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Compliance test report ID **223263-3TRFWL**

Date of issue
November 20, 2012

FCC 47 CFR Part 15 Subpart E, §15.407

Unlicensed National Information Infrastructure Devises

RSS-210, Issue 8 Annex 9

Local Area Network Devices

Applicant	**BelAir Networks**
Product	**Dual-band WIFI router**
Model	**BelAir20E**
FCC ID	**RAR40015001**
IC Reg. #	**4674A-40015001**

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
LAB Accrédité CCN

Test location

Nemko Canada Inc.
303 River Road
Ottawa, ON, K1V 1H2
Canada
FCC test site registration number: 176392 and IC registered site number: 2040A-4 (3 m semi anechoic chamber)

Telephone +1 613 737 9680
Facsimile +1 613 737 9691
Toll free +1 800 563 6336
Website www.nemko.com

Tested by Andrey Adelberg, Senior Wireless/EMC Specialist

Reviewed by Kevin Rose, Wireless/EMC Specialist

November 20, 2012
Date

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.

Copyright notification

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Section 1. Report summary

1.1 Applicant and manufacturer

BelAir Networks Inc.
603 March Road,
Ottawa, ON, Canada
K2K 2M5

1.2 Test specifications

FCC 47 CFR Part 15, Subpart E, Clause 15.407	Unlicensed National Information Infrastructure Devises
RSS-210, Issue 8 Annex 9	Local Area Network Devices

1.3 Test methods

Guidelines for Compliance Testing of Unlicensed National Information Infrastructure (U-NII) Devices Part 15, Subpart E	789033 D01 General UNII Test Procedures v01r02 (September 26, 2012)
Emissions testing of transmitters with multiple outputs in the same band (MIMO)	662911 D01 Multiple Transmitter Output v01r02 (September 26, 2012)

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 E, test results

Part	Test description	Verdict
§15.403(i)	Emission bandwidth	Not applicable
§15.407(a)(1)	5.15–5.25 GHz band power and density limits[1]	Pass
§15.407(a)(2)	5.25–5.35 GHz and 5.47–5.725 GHz bands power and density limits	Not applicable
§15.407(a)(3)	5.725–5.825 GHz band power and density limits	Not applicable
§15.407(a)(6)	Peak excursion	Not applicable
§15.407(b)(1)	5.15–5.25 GHz band undesired emission limits	Pass
§15.407(b)(2)	5.25–5.35 GHz band undesired emission limits	Not applicable
§15.407(b)(3)	5.47–5.725 GHz band undesired emission limits	Not applicable
§15.407(b)(4)	5.725–5.825 GHz band undesired emission limits	Not applicable
§15.407(b)(6)	Unwanted emissions below 1 GHz	Pass
§15.407(b)(7)	Radiated emissions within restricted bands	Pass
§15.407(e)	5.15–5.25 GHz band operational restriction	Pass
§15.407(g)	Frequency stability	Not applicable
§15.407(h)(1)	Transmit power control (TPC)[2]	Not applicable
§15.407(h)(2)	Dynamic Frequency Selection (DFS)[2]	Not applicable

Note: [1]Within the 5.15–5.25 GHz band, U-NII devices will be restricted to indoor operations to reduce any potential for harmful interference to co-channel MSS operations.

[2]Not applicable for devices operating within 5.15–5.25 GHz U-NII band.

2.3 IC RSS-GEN, Issue 3, test results

Part	Test description	Verdict
4.6.1	Occupied bandwidth	Pass
4.7	Transmitter frequency stability	Not applicable
6.1	Receiver spurious emissions limits (radiated)	Not applicable
6.2	Receiver spurious emissions limits (antenna conducted)	Not applicable
7.2.4	AC power lines conducted emission limits	Pass

Notes: [1]According to Notice 2012-DRS0126 (from January 2012) section 2.2 of RSS-Gen, Issue 3 has been revised. 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
A9.2	Transmitter power and e.i.r.p. limits	
A9.2 (1)	5150–5250 MHz band	Pass
A9.2 (2)	5250–5350 MHz and 5470–5725 MHz bands	Not applicable
A9.2 (3)	5725–5825 MHz band	Not applicable
A9.3	Out-of-band emission limits	
A9.3 (1)	5150–5250 MHz band	Pass
A9.3 (2)	5250–5350 MHz band	Not applicable
A9.3 (3)	5470–5725 MHz band	Not applicable
A9.3 (4)	5725–5825 MHz band	Not applicable
A9.4	Dynamic Frequency Selection (DFS) for devices operating in the 5250–5350 MHz and 5470–5725 MHz bands	Not applicable
A9.5	Other Requirements for all bands	
A9.5 (a)	Digital modulation	Pass
A9.5 (b)	PSD to average power ratio	Pass
A9.5 (c)	Test frequencies	Pass
A9.5 (d)	Discontinuation of transmission	Not applicable
A9.5 (e)	Transmitter frequency stability	Not applicable
A9.5 (f)	Mobile satellite services	Not applicable

Notes: None

Section 3. Equipment under test (EUT) details

3.1 Sample information

Receipt date	October 10, 2012
Nemko sample ID number	1

3.2 EUT information

Product name	Dual-band WIFI router
Model	BelAir20E
Serial number	BA114300032

3.3 Technical information

Operating band	5150–5250 MHz
Operating frequency (FCC)	5180–5240 MHz (20 MHz channel) and 5200–5220 MHz (40 MHz channel)
Operating frequency (IC)	5180–5220 MHz (20 MHz channel) and 5200–5220 MHz (40 MHz channel)
Modulation type	802.11a/n
Occupied bandwidth (99 %)	17.12 MHz (802.11a); 18.17 MHz (802.11n HT20); 37.10 MHz (802.11n HT40)
Emission designator	W7D
Power requirements	48 V_{DC}
Antenna information	2 internal 4 dBi antennas The EUT uses a unique antenna coupling/ non-detachable antenna to the intentional radiator.

3.4 Product description and theory of operation

The EUT is a 2×2 MIMO device designed to operate in the 2.4 GHz band, and 5 GHz ISM and UNII bands.
There are two independent radio units. This report covers only the 5.1 GHz UNII band radio.

3.5 EUT exercise details

The EUT was controlled to transmit at desired frequency and modulation from laptop using Art GUI software and telnet session.

3.6 EUT setup diagram

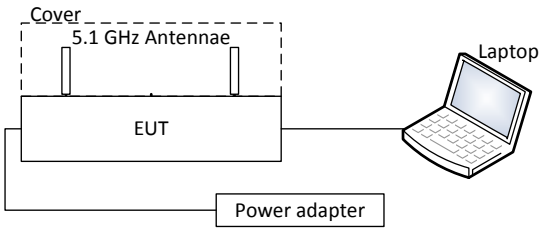


Diagram 3.6-1: *Setup diagram*

3.7 EUT sub assemblies

Table 3.7-1: *EUT sub assemblies*

Description	Brand name	Model/Part number	Serial number
Laptop	Toshiba	Satellite	BelAir asset number: 441
I.T.E. Power Supply	Leader Electronics Inc.	MU24-B480050-A1	None

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

Nemko Canada Inc. has calculated measurement uncertainty and is documented in EMC/MUC/001 “Uncertainty in EMC measurements.” Measurement uncertainty was calculated using the methods described in CISPR 16-4 Specification for radio disturbance and immunity measuring apparatus and methods – Part 4: Uncertainty in EMC measurements; as well as described in UKAS LAB34: The expression of Uncertainty in EMC Testing. Measurement uncertainty calculations assume a coverage factor of K=2 with 95% certainty.

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	Mar. 09/13
Flush mount turntable	Sunol	FM2022	FA002082	—	NCR
Controller	Sunol	SC104V	FA002060	—	NCR
Antenna mast	Sunol	TLT2	FA002061	—	NCR
Power supply	California Inst.	3001I	FA001021	1 year	Feb 08/13
Receiver/spectrum analyzer	Rohde & Schwarz	ESU 26	FA002043	1 year	May 16/13
Spectrum analyzer	Rohde & Schwarz	FSU	FA001877	1 year	Jan. 10/13
Bilog antenna	Sunol	JB3	FA002108	1 year	Feb. 07/13
Horn antenna #2	EMCO	3115	FA000825	1 year	Feb. 24/13
Horn antenna 18–26.5 GHz	Electro-metrics	SH-50/60-1	FA000479	—	VOU
1–18 GHz pre-amplifier	JCA	JCA118-503	FA002091	1 year	July 03/13
18–26 GHz pre-amplifier	Narda	BBS-1826N612	FA001550	—	VOU
LISN	Rohde & Schwarz	ENV216	FA002023	1 year	Nov. 18/12
Power meter	Agilent	N1911A	FA001946	1 year	Feb. 13/13
Power sensor	Agilent	N1922A	FA001947	1 year	Feb. 13/13
Temperature chamber	Thermotron	SM-16C	FA001030	1 year	NCR
26–40 GHz pre-amplifier	Narda	DBL-2640N610	FA001556	—	VOU
Horn antenna 18–40 GHz	EMCO	3116	FA001847	1 year	Sept. 06/13

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

Section 8. Testing data

8.1 FCC 15.207(a) and RSS-Gen 7.2.4 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:
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.

Except when the requirements applicable to a given device state otherwise, for any licence-exempt radiocommunication device equipped to operate from the public utility AC power supply, either directly or indirectly, the radio frequency voltage that is 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 2. The tighter limit applies at the frequency range boundaries.

The conducted emissions shall be measured with a 50 Ω/50 µH line impedance stabilization network (LISN).

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: * - Decreases with the logarithm of the frequency.

8.1.2 Test summary

Test date	October 15, 2012	**Test engineer**	Andrey Adelberg	**Verdict**	Pass
Temperature	23 °C	**Air pressure**	1006 mbar	**Relative humidity**	32 %

8.1.3 Observations/special notes

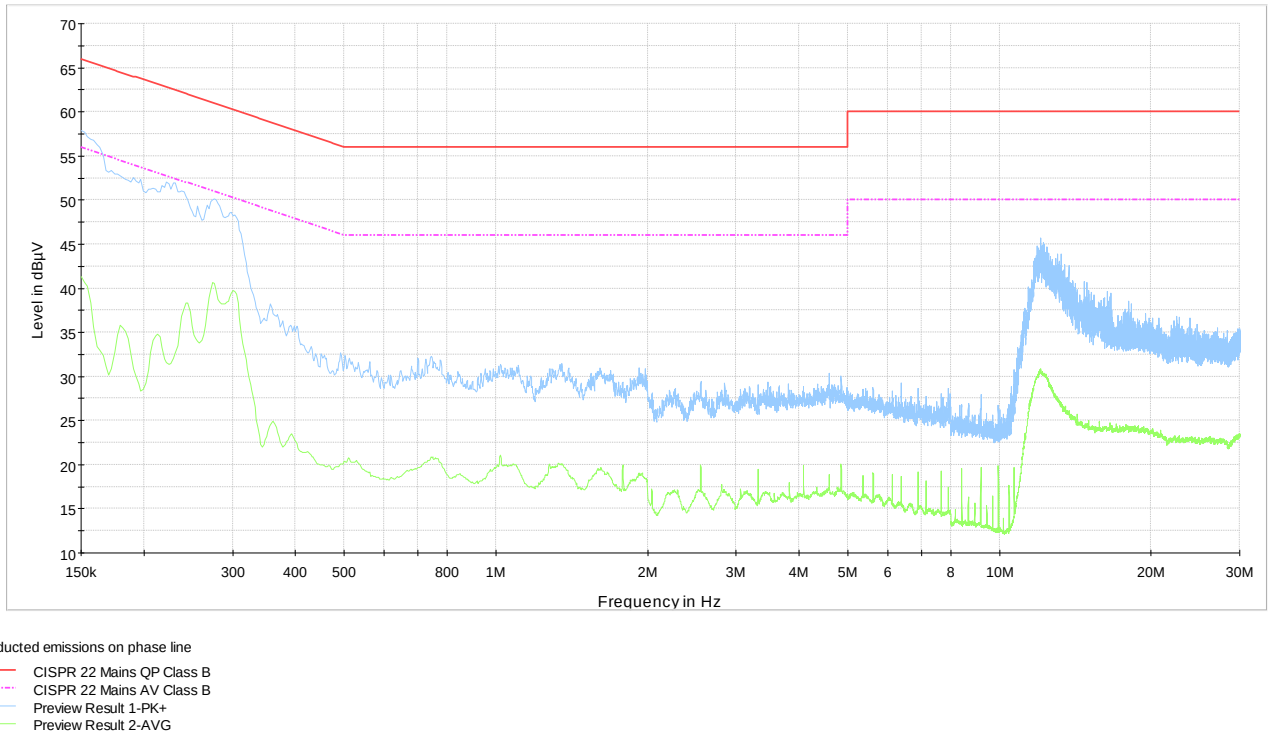
The EUT was set up as tabletop configuration.

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.

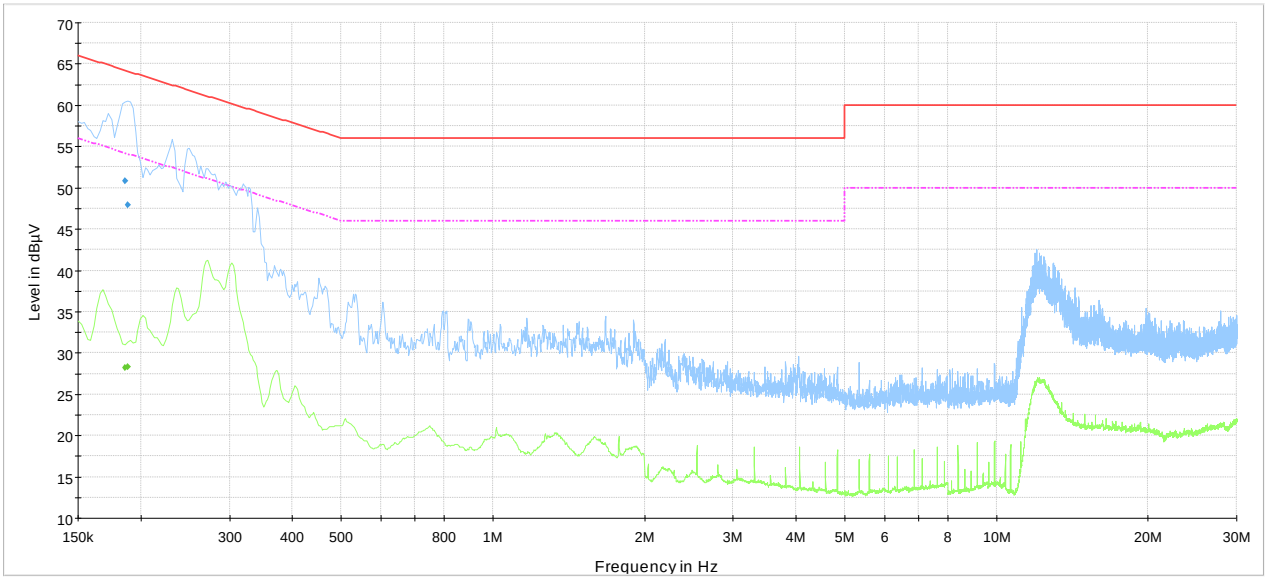
Receiver settings for preview measurements: Peak and Average detector (Max hold), RBW = 9 kHz, VBW = 30 kHz, Measurement time = 100 ms
Receiver settings for final measurements: Q-Peak and Average detector, RBW = 9 kHz, VBW = 30 kHz, Measurement time = 100 ms

8.1.4 Test data



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

8.1.4 Test data, continued



Conducted emissions on neutral line
CISPR 22 Mains QP Class B
CISPR 22 Mains AV Class B
Preview Result 1-PK+
Preview Result 2-AVG
Final Result 1-QPK
Final Result 2-AVG

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

Table 8.1-2: *Quasi-Peak conducted emissions results*

Frequency, MHz	Q-Peak result, dBµV	Meas. Time, ms	Bandwidth, kHz	Filter	Conductor	Correction, dB	Margin, dB	Limit, dBµV
0.186000	50.8	100.0	9.000	On	N	10.2	13.4	64.2
0.188250	47.9	100.0	9.000	On	N	10.2	16.2	64.1

Note: 43.5 dBµV = 23.2 dBµV (receiver reading) + 10.1 dB (LISN factor IL) + 0.2 dB (cable loss) + 10 dB (attenuator)

Table 8.1-3: *Average conducted emissions results*

Frequency, MHz	Average result, dBµV	Meas. Time, ms	Bandwidth, kHz	Filter	Conductor	Correction, dB	Margin, dB	Limit, dBµV
0.186000	28.2	100.0	9.000	On	N	10.2	26.1	54.2
0.188250	28.3	100.0	9.000	On	N	10.2	25.8	54.1

Sample calculation:
Correction factor (dB) = LISN factor IL (dB) + cable loss (dB) + attenuator (dB)
Result (dBµV) = XX dBµV (reading from receiver) + XX dB (Correction factor)

Example:
43.5 dBµV = 23.2 dBµV (receiver reading) + 10.1 dB (LISN factor IL) + 0.2 dB (cable loss) + 10 dB (attenuator)

8.2 FCC 15.403(i) Emission bandwidth

8.2.1 Definitions and limits

For purposes of this subpart the emission bandwidth shall be determined by measuring the width of the signal between two points, one below the carrier center frequency and one above the carrier center frequency, that are 26 dB down relative to the maximum level of the modulated carrier. Determination of the emissions bandwidth is based on the use of measurement instrumentation employing a peak detector function with an instrument resolution bandwidth approximately equal to 1.0 percent of the emission bandwidth of the device under measurement.

8.2.2 Test summary

Test date	October 18, 2012	**Test engineer**	Andrey Adelberg	**Verdict**	Pass
Temperature	23 °C	**Air pressure**	1004 mbar	**Relative humidity**	32 %

8.2.3 Observations/special notes

Measurements were performed with peak detector using RBW = 1 % of the emission BW. VBW was set three times RBW.

8.2.4 Test data

Table 8.2-1: *26 dB bandwidth results*

Antenna chain	Modulation	Channel	26 dB bandwidth, kHz
ch0	802.11a	5180	22.93
ch0	802.11a	5200	23.03
ch0	802.11a	5240	22.60
ch0	802.11n HT20	5180	23.75
ch0	802.11n HT20	5200	23.70
ch0	802.11n HT20	5240	23.85
ch0	802.11n HT40	5200	47.50
ch0	802.11n HT40	5220	47.12
ch1	802.11a	5180	22.98
ch1	802.11a	5200	22.79
ch1	802.11a	5240	22.93
ch1	802.11n HT20	5180	24.13
ch1	802.11n HT20	5200	23.75
ch1	802.11n HT20	5240	24.18
ch1	802.11n HT40	5200	47.69
ch1	802.11n HT40	5220	48.27

8.2.4 Test data, continued

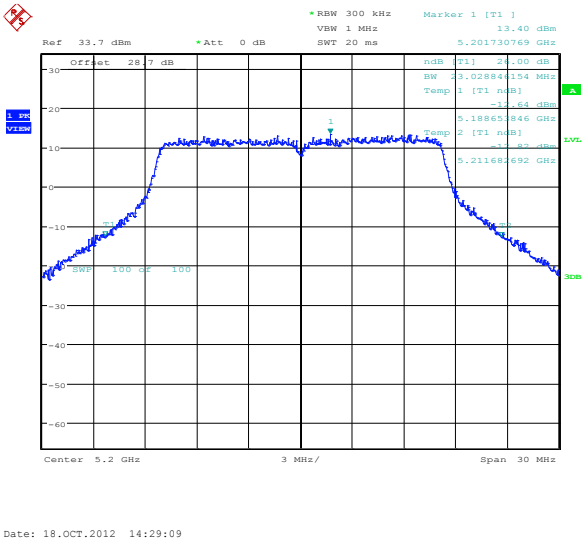


Diagram 8.2-1: *26 dB bandwidth on 802.11a, sample plot*

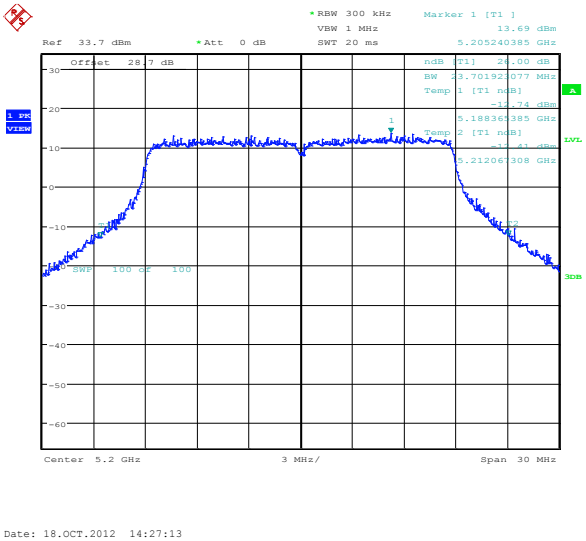


Diagram 8.2-2: *26 dB bandwidth on 802.11n HT20, sample plot*

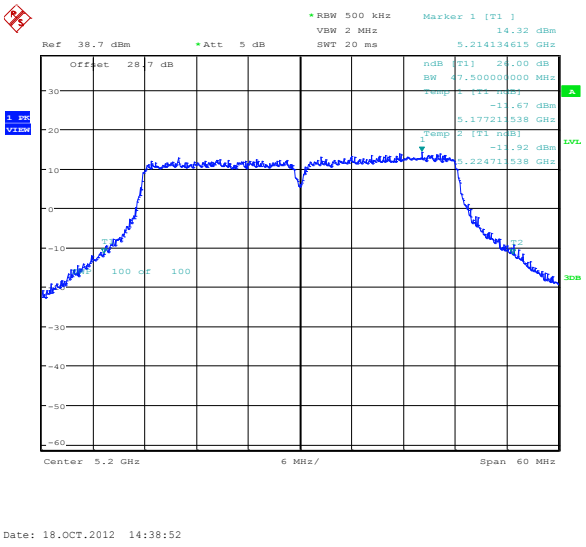


Diagram 8.2-3: *26 dB bandwidth on 802.11n HT40, sample plot*

8.3 RSS-Gen 4.6.1 Occupied bandwidth

8.3.1 Definitions and limits

When an occupied bandwidth value is not specified in the applicable RSS, the transmitted signal bandwidth to be reported is to be its 99 percent emission bandwidth, as calculated or measured.

The transmitter shall be operated at its maximum carrier power measured under normal test conditions.

The span of the analyzer shall be set to capture all products of the modulation process, including the emission skirts. The resolution bandwidth shall be set to as close to 1 percent of the selected span as is possible without being below 1 percent. The video bandwidth shall be set to 3 times the resolution bandwidth. Video averaging is not permitted. Where practical, a sampling detector shall be used since a peak or, peak hold, may produce a wider bandwidth than actual.

The trace data points are recovered and are directly summed in linear terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5 percent of the total is reached and that frequency recorded. The process is repeated for the highest frequency data points. This frequency is recorded.

The span between the two recorded frequencies is the occupied bandwidth.

8.3.2 Test summary

Test date	October 18, 2012	**Test engineer**	Andrey Adelberg	**Verdict**	Pass
Temperature	23 °C	**Air pressure**	1005 mbar	**Relative humidity**	34 %

8.3.3 Observations/special notes

Measurements were performed with peak detector using RBW ≥ 1 % of span; VBW was set three times RBW.

8.3.4 Test data

Table 8.3-1: *99 % bandwidth results*

Modulation	99 % bandwidth, MHz
802.11a	17.12
802.11n HT20	18.17
802.11n HT40	37.10

8.3.4 Test data, continued

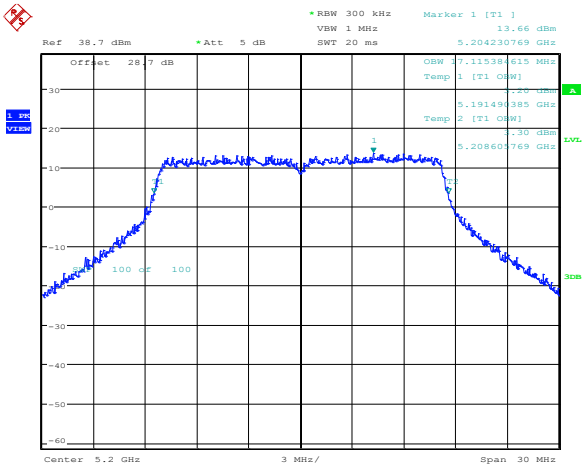


Diagram 8.3-1: *99 % bandwidth on 802.11a, sample plot*

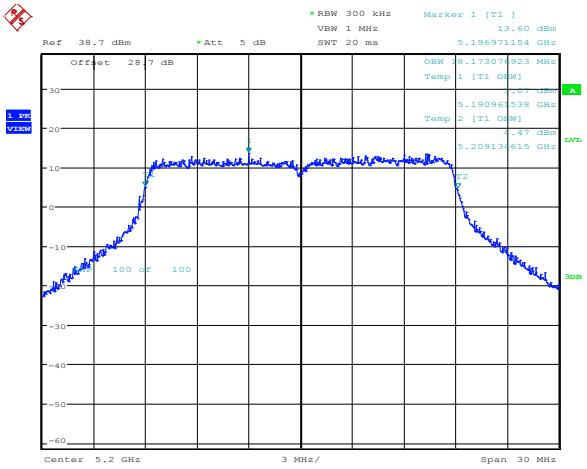


Diagram 8.3-2: *99 % bandwidth on 802.11n HT20, sample plot*

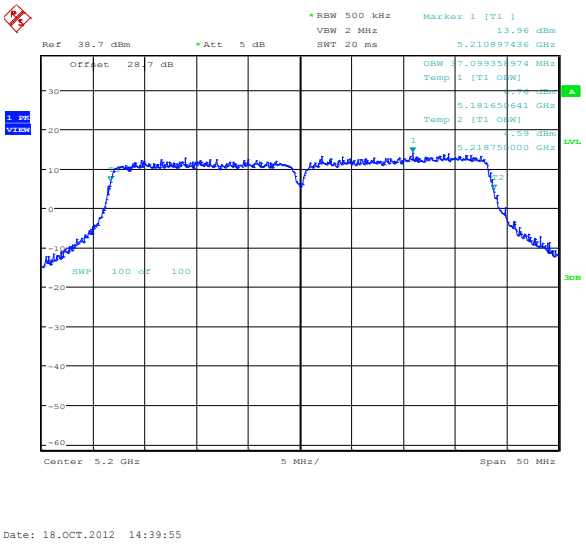


Diagram 8.3-3: *99 % bandwidth on 802.11n HT40, sample plot*

8.4 FCC 15.407(a)(1) and RSS-210 A9.2(1) 5.15–5.25 GHz band output power, EIRP and spectral density limits

8.4.1 Definitions and limits

FCC:

For the band 5.15–5.25 GHz, the maximum conducted output power over the frequency band of operation shall not exceed the lesser of 50 mW (17 dBm) or 4 dBm + 10 log B, where B is the 26 dB emission bandwidth in MHz. In addition, the peak power spectral density shall not exceed 4 dBm in any 1 MHz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the peak power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

The maximum conducted output power must be measured over any interval of continuous transmission using instrumentation calibrated in terms of an rms-equivalent voltage. The measurement results shall be properly adjusted for any instrument limitations, such as detector response times, limited resolution bandwidth capability when compared to the emission bandwidth, sensitivity, etc., so as to obtain a true peak measurement conforming to the above definitions for the emission in question.

The peak power spectral density is measured as a conducted emission by direct connection of a calibrated test instrument to the equipment under test. If the device cannot be connected directly, alternative techniques acceptable to the Commission may be used. Measurements are made over a bandwidth of 1 MHz or the 26 dB emission bandwidth of the device, whichever is less. A resolution bandwidth less than the measurement bandwidth can be used, provided that the measured power is integrated to show total power over the measurement bandwidth. If the resolution bandwidth is approximately equal to the measurement bandwidth, and much less than the emission bandwidth of the equipment under test, the measured results shall be corrected to account for any difference between the resolution bandwidth of the test instrument and its actual noise bandwidth.

IC:

The maximum e.i.r.p. shall not exceed 200 mW (23 dBm) or 10 + 10 $\log_{10}$ (B), dBm, whichever power is less. B is the 99 % emission bandwidth in MHz. The e.i.r.p. spectral density shall not exceed 10 dBm in any 1 MHz band.

8.4.2 Test summary

Test date	October 18, 2012	**Test engineer**	Andrey Adelberg	**Verdict**	Pass
Temperature	24 °C	**Air pressure**	1004 mbar	**Relative humidity**	32 %

8.4.3 Observations/special notes

The test was performed according to UNII guidelines section C) 4) Method PM: maximum conducted (average) output power using wideband RF average power meter with a thermocouple detector.
The 802.11n HT40 has only two channels.

8.4.4 Test data

Table 8.4-1: *Output power measurements and EIRP calculations results for FCC*

Modulation	Frequency, MHz	Average power on ch0, dBm	Average power on ch1, dBm	Combined average power, dBm	Output power limit, dBm	Output power margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
802.11n HT20	5180	12.60	12.15	15.39	16.0	0.61	7.0	22.39	23.00	0.61
802.11n HT20	5200	13.00	12.60	15.81	16.0	0.19	7.0	22.81	23.00	0.19
802.11n HT20	5240	12.85	12.05	15.48	16.0	0.52	7.0	22.48	23.00	0.52
802.11n HT40	5200	12.60	13.05	15.84	16.0	0.16	7.0	22.84	23.00	0.16
802.11n HT40	5220	12.75	12.55	15.66	16.0	0.34	7.0	22.66	23.00	0.34
802.11a	5180	12.55	12.30	15.44	16.0	0.56	7.0	22.44	23.00	0.56
802.11a	5200	13.00	12.45	15.74	16.0	0.26	7.0	22.74	23.00	0.26
802.11a	5240	12.85	12.10	15.50	16.0	0.50	7.0	22.50	23.00	0.50

Notes: Combined average output power was calculated as follows:

$$P_{combined} = 10 \times log_{10}\left(\left(10^{P_{ch0}/10}\right) + \left(10^{P_{ch1}/10}\right)\right)$$

EIRP was calculated as follows:

$$EIRP = P_{combined} + antenna\ gain$$

MIMO Correlated 2×2 (CDD/TXBF), Directional gain = 4 dBi + 10×log$_{10}$ (N) dB = 4 dBi + 3 dB = 7 dBi, where "N" is number of antennae.
Since the direct antenna gain is more than 6 dBi by 1 dB, therefore the output power limit was reduced by 1 dB.

Table 8.4-2: *Output power measurements and EIRP calculations results for IC*

Modulation	Frequency, MHz	Average power on ch0, dBm	Average power on ch1, dBm	Combined average power, dBm	Output power limit, dBm	Output power margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
802.11n HT20	5180	11.60	11.05	14.34	15.59	1.25	7.00	21.34	22.59	1.25
802.11n HT20	5200	12.20	11.30	14.78	15.59	0.81	7.00	21.78	22.59	0.81
802.11n HT20	5220	11.80	11.40	14.61	15.59	0.98	7.00	21.61	22.59	0.98
802.11n HT40	5200	12.60	13.05	15.84	16.00	0.16	7.00	22.84	23.00	0.16
802.11n HT40	5220	12.75	12.55	15.66	16.00	0.34	7.00	22.66	23.00	0.34
802.11a	5180	11.60	11.00	14.32	15.34	1.02	7.00	21.32	22.34	1.02
802.11a	5200	11.55	11.30	14.44	15.34	0.90	7.00	21.44	22.34	0.90
802.11a	5220	11.30	11.00	14.16	15.34	1.18	7.00	21.16	22.34	1.18

Notes: Combined average output power was calculated as follows:

$$P_{combined} = 10 \times log_{10}\left(\left(10^{P_{ch0}/10}\right) + \left(10^{P_{ch1}/10}\right)\right)$$

EIRP was calculated as follows:

$$EIRP = P_{combined} + antenna\ gain$$

MIMO Correlated 2×2 (CDD/TXBF), Directional gain = 4 dBi + 10×log$_{10}$ (N) dB = 4 dBi + 3 dB = 7 dBi, where "N" is number of antennae.
Since the direct antenna gain is more than 6 dBi by 1 dB, therefore the output power limit was reduced by 1 dB.
EIRP limit was calculated as follows: 10 + 10 log10 (B), dBm, B is the 99 % emission bandwidth in MHz.

8.4.4 Test data, continued

Table 8.4-3: *PSD measurements results for FCC*

Modulation	Frequency, MHz	PSD at ch0, dBm/1 MHz	PSD at ch1, dBm/1 MHz	Combined PSD, dBm/1 MHz	PSD limit, dBm/1 MHz	Margin, dB
802.11n HT20	5180	0.32	0.40	3.37	4.0	0.63
802.11n HT20	5200	1.15	0.59	3.89	4.0	0.11
802.11n HT20	5240	1.56	0.13	3.91	4.0	0.09
802.11n HT40	5200	-2.30	-1.29	1.24	4.0	2.76
802.11n HT40	5220	-2.07	-2.31	0.82	4.0	3.18
802.11a	5180	1.29	0.67	4.00	4.0	0.00
802.11a	5200	1.45	0.42	3.98	4.0	0.02
802.11a	5240	1.10	0.48	3.81	4.0	0.19

Notes: Combined PSD was calculated as follows:

$$PSD_{combined} = 10 \times log_{10}\left(\left(10^{PSD_{ch0}/10}\right) + \left(10^{PSD_{ch1}/10}\right)\right)$$

Table 8.4-4: *PSD measurements results for IC*

Modulation	Frequency, MHz	PSD at ch0, dBm/1 MHz	PSD at ch1, dBm/1 MHz	Combined PSD, dBm/1 MHz	Antenna gain, dBi	PSD EIRP, dBm/1 MHz	Limit, dBm/1 MHz	Margin, dB
802.11n HT20	5180	-0.11	-0.03	2.94	7.00	9.94	10.0	0.06
802.11n HT20	5200	0.30	-0.37	2.99	7.00	9.99	10.0	0.01
802.11n HT20	5220	0.20	-0.25	2.99	7.00	9.99	10.0	0.01
802.11n HT40	5200	-2.30	-1.29	1.24	7.00	8.24	10.0	1.76
802.11n HT40	5220	-2.07	-2.31	0.82	7.00	7.82	10.0	2.18
802.11a	5180	0.15	-0.23	2.97	7.00	9.97	10.0	0.03
802.11a	5200	0.05	-0.09	2.99	7.00	9.99	10.0	0.01
802.11a	5220	0.05	-0.23	2.92	7.00	9.92	10.0	0.08

Notes: Combined PSD was calculated as follows:

$$PSD_{combined} = 10 \times log_{10}\left(\left(10^{PSD_{ch0}/10}\right) + \left(10^{PSD_{ch1}/10}\right)\right)$$

PSD EIRP was calculated as follows:

$$PSD\ EIRP = PSD_{combined} + antenna\ gain$$

MIMO Correlated 2×2 (CDD/TXBF), Directional gain = 4 dBi + 10×log$_{10}$ (N) dB = 4 dBi + 3 dB = 7 dBi, where “N” is number of antennae.

8.4.4 Test data, continued

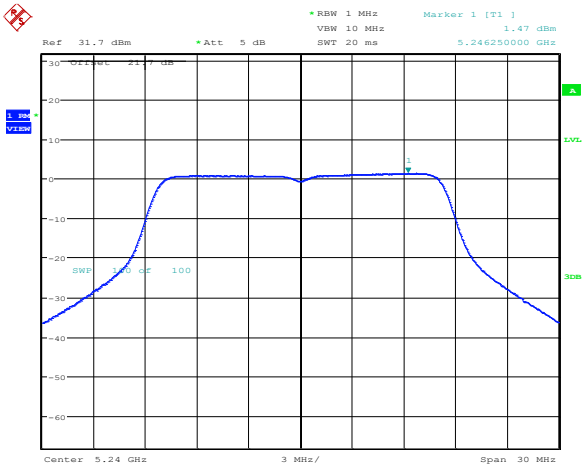


Diagram 8.4-1: *Sample plot for PSD on 802.11a*

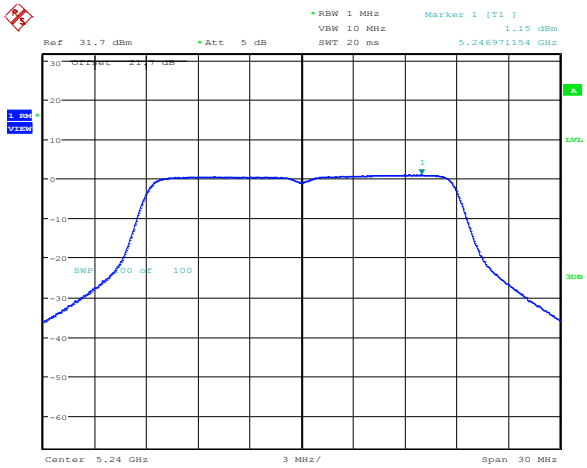


Diagram 8.4-2: *Sample plot for PSD on 802.11n HT20*

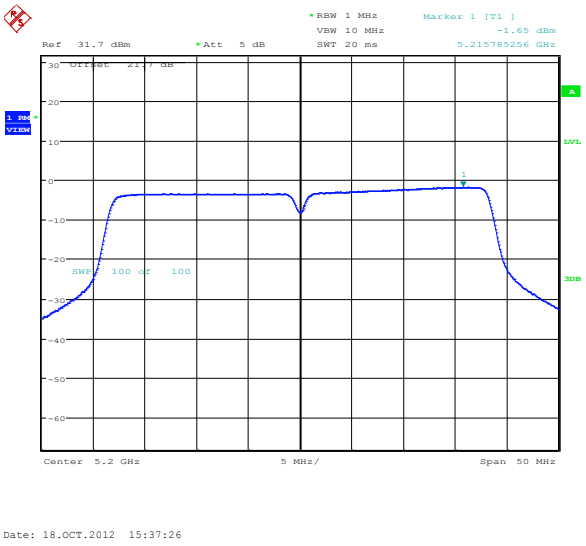


Diagram 8.4-3: *Sample plot for PSD on 802.11n HT40*

8.5 FCC 15.407(b) and RSS-210 A9.2(1) Spurious (out-of-band) emissions

8.5.1 Definitions and limits

FCC:
(1) For transmitters operating in the 5.15–5.25 GHz band: all emissions outside of the 5.15–5.35 GHz band shall not exceed an EIRP of −27 dBm/MHz.
(5) The emission measurements shall be performed using a minimum resolution bandwidth of 1 MHz. A lower resolution bandwidth may be employed near the band edge, when necessary, provided the measured energy is integrated to show the total power over 1 MHz.
(6) Unwanted emissions below 1 GHz must comply with the general field strength limits set forth in § 15.209.
(7) The provisions of § 15.205 apply to intentional radiators operating under this section.
(8) When measuring the emission limits, the nominal carrier frequency shall be adjusted as close to the upper and lower frequency block edges as the design of the equipment permits.

IC:
Emissions outside the band 5150–5250 MHz shall not exceed −27 dBm/MHz e.i.r.p.
The outermost carrier frequencies or channels, as permitted by the design of the equipment, shall be used when measuring unwanted emissions. Such carrier or channel center frequencies are to be indicated in the test report.

RSS-Gen 7.2.2 Emissions falling within restricted frequency bands
Restricted bands, identified in below, are designated primarily for safety-of-life services (distress calling and certain aeronautical bands), certain satellite downlinks, radio astronomy and some government uses. Except where otherwise indicated, the following restrictions apply:
(a) fundamental components of modulation of licence-exempt radio apparatus shall not fall within the restricted bands of below;
(b) unwanted emissions falling into restricted bands of below shall comply with the limits specified in RSS-Gen;
(c) unwanted emissions not falling within restricted frequency bands shall either comply with the limits specified in the applicable RSS, or with those specified in RSS-Gen.

Table 8.5-1: *FCC §15.209 and RSS-Gen – Radiated emission limits*

Frequency, MHz	Field strength of emissions µV/m	Field strength of emissions dBµV/m	Measurement distance, 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: Applicable only to FCC requirements
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

8.5.1 Definitions and limits, continued

Table 8.5-2: *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 8.5-2 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 8.5-3: *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			

8.5.2 Test summary

Test date	October 24, 2012	**Test engineer**	Andrey Adelberg	**Verdict**	Pass
Temperature	22 °C	**Air pressure**	1002 mbar	**Relative humidity**	32 %

8.5.3 Observations/special notes

The spectrum was searched from 30 MHz to the 40 GHz.
Radiated measurements were performed at a distance of 3 m, the EUT was transmitting on both MIMO chains simultaneously.
Settings for radiated measurements within restricted bands:
For frequencies below 1 GHz, RBW was set to 100 kHz, VBW was 3 times wider than RBW.
Peak detector was used for measurements.
For frequencies above 1 GHz, RBW was set to 1 MHz, VBW was 3 times wider than RBW for peak measurements, and VBW was set to 10 Hz for average measurements. Peak detector was used for measurements.
EUT was set to transmit with 100 % duty cycle.
Only worst case emissions were reported.

8.5.4 Test data

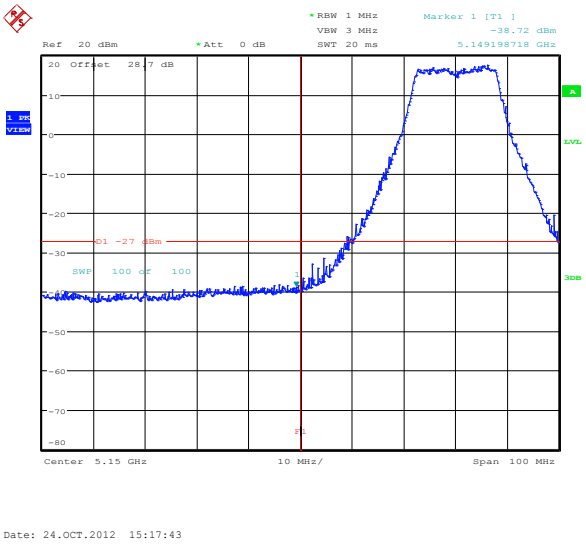


Diagram 8.5-1: *Lower band edge, 802.11a, ch0*

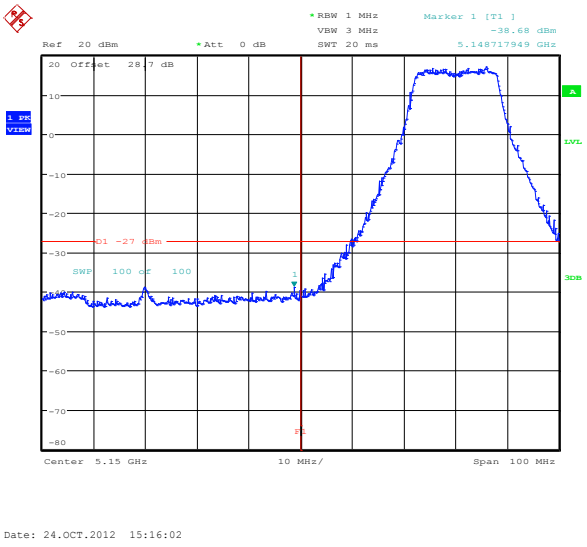


Diagram 8.5-2: *Lower band edge, 802.11a, ch1*

Conducted emissions were performed on each individual MIMO chain and plots were adjusted to include 3 dB (10 × log(total number of chains)) and antenna directional gain of 7 dBi (4 dBi + 10 × log(total number of antennas)).

8.5.4 Test data, continued

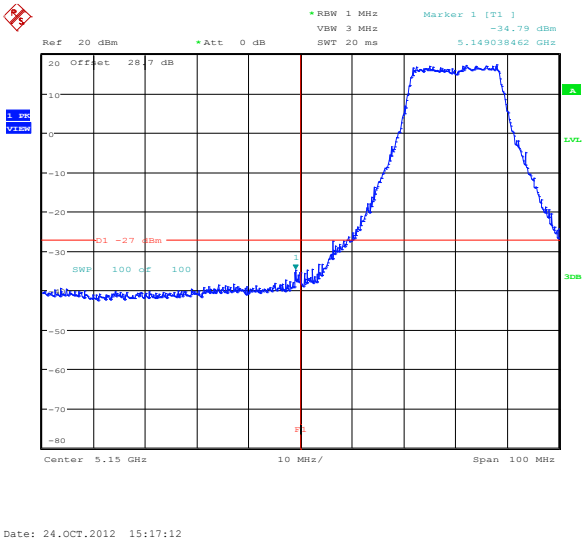


Diagram 8.5-3: *Lower band edge, 802.11n HT20, ch0*

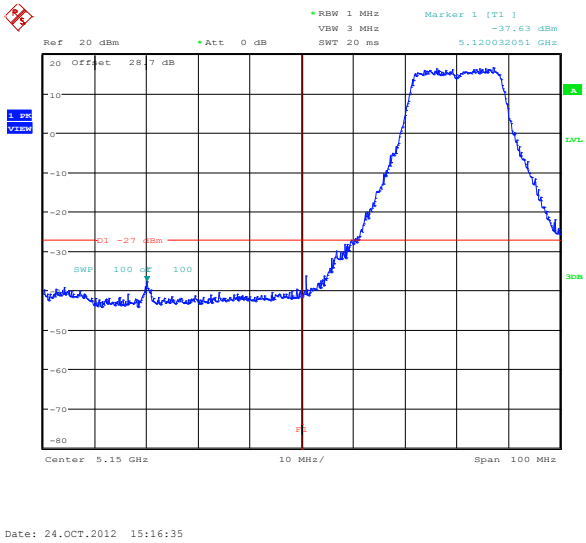


Diagram 8.5-4: *Lower band edge, 802.11n HT20, ch1*

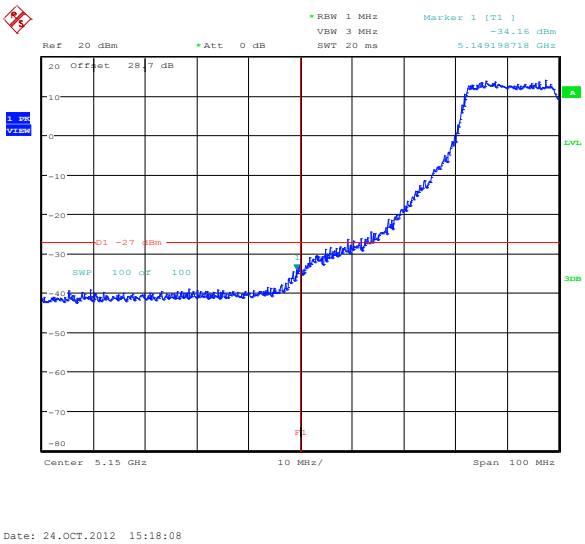


Diagram 8.5-5: *Lower band edge, 802.11n HT40, ch0*

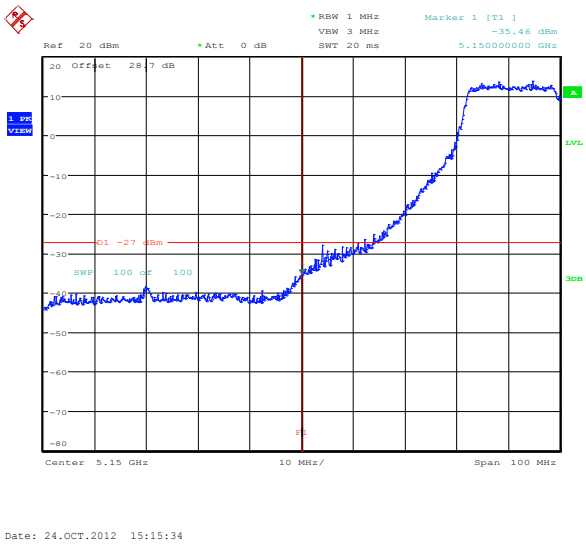


Diagram 8.5-6: *Lower band edge, 802.11n HT40, ch1*

Conducted emissions were performed on each individual MIMO chain and plots were adjusted to include 3 dB (10 × log(total number of chains)) and antenna directional gain of 7 dBi (4 dBi + 10 × log(total number of antennas)).

8.5.4 Test data, continued

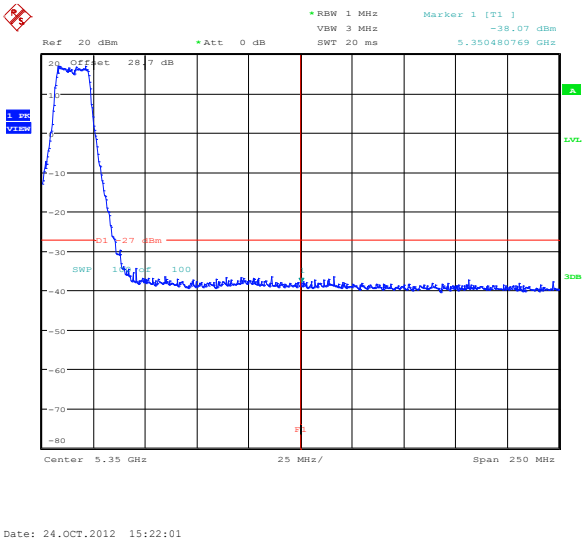


Diagram 8.5-7: *Upper band edge as per FCC, 802.11a, ch0*

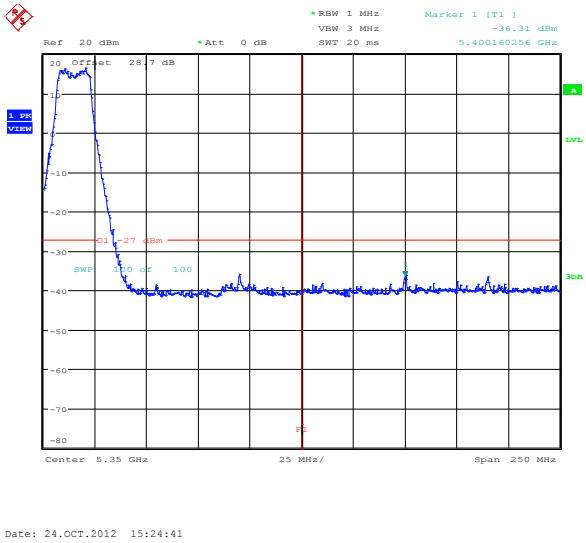


Diagram 8.5-8: *Upper band edge as per FCC, 802.11a, ch1*

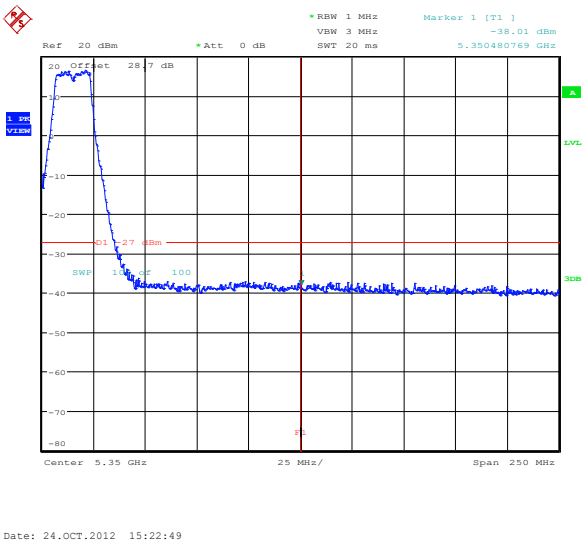


Diagram 8.5-9: *Upper band edge as per FCC, 802.11n HT20, ch0*

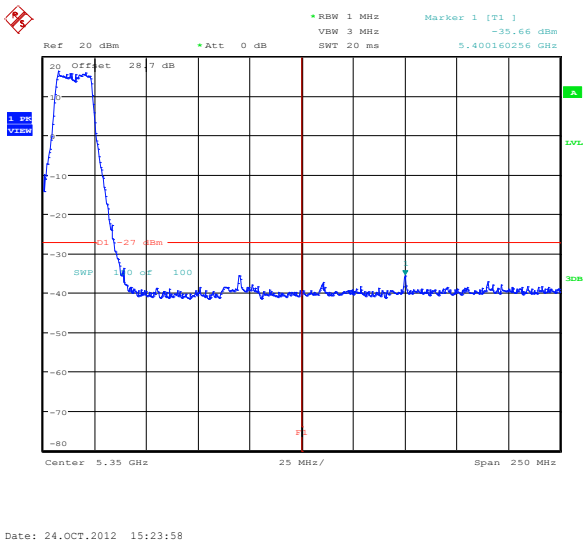


Diagram 8.5-10: *Upper band edge as per FCC, 802.11n HT20, ch1*

Conducted emissions were performed on each individual MIMO chain and plots were adjusted to include 3 dB (10 × log(total number of chains)) and antenna directional gain of 7 dBi (4 dBi + 10 × log(total number of antennas)).

8.5.4 Test data, continued

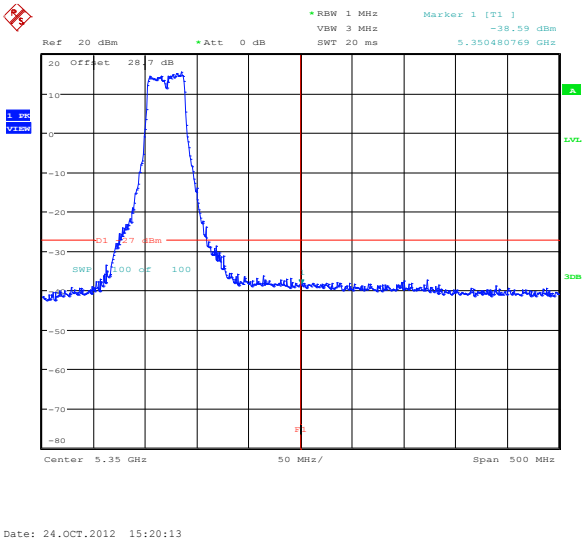


Diagram 8.5-11: *Upper band edge as per FCC, 802.11n HT40, ch0*

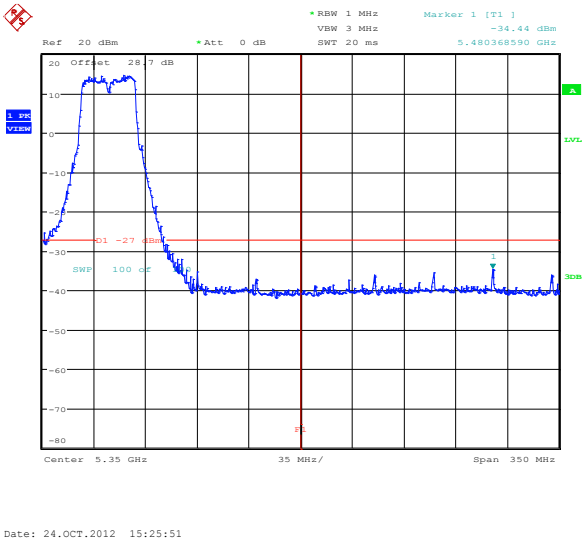


Diagram 8.5-12: *Upper band edge as per FCC, 802.11n HT40, ch1*

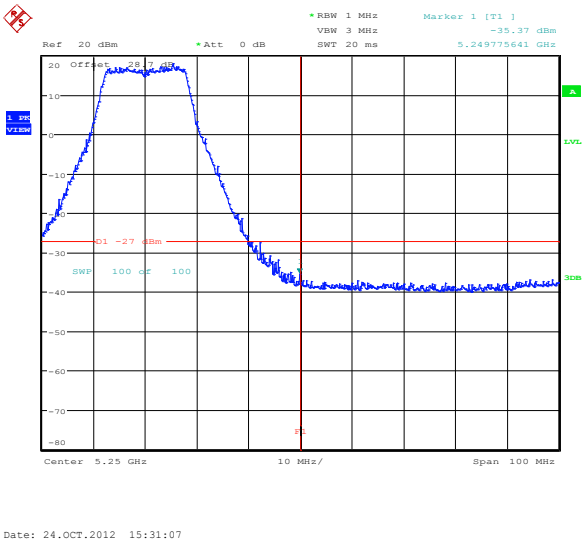


Diagram 8.5-13: *Upper band edge as per IC, 802.11a, ch0*

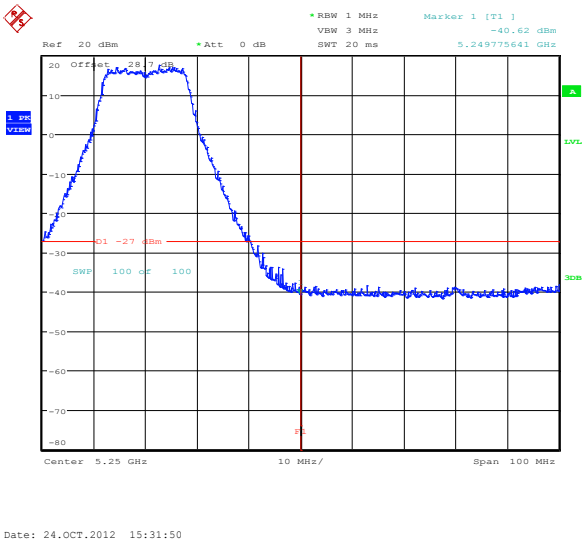


Diagram 8.5-14: *Upper band edge as per IC, 802.11a, ch1*

Conducted emissions were performed on each individual MIMO chain and plots were adjusted to include 3 dB (10 × log(total number of chains)) and antenna directional gain of 7 dBi (4 dBi + 10 × log(total number of antennas)).

8.5.4 Test data, continued

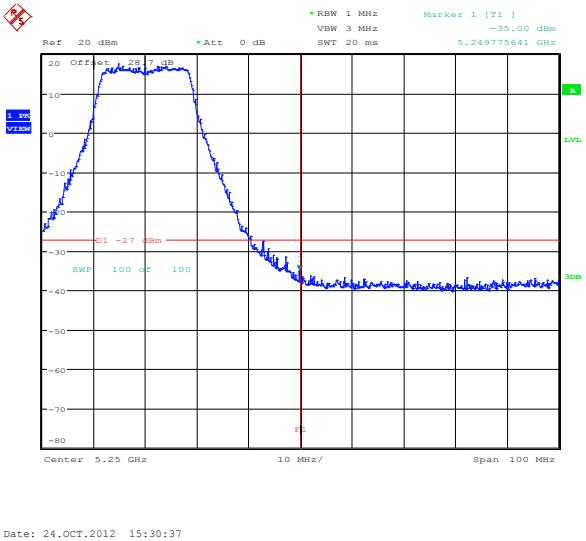


Diagram 8.5-15: *Upper band edge as per IC, 802.11n HT20, ch0*

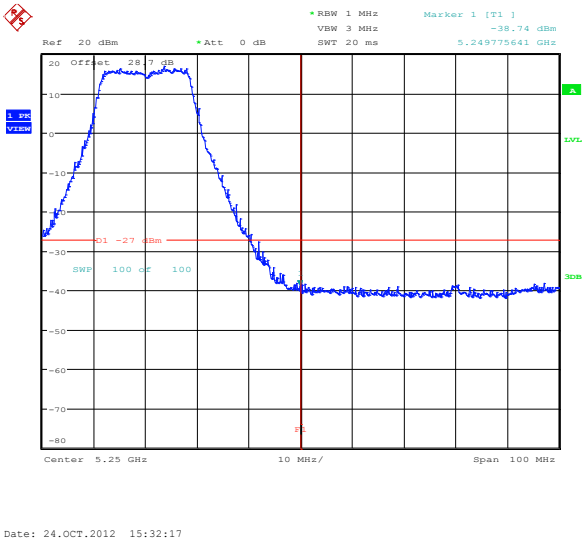


Diagram 8.5-16: *Upper band edge as per IC, 802.11n HT20, ch1*

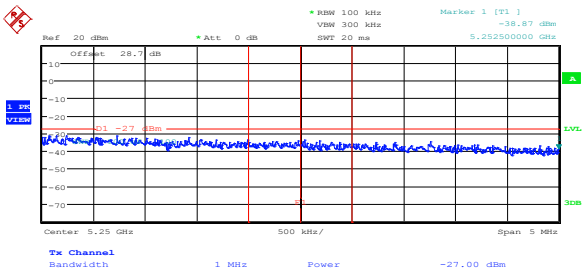


Diagram 8.5-17: *Upper band edge as per IC, 802.11n HT40, ch0*

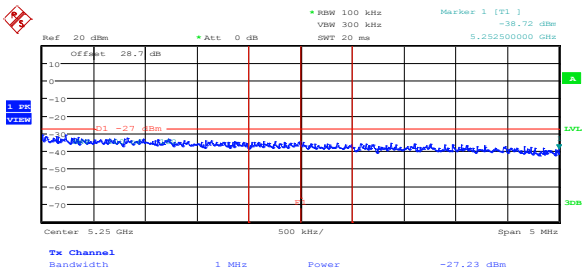


Diagram 8.5-18: *Upper band edge as per IC, 802.11n HT40, ch1*

Conducted emissions were performed on each individual MIMO chain and plots were adjusted to include 3 dB (10 × log(total number of chains)) and antenna directional gain of 7 dBi (4 dBi + 10 × log(total number of antennas)).

Table 8.5-4: *Radiated field strength measurement results*

Modulation	Channel	Frequency, MHz	Peak Field strength, dBµV/m	Peak limit, dBµV/m	Margin, dB	Average Field strength, dBµV/m	Average limit, dBµV/m	Margin, dB
802.11a	Low	5440	67.25	74.00	6.75	52.13	54.00	1.87
802.11n HT20	Low	5440	63.75	74.00	10.25	51.99	54.00	2.01
802.11n HT40	Mid	5440	64.33	74.00	9.67	53.10	54.00	0.90

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

8.5.4 Test data, continued

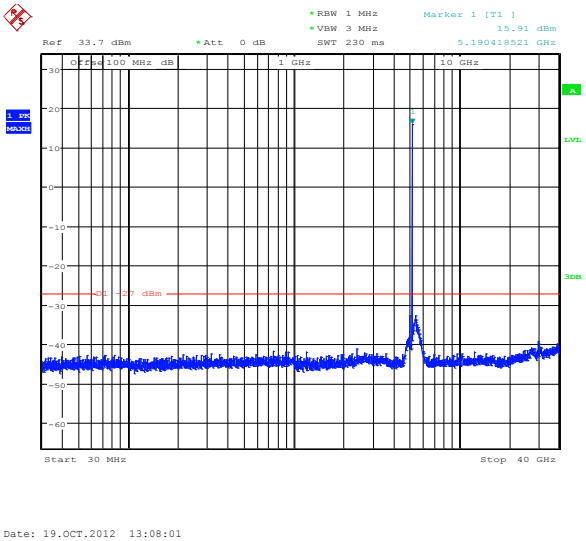


Diagram 8.5-19: *Conducted spurious emissions for 802.11a, ch0, low channel*

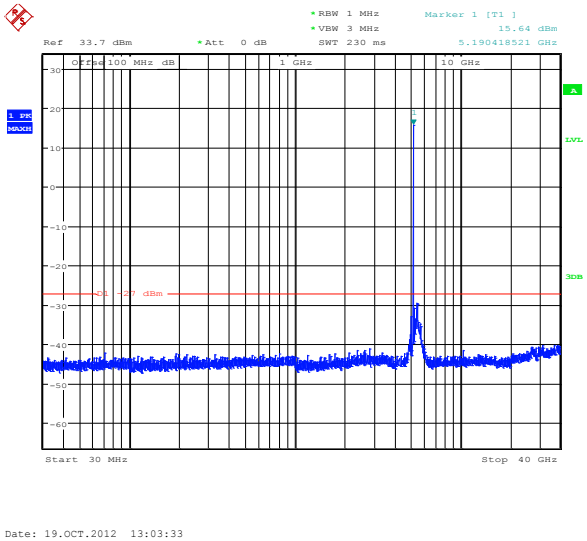


Diagram 8.5-20: *Conducted spurious emissions for 802.11a, ch1, low channel*

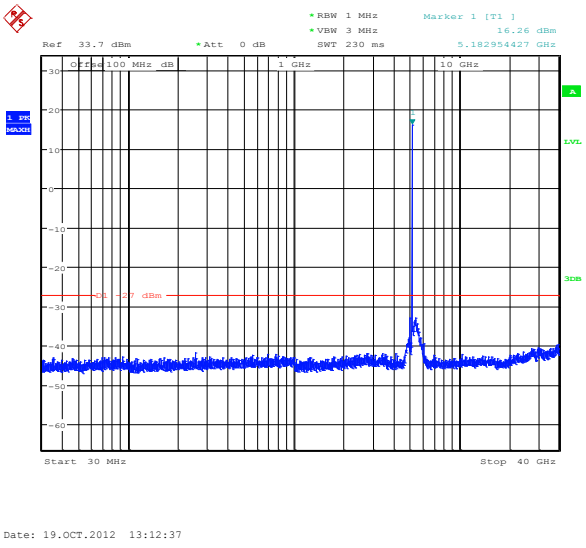


Diagram 8.5-21: *Conducted spurious emissions for 802.11n HT20, ch0, low channel*

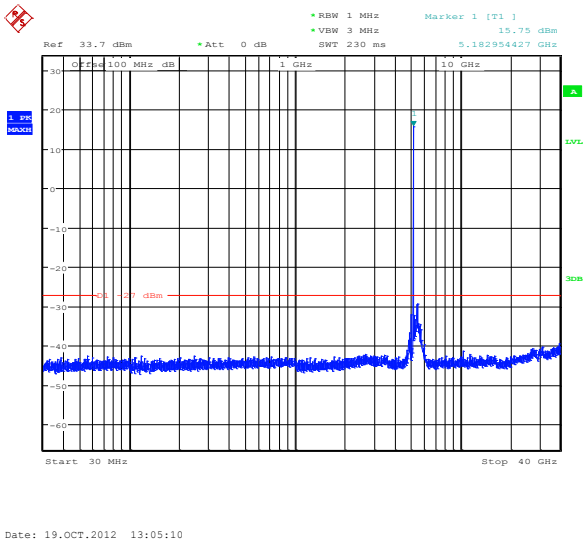


Diagram 8.5-22: *Conducted spurious emissions for 802.11n HT20, ch1, low channel*

Conducted emissions were performed on each individual MIMO chain and plots were adjusted to include 3 dB (10 × log(total number of chains)) and antenna directional gain of 7 dBi (4 dBi + 10 × log(total number of antennas)).

8.5.4 Test data, continued

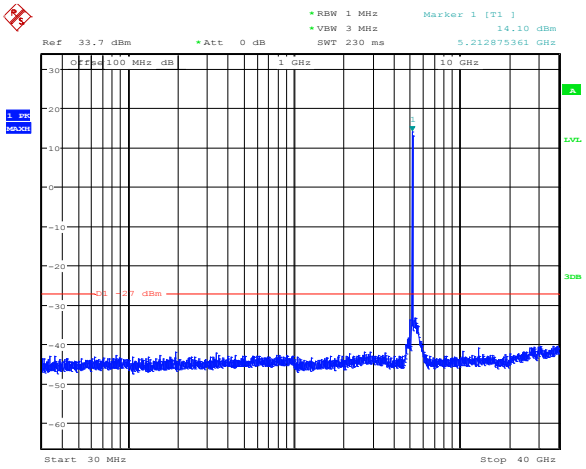


Diagram 8.5-23: *Conducted spurious emissions for 802.11n HT40, ch0, low channel*

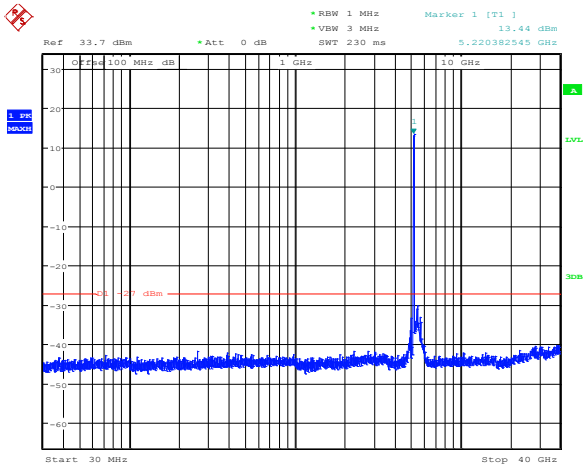


Diagram 8.5-24: *Conducted spurious emissions for 802.11n HT40, ch1, low channel*

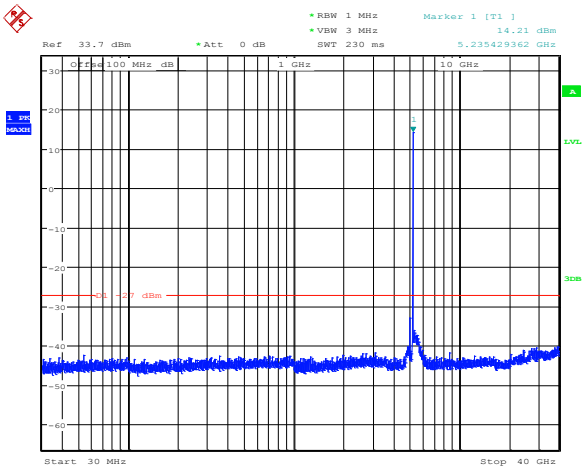


Diagram 8.5-25: *Conducted spurious emissions for 802.11a, ch0, high channel for FCC*

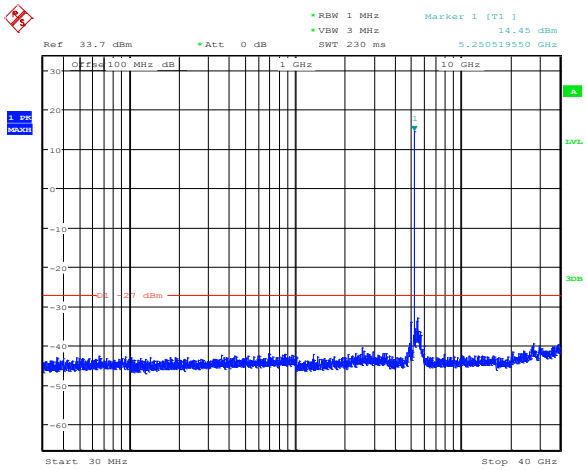


Diagram 8.5-26: *Conducted spurious emissions for 802.11a, ch1, high channel for FCC*

Conducted emissions were performed on each individual MIMO chain and plots were adjusted to include 3 dB (10 × log(total number of chains)) and antenna directional gain of 7 dBi (4 dBi + 10 × log(total number of antennas)).

8.5.4 Test data, continued

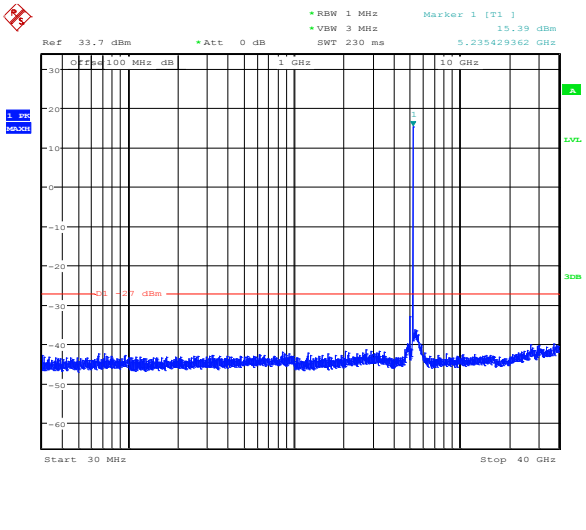


Diagram 8.5-27: *Conducted spurious emissions for 802.11n HT20, ch0, high channel for FCC*

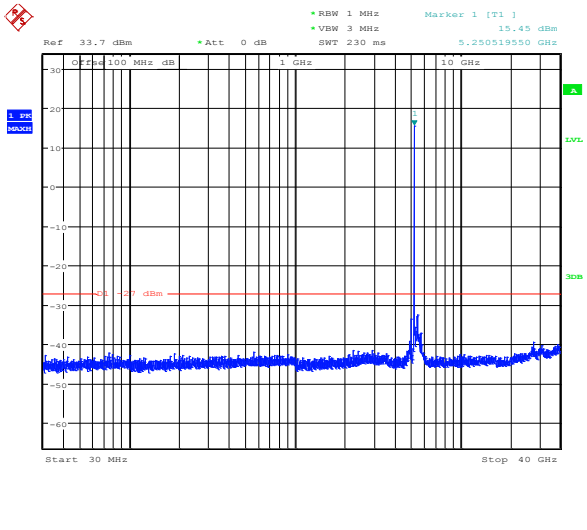


Diagram 8.5-28: *Conducted spurious emissions for 802.11n HT20, ch1, high channel for FCC*

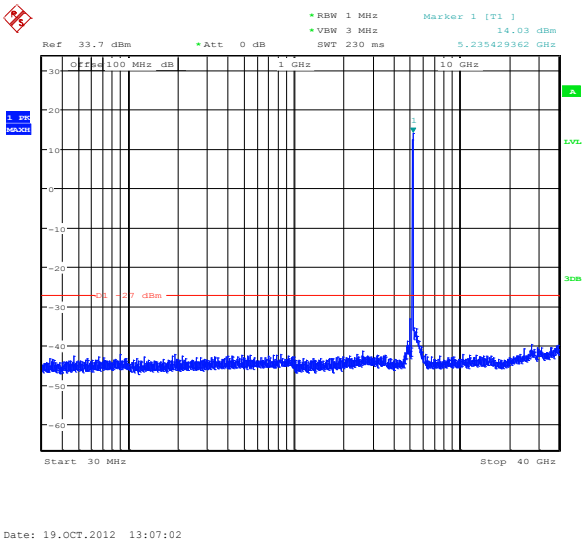


Diagram 8.5-29: *Conducted spurious emissions for 802.11n HT40, ch0, high channel*

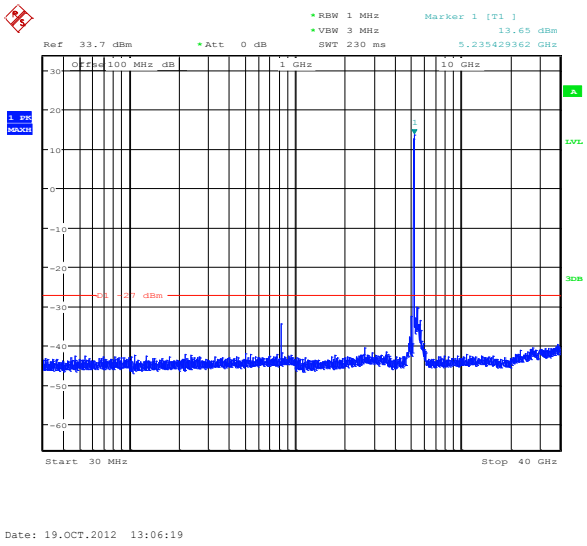


Diagram 8.5-30: *Conducted spurious emissions for 802.11n HT40, ch1, high channel*

Conducted emissions were performed on each individual MIMO chain and plots were adjusted to include 3 dB (10 × log(total number of chains)) and antenna directional gain of 7 dBi (4 dBi + 10 × log(total number of antennas)).

8.5.4 Test data, continued

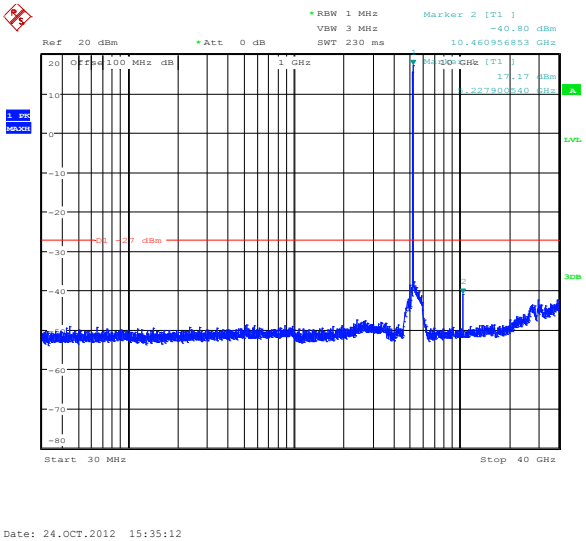


Diagram 8.5-31: *Conducted spurious emissions for 802.11a, ch0, high channel for IC*

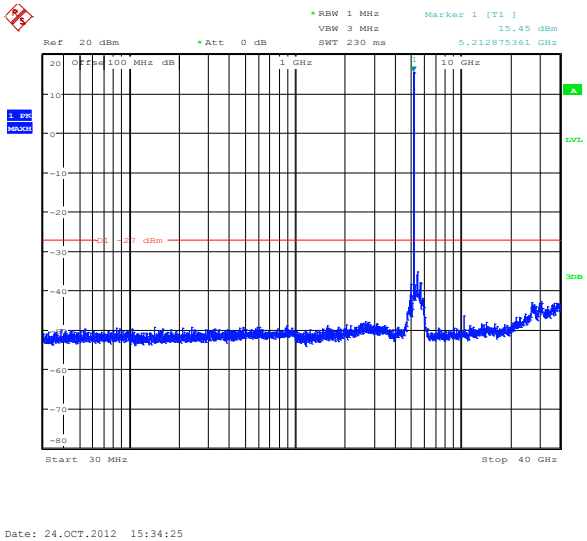


Diagram 8.5-32: *Conducted spurious emissions for 802.11a, ch1, high channel for IC*

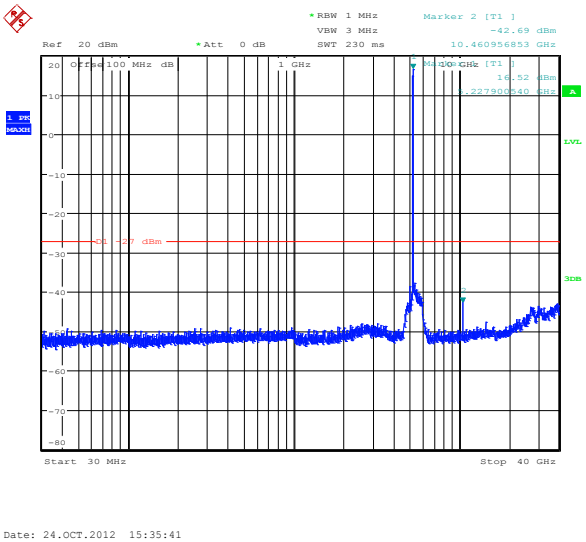


Diagram 8.5-33: *Conducted spurious emissions for 802.11n HT20, ch0, high channel for IC*

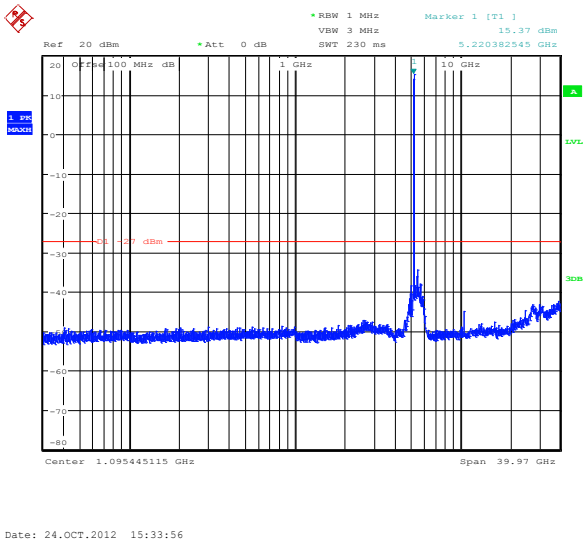


Diagram 8.5-34: *Conducted spurious emissions for 802.11n HT20, ch1, high channel for IC*

Conducted emissions were performed on each individual MIMO chain and plots were adjusted to include 3 dB (10 × log(total number of chains)) and antenna directional gain of 7 dBi (4 dBi + 10 × log(total number of antennas)).

8.6 FCC 15.407(g) Frequency stability

8.6.1 Definitions and limits

Manufacturers of U-NII devices are responsible for ensuring frequency stability such that an emission is maintained within the band of operation under all conditions of normal operation as specified in the user's manual.

8.6.2 Test summary

Test date	October 11, 2012	**Test engineer**	Andrey Adelberg	**Verdict**	Pass
Temperature	23 °C	**Air pressure**	1004 mbar	**Relative humidity**	33 %

8.6.3 Observations/special notes

None

8.6.4 Test data

Table 8.6-1: *Frequency drift measurement*

Test conditions	Frequency, GHz	Drift, Hz
+50 °C, Nominal	5.179988191	210
+40 °C, Nominal	5.179988099	118
+30 °C, Nominal	5.179988110	129
+20 °C, +15 %	5.179988031	50
+20 °C, Nominal	5.179987981	*Reference*
+20 °C, -15 %	5.179988059	78
+10 °C, Nominal	5.179988092	111
0 °C, Nominal	5.179987754	-227
−10 °C, Nominal	5.179987800	-181
−20 °C, Nominal	5.179987813	-168
−30 °C, Nominal	5.179987871	-110

Table 8.6-2: *Band edge drift calculation*

Modulation	−26 dBc lower cross point, GHz	Max negative drift, Hz	Drifted lower cross point, GHz	Band edge, GHz	Margin, MHz
802.11a	5.16879808	227	5.1687979	5.15	18.797850
802.11n HT20	5.16817308	227	5.1681729	5.15	18.172850
802.11n HT40	5.17682692	227	5.1768267	5.15	26.826696
Modulation	**−26 dBc upper cross point, GHz**	**Max positive drift, Hz**	**Drifted upper cross point, GHz**	**Band edge, GHz**	**Margin, MHz**
802.11a	5.228846154	210	5.228846364	5.25	21.153636
802.11n HT20	5.228605769	210	5.228605979	5.25	21.394021
802.11n HT40	5.197500000	210	5.197500210	5.25	52.499790

Notes: Drifted lower cross point = −26 dBc lower cross point – max negative drift. Drifted upper cross point = −26 dBc upper cross point + max positive drift.

8.7 FCC 15.407(a)(6) and RSS-210 A9.4(2) Peak excursion and PSD-to-average ratio

8.7.1 Definitions and limits

FCC:
(6) The ratio of the peak excursion of the modulation envelope (measured using a peak hold function) to the maximum conducted output power (measured as specified above) shall not exceed 13 dB across any 1 MHz bandwidth or the emission bandwidth whichever is less.
IC:
Within the emission bandwidth, when the peak spectral density per MHz over any continuous transmission exceeds the average (10 $\log_{10}$ (B)) value by more than 3 dB, the permissible power spectral density shall be reduced by the excess amount.

8.7.2 Test summary

Test date	October 19, 2012	**Test engineer**	Andrey Adelberg	**Verdict**	Pass
Temperature	24 °C	**Air pressure**	1004 mbar	**Relative humidity**	32 %

8.7.3 Observations/special notes

The test was performed using method described in 789033 D01 General UNII Test Procedures v01r02 under sections F, E and C.

8.7.4 Test data

Table 8.7-1: *FCC peak excursion measurements results*

Chain	Modulation	Frequency, MHz	Peak excursion, dB	Limit, dB	Margin, dB
ch0	802.11a	5180	10.49	13.00	2.51
ch0	802.11a	5200	10.28	13.00	2.72
ch0	802.11a	5240	10.53	13.00	2.47
ch0	802.11n HT20	5180	10.39	13.00	2.61
ch0	802.11n HT20	5200	10.15	13.00	2.85
ch0	802.11n HT20	5240	10.38	13.00	2.62
ch0	802.11n HT40	5200	10.27	13.00	2.73
ch0	802.11n HT40	5220	11.35	13.00	1.65
ch1	802.11a	5180	10.80	13.00	2.20
ch1	802.11a	5200	10.09	13.00	2.91
ch1	802.11a	5240	10.81	13.00	2.19
ch1	802.11n HT20	5180	10.85	13.00	2.15
ch1	802.11n HT20	5200	10.16	13.00	2.84
ch1	802.11n HT20	5240	10.84	13.00	2.16
ch1	802.11n HT40	5200	10.47	13.00	2.53
ch1	802.11n HT40	5220	10.33	13.00	2.67

8.7.4 Test data, continued

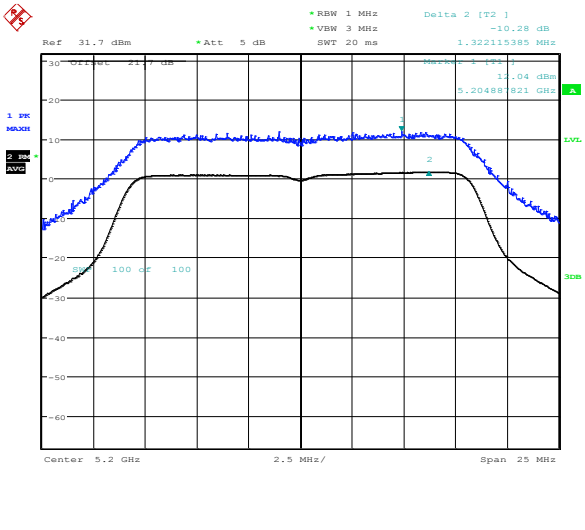


Diagram 8.7-1: *Sample plot for peak excursion on 802.11a*

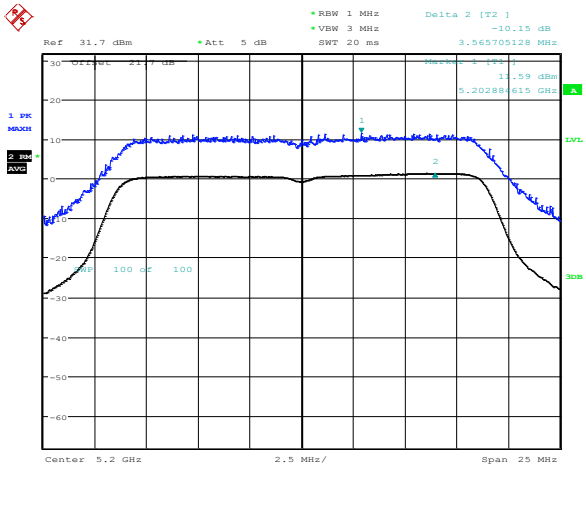


Diagram 8.7-2: *Sample plot for peak excursion on 802.11n HT20*

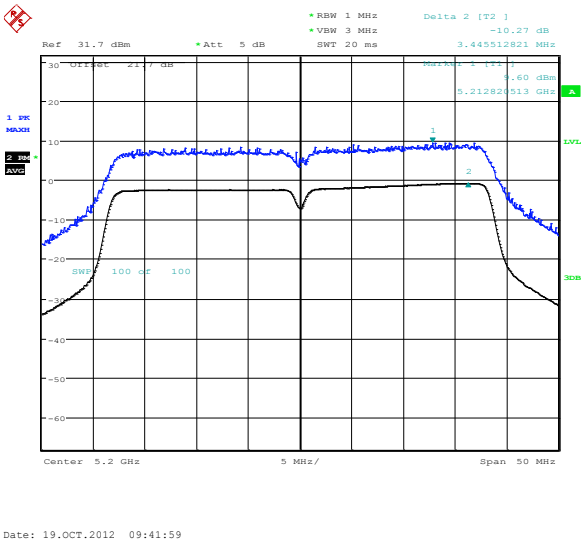


Diagram 8.7-3: *Sample plot for peak excursion on 802.11n HT40*

8.7.4 Test data, continued

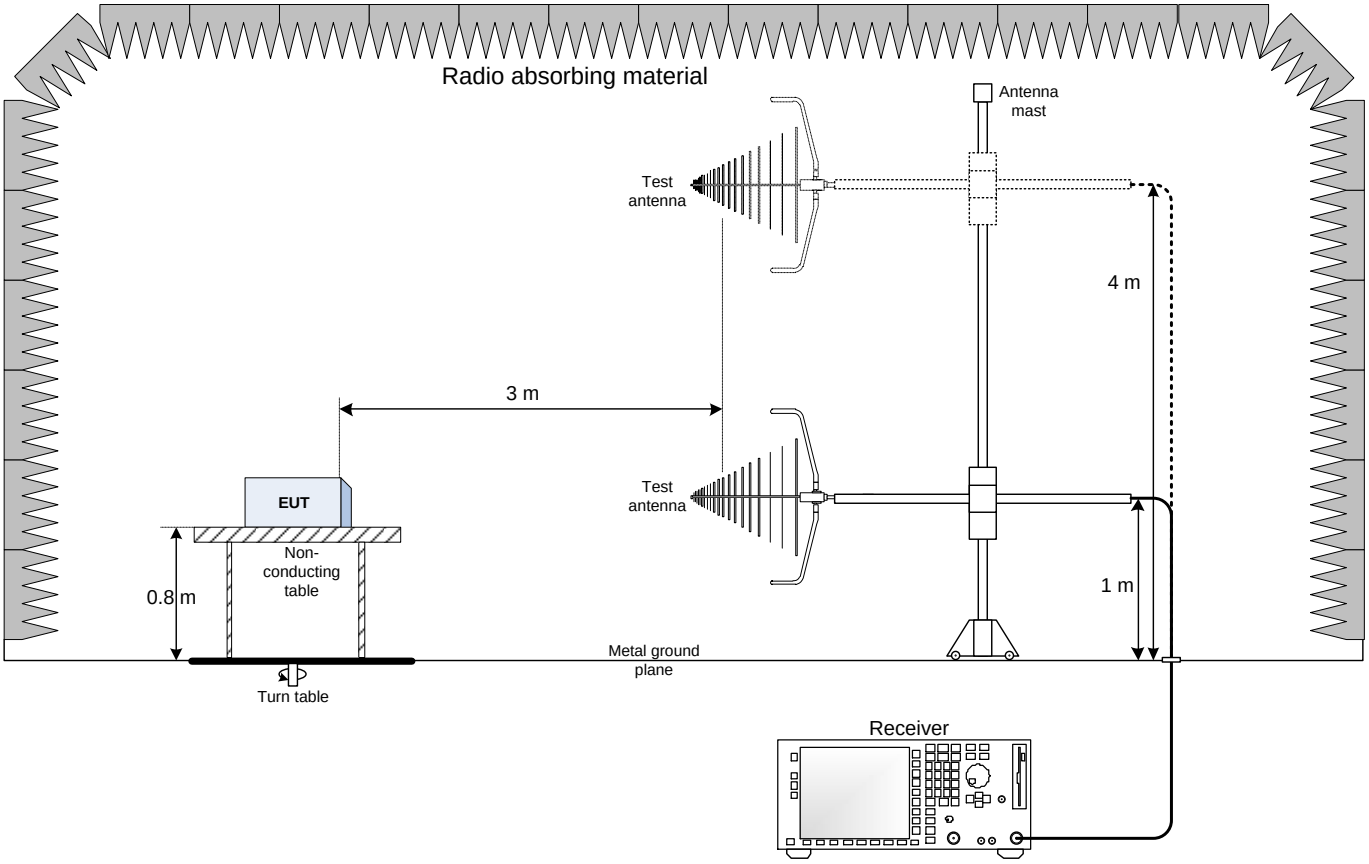
Table 8.7-2: *IC PSD-to-average calculations results*

Modulation	Frequency, MHz	PSD result, dBm/MHz	Average result, dBm	Delta dB	Limit, dB	Margin, dB
802.11a	5180	2.94	14.34	-11.40	3.00	14.40
802.11a	5200	2.99	14.78	-11.80	3.00	14.80
802.11a	5220	2.99	14.61	-11.62	3.00	14.62
802.11n HT20	5180	1.24	15.84	-14.60	3.00	17.60
802.11n HT20	5200	0.82	15.66	-14.84	3.00	17.84
802.11n HT20	5220	2.97	14.32	-11.35	3.00	14.35
802.11n HT40	5200	2.99	14.44	-11.45	3.00	14.45
802.11n HT40	5220	2.92	14.16	-11.24	3.00	14.24
802.11a	5180	2.94	14.34	-11.40	3.00	14.40

Note: Delta is calculated as follows: PSD result – Average result.

Section 9. Block diagrams of test set-ups

9.1 Radiated emissions set-up



9.2 Conducted emissions set-up