measurements performed according to:

ANSI C63.4 (2014)

7.4 RF Conducted Measurement Procedure

7.4.1 Conducted Measurement Setup without companion device



8 Maximum Conducted Output Power Verification

8.1 Measurement Settings

Conducted RMS power measurements were taken according to ANSI C63.10-2013 Section 11.9.2.3.2, using a gated RF average power meter capable of 5 MS/s RMS measurements (Equipment number 19 in section 12).

Conducted Peak power measurements were taken according to ANSI C63.10-2013 Section 11.9.1.2, using a spectrum analyzer. (Equipment number 20 in section 16)

8.2 Limits:

- The measured RMS output power shall be within +0.2dB and -1dB from the modular report power.
- The power measured on the mid channel of each RF band of operation will be compared to the Max. Output Power from the modular report as indicated in section 6.4.

8.3 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
23° C	1	Tx	120 Vac 60 Hz

8.4 Measurement result:

RMS Output Power

Frequency (MHz)	Mode	Data Rate (Mbps)	Maximum Conducted RMS Output Power (dBm)	Conducted RMS Output Power From Modular Report	Output Power Delta (dB)	Result
2437	802.11b	1	15.9	15.8	+ 0.1	Pass
	802.11g	6	15.7	16.2	- 0.5	Pass

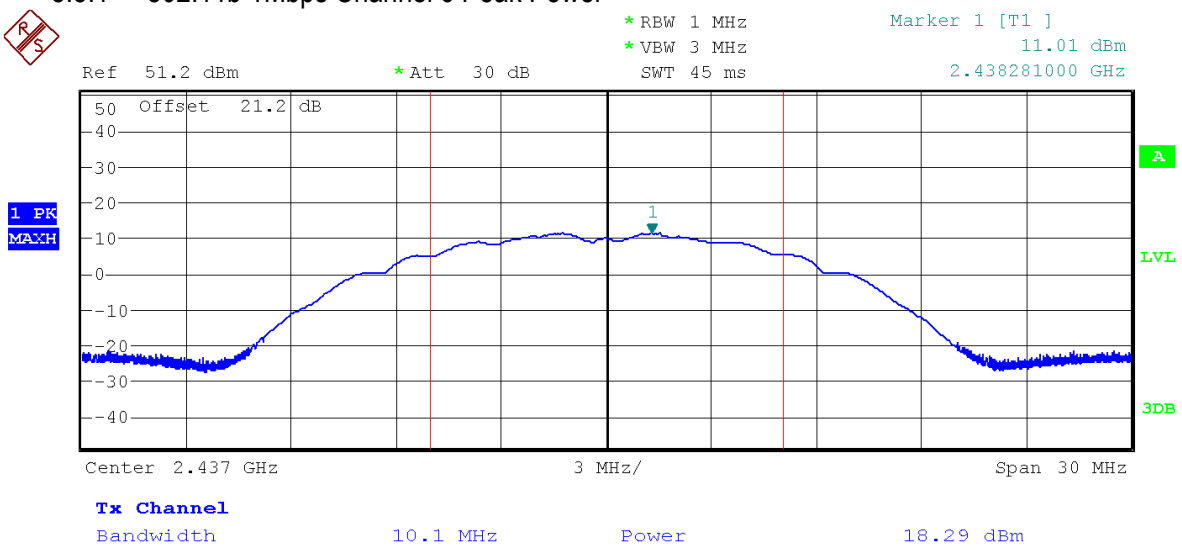
Peak Output Power

Frequency (MHz)	Mode	Data Rate (Mbps)	Maximum Conducted Peak Output Power (dBm)	Conducted Peak Output Power From Modular Report	Output Power Delta (dB)
2437	802.11b	1	18.3	18.0	+0.3
	802.11g	6	23.9	20.6	+3.3

Due to the large discrepancy of the conducted peak output power from the measurements and the module report, full testing was done on 802.11g mode.

8.5 Measurement Plots:

8.5.1 802.11b 1Mbps Channel 6 Peak Power



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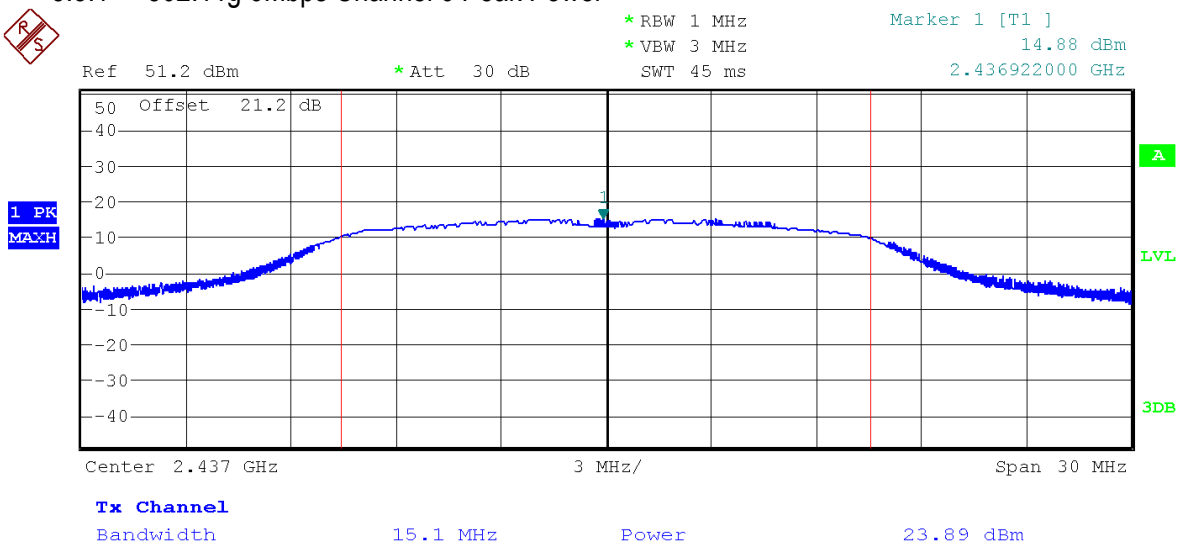
8.5.1 802.11g 6Mbps Channel 6 Peak Power



Date: 22.AUG.2016 20:24:51

9 Maximum Conducted Output Power

9.1 Limits:

Maximum Conducted Output Power:
FCC §15.247 (b)(3): 1W

9.2 Test Conditions:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
23° C	1	Tx	120 Vac 60 Hz

9.3 Test Procedure

Conducted Peak power measurements were taken according to ANSI C63.10-2013 Section 11.9.1.2, using a spectrum analyzer. (Equipment number 20 in section 16)

Due to the discrepancy of the conducted peak output power from the output power verification measurements and the module report (section 8.4), testing was done on all 802.11g mode channels.

For 802.11b mode, the test results from the module report were leveraged for compliance.

9.4 Test Result:

Maximum Conducted Peak Output Power (dBm)			
FCC Limit = 30 dBm	Frequency (MHz)		
Mode	2412 Channel 1	2437 Channel 6	2462 Channel 11
802.11g	20.9	23.9	20.7

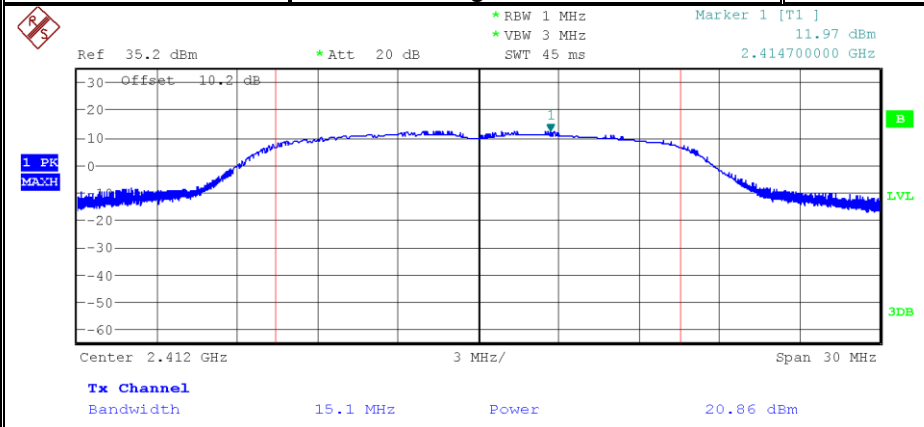
9.5 Measurement Result

Pass.

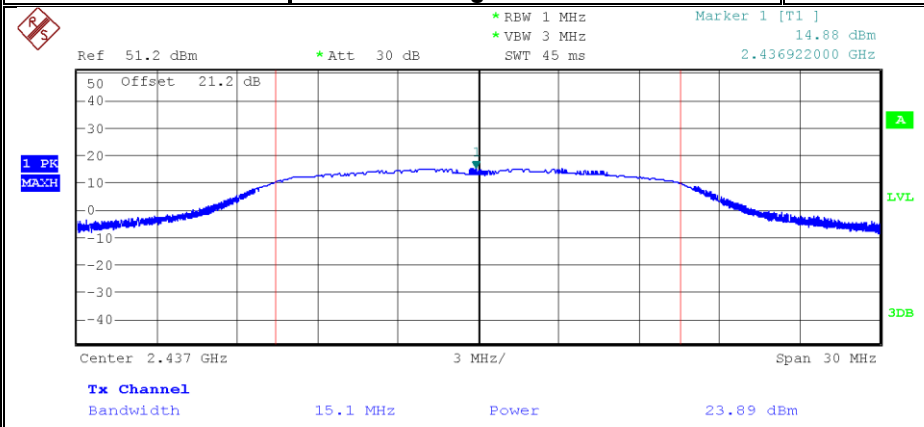
9.6 Measurement Plots:

Maximum Conducted Peak Output Power

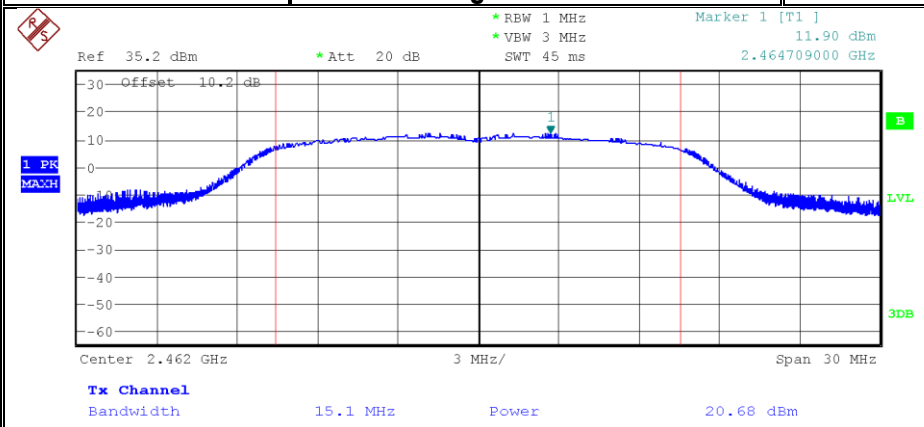
Ch.1 / 2412 MHz	Mode: 802.11g	Data Rate: 6 Mbps



Ch.6 / 2437 MHz	Mode: 802.11g	Data Rate: 6 Mbps



Ch.11 / 2462 MHz	Mode: 802.11g	Data Rate: 6 Mbps



10 Power Spectral Density

10.1 Limits:

§ 15.247 (e)

For digitally modulated systems, the peak power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8dBm in any 3 kHz band during any time interval of continuous transmission.

10.2 Test Conditions:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
23° C	1	Tx	120 Vac 60 Hz

10.3 Measurement procedure:

Conducted measurements were taken according to ANSI C63.10-2013 Section 11.10.2, using a spectrum analyzer. (Equipment number 20 in section 16)

Due to the discrepancy of the conducted peak output power from the output power verification measurements and the module report (section 8.4), testing was done on all 802.11g mode channels.

For 802.11b mode, the test results from the module report were leveraged for compliance.

10.4 Test Data:

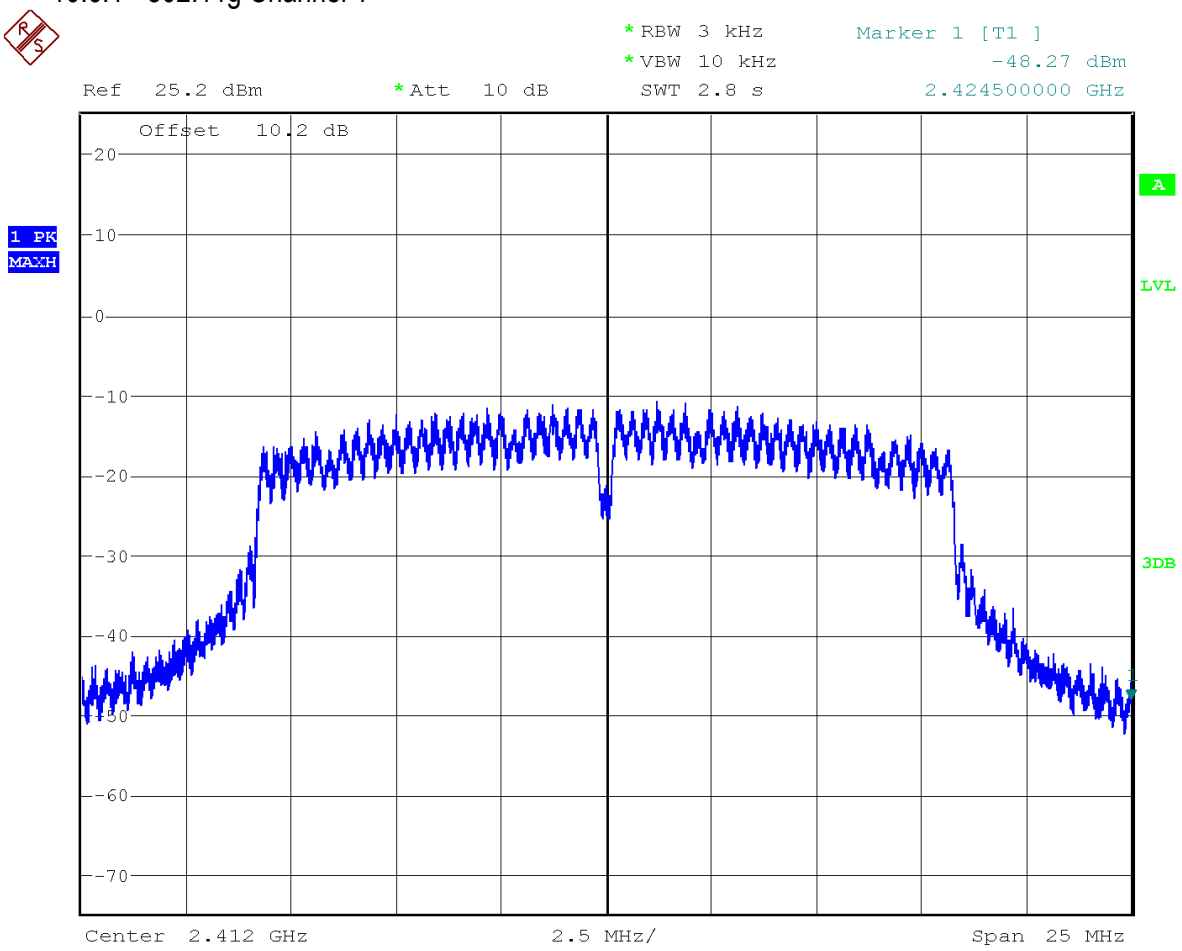
Power Spectral Density (dBm)			
Limit = 8 dBm/3kHz	Frequency (MHz)		
Mode	2412 Channel 1	2437 Channel 6	2462 Channel 11
802.11g	< -10.0	-7.7	-11.4

10.5 Measurement Result

Pass.

10.6 Measurement Plots:

10.6.1 802.11g Channel 1



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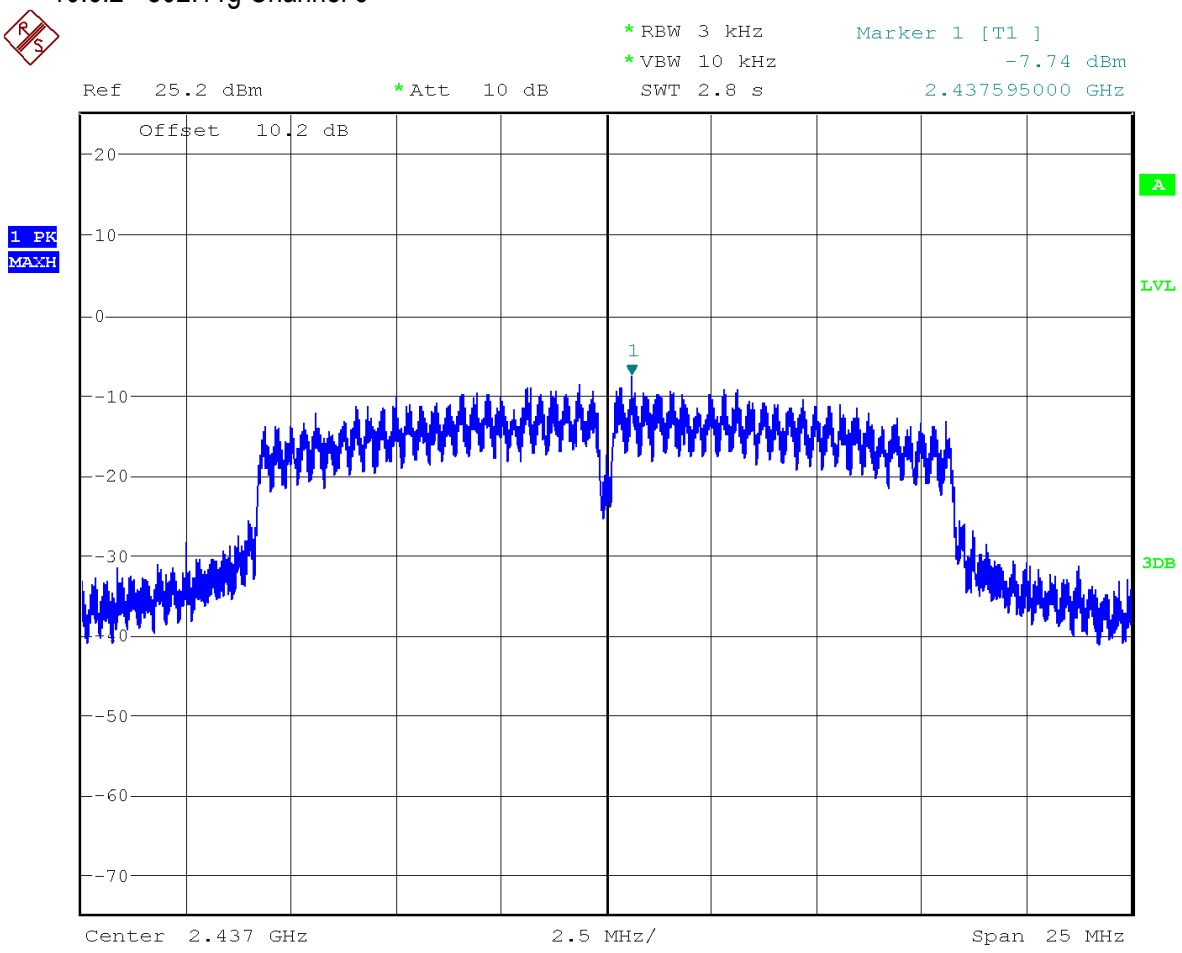
10.6.2 802.11g Channel 6



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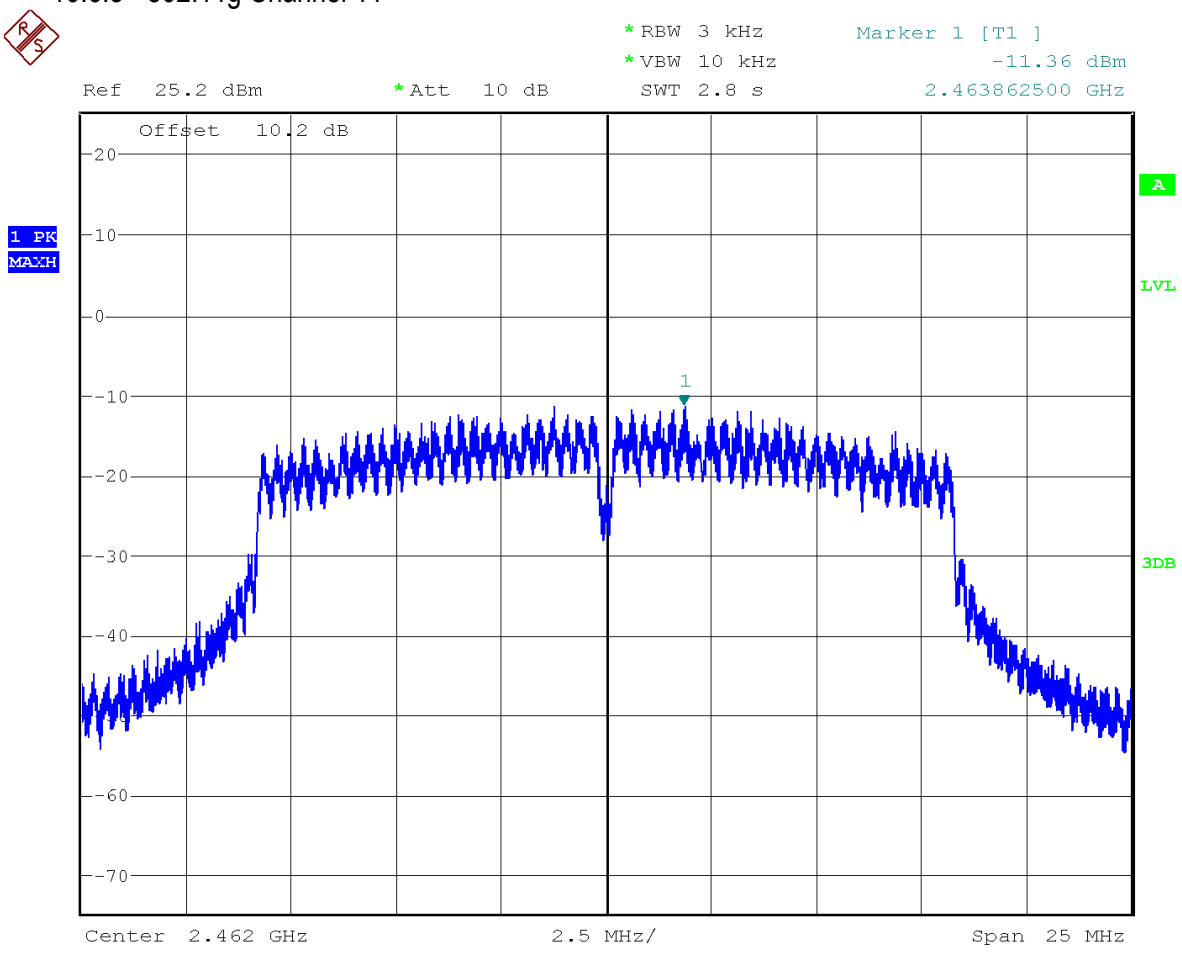
10.6.3 802.11g Channel 11



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11 Compliance at Restricted and Non-Restricted Bandedges

11.1 Limits:

§15.209/15.205

(a) Only spurious emissions are permitted in any of the frequency bands listed below:

MHz	MHz	MHz	GHz
0.090 - 0.110	16.42 - 16.423	399.9 - 410	4.5 - 5.15
[1]0.495 - 0.505	16.69475 - 16.69525	608 - 614	5.35 - 5.46
2.1735 - 2.1905	16.80425 - 16.80475	960 - 1240	7.25 - 7.75
4.125 - 4.128	25.5 - 25.67	1300 - 1427	8.025 - 8.5
4.17725 - 4.17775	37.5 - 38.25	1435 - 1626.5	9.0 - 9.2
4.20725 - 4.20775	73 - 74.6	1645.5 - 1646.5	9.3 - 9.5
6.215 - 6.218	74.8 - 75.2	1660 - 1710	10.6 - 12.7
6.26775 - 6.26825	108 - 121.94	1718.8 - 1722.2	13.25 - 13.4
6.31175 - 6.31225	123 - 138	2200 - 2300	14.47 - 14.5
8.291 - 8.294	149.9 - 150.05	2310 - 2390	15.35 - 16.2
8.362 - 8.366	156.52475 - 156.52525	2483.5 - 2500	17.7 - 21.4
8.37625 - 8.38675	156.7 - 156.9	2690 - 2900	22.01 - 23.12
8.41425 - 8.41475	162.0125 - 167.17	3260 - 3267	23.6 - 24.0
12.29 - 12.293	167.72 - 173.2	3332 - 3339	31.2 - 31.8
12.51975 - 12.52025	240 - 285	3345.8 - 3358	36.43 - 36.5
12.57675 - 12.57725	322 - 335.4	3600 - 4400	([2])
13.36 - 13.41			

(b) Except as provided in paragraphs (d) and (e) of this section, the field strength of emissions appearing within these frequency bands shall not exceed the limits shown in § 15.209. At frequencies equal to or less than 1000 MHz, compliance with the limits in § 15.209 shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1000 MHz, compliance with the emission limits in § 15.209 shall be demonstrated based on the average value of the measured emissions. The provisions in § 15.35 apply to these measurements.

§15.247 (d)

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

11.2 Measurement Procedure:

Conducted measurements were taken according to ANSI C63.10-2013 Section 11.11.1 for non restricted frequency bands and ANSI C63.10-2013 Section 11.12.2 for restricted frequency bands, using a spectrum analyzer (Equipment number 20 in section 16).

Due to the discrepancy of the conducted peak output power from the measurements and the module report (section 8.4), testing was done on all 802.11g mode channels.

For 802.11b mode, the test results from the module report were leveraged for compliance.

Since restricted band edge tests have been performed by the conducted method the measurements shown in the plots are adjusted by the duty cycle correction factor (RMS measurements only), Cable loss, External Attenuation and the declared maximum antenna gain for the comparison with the dBm value of the restricted band limits for 3m distance (peak = 74dBµV/m relates to -21.2 dBm; average = 54dBµV/m relates to -41.2 dBm).

Correction Factors (applied to measurement as offset):
Antenna Gain- 3.6 dBi
External Attenuation- 9dB
Cable Loss- 1.2 dB
Duty Cycle Correction Factor (Section 11.5.1) - 0.6 dB

11.3 Measurement Result
Pass.

11.4 Test Data:

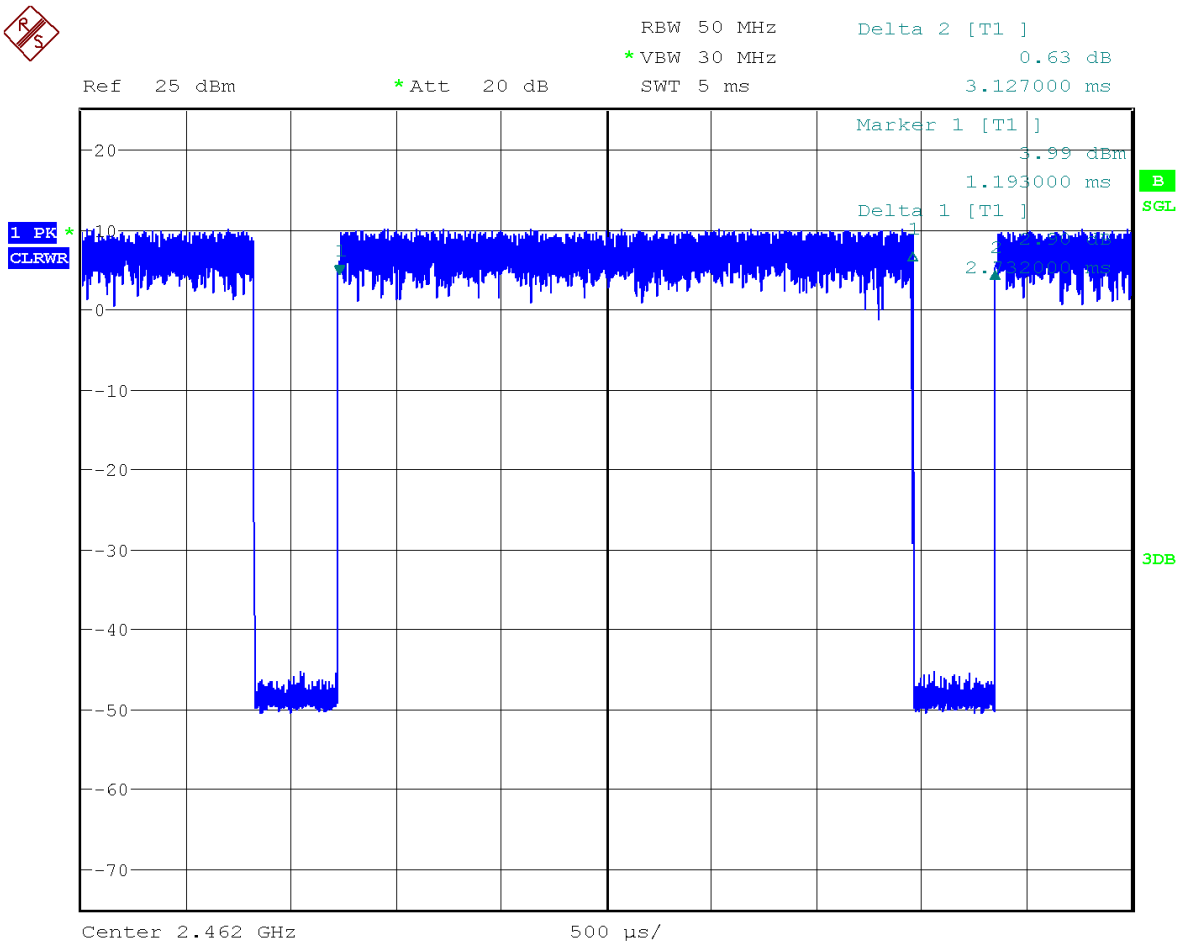
802.11g

Mode: 802.11g	Modulation: OFDM	Data Rate: 6 Mbps	Test Channel: 1			
Lower non Restricted Band / Frequency Range: 2390MHz – 2400 MHz						
Measured Frequency Range (MHz)	Fundamental Emission	Maximum Emission Level in Frequency Range (dBm)	Difference from Fundamental (dBc)	Limit (dBc)	Margin (dB)	Result
2390.0-2400	2.2	-24.9	-27.1	-20	7.1	Pass

Mode: 802.11g	Modulation: OFDM	Data Rate: 6 Mbps	Test Channel: 11	
Upper Restricted Band / Frequency Range: 2483.5 MHz – 2500 MHz				
Measured Frequency Range (MHz)	Measured Emission Level (dBm)	Limit Peak/Average (dBm)	Margin (dB)	Result
2483.5-2500	-21.4	-21.2	0.2	Pass
2483.5-2500	-41.3	-41.2	0.1	Pass

11.5 Band Edge Measurement Plots:

11.5.1 802.11g Measured Duty cycle



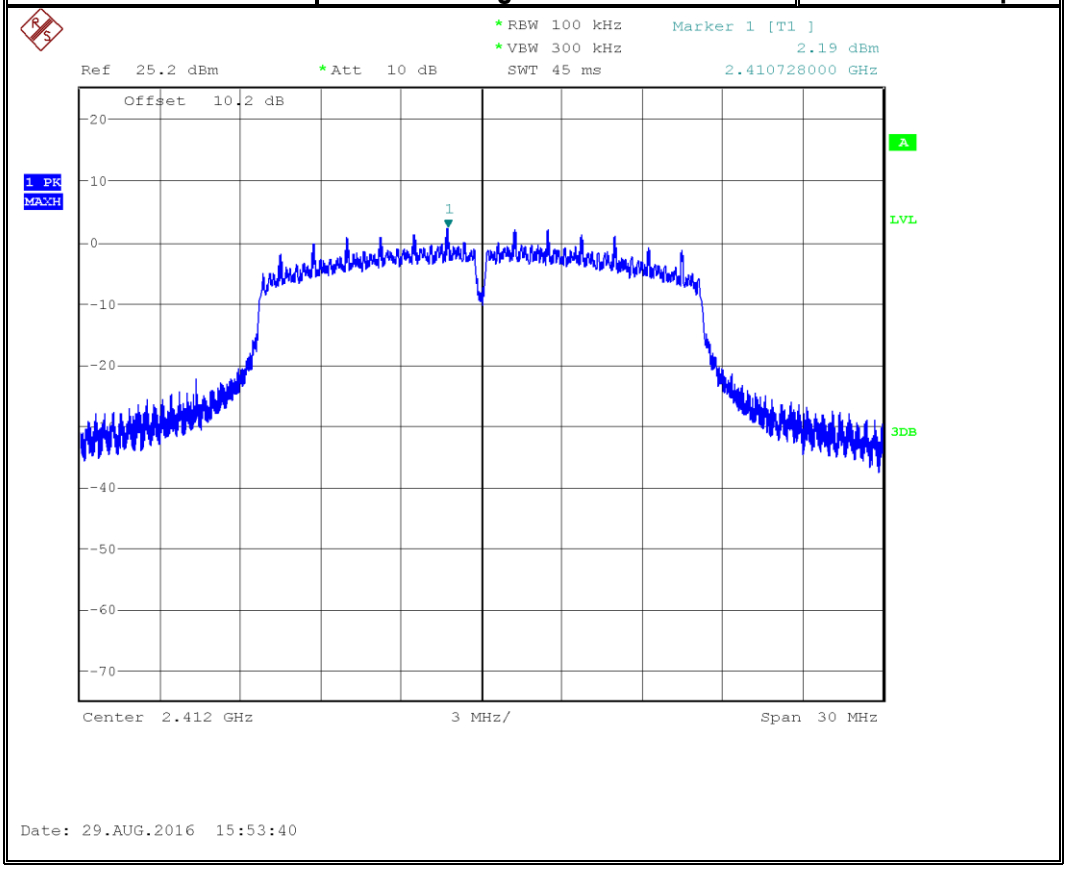
Date: 29.AUG.2016 16:07:57

Duty Cycle= 2.73/3.13=0.872= 87.2%
Duty Cycle Correction Factor = 10*log(1/0.872) = 0.6 dB

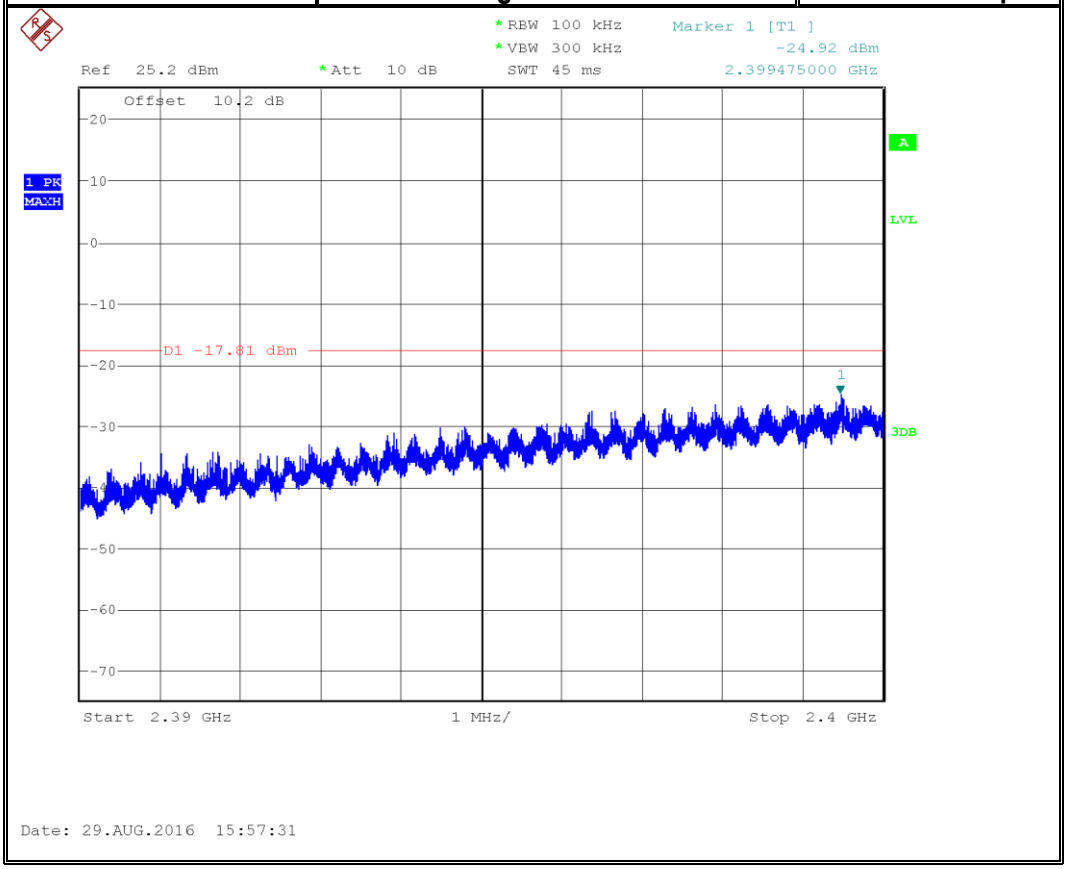
11.5.2 802.11g Lower Non-Restricted Band Edge

Fundamental Emission Reference Level

Ch. 1 / 2412 MHz	Mode: 802.11g	Data rate: 6 Mbps



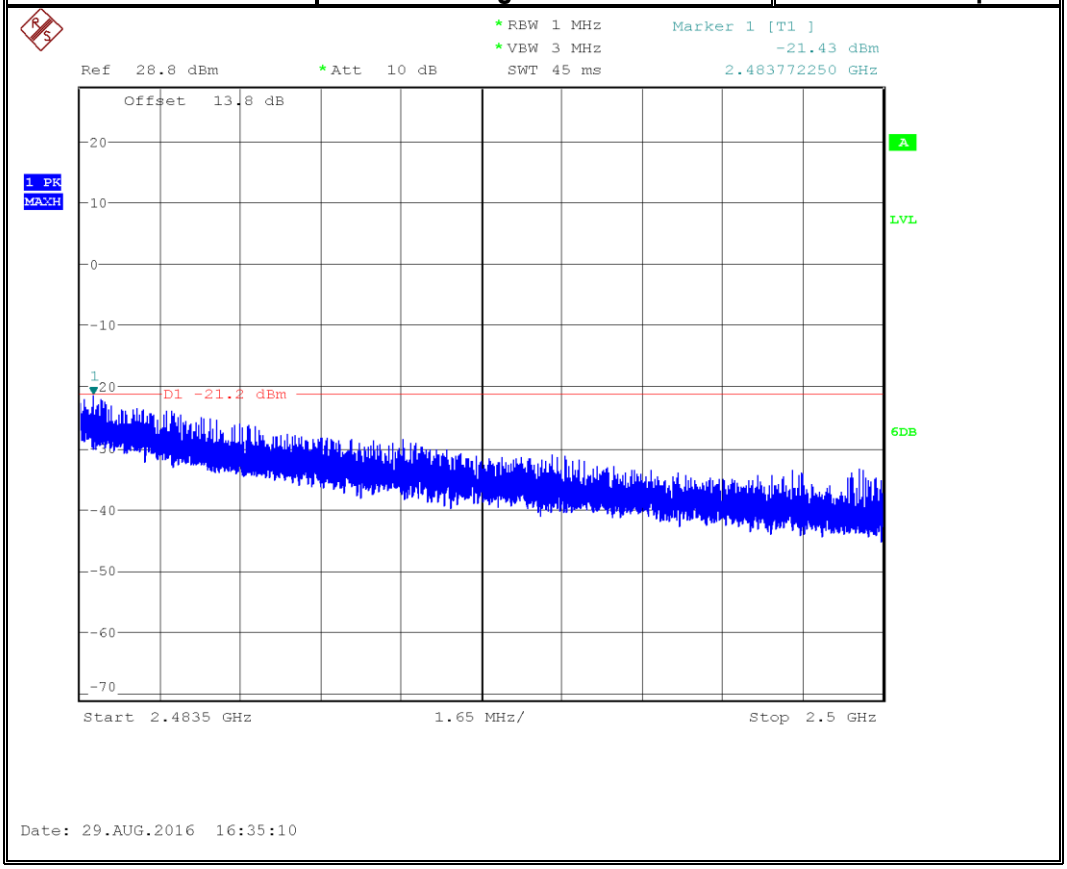
Lower Non-restricted Band Edge (2.4GHz) Emission		
Ch. 1 / 2412 MHz	**Mode: 802.11g**	**Data rate: 6 Mbps**



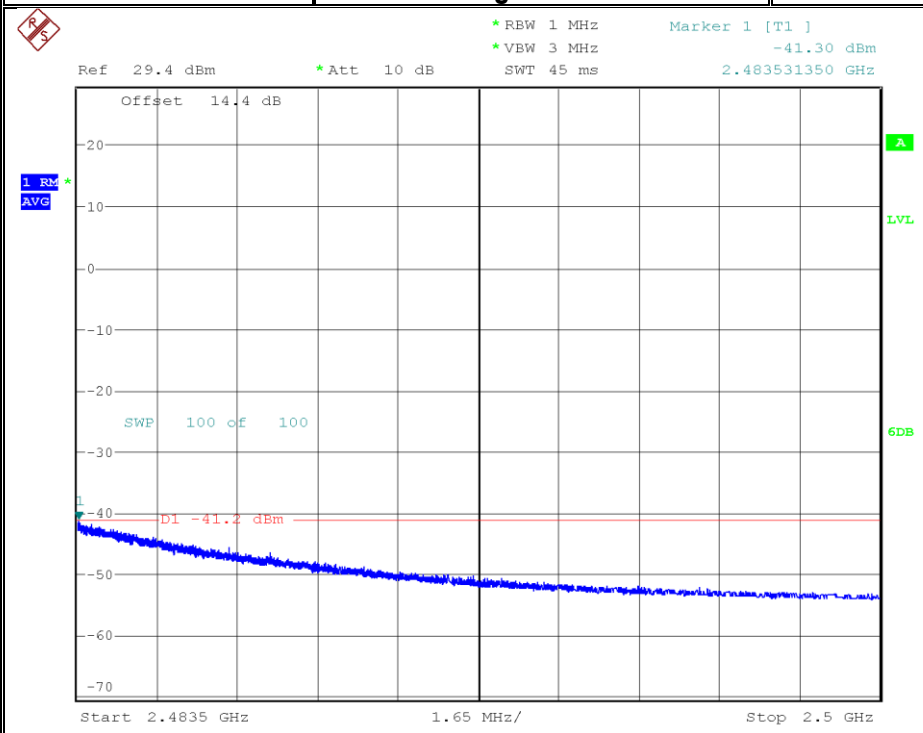
11.5.3 802.11g Upper Restricted Band Edge

Upper Restricted Band Edge (2.4GHz) Peak Detector

Ch. 11 / 2462 MHz	Mode: 802.11g	Data rate: 6 Mbps



Upper Restricted Band Edge (2.4GHz) RMS Detector		
Ch. 11 / 2412 MHz	**Mode: 802.11g**	**Data rate: 6 Mbps**



12 DTS Bandwidth

12.1 Limits:

§15.247 (a) (2)

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.

12.2 Test Conditions:

Tnom: 22 °C; Vnom: 3.7V

12.3 Measurement procedure:

Conducted measurements were taken according to ANSI C63.10-2013 Section 11.8 for DTS Bandwidth using a spectrum analyzer (Equipment number 20 in section 16).

Due to the discrepancy of the conducted peak output power from the measurements and the module report (section 8.4), testing was done on all 802.11g mode channels.

For 802.11b mode, the test results from the module report were leveraged for compliance.

12.4 Test Result: 2.4 GHz Band

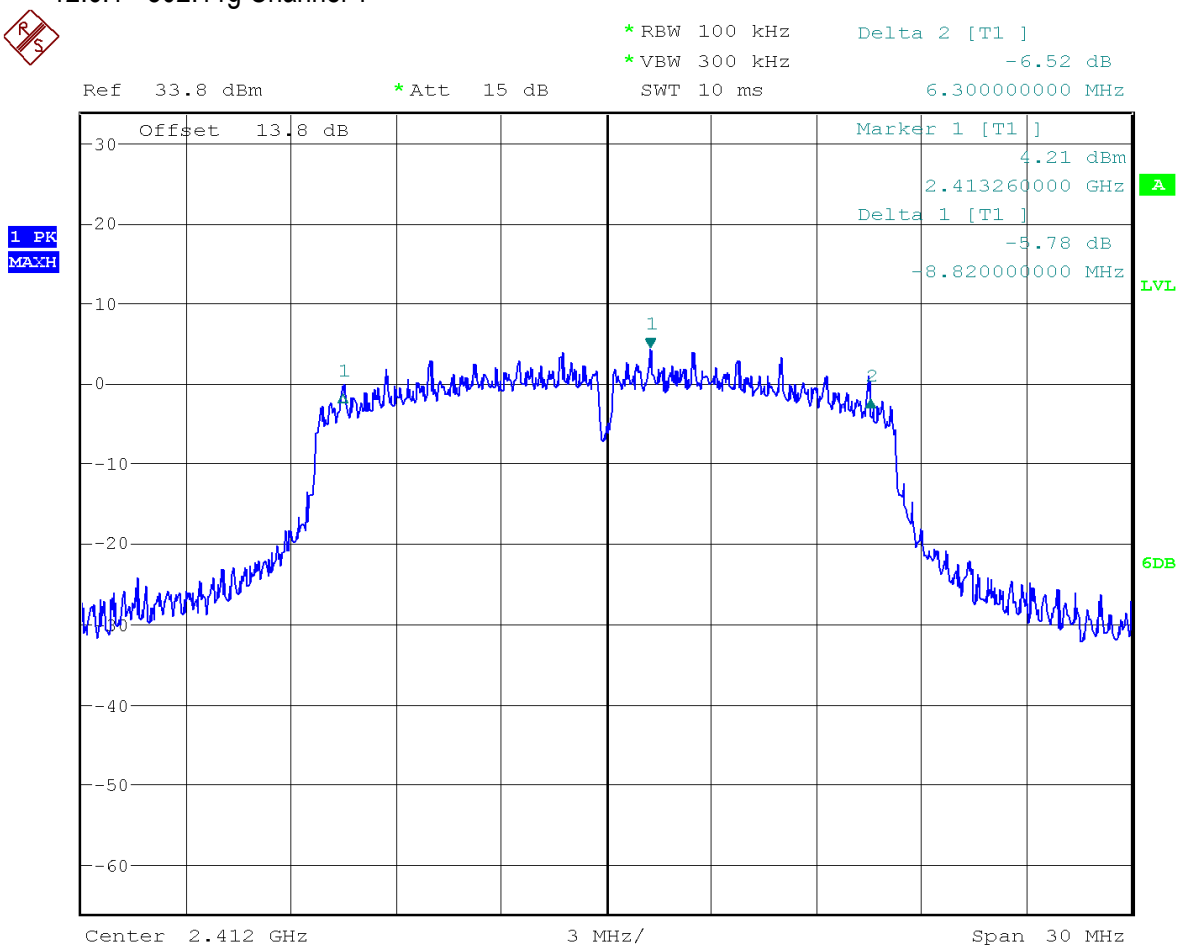
DTS Bandwidth (MHz)			
Mode	**2412 Channel 1**	**2437 Channel 6**	**2462 Channel 11**
802.11g	15.1	15.1	15.1

12.5 Measurement Result

Pass.

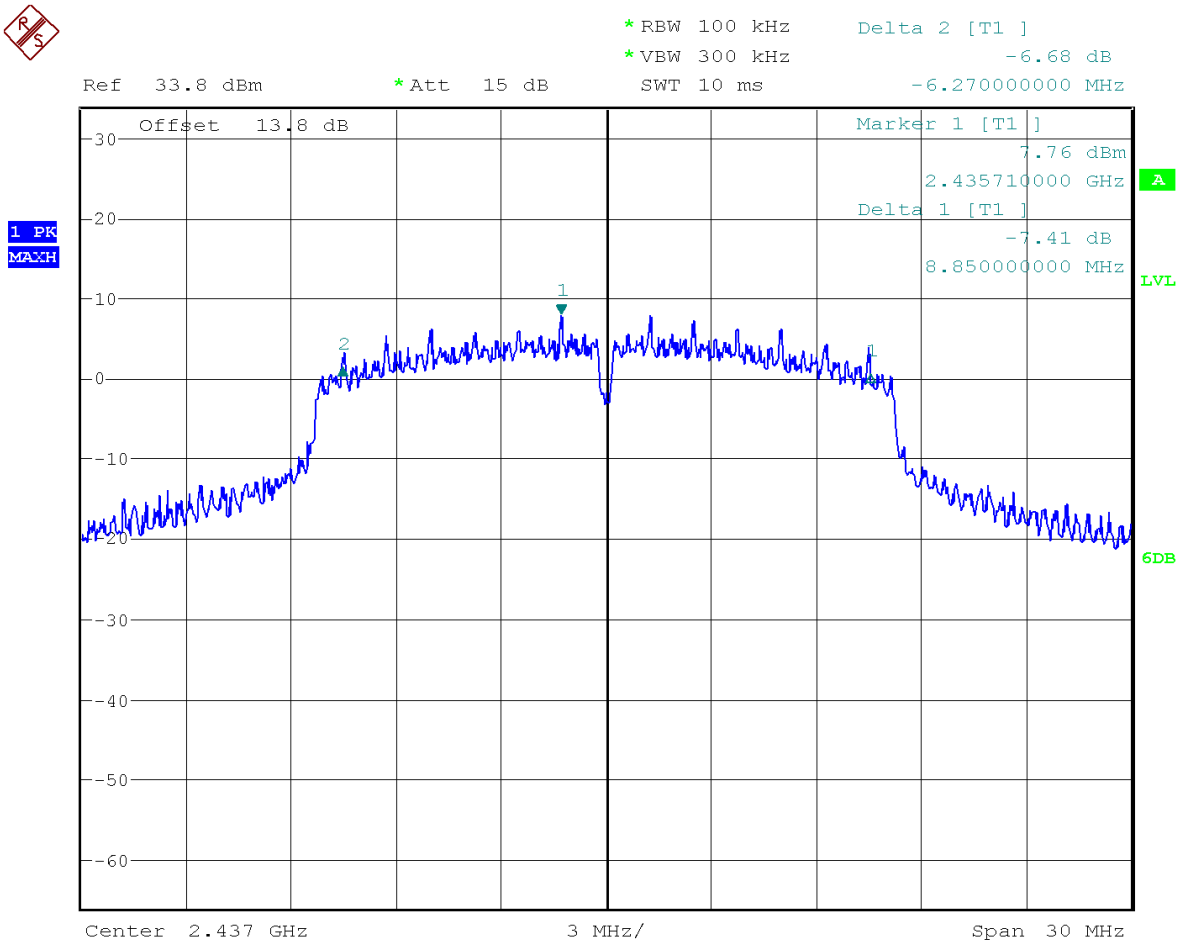
12.6 Measurement Plots

12.6.1 802.11g Channel 1



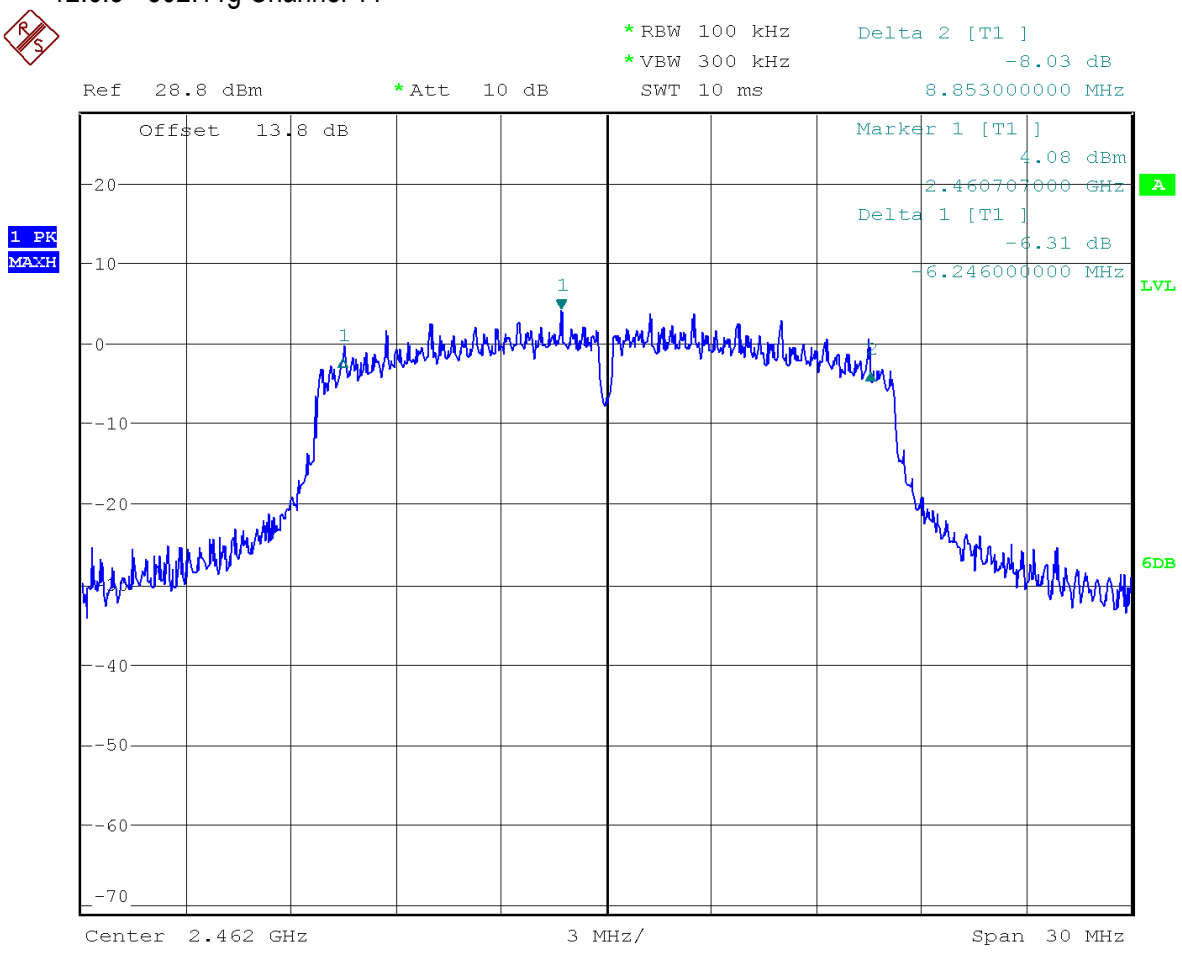
Date: 29.AUG.2016 19:31:49

12.6.2 802.11g Channel 6



Date: 29.AUG.2016 19:29:58

12.6.3 802.11g Channel 11



Date: 29.AUG.2016 19:26:20

13 Radiated Transmitter Spurious Emissions and Restricted Bands

13.1 Measurement Settings

Measurement according to ANSI C63.10 (2013)

Analyzer Settings:
Frequency = 9 KHz – 30 MHz
RBW = 9 KHz
Detector: Peak

Frequency = 30 MHz – 1 GHz
Detector = Peak / Quasi-Peak
RBW=120 KHz (<1GHz)

Frequency > 1 GHz
Detector = Peak / Average
RBW= 1MHz

Plots reported here represent the worst case emissions for horizontal and vertical antenna polarizations and for three orientations of the EUT. Unless mentioned otherwise, the emissions outside the limit lines in the plots are from the transmit signal.

13.2 Limits: §15.247/15.205/15.209

(a) Except as shown in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

MHz	MHz	MHz	GHz
0.090 - 0.110	16.42 - 16.423	399.9 - 410	4.5 - 5.15
[1]0.495 - 0.505	16.69475 - 16.69525	608 - 614	5.35 - 5.46
2.1735 - 2.1905	16.80425 - 16.80475	960 - 1240	7.25 - 7.75
4.125 - 4.128	25.5 - 25.67	1300 - 1427	8.025 - 8.5
4.17725 - 4.17775	37.5 - 38.25	1435 - 1626.5	9.0 - 9.2
4.20725 - 4.20775	73 - 74.6	1645.5 - 1646.5	9.3 - 9.5
6.215 - 6.218	74.8 - 75.2	1660 - 1710	10.6 - 12.7
6.26775 - 6.26825	108 - 121.94	1718.8 - 1722.2	13.25 - 13.4
6.31175 - 6.31225	123 - 138	2200 - 2300	14.47 - 14.5
8.291 - 8.294	149.9 - 150.05	2310 - 2390	15.35 - 16.2
8.362 - 8.366	156.52475 - 156.52525	2483.5 - 2500	17.7 - 21.4
8.37625 - 8.38675	156.7 - 156.9	2690 - 2900	22.01 - 23.12
8.41425 - 8.41475	162.0125 - 167.17	3260 - 3267	23.6 - 24.0
12.29 - 12.293	167.72 - 173.2	3332 - 3339	31.2 - 31.8
12.51975 - 12.52025	240 - 285	3345.8 - 3358	36.43 - 36.5
12.57675 - 12.57725	322 - 335.4	3600 - 4400	([2])
13.36 - 13.41			

Radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).
*PEAK LIMIT= 74dBµV/m
*AVG. LIMIT= 54dBµV/m

Table 1:

Frequency of emission (MHz)	Field strength @ 3m (µV/m)	Field strength @ 3m (dBµV/m)
30–88	100	40dBµV/m
88–216	150	43.5 dBµV/m
216–960	200	46 dBµV/m
Above 960	500	54 dBµV/m

Table 2:

Frequency of emission (MHz)	Field strength (µV/m) / (dBuV/m)	Measurement Distance (m)
0.009–0.490	2400/F(kHz) / ---------	300
0.490–1.705	24000/F(kHz) / --------	30
1.705–30.0	30 / (29.5)	30

Radiated spurious emissions shall be measured for the transmit frequencies, transmit power, and data rate for the middle channel in each frequency band of operation and for the highest gain antenna for each antenna type, and using the appropriate parameters and test requirements described in 5.4.

For testing at distance other than the specified in the standard, the limit conversion is calculated by using 40 dB/decade extrapolation factors as follow:

Conversion factor (CF) = 40 log (D/d) = 40 log (300m / 3m) = 80dB

13.3 Test conditions and setup:

Please see section 7.1 for detailed test setup. Equipment numbers 1-16 in section 16 of this report were used for this test case in a semi-anechoic chamber.

Due to the discrepancy of the conducted peak output power from the measurements and the module report (section 8.4), full testing was done on all 802.11g mode channels.

For 802.11b mode, only mid channel was tested as the highest RMS output power in the module report referenced in section 6.4 was the mid channel for each technology.

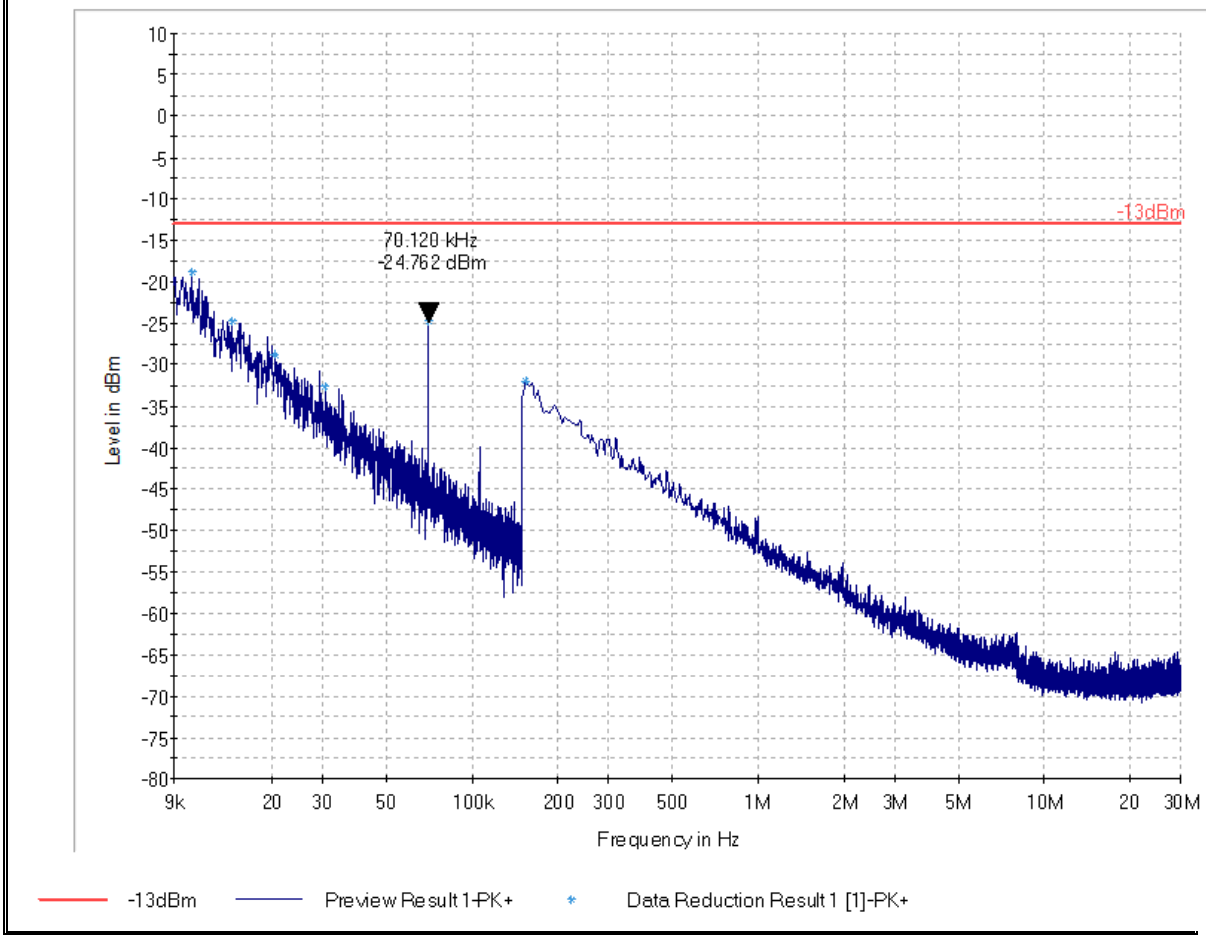
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
23° C	1	Tx	120 Vac 60 Hz

13.4 Measurement result:

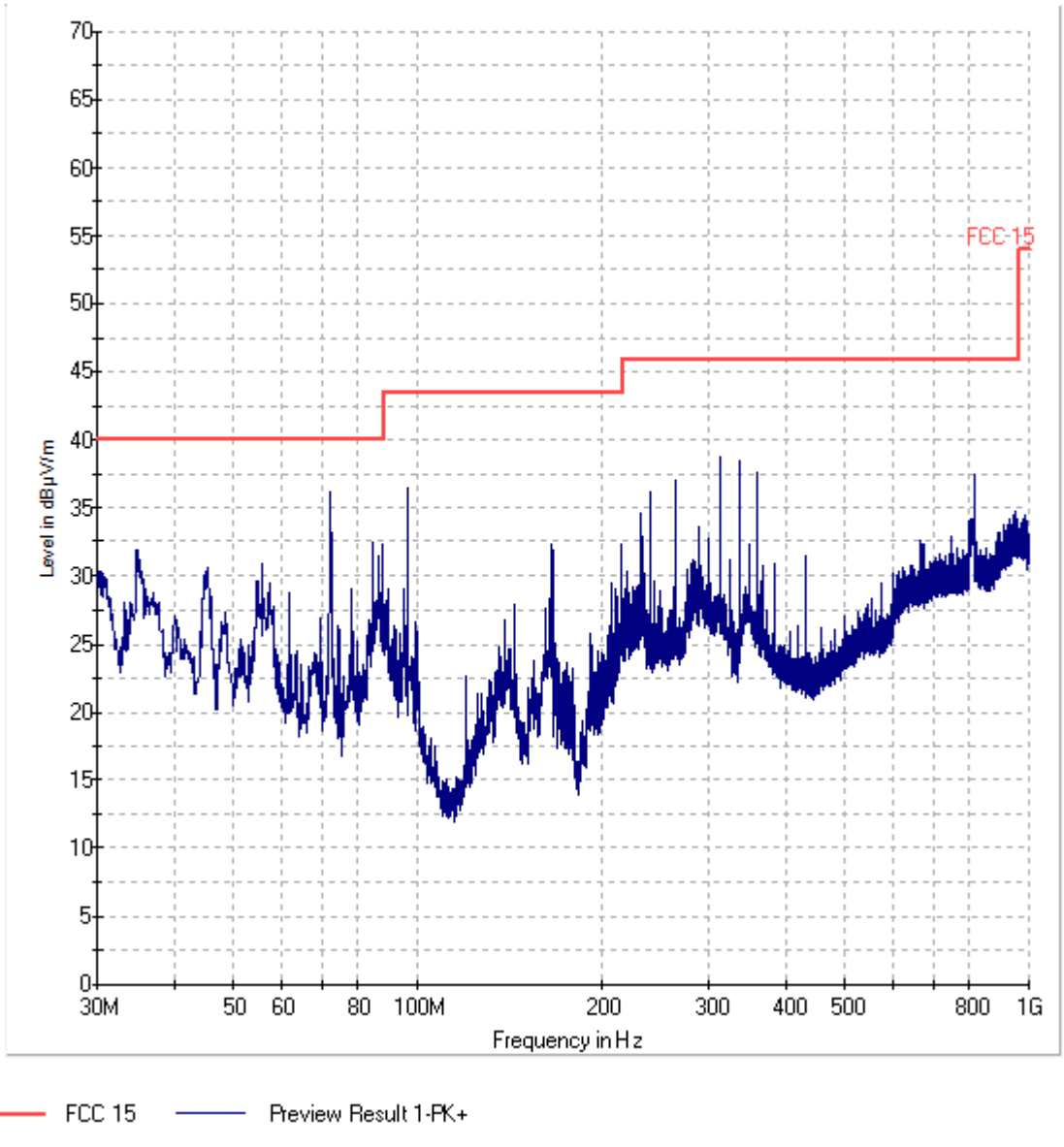
Plot #	Mode	Channel #	Limit	Result
1-5	802.11b	6	See section 13.2	Pass
6-8	802.11g	1		Pass
9-13		6		Pass
14-16		11		Pass

13.5 Measurement Plots:

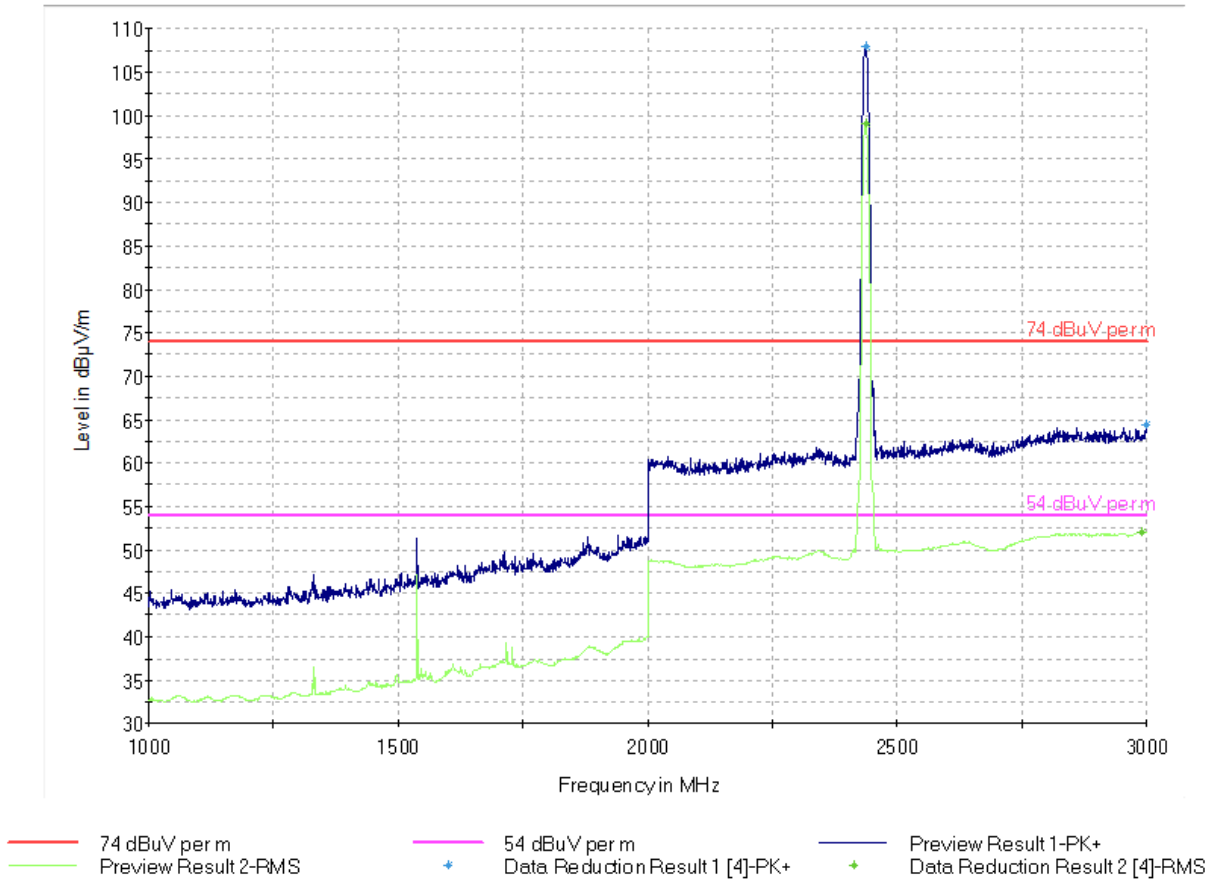
Plot # 1		
RE: 9 KHz – 30 MHz	**Ch. 6**	**Modulation: 802.11b (11Mbps_CCK)**



Plot #2		
RE: 30 MHz – 1 GHz	**Ch. 6**	**Modulation: 802.11b (11Mbps_CCK)**

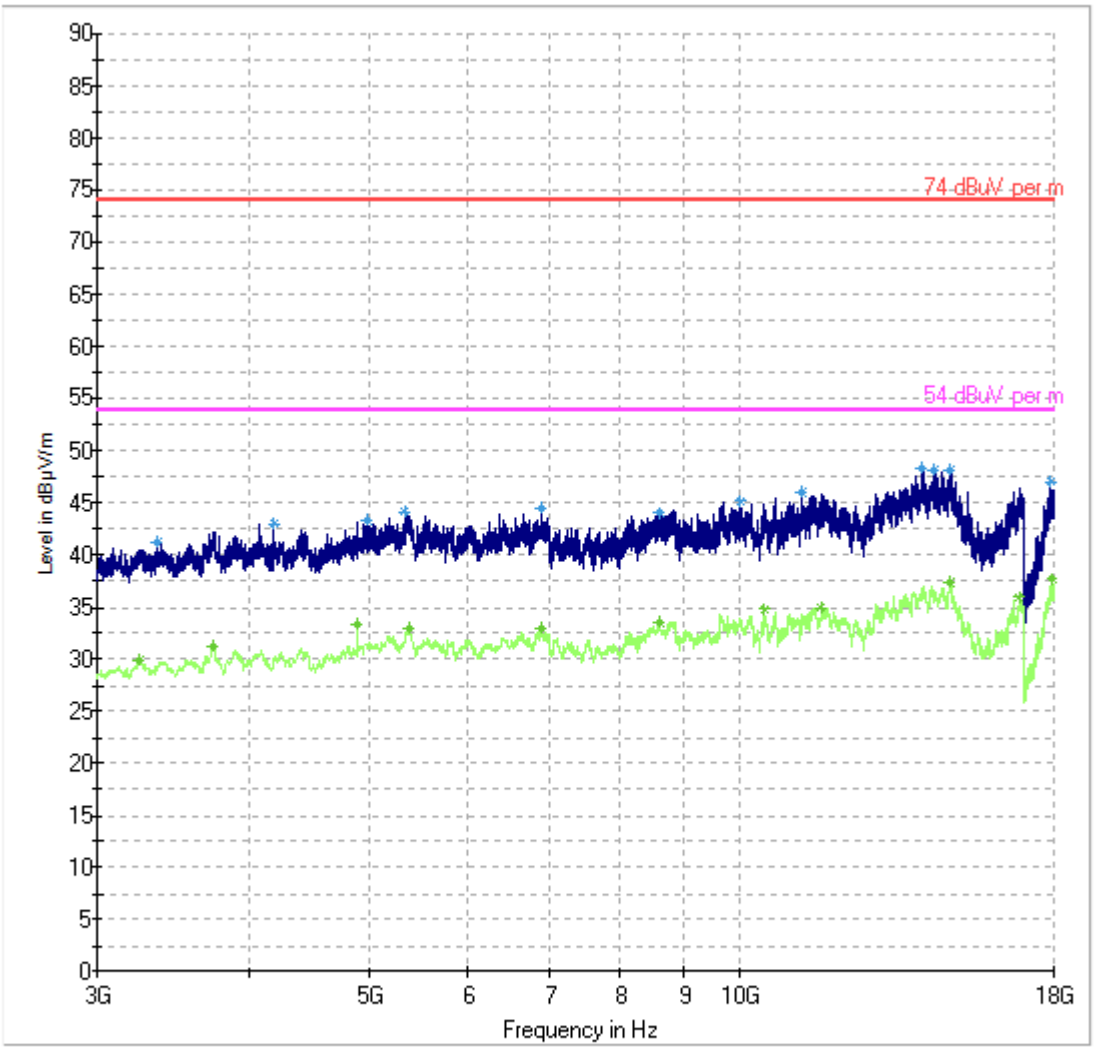


Plot #3		
RE: 1 GHz – 3 GHz	**Ch. 6**	**Modulation: 802.11b (11Mbps_CCK)**

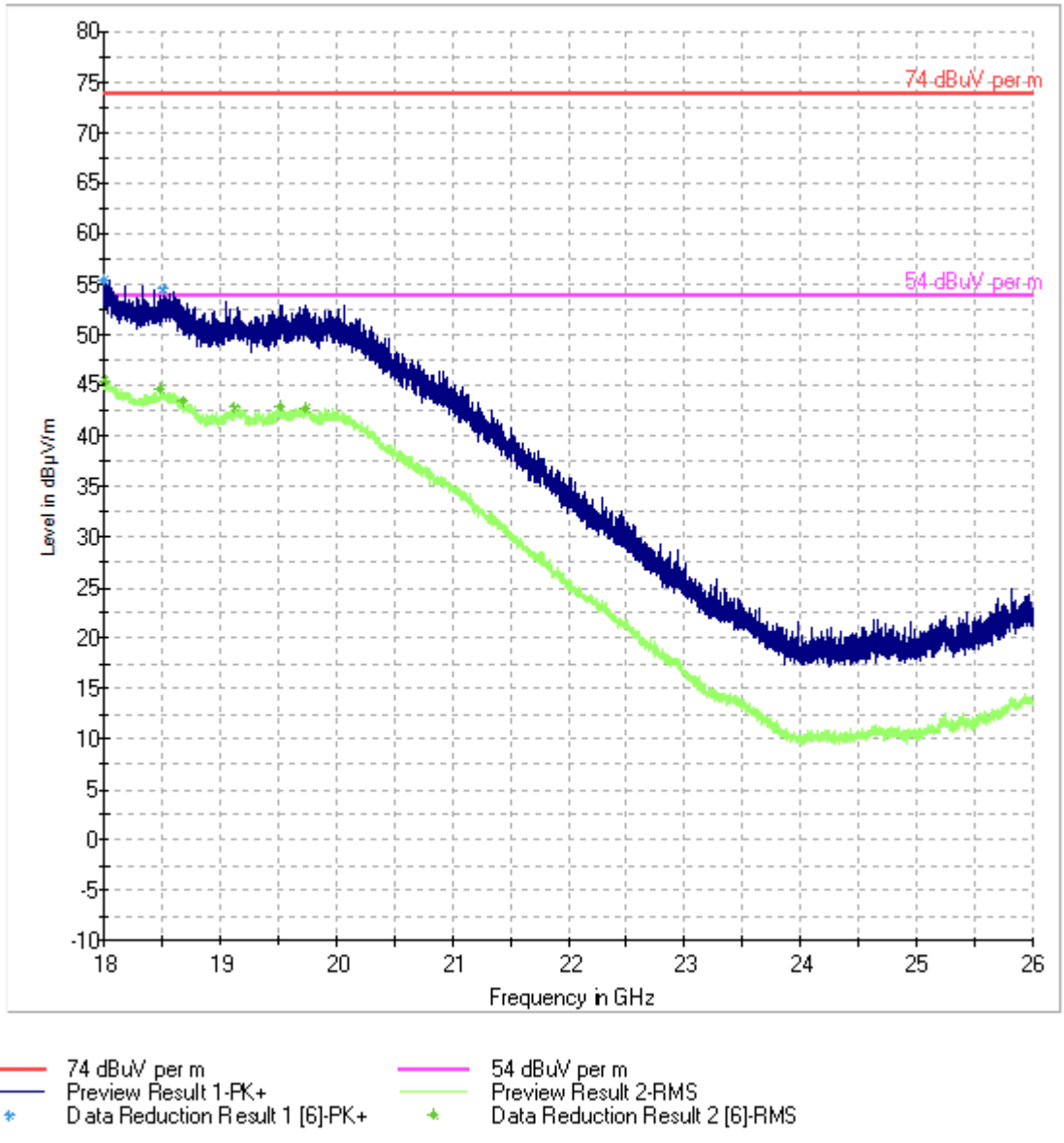


Note: The emission above the limit is the Tx Ch.6.

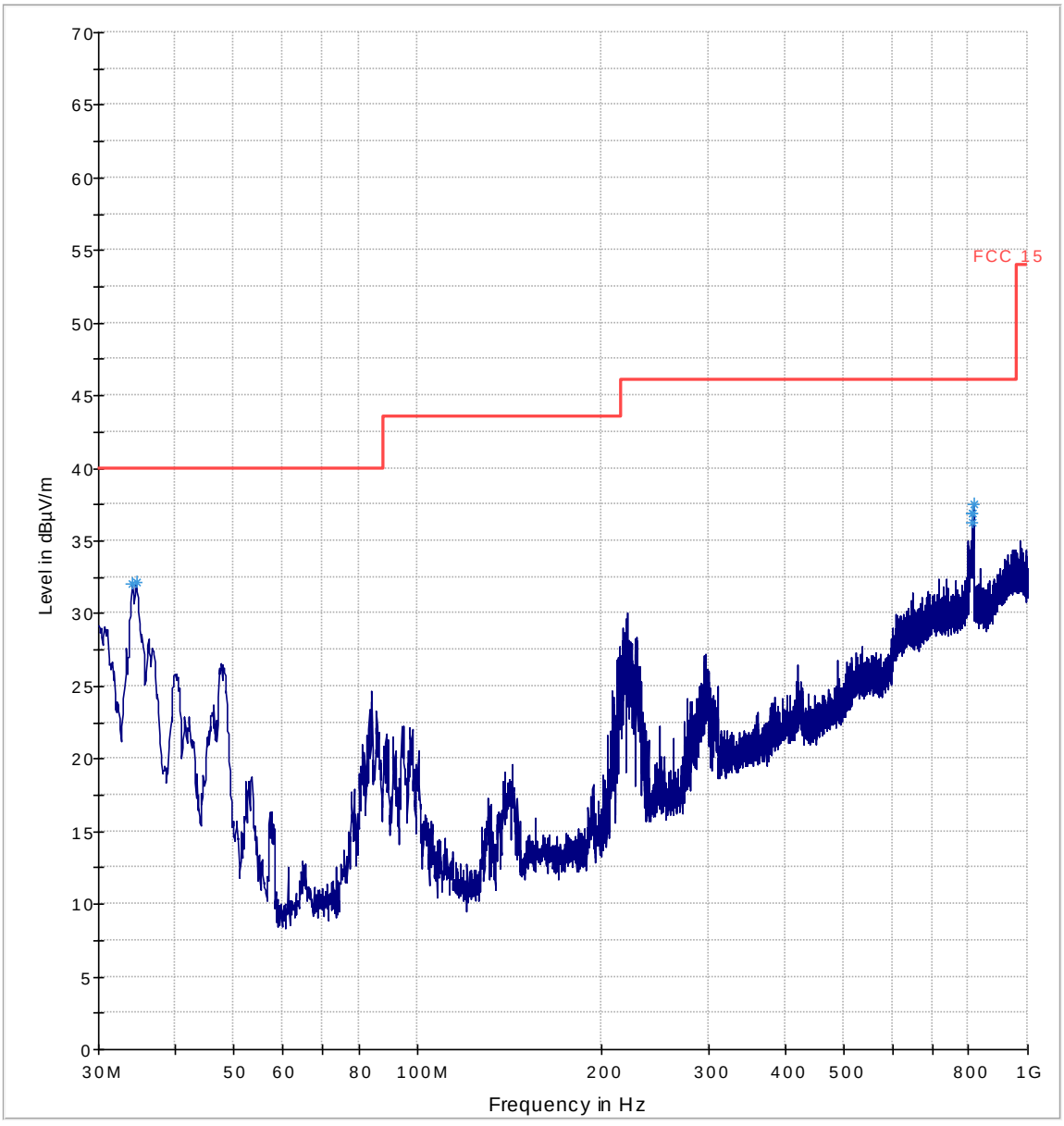
Plot #4		
RE: 3 GHz – 18 GHz	**Ch. 6**	**Modulation: 802.11b (11Mbps_CCK)**



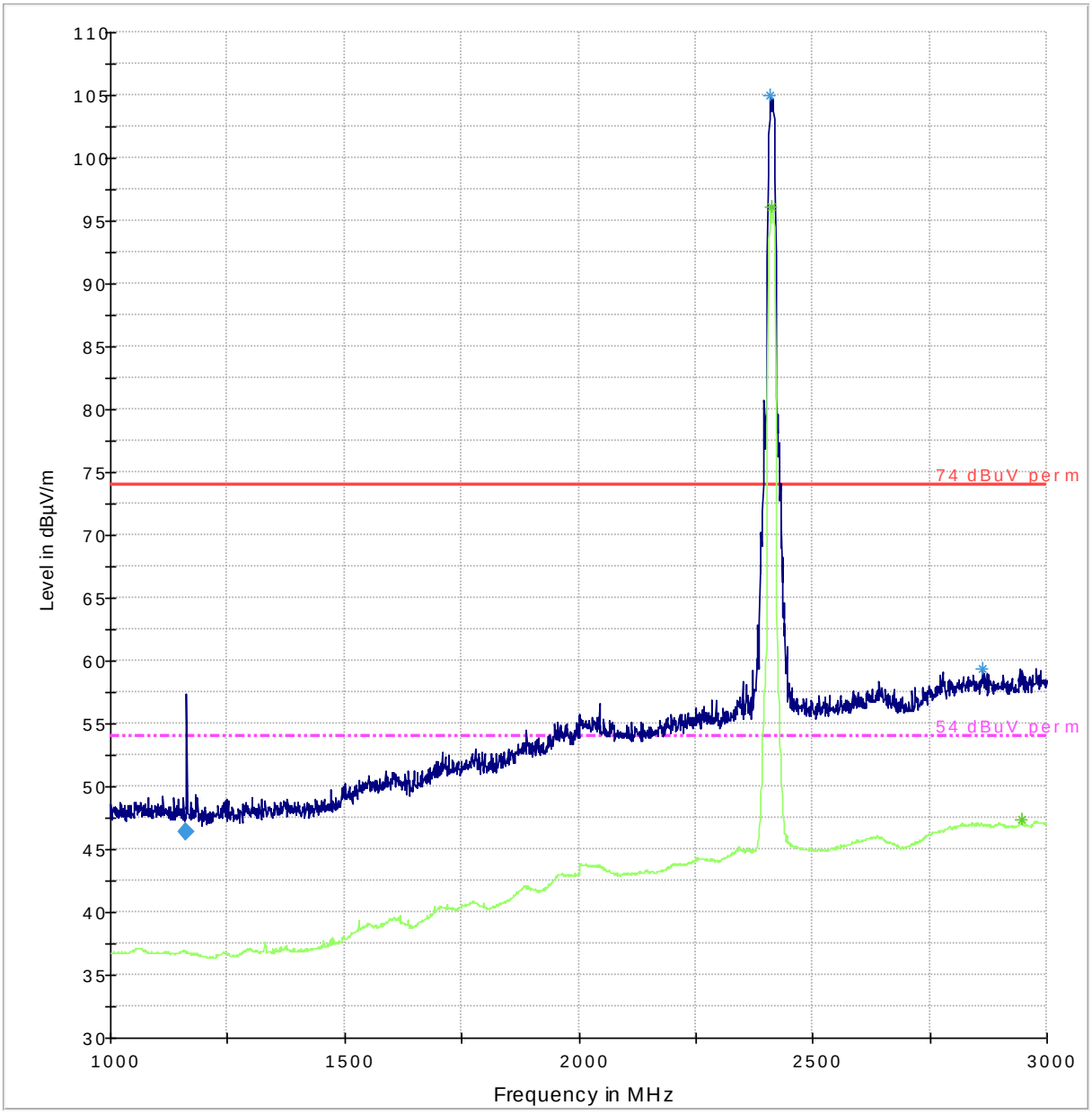
Plot #5		
RE: 18 GHz – 26 GHz	**Ch. 6**	**Modulation: 802.11b (11Mbps_CCK)**



Plot #6		
RE: 30 MHz – 1 GHz	**Ch. 1**	**Modulation: 802.11g (6Mbps_OFDM)**

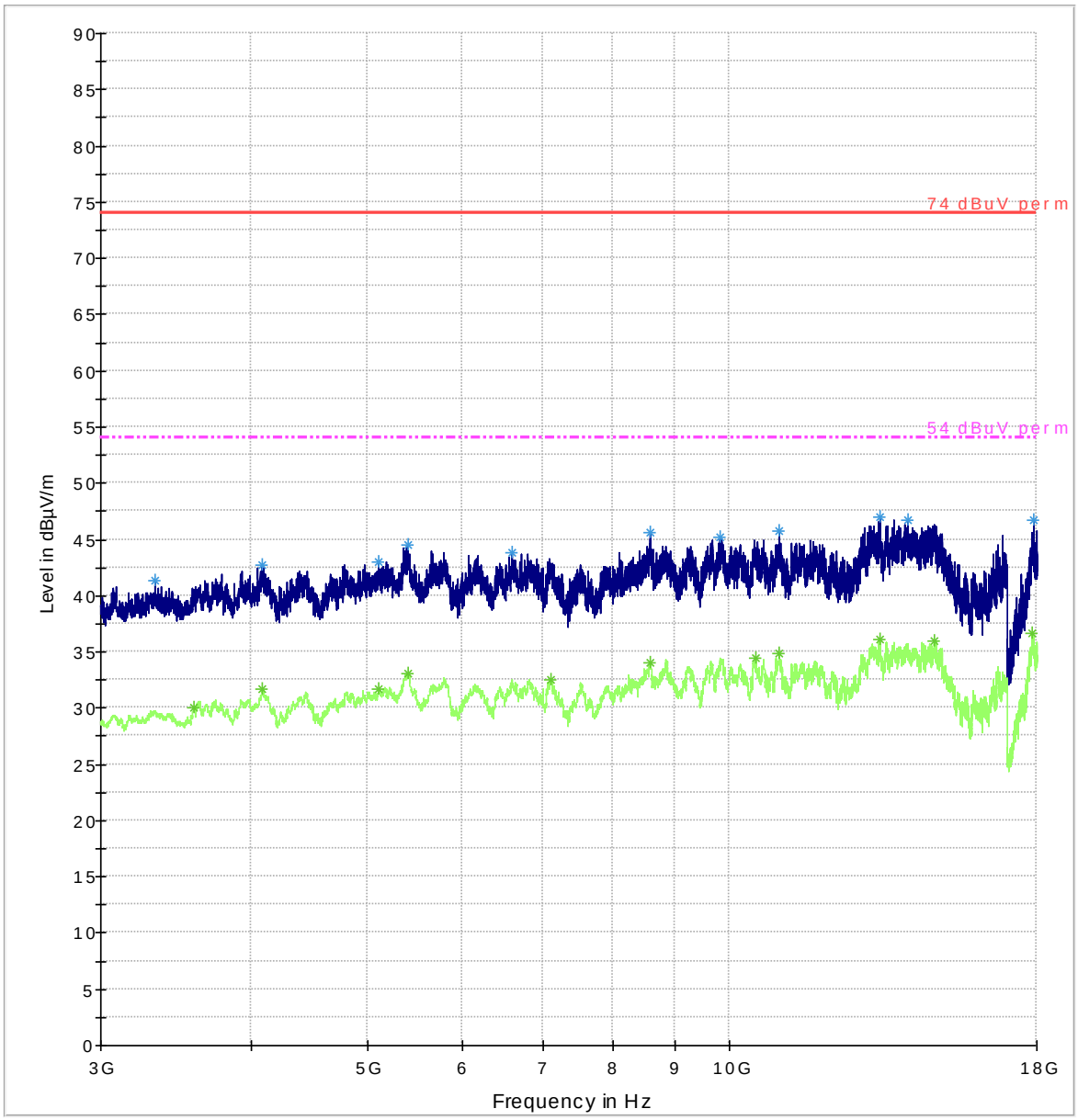


Plot #7		
RE: 1 GHz – 3 GHz	**Ch. 1**	**Modulation: 802.11g (6Mbps_OFDM)**

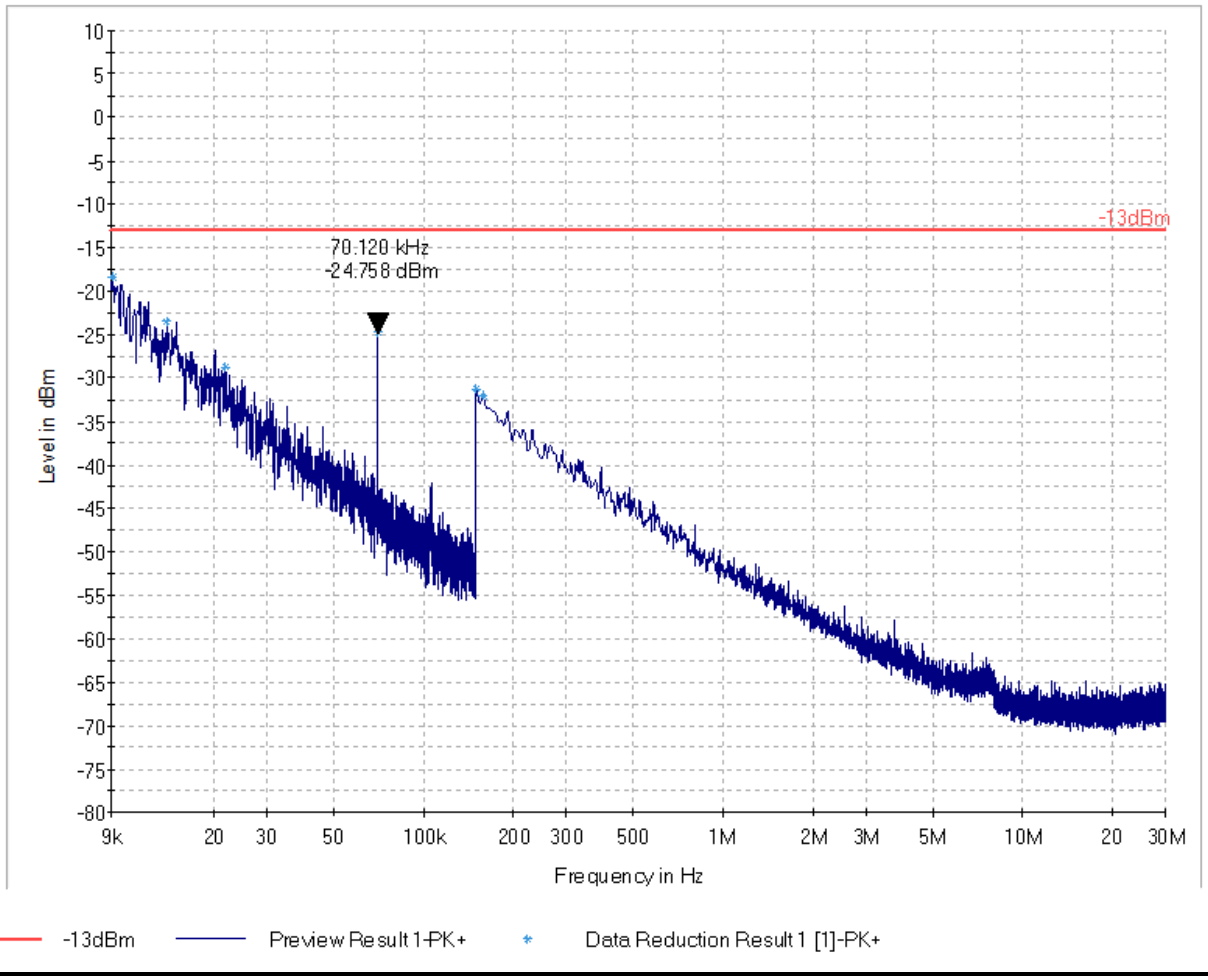


Note: The emission above the limit is the Tx Ch.6.

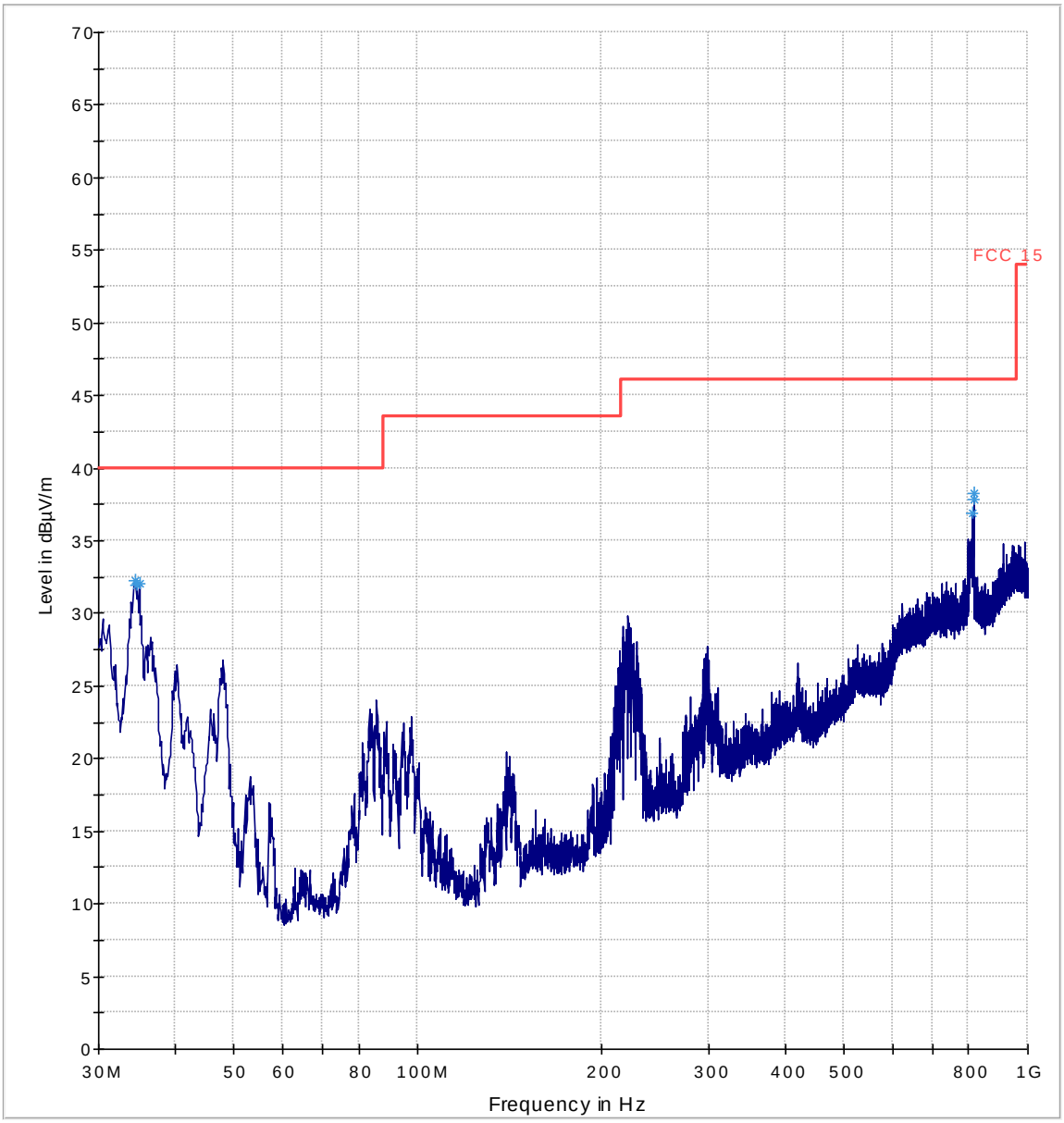
Plot #8		
RE: 3 GHz – 18 GHz	Ch. 1	Modulation: 802.11g (6Mbps_OFDM)



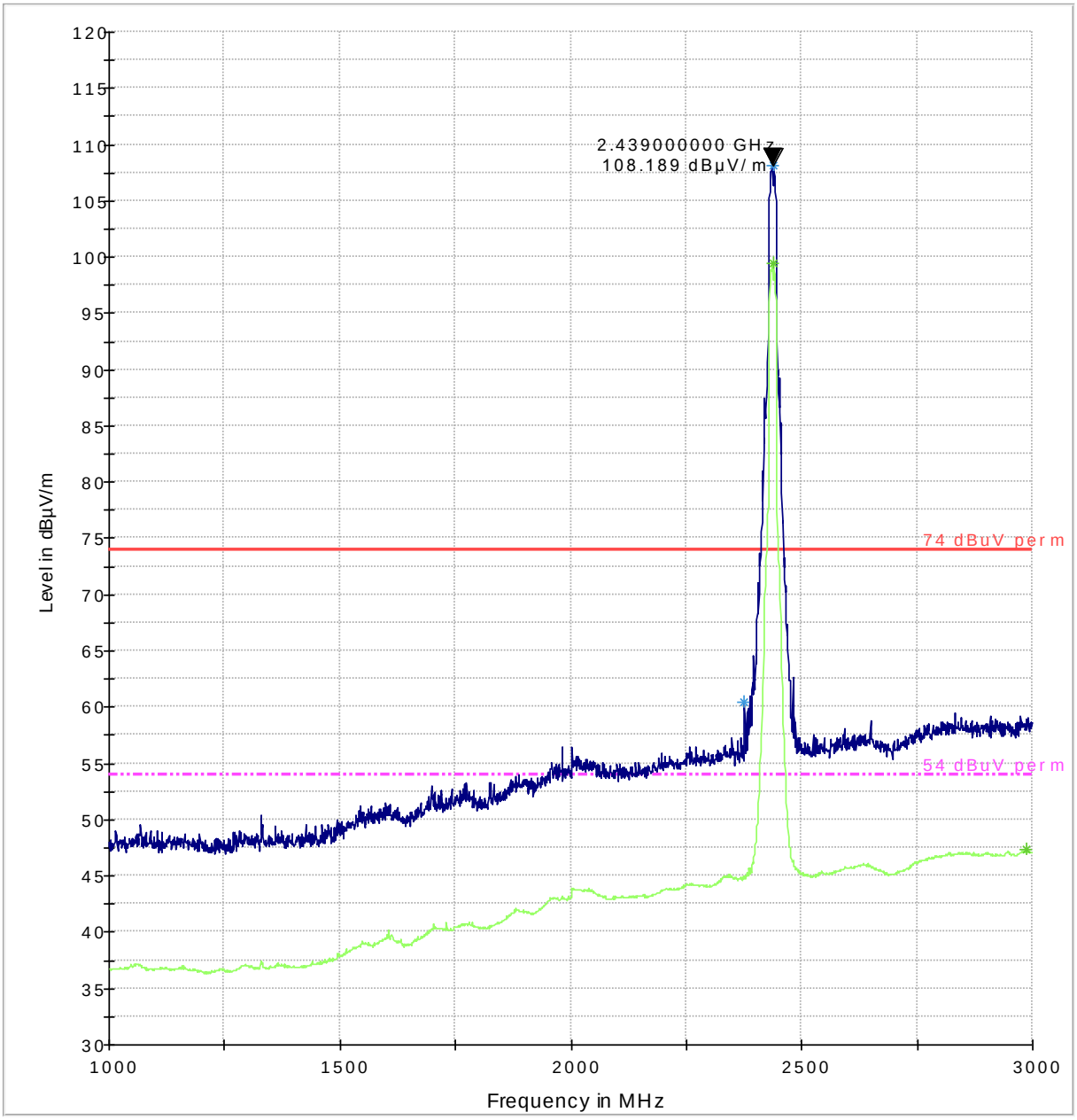
Plot # 9		
RE: 9 KHz – 30 MHz	**Ch. 6**	**Modulation: 802.11g (6Mbps_OFDM)**



Plot #10		
RE: 30 MHz – 1 GHz	Ch. 6	Modulation: 802.11g (6Mbps_OFDM)

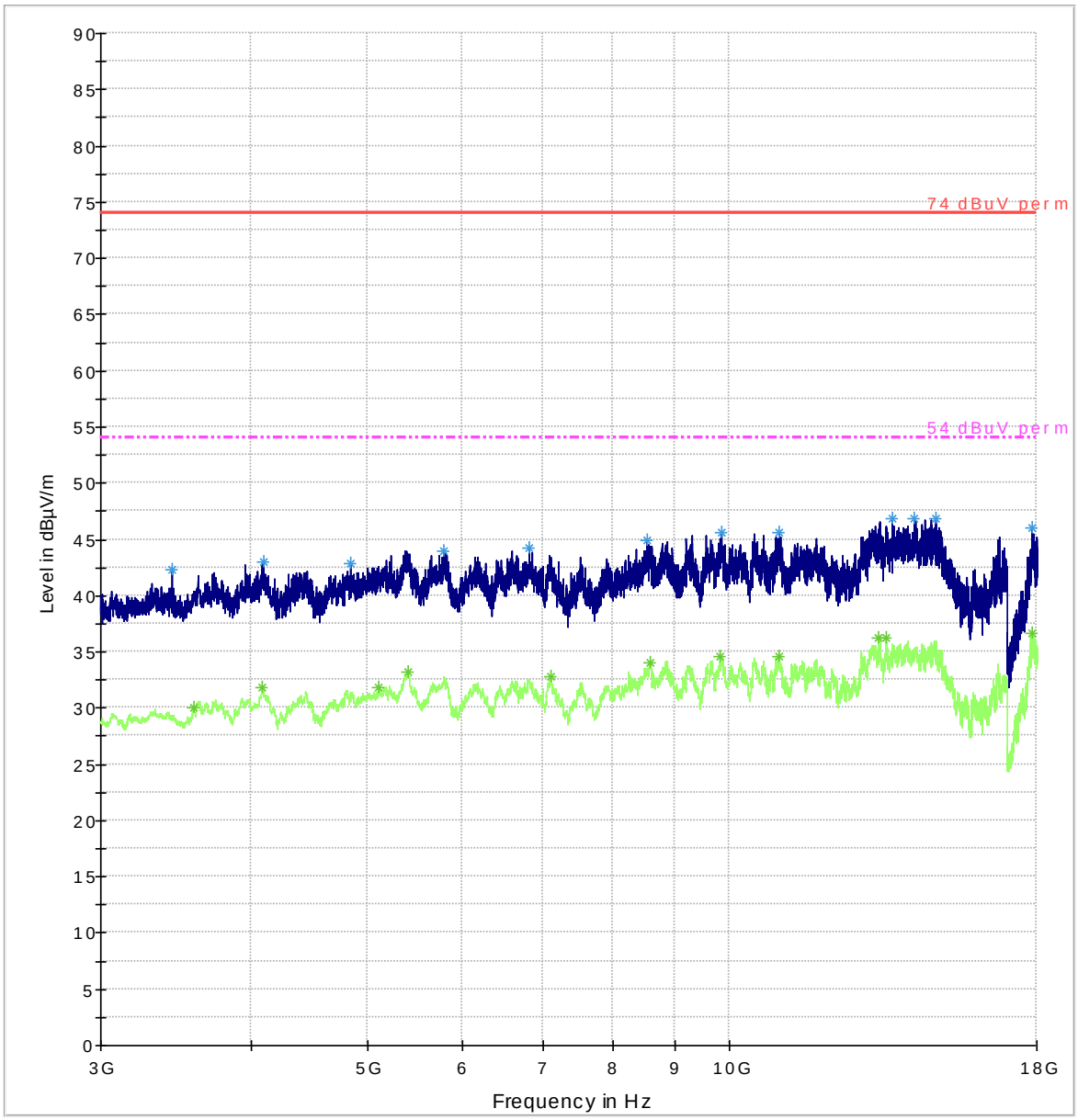


Plot #11		
RE: 1 GHz – 3 GHz	**Ch. 6**	**Modulation: 802.11g (6Mbps_OFDM)**

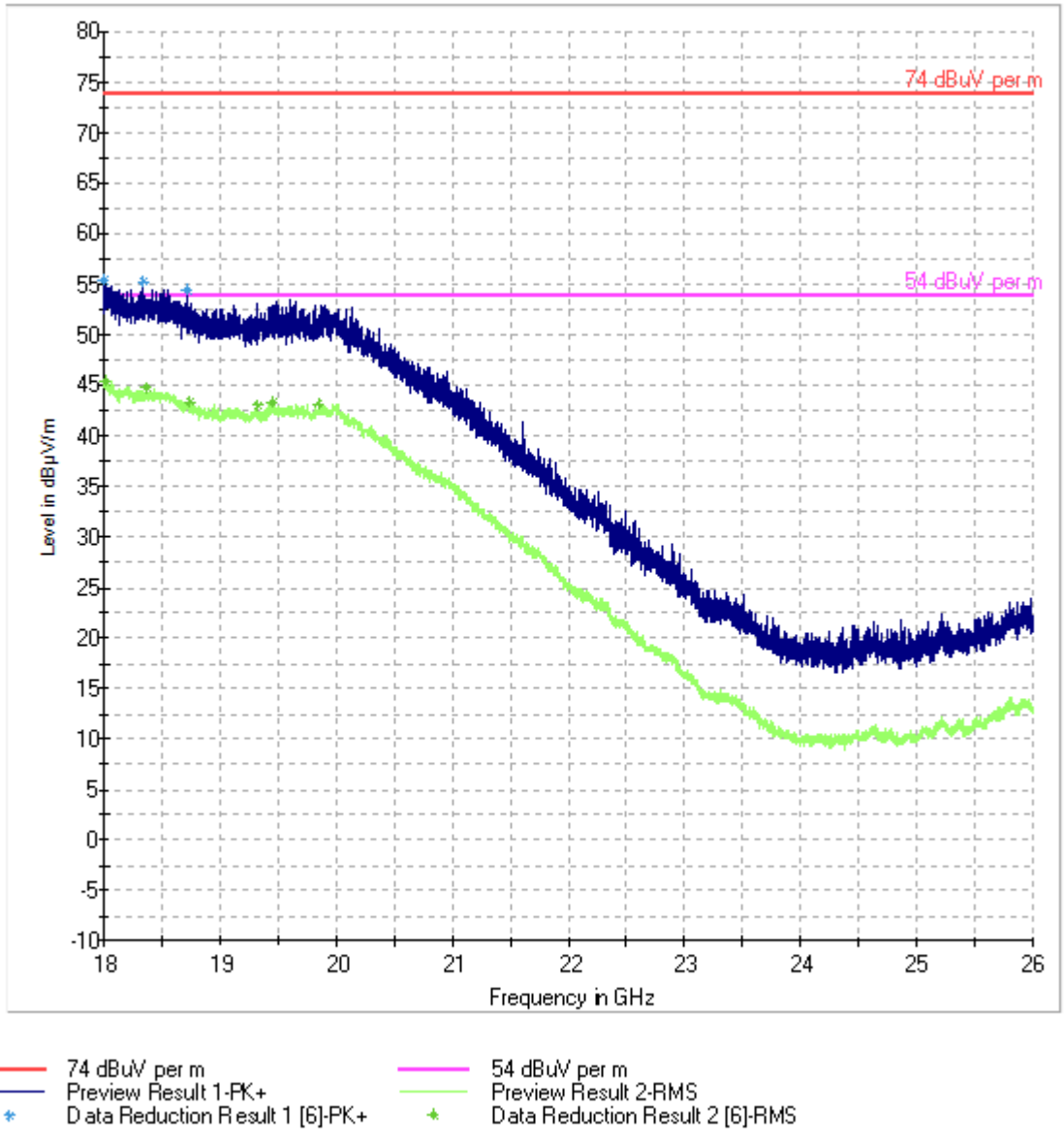


Note: The emission above the limit is the Tx Ch.6.

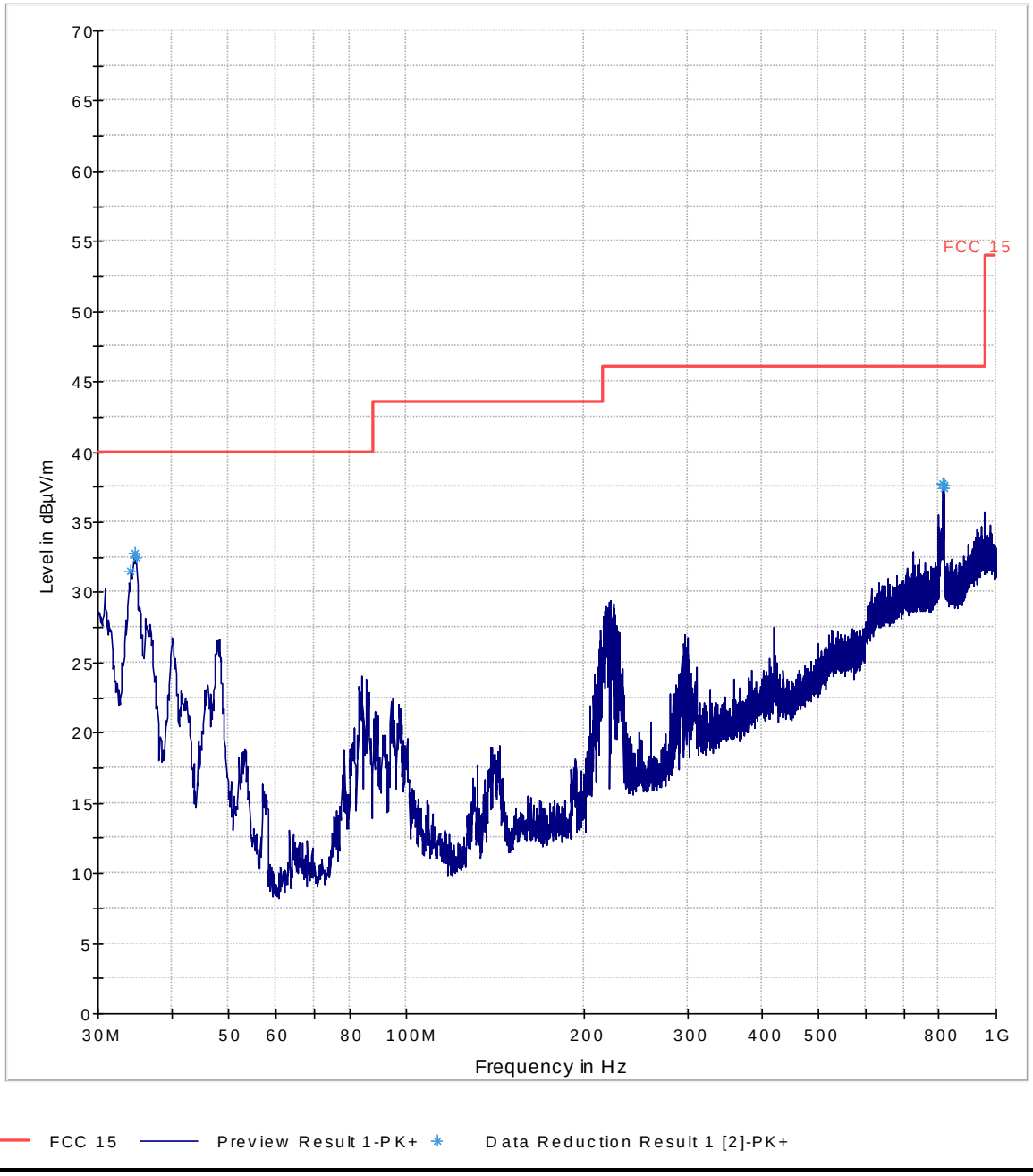
Plot #12		
RE: 3 GHz – 18 GHz	Ch. 6	Modulation: 802.11g (6Mbps_OFDM)



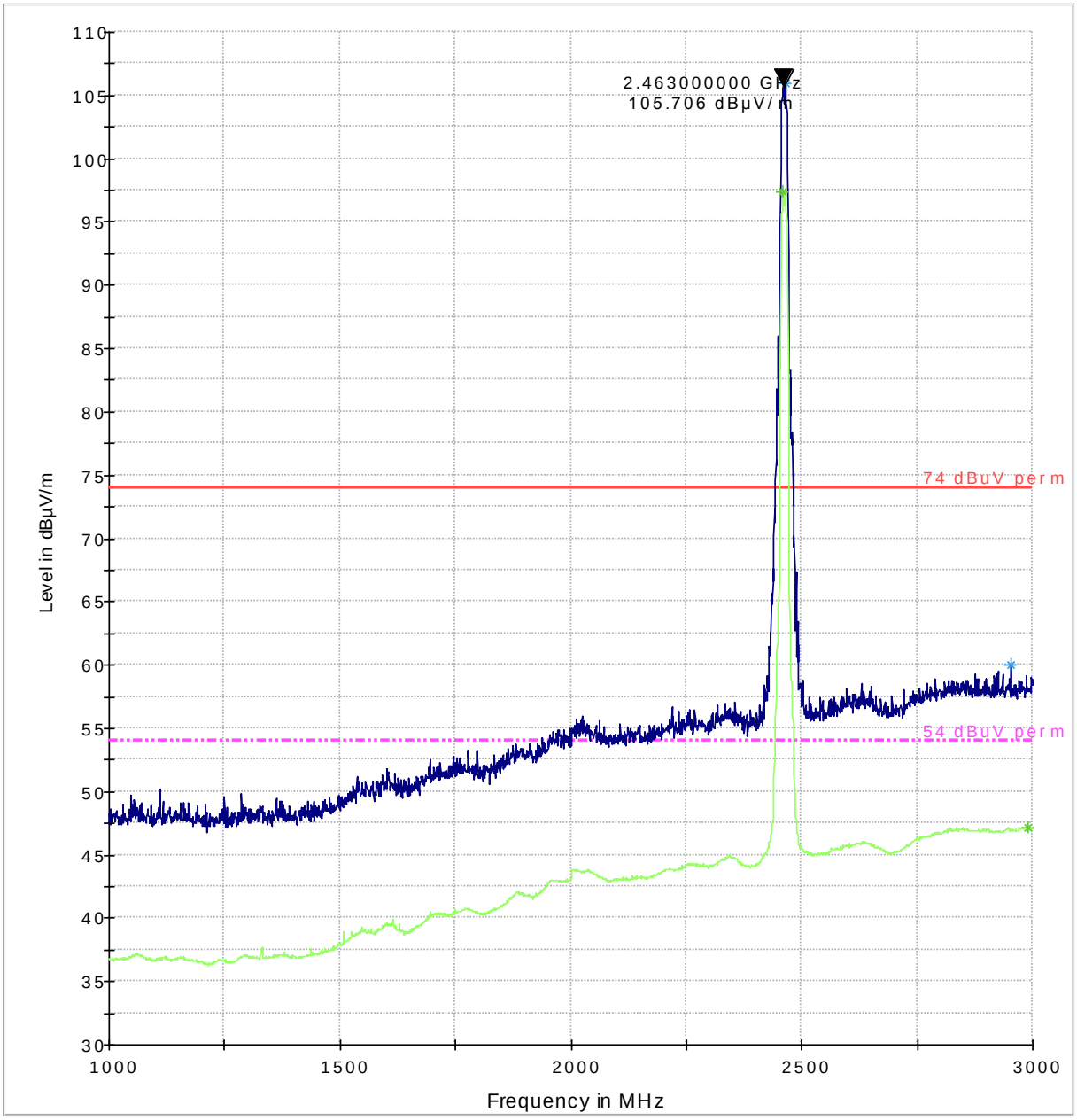
Plot #13		
RE: 18 GHz – 26 GHz	**Ch. 6**	**Modulation: 802.11g (6Mbps_OFDM)**



Plot #14		
RE: 30 MHz – 1 GHz	**Ch. 11**	**Modulation: 802.11g (6Mbps_OFDM)**

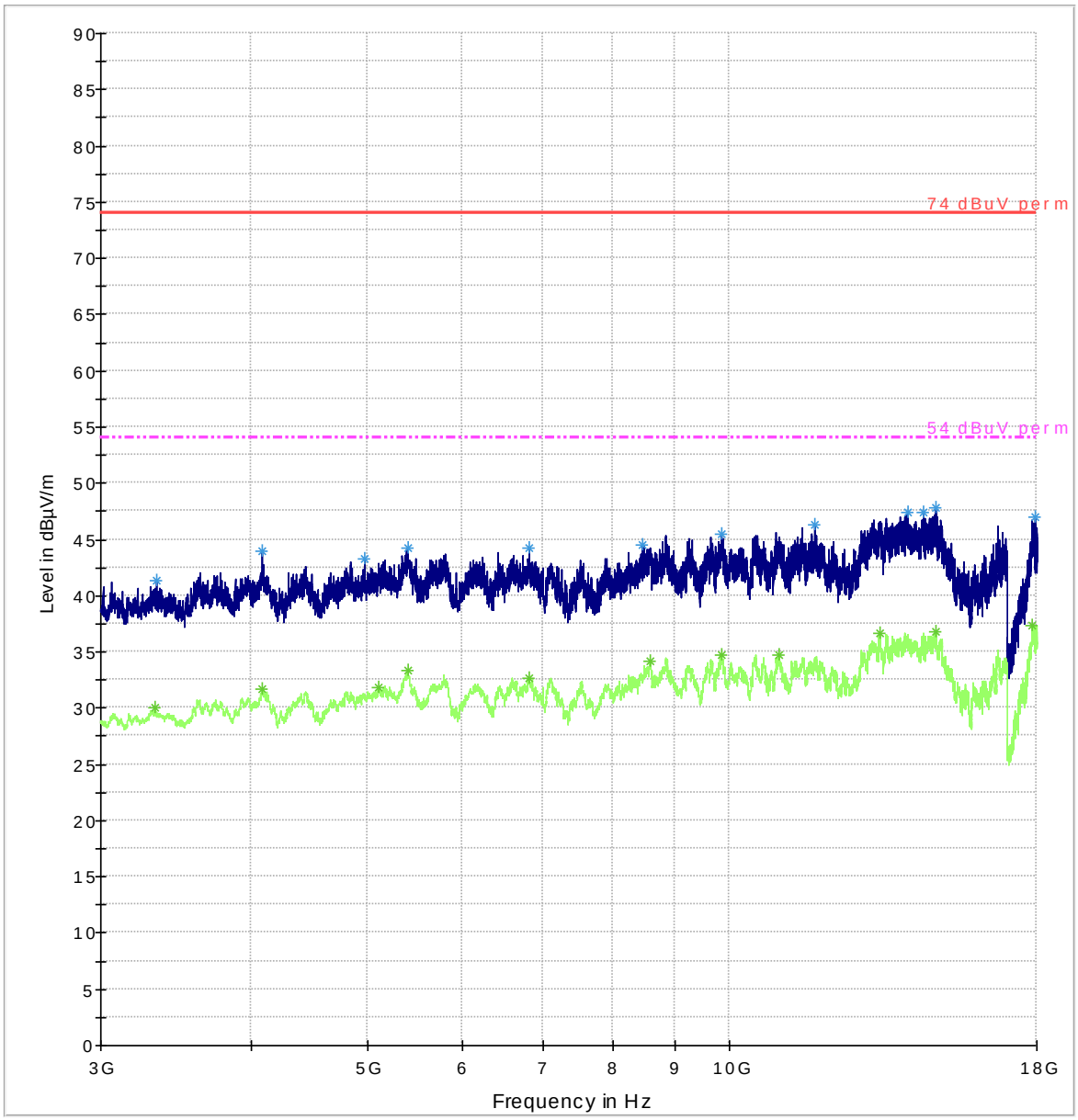


Plot #15		
RE: 1 GHz – 3 GHz	**Ch. 11**	**Modulation: 802.11g (6Mbps_OFDM)**



Note: The emission above the limit is the Tx Ch.6.

Plot #9		
RE: 3 GHz – 18 GHz	Ch. 11	Modulation: 802.11g (6Mbps_OFDM)



14 AC Power Line Conducted Emissions

The purpose of this test is to measure unwanted radio frequency currents induced in any AC conductor external to the equipment which could conduct interference to other equipment via the AC electrical network.

14.1 Limits:

§15.207

(a) Except as shown in paragraphs (b) and (c) of this section of the CFR, for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table (1), as measured using a 50 µH/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

Table 1:

Frequency of emission (MHz)	Conducted limit (dBµV)	
	Quasi-peak	Average
0.15–0.5	66 to 56*	56 to 46*
0.5–5	56	46
5–30	60	50

*Decreases with the logarithm of the frequency.

14.2 Test conditions and setup:

Mid channel on 802.11b and the 802.11n radios were set according to section 3.4.

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
23° C	1	Tx	AC/DC Power Supply

14.3 Test Procedure:

Measurement according to ANSI C63.10:2013 section 6.2 and 4.1.

Equipment numbers 9, 17 in section 16 of this report were used for this test case.

Analyzer Settings:
RBW = 9 KHz (CISPR Bandwidth)
Detector: Quasi-Peak / Average

14.4 Results:

Pass

14.5 Test Data:

Conducted Emissions: 150 KHz – 30 MHz

14.5.1 802.11b (11Mbps) Channel 6

Frequency (MHz)	QuasiPeak (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	PE	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)	Comment
0.414000	43.7	500.0	9.000	GND	N	2.8	13.9	57.6	
0.434000	43.1	500.0	9.000	GND	N	2.5	14.1	57.2	
0.678000	34.9	500.0	9.000	GND	N	1.5	21.1	56.0	
28.250000	38.0	500.0	9.000	GND	L1	0.5	22.0	60.0	

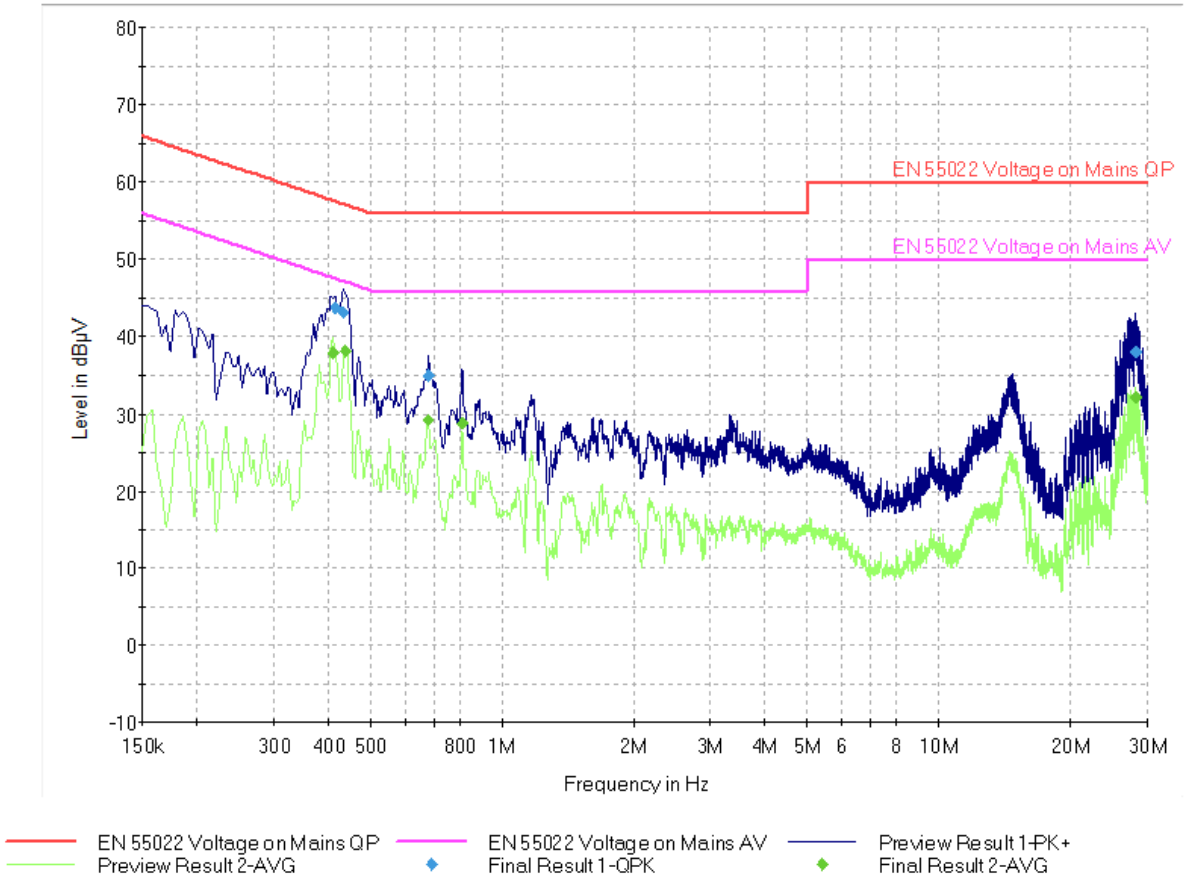
14.5.1 802.11g (6Mbps) Channel 6

Frequency (MHz)	QuasiPeak (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	PE	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)	Comment
0.422000	42.5	500.0	9.000	GND	N	2.7	14.9	57.4	
0.438000	43.0	500.0	9.000	GND	N	2.5	14.1	57.1	
28.242000	37.9	500.0	9.000	GND	N	0.5	22.1	60.0	

14.6 Measurement Plots:

14.6.1 802.11b (11Mbps) Channel 6

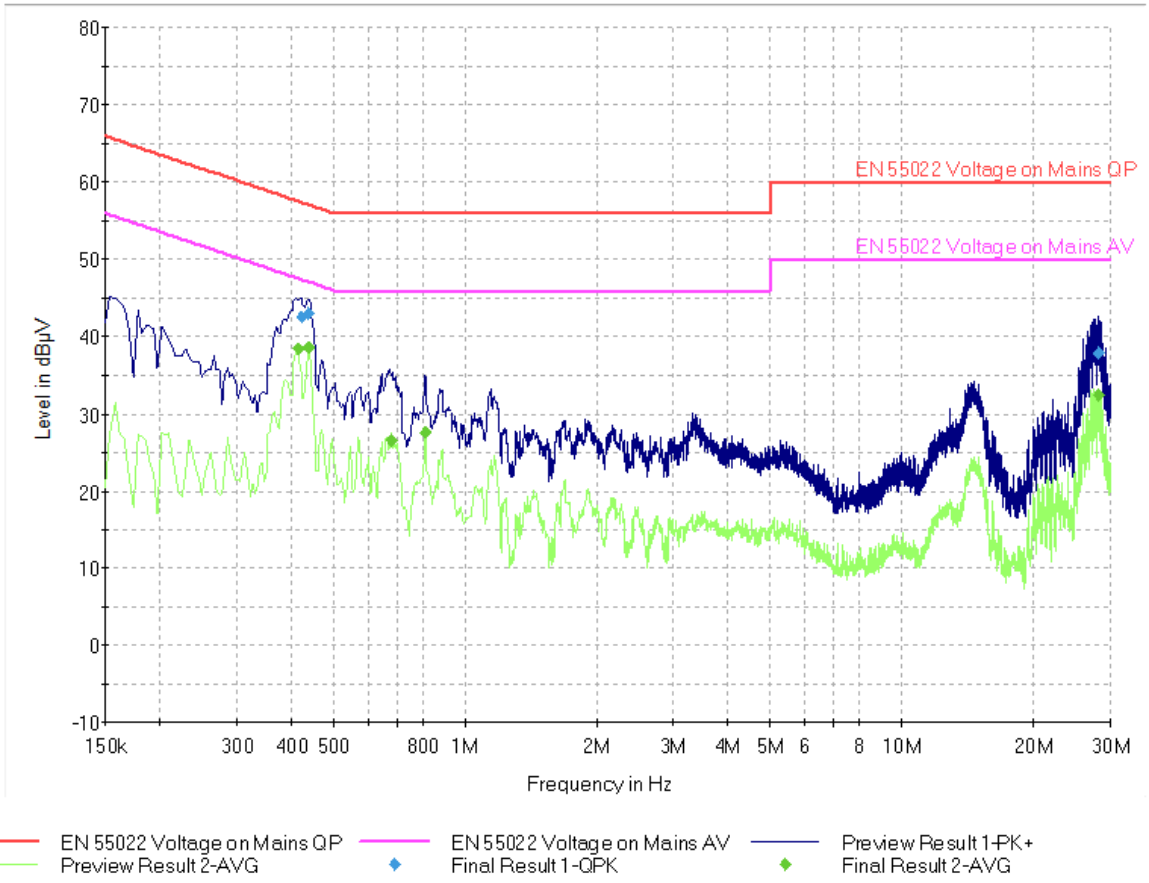
Conducted Emissions: 150 KHz – 30 MHz



Note: Plots shown here represent the combined worse case emissions for power lines (phases and neutral line).

14.6.2 802.11g (6Mbps) Channel 6

Conducted Emissions: 150 KHz – 30 MHz



Note: Plots shown here represent the combined worse case emissions for power lines (phases and neutral line).

15 Setup Pictures

Please refer to EMC_HAPIN-001-16501_FCC_Test_Setup_Photos_rev1.pdf

16 Test Equipment and Ancillaries Used For Testing

No.	Equipment Name	Manufacturer	Type/model	Serial No.	Cal Date	Cal Interval
1	Turn table	EMCO	2075	N/A	N/A	N/A
2	MAPS Position Controller	ETS Lindgren	2092	0004-1510	N/A	N/A
3	Antenna Mast	EMCO	2075	N/A	N/A	N/A
4	High Pass Filter	5HC2700	Trilithic Inc.	9926013	Part of system calibration	
5	High Pass Filter	4HC1600	Trilithic Inc.	9922307	Part of system calibration	
6	6GHz High Pass Filter	HPM50106	Microtronics	001	Part of system calibration	
7	Pre-Amplifier	JS4-00102600	Miteq	00616	Part of system calibration	
8	Relay Switch Unit	Rohde&Schwarz	RSU	338964/001	N/A	N/A
9	EMI Receiver/Analyzer	Rohde&Schwarz	ESU 40	100251	June 2015	3 Years
10	1500MHz HP Filter	Filtek	HP12/1700	14c48	N/A	N/A
11	2800 MHZ HP Filter	Filtek	HP12/2800	14C47	N/A	N/A
12	Pre-Amplifier	Miteq	JS40010260	340125	N/A	N/A
13	Binconilog Antenna	ETS	3142E	166067	Jun 2014	3 years
14	Horn Antenna	EMCO	3115	35111	Jul 2015	3 Years
15	Horn Antenna	EMCO	3116	00070497	Jul 2015	3 Years
16	Loop Antenna	EMCO	6512	00049838	Mar 2014	3 years
17	LISN	R&S	ESH3-Z5	836679/003	Jun 2013	3 Years
18	Spectrum Analyzer	Rohde&Schwarz	FSU	100189	June 2013	3 Years
19	Fast Power Detector 5Ms/s	ETS Lindgren	7002-006	00160034	Sep 2014	2 Years
20	Spectrum Analyzer	Rohde&Schwarz	FSU-8	200256	Jul 2015	2 Years

Equipment used meets the measurement uncertainty requirements as required per applicable standards for 95% confidence levels.
Calibration due dates, unless defined specifically, falls on the last day of the month.
Items indicated "N/A" for cal status either do not specifically require calibration or is internally characterized before use.

17 Revision History

Date	Report Name	Changes to report	Report prepared by
July 27, 2016	EMC_HAPIN-001-16501_15.247_WLAN	Initial Version	Douglas Antioco
August 18, 2016	EMC_HAPIN-001-16501_15.247_WLAN_rev1	Replaces previous version. Added Maximum Conducted Output Power Verification (Section 8), Corrected Channel discrepancy in section 9, 10. Updated sections 3.1, 6.4, 7.1, 9.3, 9.4, 9.5, 10.3, and 12.	Douglas Antioco
August 30, 2016	EMC_HAPIN-001-16501_15.247_WLAN_rev2	Replaces previous version. Updated Section 8. Added Full testing on 802.11g mode (Sections 9-13).	Douglas Antioco
September 1, 2016	EMC_HAPIN-001-16501_15.247_WLAN_rev3	Replaces previous version. Updated sections 9.3 and 10.3.	Douglas Antioco