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Test report

283832-1TRFWL

Date of issue: May 27, 2015

Applicant:

L-3 Communications Display Systems

Product:

CrewMate 840 Electronic Flight Bag (EFB)

Model:

Crewmate840IC

FCC ID:

RD9CM840IC

IC Registration number:

3494F-CM840IC

Specifications:

- FCC 47 CFR Part 15 Subpart C, §15.247

  Operation in the 902–928 MHz, 2400–2483.5 MHz, 5725–5850 MHz

- RSS-210, Issue 8, December 2010, Annex 8

  Frequency Hopping and Digital Modulation Systems Operating in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz Bands

Nemko Canada Inc., a testing laboratory, is accredited by the Standards Council of Canada. The tests included in this report are within the scope of this accreditation

SCC Accredited LAB
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Test location

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Website	www.nemko.com
Site number	FCC: 176392; IC: 2040A-4 (3 m semi anechoic chamber)

Tested by	Andrey Adelberg, Senior Wireless/EMC Specialist
Reviewed by	Kevin Rose, Wireless/EMC Specialist
Review date	May 27, 2015
Reviewer signature	

Limits of responsibility

Note that the results contained in this report relate only to the items tested and were obtained in the period between the date of initial receipt of samples and the date of issue of the report.
This test report has been completed in accordance with the requirements of ISO/IEC 17025. All results contain in this report are within Nemko Canada's ISO/IEC 17025 accreditation.

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Section 1. Report summary

1.1 Applicant and manufacturer

Company name	L-3 Communications Display Systems
Address	1355 Bluegrass Lakes Parkway
City	Alpharetta
State	GA
Zip code	30004-8458
Country	USA

1.2 Test specifications

FCC 47 CFR Part 15, Subpart C, Clause 15.247	Operation in the 902–928 MHz, 2400–2483.5 MHz, 5725–5850 MHz
RSS-210, Issue 8 Annex 8	Frequency Hopping and Digital Modulation Systems Operating in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz Bands

1.3 Test methods

558074 D01 DTS Meas Guidance v03r02 (June 5, 2014)	Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247
ANSI C64.10 v2009	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

1.4 Statement of compliance

In the configuration tested, the EUT was found compliant.

Testing was completed against all relevant requirements of the test standard. Results obtained indicate that the product under test complies in full with the requirements tested. The test results relate only to the items tested.

See “Summary of test results” for full details.

1.5 Exclusions

None

1.6 Test report revision history

Revision #	Details of changes made to test report
TRF	Original report issued

Section 2. Summary of test results

2.1 FCC Part 15 Subpart C, general requirements test results

Part	Test description	Verdict
§15.207(a)	Conducted limits	Pass
§15.31(e)	Variation of power source	Pass[1]
§15.203	Antenna requirement	Pass[2]

Notes: [1] Measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission, as appropriate, was performed with the supply voltage varied between 85 % and 115 % of the nominal rated supply voltage. No noticeable output power variation was observed

[2] The Antennas are located within the enclosure of EUT and not user accessible.

2.2 FCC Part 15 Subpart C, intentional radiators test results

Part	Test description	Verdict
§15.247(a)(1)(i)	Frequency hopping systems operating in the 902–928 MHz band	Not applicable
§15.247(a)(1)(ii)	Frequency hopping systems operating in the 5725–5850 MHz band	Not applicable
§15.247(a)(1)(iii)	Frequency hopping systems operating in the 2400–2483.5 MHz band	Not applicable
§15.247(a)(2)	Minimum 6 dB bandwidth for systems using digital modulation techniques	Pass
§15.247(b)(1)	Maximum peak output power of frequency hopping systems operating in the 2400–2483.5 MHz band and 5725–5850 MHz band	Not applicable
§15.247(b)(2)	Maximum peak output power of Frequency hopping systems operating in the 902–928 MHz band	Not applicable
§15.247(b)(3)	Maximum peak output power of systems using digital modulation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands	Pass
§15.247(c)(1)	Fixed point-to-point operation with directional antenna gains greater than 6 dBi	Not applicable
§15.247(c)(2)	Transmitters operating in the 2400–2483.5 MHz band that emit multiple directional beams	Not applicable
§15.247(d)	Spurious emissions	Not applicable
§15.247(e)	Power spectral density for digitally modulated devices	Pass
§15.247(f)	Time of occupancy for hybrid systems	Not applicable

2.3 IC RSS-GEN, Issue 4, test results

Part	Test description	Verdict
7.1.2	Receiver radiated emission limits	Not applicable
7.1.3	Receiver conducted emission limits	Not applicable
8.8	Power Line Conducted Emissions Limits for Licence-Exempt Radio Apparatus	Pass

Notes: [1] According to sections 5.2 and 5.3 of RSS-Gen, Issue 4 the EUT does not have a stand-alone receiver neither scanner receiver, therefore exempt from receiver requirements.

2.4 IC RSS-210, Issue 8, test results

Part	Test description	Verdict
A8.1	Frequency hopping systems	
A8.1 (a)	Bandwidth of a frequency hopping channel	Not applicable
A8.1 (b)	Minimum channel spacing for frequency hopping systems	Not applicable
A8.1 (c)	Frequency hopping systems operating in the 902–928 MHz band	Not applicable
A8.1 (d)	Frequency hopping systems operating in the 2400–2483.5 MHz band	Not applicable
A8.1 (e)	Frequency hopping systems operating in the 5725–5850 MHz band	Not applicable
A8.2	Digital modulation systems	
A8.2 (a)	Minimum 6 dB bandwidth	Pass
A8.2 (b)	Maximum power spectral density	Pass
A8.3	Hybrid systems	
A8.3 (1)	Digital modulation turned off	Not applicable
A8.3 (2)	Frequency hopping turned off	Not applicable
A8.4	Transmitter output power and e.i.r.p. requirements	
A8.4 (1)	Frequency hopping systems operating in the 902–928 MHz band	Not applicable
A8.4 (2)	Frequency hopping systems operating in the 2400–2483.5 MHz band	Not applicable
A8.4 (3)	Frequency hopping systems operating in the 5725–5850 MHz	Not applicable
A8.4 (4)	Systems employing digital modulation techniques	Pass
A8.4 (5)	Point-to-point systems in 2400–2483.5 MHz and 5725–5850 MHz band	Not applicable
A8.4 (6)	Transmitters which operate in the 2400–2483.5 MHz band with multiple directional beams	Not applicable
A8.5	Out-of-band emissions	Pass

Notes: None

Section 3. Equipment under test (EUT) details

3.1 Sample information

Receipt date	April 17, 2015
Nemko sample ID number	1

3.2 EUT information

Product name	CrewMate 840 Electronic Flight Bag (EFB)
Model	Crewmate840IC
Serial number	D09CF020046AX01

3.3 Technical information

Applicant IC company number	3494F
IC UPN number	CM840IC
All used IC test site(s) Reg. number	2040A-4
RSS number and Issue number	RSS-210 Annex 8, Issue 8, December 2010
Frequency band	2400–2483.5 MHz
Frequency Min (MHz)	2412 (20 MHz channels); 2422 (40 MHz channels)
Frequency Max (MHz)	2462 (20 MHz channels); 2452 (40 MHz channels)
RF power Max (W), Conducted	0.038 (802.11b); 0.078 (802.11g); 0.069 (802.11n HT20); 0.018 (802.11n HT40)
Field strength, Units @ distance	N/A
Measured BW (kHz) (6 dB)	12540 (802.11b); 16430 (802.11g); 17690 (802.11n HT20); 36500 (802.11n HT40)
Calculated BW (kHz), as per TRC-43	N/A
Type of modulation	802.11b/g/n
Emission classification (F1D, G1D, D1D)	W7D
Transmitter spurious, Units @ distance	40.64 dBµV/m at 2483.5 MHz @ 3 m
Power requirements	120 V_{AC}, 60 Hz
Antenna information	Johanson Technology Internal SMD Chip antenna with 2 dBi gain with 3 dB path loss. PN: 2450AT43A100. The EUT uses a unique antenna coupling/ non-detachable antenna to the intentional radiator.

3.4 Product description and theory of operation

EUT is a Wi-Fi 2.4 GHz module installed within CrewMate 840 display unit.

3.5 EUT setup diagram

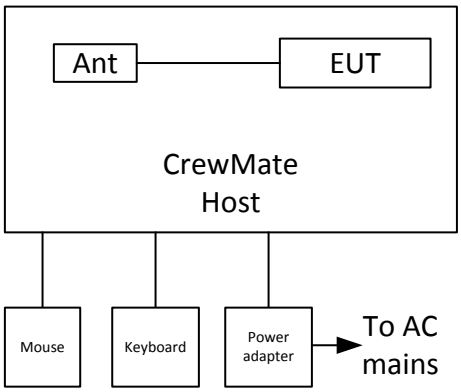


Figure 3.5-1: *Setup diagram*

3.6 EUT exercise details

EUT was controlled via command line interface using ART tool with the following power settings:

Modulation	Frequency, MHz	ART Rev. 07 Built #19 settings
802.11b	2412	16.0
802.11b	2437	18.5
802.11b	2462	16.5
802.11g	2412	14.0
802.11g	2437	21.0
802.11g	2462	13.0
802.11n MCS8 20 MHz	2412	13.5
802.11n MCS8 20 MHz	2437	20.5
802.11n MCS8 20 MHz	2462	12.0
802.11n MCS8 40 MHz	2422	10.0
802.11n MCS8 40 MHz	2437	15.0
802.11n MCS8 40 MHz	2452	8.5

Section 4. Engineering considerations

4.1 Modifications incorporated in the EUT

There were no modifications performed to the EUT during this assessment.

4.2 Technical judgment

None

4.3 Deviations from laboratory tests procedures

No deviations were made from laboratory procedures.

Section 5. Test conditions

5.1 Atmospheric conditions

Temperature	15–30 °C
Relative humidity	20–75 %
Air pressure	860–1060 mbar

When it is impracticable to carry out tests under these conditions, a note to this effect stating the ambient temperature and relative humidity during the tests shall be recorded and stated.

5.2 Power supply range

The normal test voltage for equipment to be connected to the mains shall be the nominal mains voltage. For the purpose of the present document, the nominal voltage shall be the declared voltage, or any of the declared voltages ±5 %, for which the equipment was designed.

Section 6. Measurement uncertainty

6.1 Uncertainty of measurement

Measurement uncertainty budgets for the tests are detailed below. Measurement uncertainty calculations assume a coverage factor of K = 2 with 95% certainty.

Test name	Measurement uncertainty, dB
All antenna port measurements	0.55
Conducted spurious emissions	1.13
Radiated spurious emissions	3.78
AC power line conducted emissions	3.55

Section 7. Test equipment

7.1 Test equipment list

Table 7.1-1: *Equipment list*

Equipment	Manufacturer	Model no.	Asset no.	Cal cycle	Next cal.
3 m EMI test chamber	TDK	SAC-3	FA002047	1 year	Feb. 25/16
Flush mount turntable	Sunol	FM2022	FA002082	—	NCR
Controller	Sunol	SC104V	FA002060	—	NCR
Antenna mast	Sunol	TLT2	FA002061	—	NCR
Power source	California Instruments	3001i	FA001021	1 year	June 27/15
Receiver/spectrum analyzer	Rohde & Schwarz	ESU 26	FA002043	1 year	Jan. 07/16
Spectrum analyzer	Rohde & Schwarz	FSU	FA001877	1 year	Mar. 27/16
Spectrum analyzer	Rohde & Schwarz	FSP	FA001920	1 year	July 08/15
LISN	Rohde & Schwarz	ENV216	FA002023	1 year	Jan. 09/16
50 Ω coax cable	C.C.A.	None	FA002556	1 year	May 05/16
Bilog antenna (20–3000 MHz)	Sunol	JB3	FA002108	1 year	Apr. 12/16
Horn antenna (1–18 GHz)	EMCO	3115	FA000825	1 year	Apr. 01/16
Horn antenna (18–26.5 GHz)	Electro-metrics	SH-50/60-1	FA000479	—	VOU
Pre-amplifier (1–18 GHz)	JCA	JCA118-503	FA002091	1 year	May 05/16
Pre-amplifier (18–26 GHz)	Narda	BBS-1826N612	FA001550	—	VOU

Note: NCR - no calibration required, VOU - verify on use

Section 8. Testing data

8.1 FCC 15.207(a) and RSS-Gen 8.8 AC power line conducted emissions limits

8.1.1 Definitions and limits

FCC:
Except as shown in paragraphs (b) and (c) of this section, 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, as measured using a 50 µH/50 Ω 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.

IC:
A radio apparatus that is designed to be connected to the public utility (AC) power line shall ensure that the radio frequency voltage, which is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz, shall not exceed the limits in table below.

Unless the requirements applicable to a given device state otherwise, for any radio apparatus equipped to operate from the public utility AC power supply either directly or indirectly (such as with a battery charger), the radio frequency voltage of emissions conducted back onto the AC power lines in the frequency range of 0.15 MHz to 30 MHz shall not exceed the limits shown in table below. The more stringent limit applies at the frequency range boundaries.

Table 8.1-1: *Conducted emissions limit*

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

Note: * - The level decreases linearly with the logarithm of the frequency.
** - A linear average detector is required.

8.1.2 Test summary

Test date	May 13, 2015	Temperature	23 °C
Test engineer	Andrey Adelberg	Air pressure	1005 mbar
Verdict	Pass	Relative humidity	31 %

8.1.3 Observations, settings and special notes

The EUT was set up as tabletop configuration.

The spectral scan has been corrected with transducer factors (i.e. cable loss, LISN factors, and attenuators) for determination of compliance.

A preview measurement was generated with the receiver in continuous scan mode. Emissions detected within 6 dB or above limit were re-measured with the appropriate detector against the correlating limit and recorded as the final measurement.

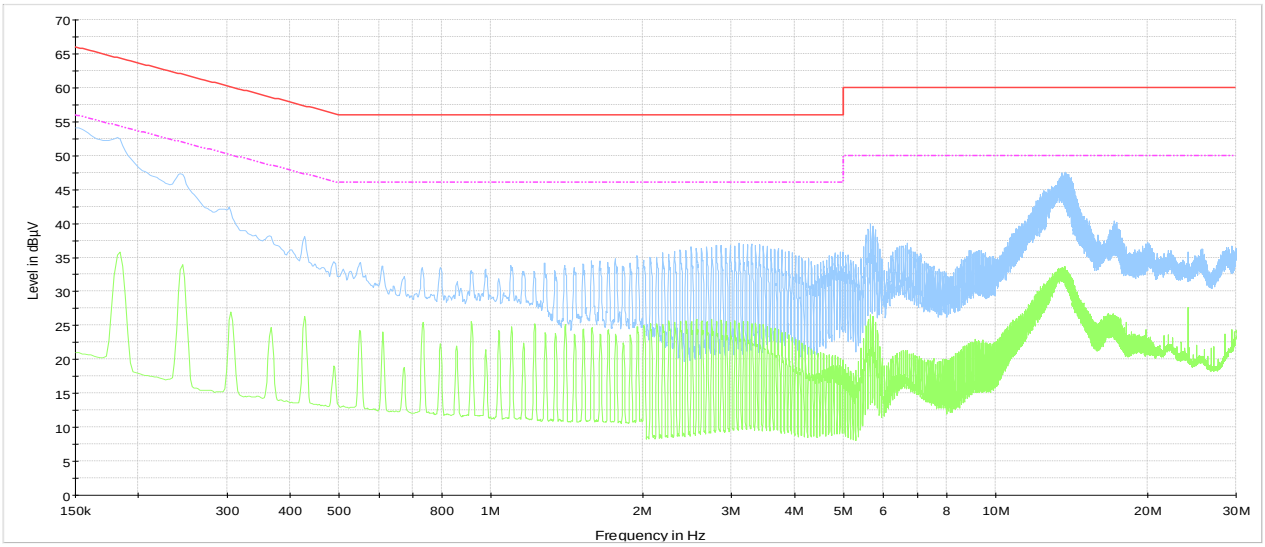
Receiver settings for preview measurements:

Resolution bandwidth	9 kHz
Video bandwidth	30 kHz
Detector mode	Peak and Average
Trace mode	Max Hold
Measurement time	1000 ms

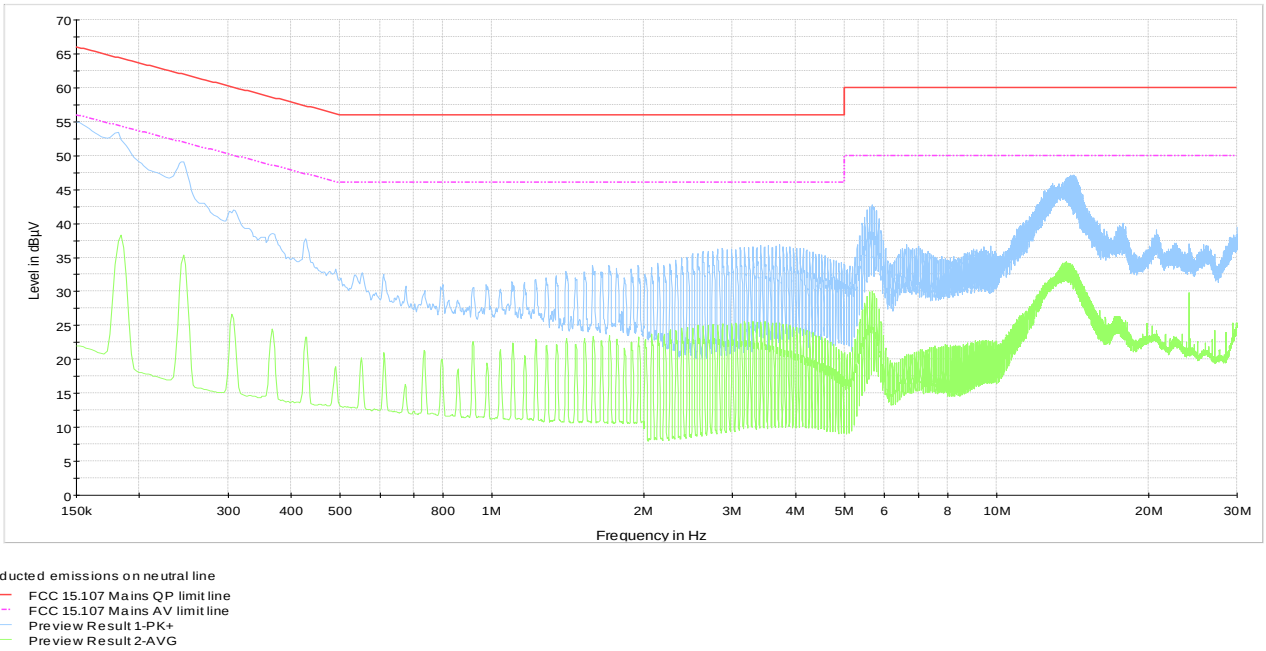
Receiver settings for final measurements:

Resolution bandwidth	9 kHz
Video bandwidth	30 kHz
Detector mode	Quasi-Peak and Average
Trace mode	Max Hold
Measurement time	1000 ms

8.1.4 Test data



Plot 8.1-1: *Conducted emissions on phase line*



Plot 8.1-2: *Conducted emissions on neutral line*

8.2 FCC 15.247(a)(2) and RSS-210 A8.2(a) Minimum 6 dB bandwidth for systems using digital modulation techniques

8.2.1 Definitions and limits

FCC and IC:

(a) Operation under the provisions of this Section is limited to frequency hopping and digitally modulated intentional radiators that comply with the following provisions:

(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.

8.2.2 Test summary

Test date	April 17, 2015	Temperature	21 °C
Test engineer	Andrey Adelberg	Air pressure	1005 mbar
Verdict	Pass	Relative humidity	30 %

8.2.3 Observations, settings and special notes

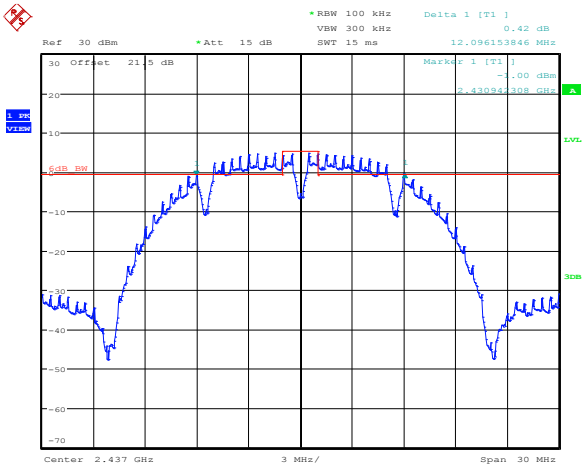
Spectrum analyser settings:

Resolution bandwidth	100 kHz
Video bandwidth	≥3 × RBW
Frequency span	30 MHz for 20 MHz channel; 70 MHz for 40 MHz channel
Detector mode	Peak
Trace mode	Max Hold

8.2.4 Test data

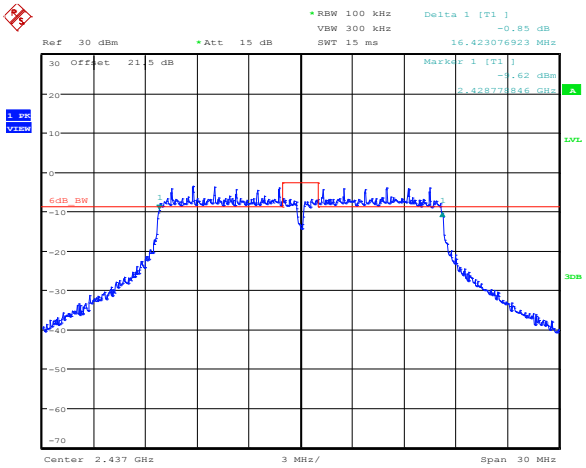
Table 8.2-1: *6 dB bandwidth results*

Modulation	Frequency, MHz	6 dB bandwidth, MHz	Minimum limit, MHz	Margin, MHz
802.11b	2412	12.07	0.50	11.57
	2437	12.09	0.50	11.59
	2462	12.54	0.50	12.04
802.11g	2412	16.39	0.50	15.89
	2437	16.42	0.50	15.92
	2462	16.43	0.50	15.93
802.11n HT20	2412	17.69	0.50	17.19
	2437	17.58	0.50	17.08
	2462	17.59	0.50	17.09
802.11n HT40	2422	36.50	0.50	36.00
	2437	36.30	0.50	35.80
	2452	36.40	0.50	35.90



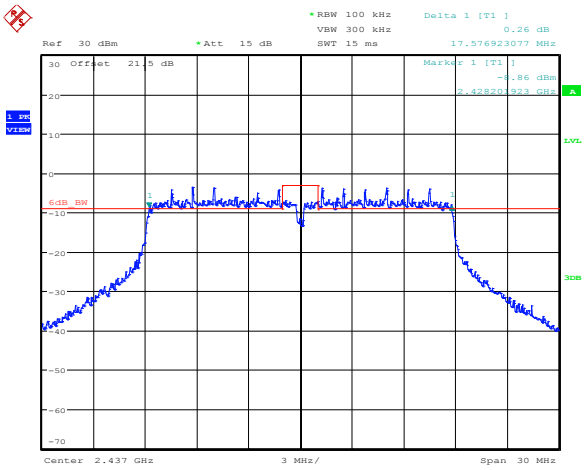
High channel
Date: 17.APR.2015 14:20:08

Figure 8.2-1: *6 dB bandwidth on 802.11b, sample plot*



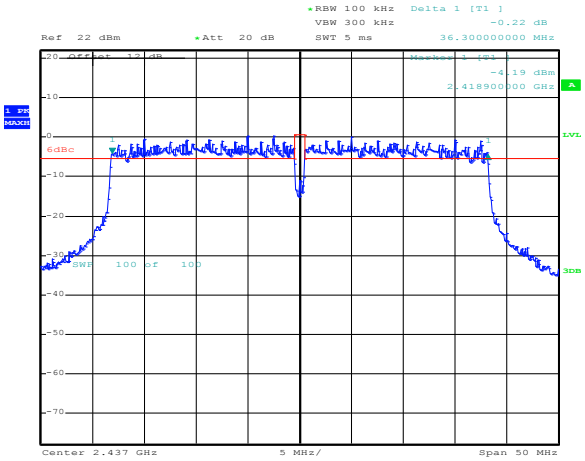
High channel
Date: 17.APR.2015 14:21:43

Figure 8.2-2: *6 dB bandwidth on 802.11g, sample plot*



High channel
Date: 17.APR.2015 14:18:39

Figure 8.2-3: *6 dB bandwidth on 802.11n HT20, sample plot*



Date: 7.MAY.2015 09:36:29

Figure 8.2-4: *6 dB bandwidth on 802.11n HT40, sample plot*

8.3 FCC 15.247(b) and RSS-210 A8.4 (4) Transmitter output power and e.i.r.p. requirements

8.3.1 Definitions and limits

FCC:

(b) The maximum peak conducted output power of the intentional radiator shall not exceed the following:

(3) For systems using digital modulation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands: 1 W (30 dBm). As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.

(4) The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

(i) Systems operating in the 2400–2483.5 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi provided the maximum peak output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi.

Fixed, point-to-point operation, as used in paragraphs (b)(3)(i) and (b)(3)(ii) of this section, excludes the use of point-to-multipoint systems, omnidirectional applications, and multiple co-located intentional radiators transmitting the same information. The operator of the spread spectrum intentional radiator or, if the equipment is professionally installed, the installer is responsible for ensuring that the system is used exclusively for fixed, point-to-point operations. The instruction manual furnished with the intentional radiator shall contain language in the installation instructions informing the operator and the installer of this responsibility.

(c) Operation with directional antenna gains greater than 6 dBi.

(2) In addition to the provisions in paragraphs (b)(1), (b)(3), (b)(4) and (c)(1)(i) of this section, transmitters operating in the 2400–2483.5 MHz band that emit multiple directional beams, simultaneously or sequentially, for the purpose of directing signals to individual receivers or to groups of receivers provided the emissions comply with the following:

(i) Different information must be transmitted to each receiver.

(ii) If the transmitter employs an antenna system that emits multiple directional beams but does not do emit multiple directional beams simultaneously, the total output power conducted to the array or arrays that comprise the device, i.e., the sum of the power supplied to all antennas, antenna elements, staves, etc. and summed across all carriers or frequency channels, shall not exceed the limit specified in paragraph (b)(1) or (b)(3) of this section, as applicable. However, the total conducted output power shall be reduced by 1 dB below the specified limits for each 3 dB that the directional gain of the antenna/antenna array exceeds 6 dBi. The directional antenna gain shall be computed as follows:

(A) The directional gain shall be calculated as the sum of 10 log (number of array elements or staves) plus the directional gain of the element or stave having the highest gain.

IC:

<u>A8.4 (4) Transmitter Output Power and e.i.r.p. Requirements for systems employing digital modulation techniques operating in the bands 902–928 MHz, 2400–2483.5 MHz and 5725–5850 MHz bands</u>

For systems employing digital modulation techniques operating in the bands 902–928 MHz, 2400–2483.5 MHz and 5725–5850 MHz, the maximum peak conducted output power shall not exceed 1 W. Except as provided in Section A8.4(5), the e.i.r.p. shall not exceed 4 W.

As an alternative to a peak power measurement, compliance can be based on a measurement of the maximum conducted output power (see RSS-Gen).

8.3.2 Test summary

Test date	May 6, 2015	Temperature	22 °C
Test engineer	Andrey Adelberg	Air pressure	1010 mbar
Verdict	Pass	Relative humidity	31 %

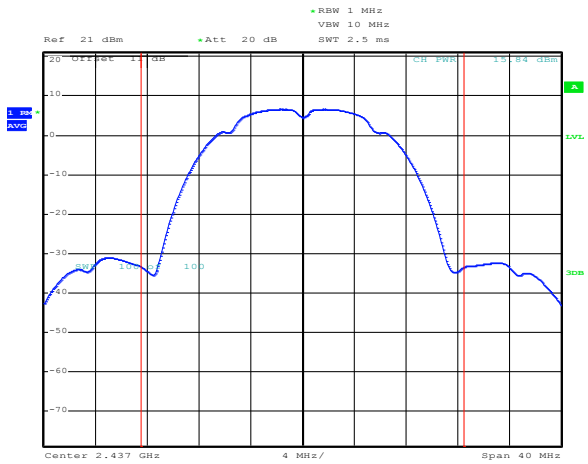
8.3.3 Observations, settings and special notes

The test was performed according to DTS guidelines section 9.2.2.1: Measurement using a spectrum analyzer (SA) Method AVGSA-1 averaging with the EUT transmitting at full power throughout each sweep. The measurements were performed at the Wi-Fi module antenna port.

8.3.4 Test data

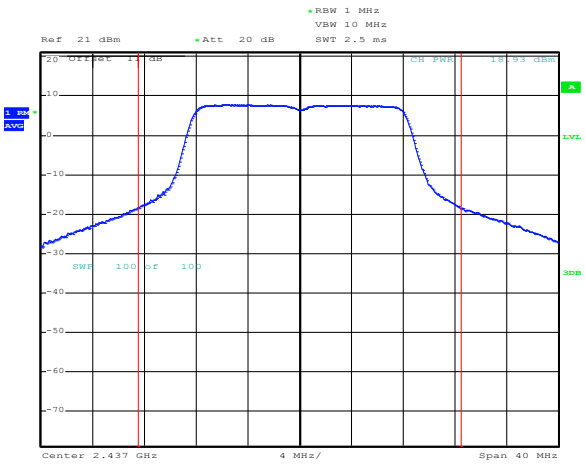
Table 8.3-1: *Output power measurements results*

Modulation	Frequency, MHz	Conducted output power, dBm		Margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
		Measured	Limit					
802.11b	2412	13.19	30.00	16.81	-1.00	12.19	36.00	23.81
	2437	15.84	30.00	14.16	-1.00	14.84	36.00	21.16
	2462	14.21	30.00	15.79	-1.00	13.21	36.00	22.79
802.11g	2412	12.63	30.00	17.37	-1.00	11.63	36.00	24.37
	2437	18.93	30.00	11.07	-1.00	17.93	36.00	18.07
	2462	11.38	30.00	18.62	-1.00	10.38	36.00	25.62
802.11n HT20	2412	12.16	30.00	17.84	-1.00	11.16	36.00	24.84
	2437	18.38	30.00	11.62	-1.00	17.38	36.00	18.62
	2462	10.34	30.00	19.66	-1.00	9.34	36.00	26.66
802.11n HT40	2422	8.86	30.00	21.14	-1.00	7.86	36.00	28.14
	2437	12.60	30.00	17.40	-1.00	11.60	36.00	24.40
	2452	7.41	30.00	22.59	-1.00	6.41	36.00	29.59



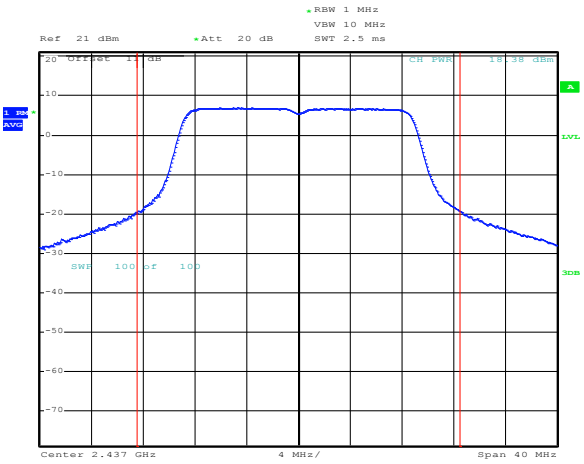
Date: 6.MAY.2015 14:09:37

Figure 8.3-1: *Output power on 802.11b, sample plot*



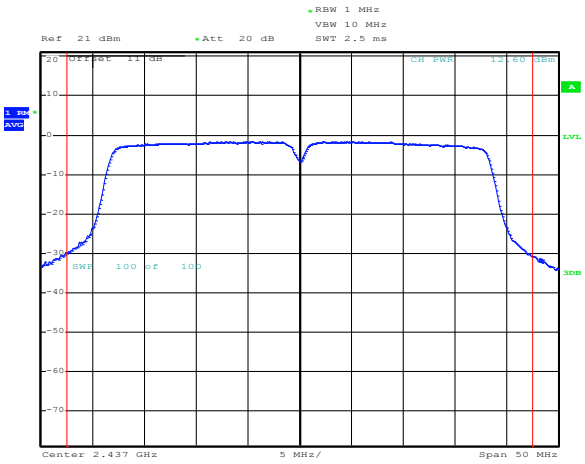
Date: 6.MAY.2015 14:10:41

Figure 8.3-2: *Output power on 802.11g, sample plot*



Date: 6.MAY.2015 14:09:01

Figure 8.3-3: *Output power on 802.11n HT20, sample plot*



Date: 6.MAY.2015 14:15:28

Figure 8.3-4: *Output power on 802.11n HT40, sample plot*

8.4 FCC 15.247(d) and RSS-210 A8.5 Spurious (out-of-band) emissions

8.4.1 Definitions and limits

FCC:
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)).

IC:
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the radio frequency power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided 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 Section A8.4(4), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in Tables 2 and 3 is not required.

Table 8.4-1: *FCC §15.209 and RSS-Gen – Radiated emission limits*

Frequency, MHz	Field strength of emissions		Measurement distance, m
	µV/m	dBµV/m	
0.009–0.490	2400/F	$67.6 – 20 \times \log_{10}(F)$	300
0.490–1.705	24000/F	$87.6 – 20 \times \log_{10}(F)$	30
1.705–30.0	30	29.5	30
30–88	100	40.0	3
88–216	150	43.5	3
216–960	200	46.0	3
above 960	500	54.0	3

Notes: In the emission table above, the tighter limit applies at the band edges.
For frequencies above 1 GHz the limit on peak RF emissions is 20 dB above the maximum permitted average emission limit applicable to the equipment under test

Table 8.4-2: *IC restricted frequency bands*

MHz	MHz	MHz	GHz
0.090–0.110	12.51975–12.52025	399.9–410	5.35–5.46
2.1735–2.1905	12.57675–12.57725	608–614	7.25–7.75
3.020–3.026	13.36–13.41	960–1427	8.025–8.5
4.125–4.128	16.42–16.423	1435–1626.5	9.0–9.2
4.17725–4.17775	16.69475–16.69525	1645.5–1646.5	9.3–9.5
4.20725–4.20775	16.80425–16.80475	1660–1710	10.6–12.7
5.677-5.683	25.5–25.67	1718.8–1722.2	13.25–13.4
6.215–6.218	37.5–38.25	2200–2300	14.47–14.5
6.26775–6.26825	73–74.6	2310–2390	15.35–16.2
6.31175–6.31225	74.8–75.2	2655–2900	17.7–21.4
8.291–8.294	108–138	3260–3267	22.01–23.12
8.362–8.366	156.52475–156.52525	3332–3339	23.6–24.0
8.37625–8.38675	156.7–156.9	3345.8–3358	31.2–31.8
8.41425–8.41475	240–285	3500–4400	36.43–36.5
12.29–12.293	322–335.4	4500–5150	Above 38.6

Note: Certain frequency bands listed in Table 8.4-2 and above 38.6 GHz are designated for low-power licence-exempt applications. These frequency bands and the requirements that apply to the devices are set out in this Standard

Table 8.4-3: *FCC restricted frequency bands*

MHz	MHz	MHz	GHz
0.090–0.110	16.42–16.423	399.9–410	4.5–5.15
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	Above 38.6
13.36–13.41			

8.4.2 Test summary

Test date	May 11, 2015	Temperature	20 °C
Test engineer	Andrey Adelberg	Air pressure	1003 mbar
Verdict	Pass	Relative humidity	31 %

8.4.3 Observations, settings and special notes

The spectrum was searched from 30 MHz to the 10th harmonic.
EUT was set to transmit with 99 % duty cycle.
In addition to conducted spurious emissions, radiated spurious emissions measurements with actual antenna were performed at a distance of 3 m, while EUT was operating at low, mid and high channels at all types of modulations. All 5.8 GHz ISM band emissions met all the technical requirements.
Since fundamental power was tested using average method, the spurious emissions limit is −30 dBc/100 kHz

Spectrum analyser settings for radiated measurements within restricted bands below 1 GHz:

Resolution bandwidth:	100 kHz
Video bandwidth:	300 kHz
Detector mode:	Peak
Trace mode:	Max Hold

Spectrum analyser settings for peak radiated measurements within restricted bands above 1 GHz:

Resolution bandwidth:	1 MHz
Video bandwidth:	3 MHz
Detector mode:	Peak
Trace mode:	Max Hold

Spectrum analyser settings for average radiated measurements within restricted bands above 1 GHz:

Resolution bandwidth:	1 MHz
Video bandwidth:	10 Hz
Detector mode:	Peak
Trace mode:	Max Hold

Spectrum analyser settings for conducted spurious emissions measurements:

Resolution bandwidth:	100 kHz
Video bandwidth:	300 kHz
Detector mode:	Peak
Trace mode:	Max Hold

Conducted spurious emissions limit for frequencies that fall within restricted bands was calculated as follows:
Peak: 74 dBµV/m – 95.23 dB – (−1 dBi) = −20.23 dBm
Average: 54 dBµV/m – 95.23 dB – (−1 dBi) = −40.23 dBm

8.4.4 Test data

Table 8.4-4: *Radiated field strength measurement results for 802.11b*

Channel	Frequency, MHz	Peak Field strength, dBµV/m		Margin, dB	Average Field strength, dBµV/m		Margin, dB
		Measured	Limit		Measured	Limit	
Low	2390.0	52.54	74.00	21.46	39.59	54.00	14.41
High	2483.5	53.54	74.00	20.46	40.61	54.00	13.39

Notes: Field strength includes correction factor of antenna, cable loss, amplifier, and attenuators where applicable.

Table 8.4-5: *Radiated field strength measurement results for 802.11g*

Channel	Frequency, MHz	Peak Field strength, dBµV/m		Margin, dB	Average Field strength, dBµV/m		Margin, dB
		Measured	Limit		Measured	Limit	
Low	2390.0	52.37	74.00	21.63	39.92	54.00	14.08
High	2483.5	50.80	74.00	23.20	40.64	54.00	13.36

Notes: Field strength includes correction factor of antenna, cable loss, amplifier, and attenuators where applicable.

Table 8.4-6: *Radiated field strength measurement results for 802.11n HT20*

Channel	Frequency, MHz	Peak Field strength, dBµV/m		Margin, dB	Average Field strength, dBµV/m		Margin, dB
		Measured	Limit		Measured	Limit	
Low	2390.0	52.13	74.00	21.87	40.01	54.00	13.99
High	2483.5	53.45	74.00	20.55	40.62	54.00	13.38

Notes: Field strength includes correction factor of antenna, cable loss, amplifier, and attenuators where applicable.

Table 8.4-7: *Radiated field strength measurement results for 802.11n HT40*

Channel	Frequency, MHz	Peak Field strength, dBµV/m		Margin, dB	Average Field strength, dBµV/m		Margin, dB
		Measured	Limit		Measured	Limit	
Low	2390.0	53.21	74.00	20.79	40.54	54.00	13.46
High	2483.5	54.22	74.00	19.78	40.64	54.00	13.36

Notes: Field strength includes correction factor of antenna, cable loss, amplifier, and attenuators where applicable.

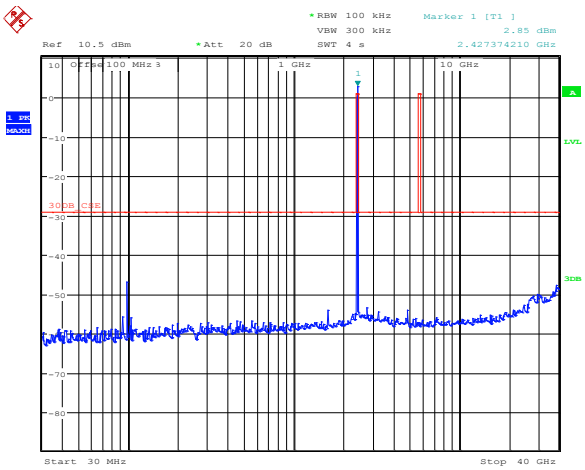


Figure 8.4-1: *Conducted spurious emissions outside restricted bands for 802.11b, low channel*

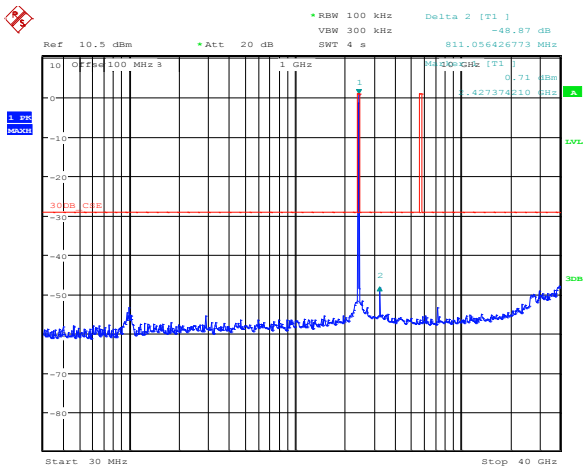


Figure 8.4-2: *Conducted spurious emissions outside restricted bands for 802.11g, low channel*

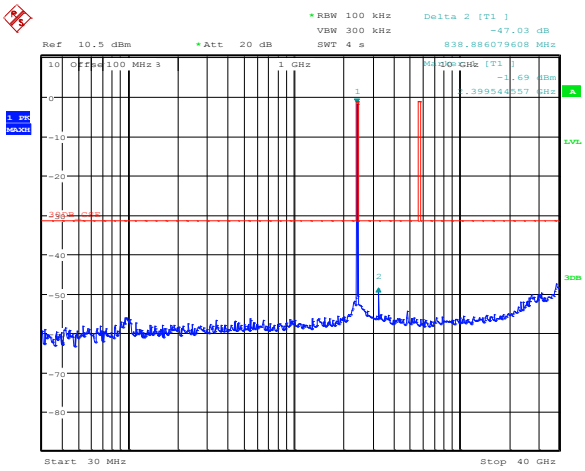


Figure 8.4-3: *Conducted spurious emissions outside restricted bands for 802.11n HT20, low channel*

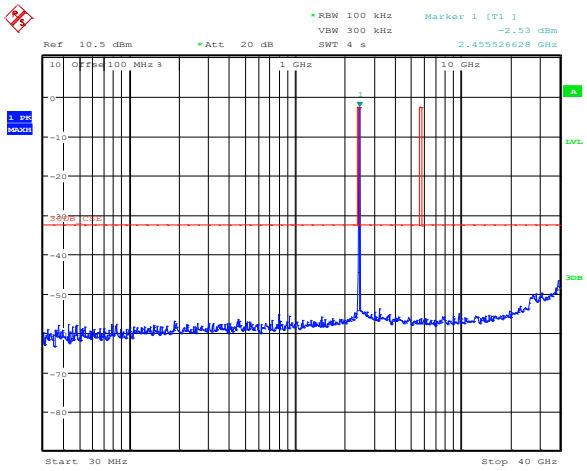


Figure 8.4-4: *Conducted spurious emissions outside restricted bands for 802.11n HT40, low channel*

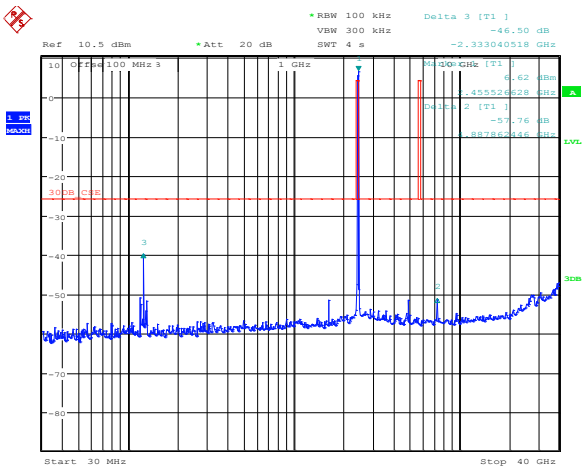


Figure 8.4-5: *Conducted spurious emissions outside restricted bands for 802.11b, mid channel*

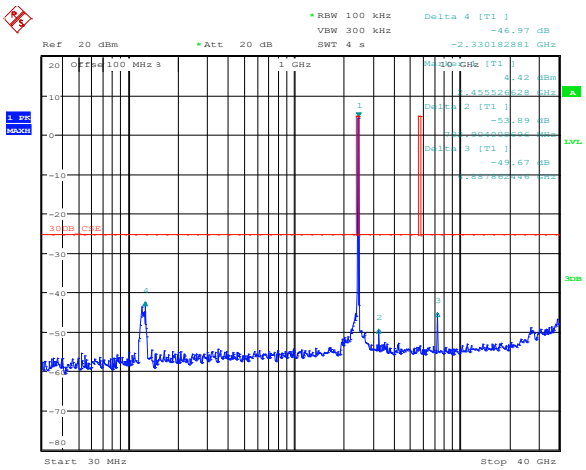


Figure 8.4-6: *Conducted spurious emissions outside restricted bands for 802.11g, mid channel*

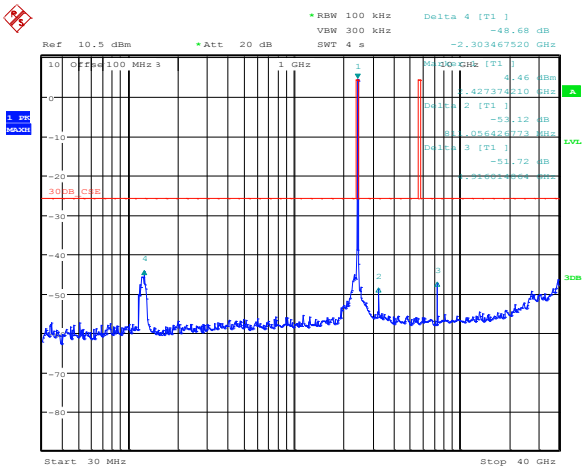


Figure 8.4-7: *Conducted spurious emissions outside restricted bands for 802.11n HT20, mid channel*

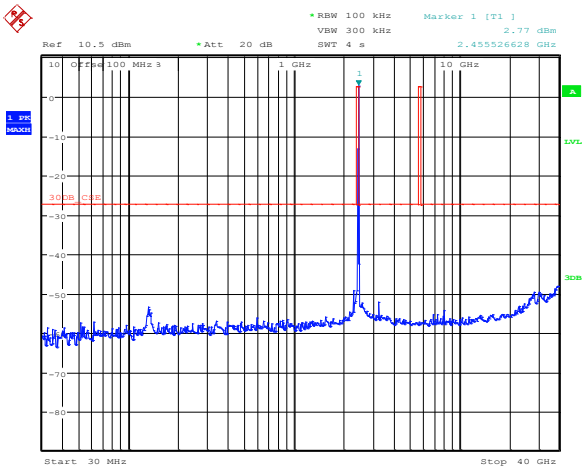


Figure 8.4-8: *Conducted spurious emissions outside restricted bands for 802.11n HT40, mid channel*

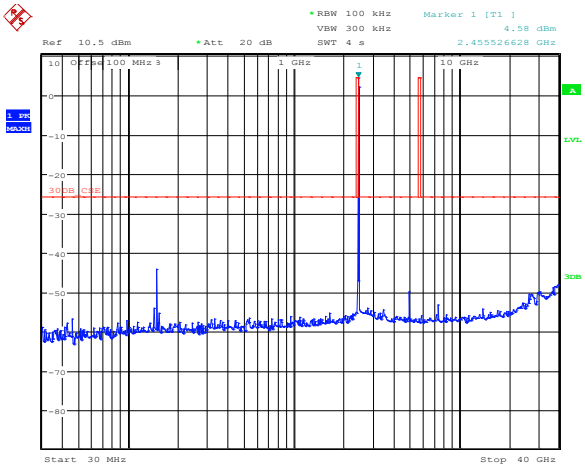


Figure 8.4-9: *Conducted spurious emissions outside restricted bands for 802.11b, high channel*

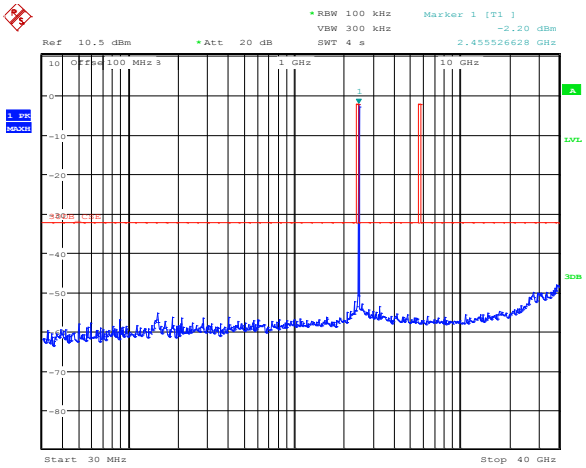


Figure 8.4-10: *Conducted spurious emissions outside restricted bands for 802.11g, high channel*

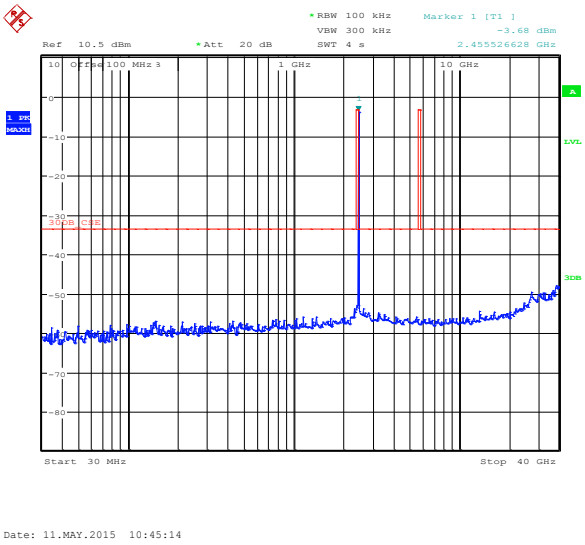


Figure 8.4-11: *Conducted spurious emissions outside restricted bands for 802.11n HT20, high channel*

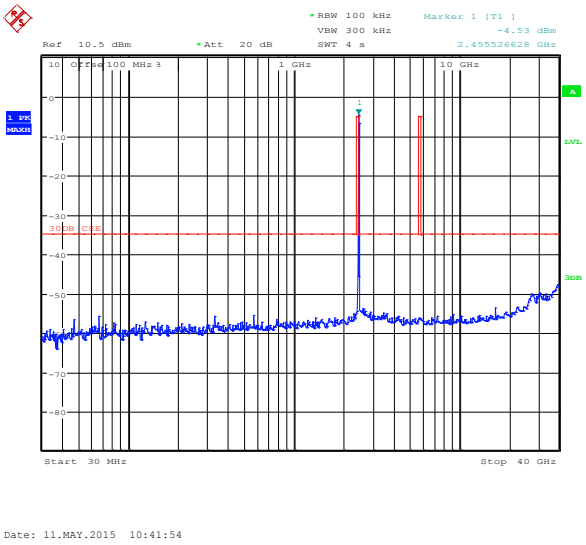


Figure 8.4-12: *Conducted spurious emissions outside restricted bands for 802.11n HT40, high channel*

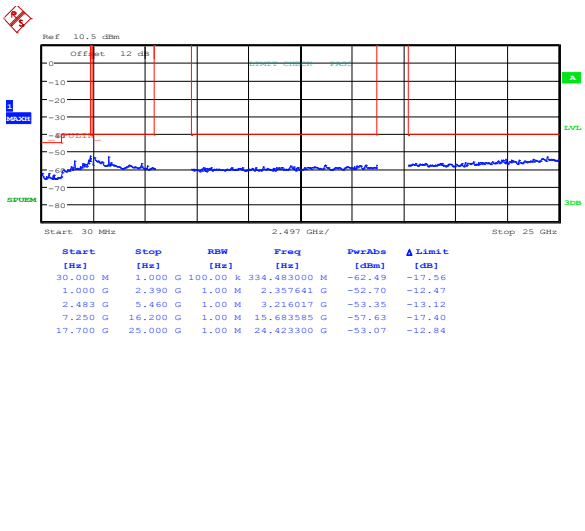


Figure 8.4-13: *Conducted spurious emissions within restricted bands for 802.11b, low channel*

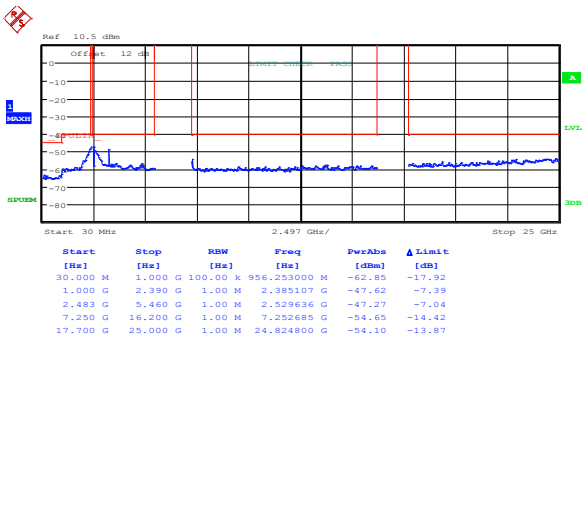


Figure 8.4-14: *Conducted spurious emissions within restricted bands for 802.11g, low channel*

Figure 8.4-15: *Conducted spurious emissions within restricted bands for 802.11n HT20, low channel*

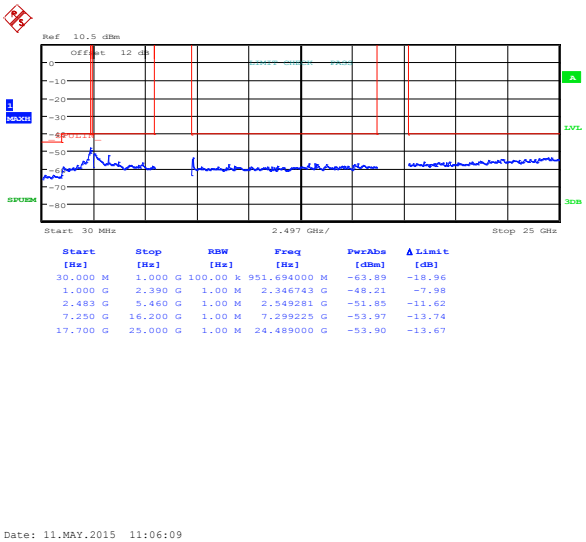


Figure 8.4-16: *Conducted spurious emissions within restricted bands for 802.11n HT40, low channel*

Note: measurements were obtained using peak detector. Limits on the plots are for average results. Since peak measurements met average limits, no average measurements were repeated.

Peak limit: 74 dBµV/m – 95.23 dB – (−1 dBi) = −20.23 dBm

Average limit: 54 dBµV/m – 95.23 dB – (−1 dBi) = −40.23 dBm

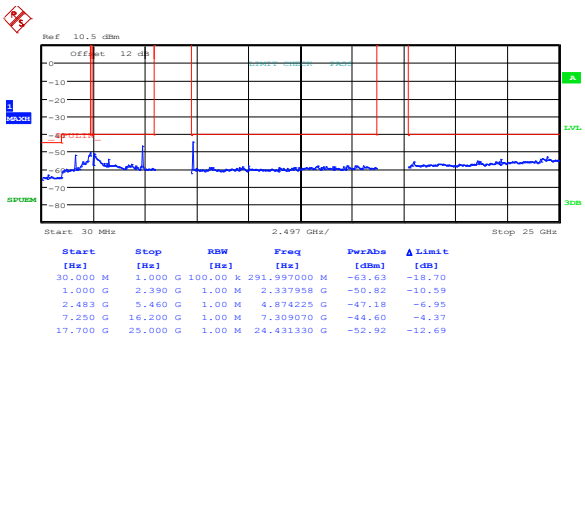


Figure 8.4-17: *Conducted spurious emissions within restricted bands for 802.11b, mid channel*

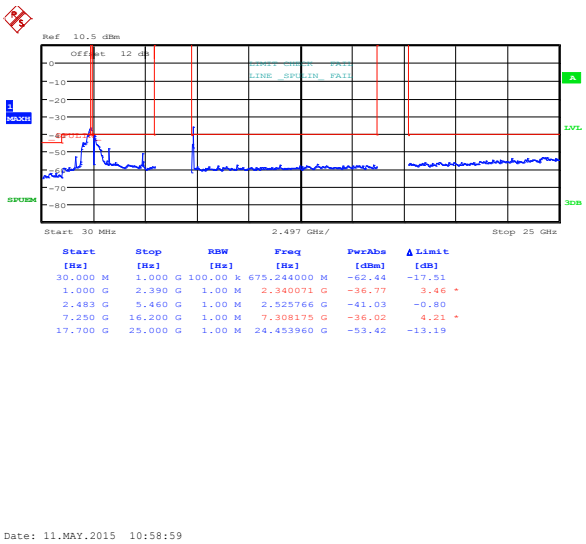


****Figure 8.4-18:*** *Conducted spurious emissions within restricted bands for 802.11g, mid channel*

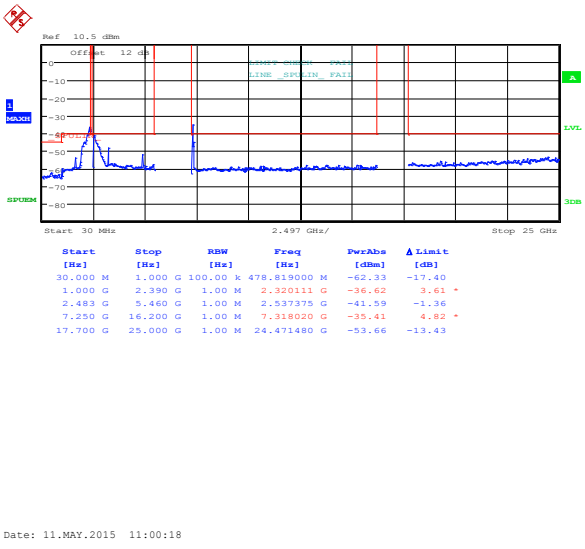


****Figure 8.4-19:*** *Conducted spurious emissions within restricted bands for 802.11n HT20, mid channel*

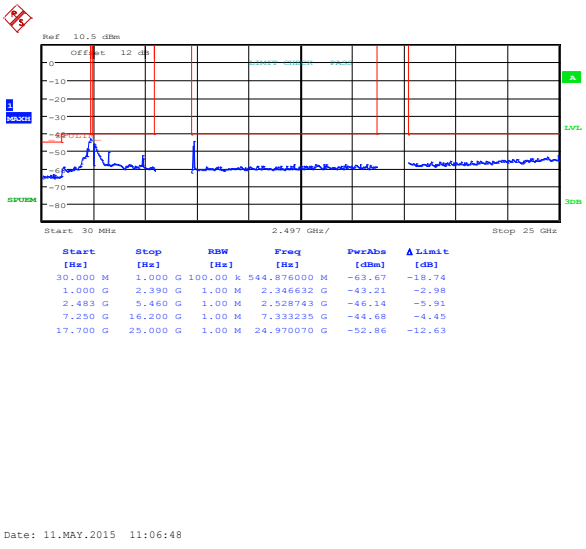


Figure 8.4-20: *Conducted spurious emissions within restricted bands for 802.11n HT40, mid channel*

*Note: measurements were obtained using peak detector. Limits on the plots are for average results. Since peak measurements met average limits, no average measurements were repeated. More detailed measurements for emissions indicated in red provided further in this section.
Peak limit: 74 dBµV/m – 95.23 dB – (−1 dBi) = −20.23 dBm
Average limit: 54 dBµV/m – 95.23 dB – (−1 dBi) = −40.23 dBm

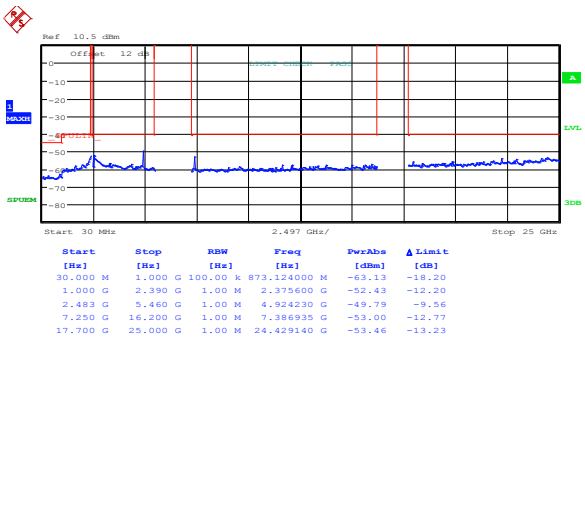


Figure 8.4-21: *Conducted spurious emissions within restricted bands for 802.11b, high channel*

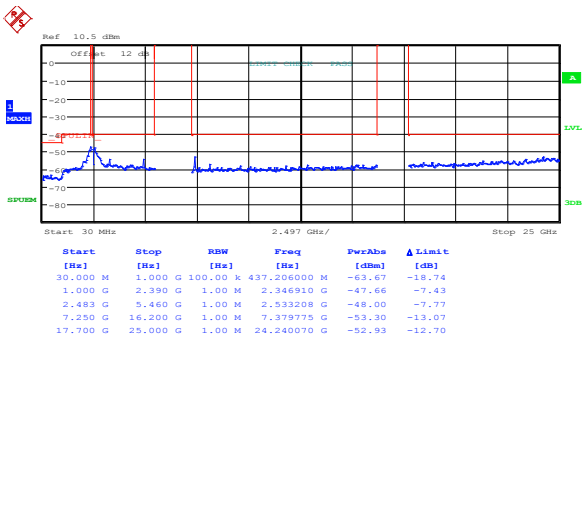


Figure 8.4-22: *Conducted spurious emissions within restricted bands for 802.11g, high channel*

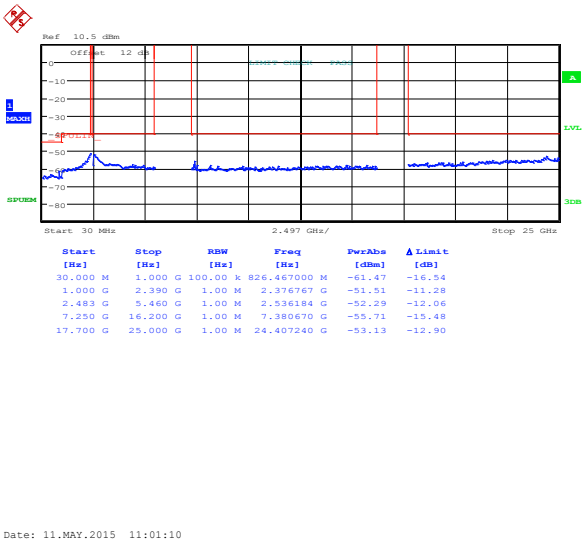


Figure 8.4-23: *Conducted spurious emissions within restricted bands for 802.11n HT20, high channel*

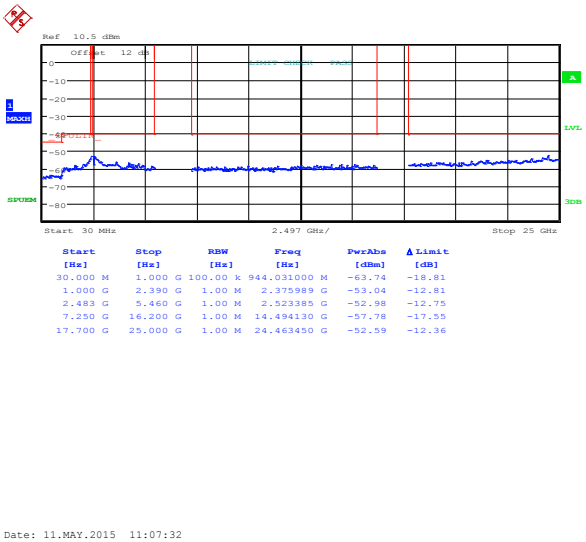


Figure 8.4-24: *Conducted spurious emissions within restricted bands for 802.11n HT40, high channel*

Note: measurements were obtained using peak detector. Limits on the plots are for average results. Since peak measurements met average limits, no average measurements were repeated.

Peak limit: 74 dBµV/m – 95.23 dB – (−1 dBi) = −20.23 dBm

Average limit: 54 dBµV/m – 95.23 dB – (−1 dBi) = −40.23 dBm

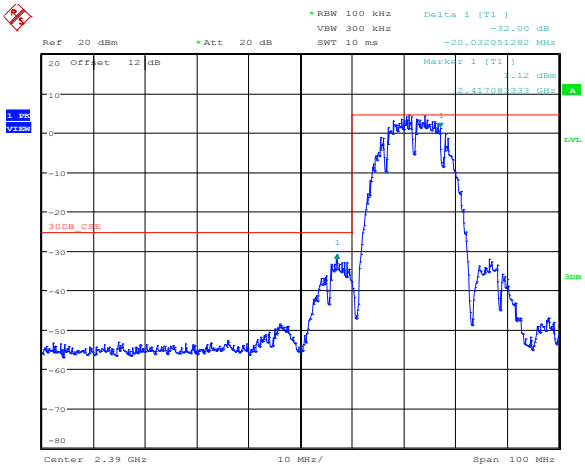


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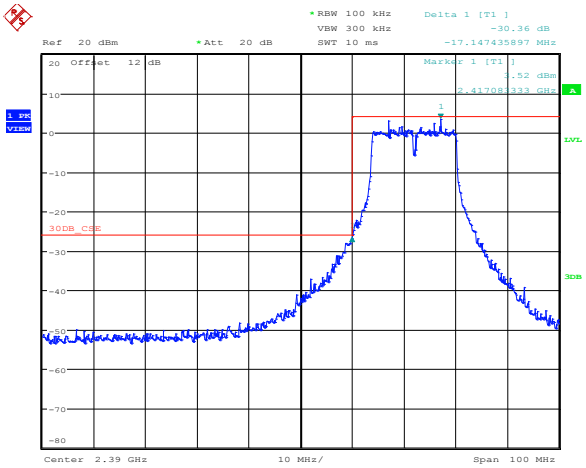
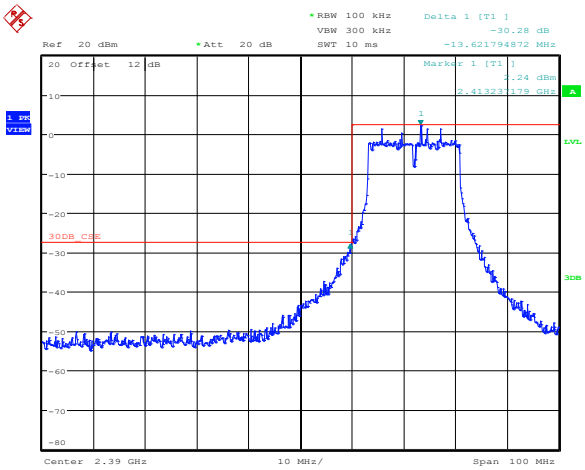
Figure 8.4-25: *Conducted lower band edge emission outside restricted bands for 802.11b*



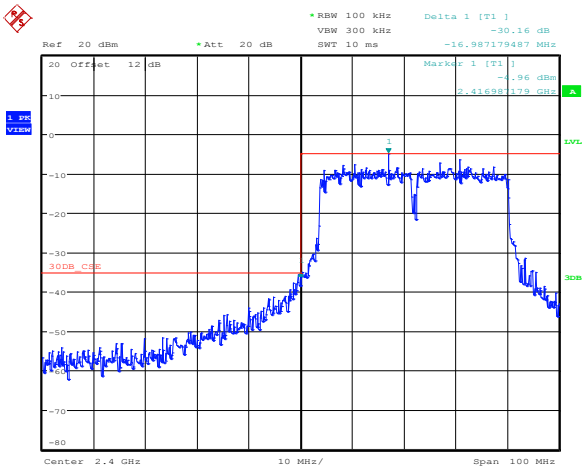
Date: 11.MAY.2015 15:33:56

Figure 8.4-26: *Conducted lower band edge emission outside restricted bands for 802.11g*



Date: 11.MAY.2015 15:36:05

Figure 8.4-27: *Conducted lower band edge emission outside restricted bands for 802.11n HT20*



Date: 11.MAY.2015 15:45:35

Figure 8.4-28: *Conducted lower band edge emission outside restricted bands for 802.11n HT40*

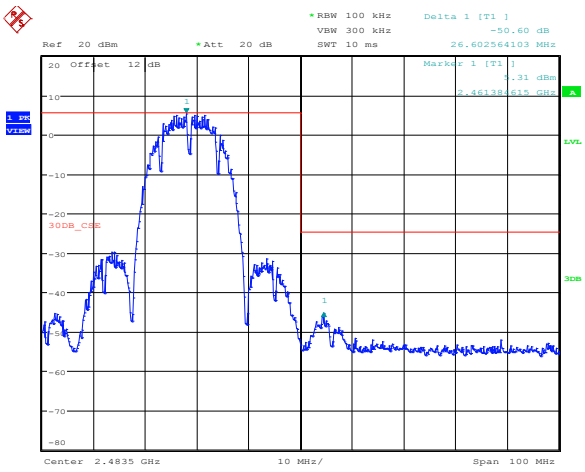


Figure 8.4-29: *Conducted upper band edge emission outside restricted bands for 802.11b*

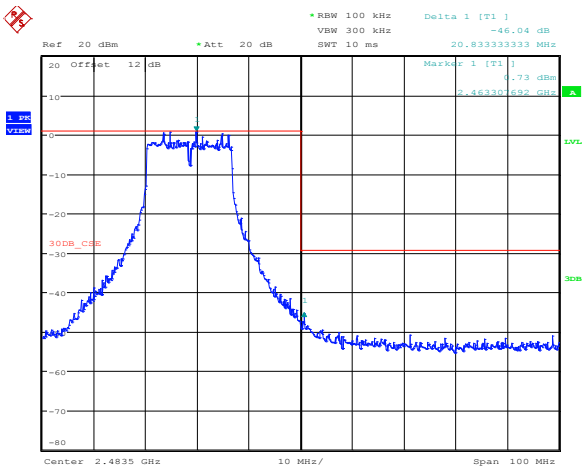


Figure 8.4-30: *Conducted upper band edge emission outside restricted bands for 802.11g*

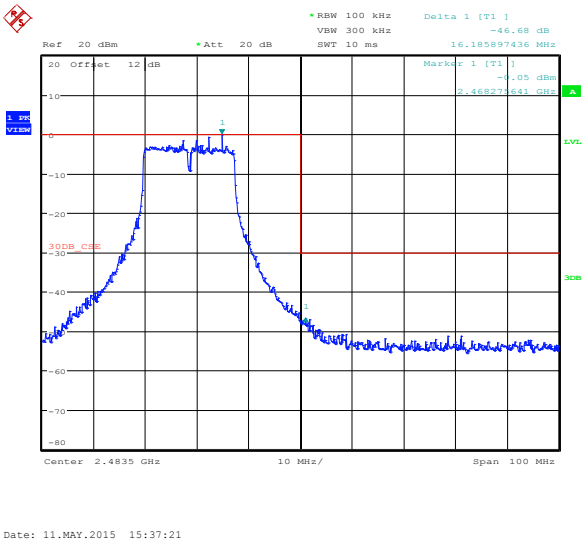


Figure 8.4-31: *Conducted upper band edge emission outside restricted bands for 802.11n HT20*

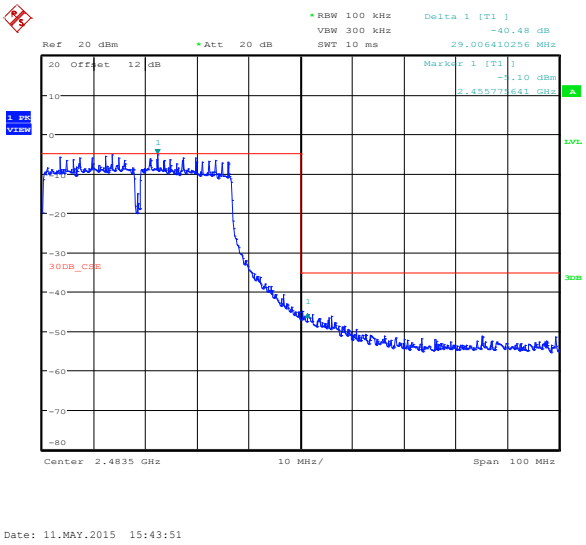


Figure 8.4-32: *Conducted upper band edge emission outside restricted bands for 802.11n HT40*

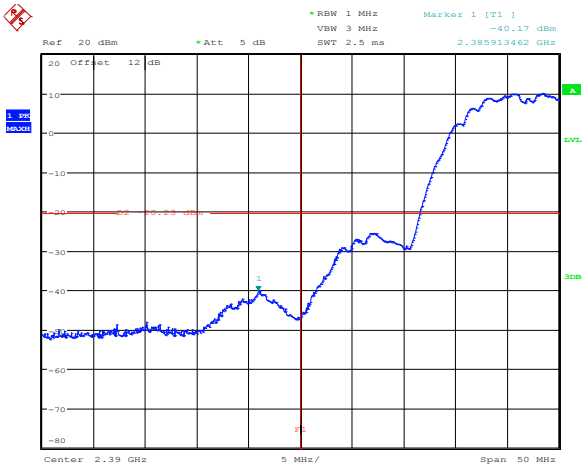


Figure 8.4-33: *Conducted lower band edge emission within restricted bands for 802.11b, peak measurement*

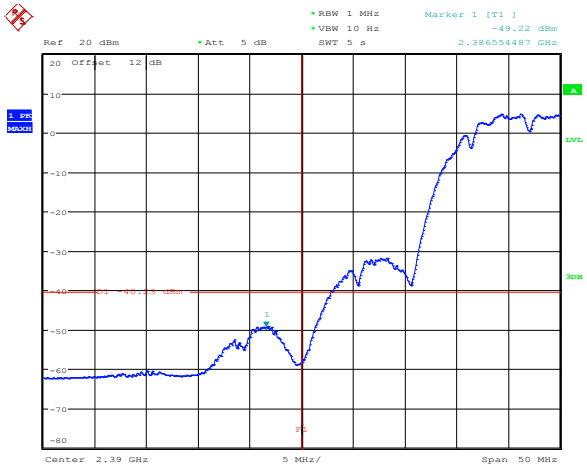


Figure 8.4-34: *Conducted lower band edge emission within restricted bands for 802.11b, average measurement*

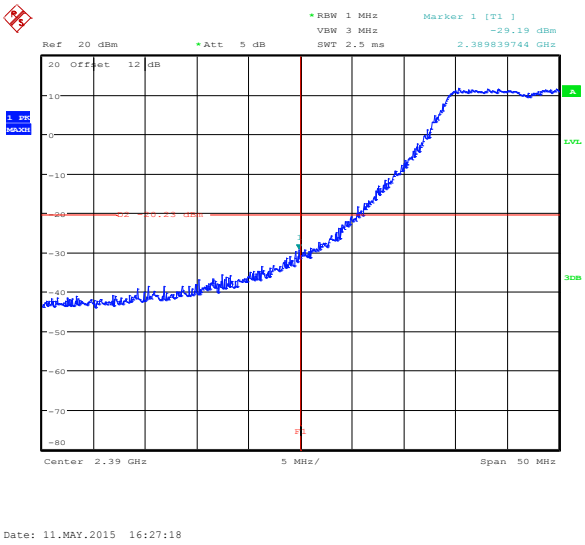


Figure 8.4-35: *Conducted lower band edge emission within restricted bands for 802.11g, peak measurement*

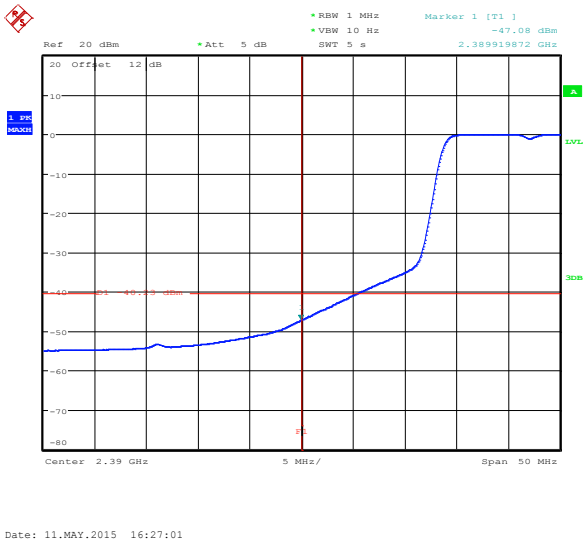


Figure 8.4-36: *Conducted lower band edge emission within restricted bands for 802.11g, average measurement*

Note: Peak limit: 74 dBµV/m – 95.23 dB – (−1 dBi) = −20.23 dBm
Average limit: 54 dBµV/m – 95.23 dB – (−1 dBi) = −40.23 dBm

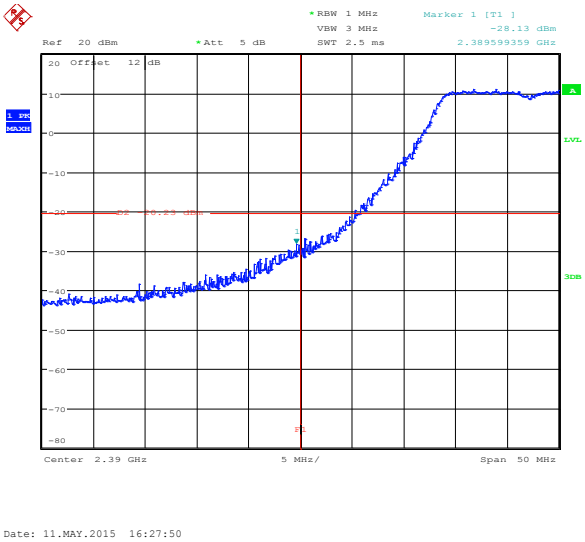


Figure 8.4-37: *Conducted lower band edge emission within restricted bands for 802.11n HT20, peak measurement*

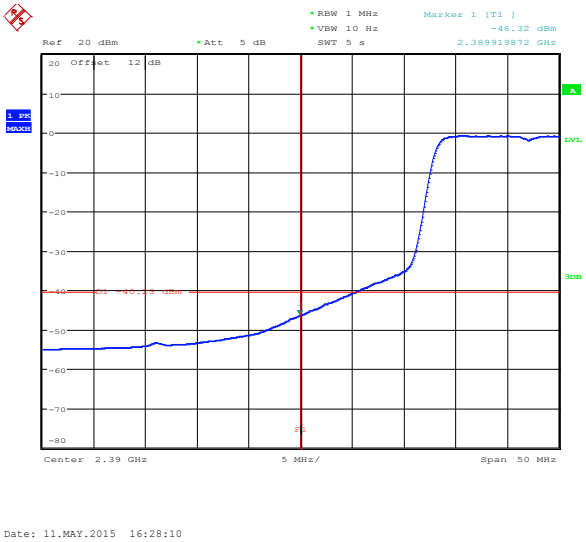


Figure 8.4-38: *Conducted lower band edge emission within restricted bands for 802.11n HT20, average measurement*

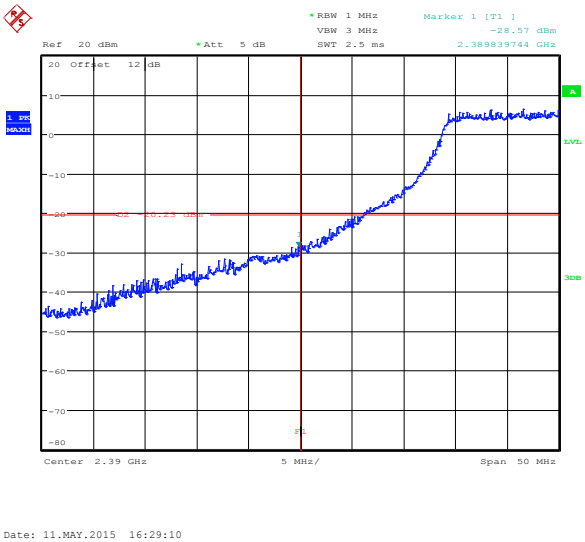


Figure 8.4-39: *Conducted lower band edge emission within restricted bands for 802.11n HT40, peak measurement*

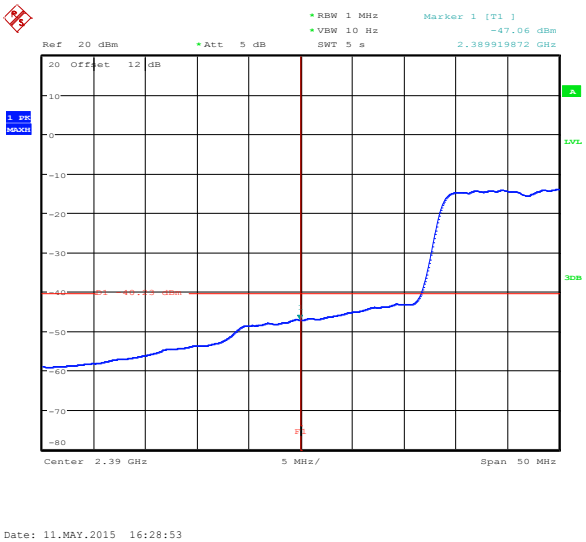


Figure 8.4-40: *Conducted lower band edge emission within restricted bands for 802.11n HT40, average measurement*

Note: Peak limit: 74 dBµV/m – 95.23 dB – (−1 dBi) = −20.23 dBm
Average limit: 54 dBµV/m – 95.23 dB – (−1 dBi) = −40.23 dBm

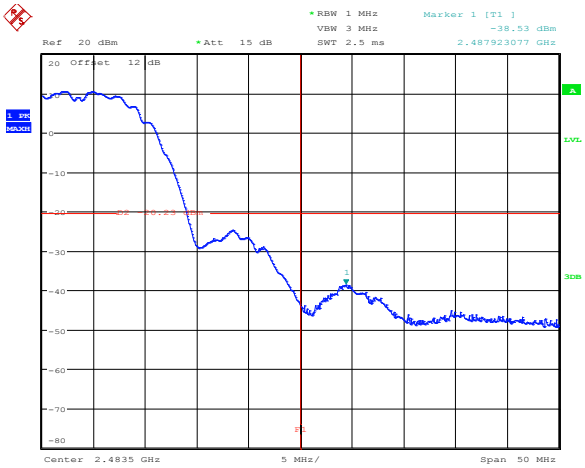


Figure 8.4-41: *Conducted upper band edge emission within restricted bands for 802.11b, peak measurement*

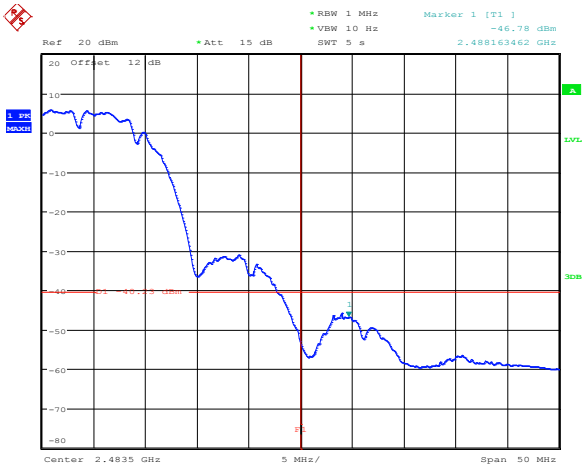


Figure 8.4-42: *Conducted upper band edge emission within restricted bands for 802.11b, average measurement*

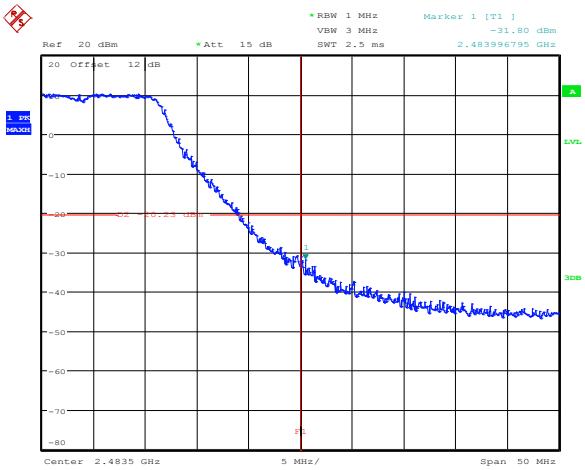


Figure 8.4-43: *Conducted upper band edge emission within restricted bands for 802.11g, peak measurement*

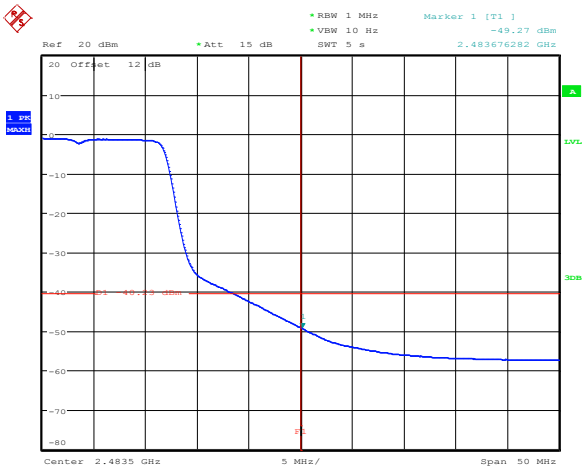


Figure 8.4-44: *Conducted upper band edge emission within restricted bands for 802.11g, average measurement*

Note: Peak limit: 74 dBµV/m – 95.23 dB – (−1 dBi) = −20.23 dBm
Average limit: 54 dBµV/m – 95.23 dB – (−1 dBi) = −40.23 dBm

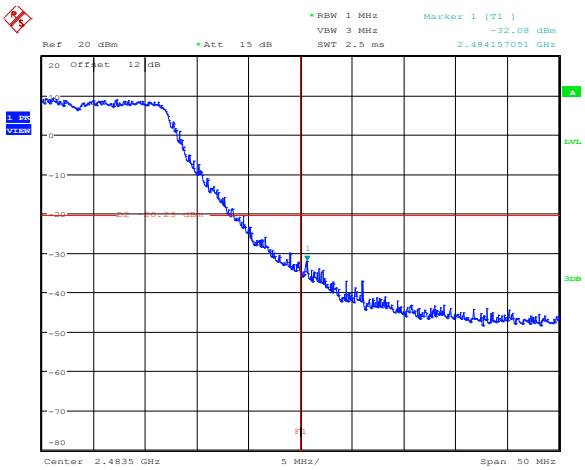


Figure 8.4-45: *Conducted upper band edge emission within restricted bands for 802.11n HT20, peak measurement*

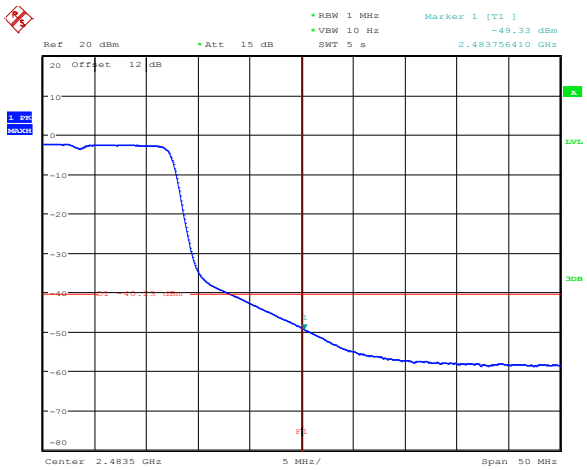


Figure 8.4-46: *Conducted upper band edge emission within restricted bands for 802.11n HT20, average measurement*

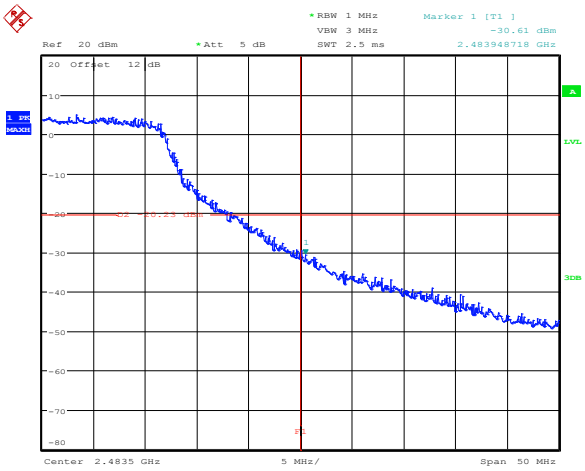


Figure 8.4-47: *Conducted upper band edge emission within restricted bands for 802.11n HT40, peak measurement*

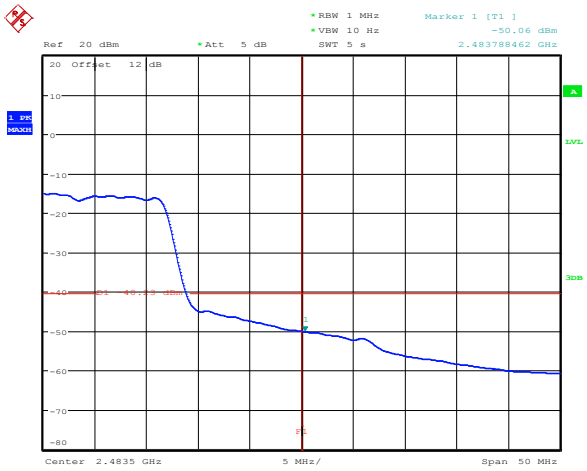


Figure 8.4-48: *Conducted upper band edge emission within restricted bands for 802.11n HT40, average measurement*

Note: Peak limit: 74 dBµV/m – 95.23 dB – (−1 dBi) = −20.23 dBm
Average limit: 54 dBµV/m – 95.23 dB – (−1 dBi) = −40.23 dBm

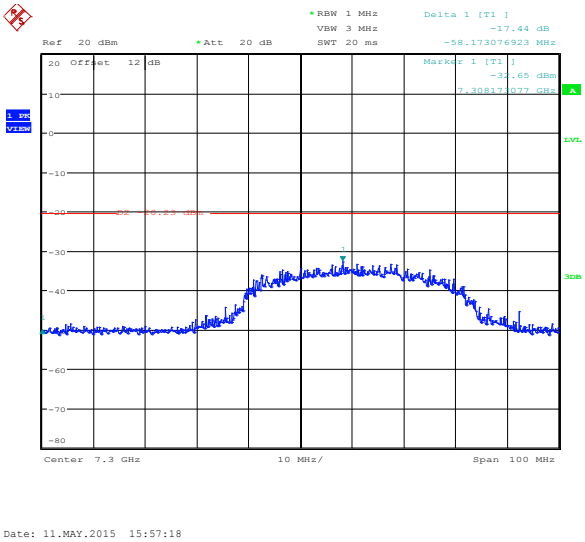


Figure 8.4-49: *Third harmonic for 802.11g, peak measurement*

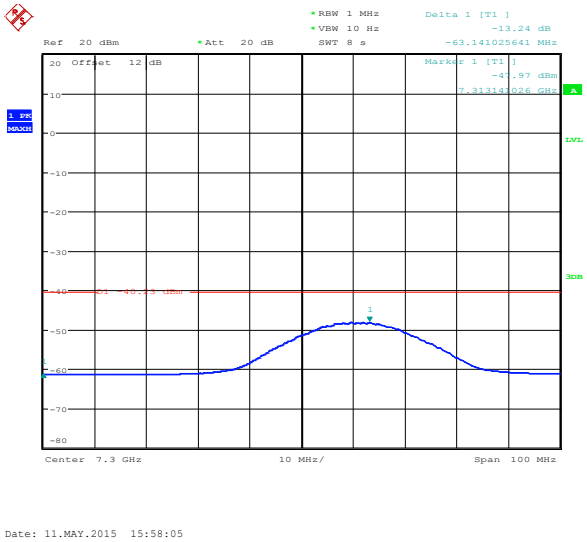


Figure 8.4-50: *Third harmonic for 802.11g, average measurement*

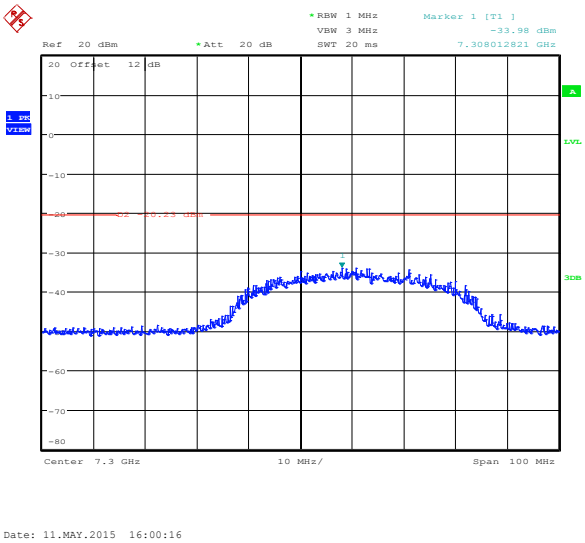


Figure 8.4-51: *Third harmonic for 802.11n HT20, peak measurement*

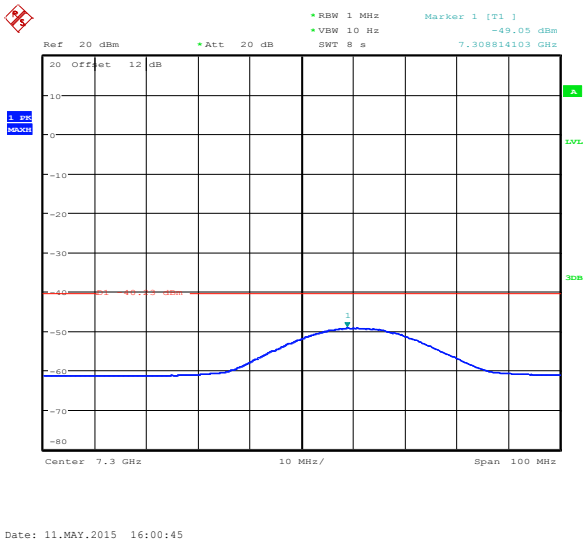


Figure 8.4-52: *Third harmonic for 802.11n HT20, average measurement*

Note: Peak limit: 74 dBµV/m – 95.23 dB – (−1 dBi) = −20.23 dBm
Average limit: 54 dBµV/m – 95.23 dB – (−1 dBi) = −40.23 dBm

8.5 FCC 15.247(e) and RSS-210 A8.2(b) Power spectral density for digitally modulated devices

8.5.1 Definitions and limits

FCC:
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. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the conducted output power shall be used to determine the power spectral density.

IC:
The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission or over 1.0 second if the transmission exceeds 1.0-second duration. This power spectral density shall be determined in accordance with the provisions of Section A8.4(4); (i.e. the power spectral density shall be determined using the same method for determining the conducted output power).

8.5.2 Test summary

Test date	May 7, 2015	Temperature	22 °C
Test engineer	Andrey Adelberg	Air pressure	1004 mbar
Verdict	Pass	Relative humidity	31 %

8.5.3 Observations, settings and special notes

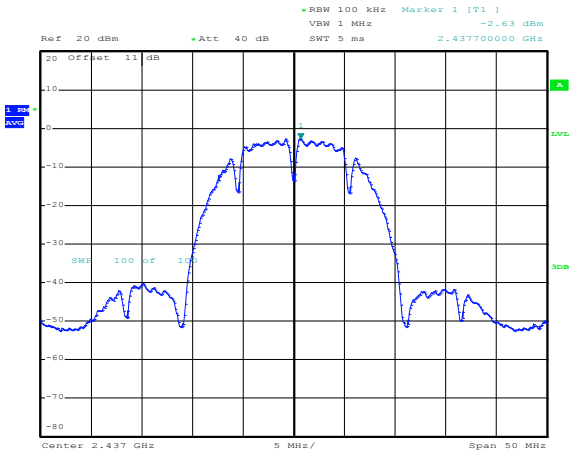
The test was performed using method described in section 10.3 Method AVGPSD-1 (trace averaging with EUT transmitting at full power throughout each sweep). Spectrum analyser settings:

Resolution bandwidth:	100 kHz
Video bandwidth:	1 MHz
Frequency span:	50 MHz
Detector mode:	RMS
Trace mode:	Power average
Averaging sweeps number:	100

8.5.4 Test data

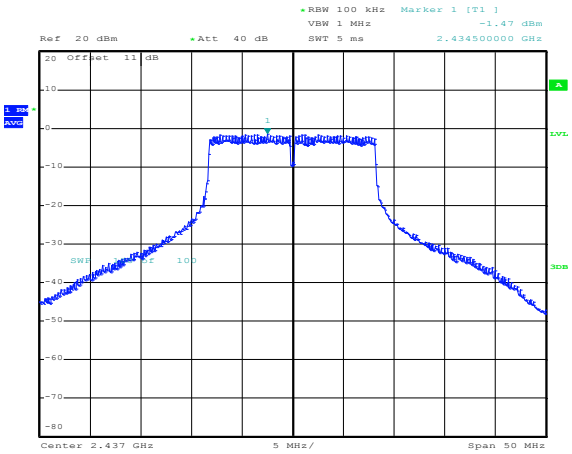
Table 8.5-1: *PSD measurements results*

Modulation	Frequency, MHz	PSD, dBm/100 kHz	PSD limit, dBm/3 kHz	Margin, dB
802.11b	2412	-5.37	8.00	13.37
	2437	-2.63	8.00	10.63
	2462	-4.17	8.00	12.17
802.11g	2422	-7.76	8.00	15.76
	2437	-1.47	8.00	9.47
	2457	-8.99	8.00	16.99
802.11n HT20	2412	-8.42	8.00	16.42
	2437	-2.40	8.00	10.4
	2462	-8.96	8.00	16.96
802.11n HT40	2422	-14.39	8.00	22.39
	2437	-10.81	8.00	18.81
	2452	-16.07	8.00	24.07



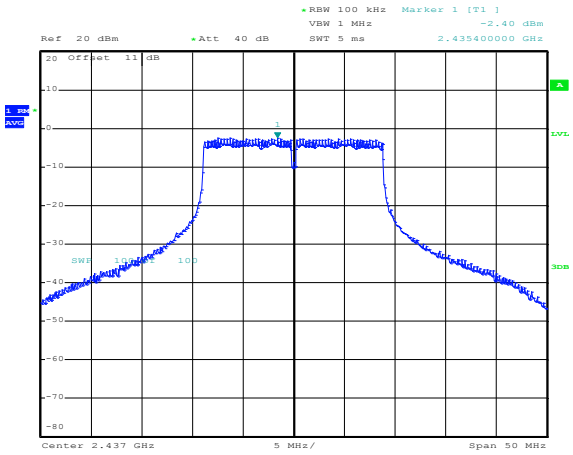
Date: 7.MAY.2015 11:37:18

Figure 8.5-1: *PSD sample plot on 802.11b*



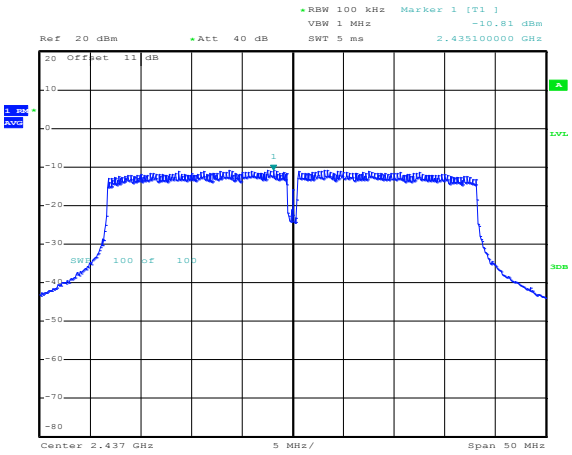
Date: 7.MAY.2015 11:38:33

Figure 8.5-2: *PSD sample plot on 802.11g*



Date: 7.MAY.2015 11:35:27

Figure 8.5-3: *PSD sample plot on 802.11n HT20*

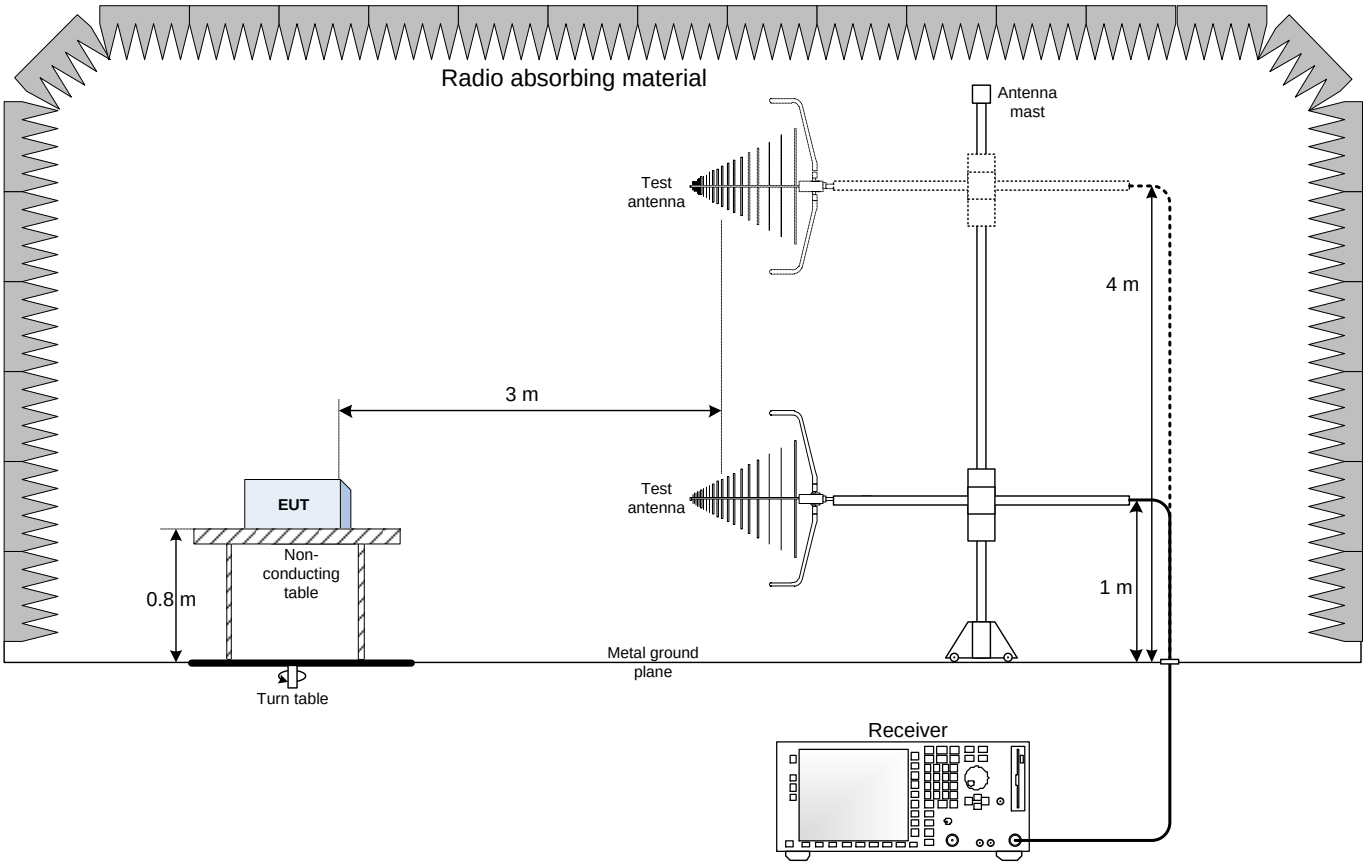
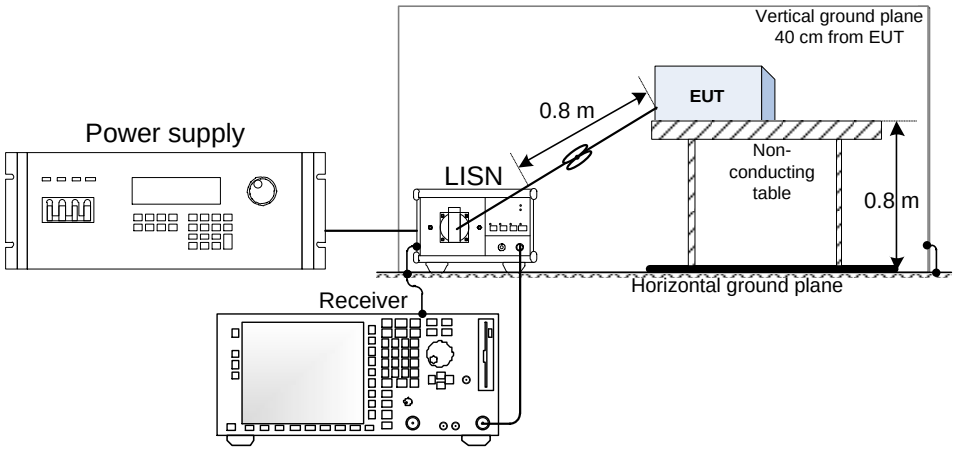


Date: 7.MAY.2015 11:33:32

Figure 8.5-4: *PSD sample plot on 802.11n HT40*

Section 9. Block diagrams of test set-ups

9.1 Radiated emissions set-up



9.2 Conducted emissions set-up