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Wireless Test Report – 387256-10R1TRFWL

Applicant:

Ring LLC

Product name:

Ring

Model:

4HB1V9

FCC ID:

2AEUPBHABV002

Specifications:

FCC 47 CFR Part 15 Subpart C, §15.247

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

Date of issue: July 7, 2020

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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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Table of contents

Table of contents	3
Section 1. Report summary	4
1.1 Applicant and manufacturer	4
1.2 Test specifications	4
1.3 Test methods	4
1.4 Exclusions	4
1.5 Statement of compliance	4
1.6 Test report revision history	4
Section 2. Summary of test results	5
2.1 Testing period	5
2.2 FCC Part 15 Subpart C, general requirements test results	5
2.3 FCC Part 15 Subpart C, intentional radiators test results for digital transmission systems (DTS)	5
Section 3. Equipment under test (EUT) details	6
3.1 Sample information	6
3.2 EUT information	6
3.3 Technical information	6
3.4 Product description and theory of operation	6
3.5 EUT exercise details	6
3.6 EUT setup diagram	7
3.7 EUT sub assemblies	7
Section 4. Engineering considerations	8
4.1 Modifications incorporated in the EUT for compliance	8
4.2 Technical judgment	8
4.3 Deviations from laboratory tests procedures	8
Section 5. Test conditions	9
5.1 Atmospheric conditions	9
5.2 Power supply range	9
Section 6. Measurement uncertainty	10
6.1 Uncertainty of measurement	10
Section 7. Test equipment	11
7.1 Test equipment list	11
Section 8. Testing data	12
8.1 FCC 15.31(e) Variation of power source	12
8.2 FCC 15.31(m) Number of frequencies	13
8.3 FCC 15.203 Antenna requirement	15
8.4 FCC 15.207(a) AC power line conducted emissions limits	16
8.5 FCC 15.247(a)(2) Minimum 6 dB bandwidth for systems using digital modulation techniques	18
8.6 FCC 15.247(b)(3)(4) Transmitter output power and e.i.r.p. requirements	22
8.7 FCC 15.247(d) Spurious (out-of-band) unwanted emissions	25
8.8 FCC 15.247(e) Power spectral density for digitally modulated devices	49
Section 9. Block diagrams of test set-ups	51
9.1 Radiated emissions set-up for frequencies below 1 GHz	51
9.2 Radiated emissions set-up for frequencies above 1 GHz	51
9.3 Conducted emissions set-up	52
9.4 Antenna port set-up	52

Section 1. Report summary

1.1 Applicant and manufacturer

Company name	Ring LLC
Address	1523 26 th Street, Santa Monica, CA, United States, 90404

1.2 Test specifications

FCC 47 CFR Part 15, Subpart C, Clause 15.247	Operation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz
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1.3 Test methods

558074 D01 15.247 Meas Guidance v05r02 (April 2, 2019)	Guidance for compliance measurements on digital transmission system, frequency hopping spread spectrum system, and hybrid system devices operating under section 15.247 of the FCC rules.
ANSI C63.10 v2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

1.4 Exclusions

None

1.5 Statement of compliance

In the configuration tested, the EUT was found compliant.

Testing was performed against all relevant requirements of the test standard except as noted in section 1.4 below. 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.

1.6 Test report revision history

Table 1.6-1: Test report revision history

Revision #	Date of issue	Details of changes made to test report
TRF	November 27, 2019	Original report issued
R1TRF	July 7, 2020	Updated product model and description/theory of operation

Section 2. Summary of test results

2.1 Testing period

Test start date	October 16, 2019
Test end date	November 11, 2019

2.2 FCC Part 15 Subpart C, general requirements test results

Table 2.2-1: FCC general requirements results

Part	Test description	Verdict
§15.207(a)	Conducted limits	Pass
§15.31(e)	Variation of power source	Pass
§15.31(m)	Number of tested frequencies	Pass
§15.203	Antenna requirement	Pass

2.3 FCC Part 15 Subpart C, intentional radiators test results for digital transmission systems (DTS)

Table 2.3-1: FCC 15.247 results for DTS

Part	Test description	Verdict
§15.247(a)(2)	Minimum 6 dB bandwidth	Pass
§15.247(b)(3)	Maximum peak output power in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands	Pass
§15.247(d)	Spurious emissions	Pass
§15.247(e)	Power spectral density	Pass

Notes: Only tests applicable to the EUT have been included in this table.

Section 3. Equipment under test (EUT) details

3.1 Sample information

Receipt date	October 16, 2019
Nemko sample ID number	Item # 1 (conducted sample), Item # 2 (radiated sample)

3.2 EUT information

Product name	Ring
Model	4HB1V9
Serial number	BHBV21931PG000001 (conducted sample), BHBV21931PG001894 (radiated sample)

3.3 Technical information

Frequency band	2400–2483.5 MHz
Frequency Min (MHz)	2412 (20 MHz), 2422 (40 MHz)
Frequency Max (MHz)	2462 (20 MHz), 2452 (40 MHz)
RF power Min (W), Conducted/ERP/EIRP	N/A
RF power Max (W), Conducted	0.047 (16.7 dBm) 20 MHz, 0.007 (8.2 dBm) 40 MHz
Field strength, Units @ distance	N/A
Measured BW (kHz) (6 dB)	17700 (20 MHz), 36400 (40 MHz)
Type of modulation	802.11b, 802.11g, 802.11n_HT20 and 802.11n_HT40
Emission classification (F1D, G1D, D1D)	W7D
Transmitter spurious, Units @ distance	7.236 GHz 58.5 dBμV/m (peak) and 4.824 GHz 53.6 dBμV/m (average) @ 3 m
Power requirements	5 V _{DC} (via external 100-240 VAC, 50/60 Hz power adapter)
Antenna information	Internal Inverted F type antenna, peak gain 3.96 dBi The EUT uses a unique antenna coupling/ non-detachable antenna to the intentional radiator.

3.4 Product description and theory of operation

Communications device using LTE, BLE, Wi-Fi, ZigBee, Z-Wave, and SimpleLink (TI1310) technologies.

3.5 EUT exercise details

The EUT was setup in continuous transmit state using Wi-Fi (2.4G band).

During the test, power setting was set at different levels as below:

Modulation	Conducted test power setting			Radiated test power setting		
	Low Channel	Mid Channel	High Channel	Low Channel	Mid Channel	High Channel
802.11b	18	18	18	18	18	18
802.11g	16	16	16	18	18	16
802.11n_HT20	15	15	15	18	18	16
802.11n_HT40	15	15	15	17	18	16

3.6 EUT setup diagram

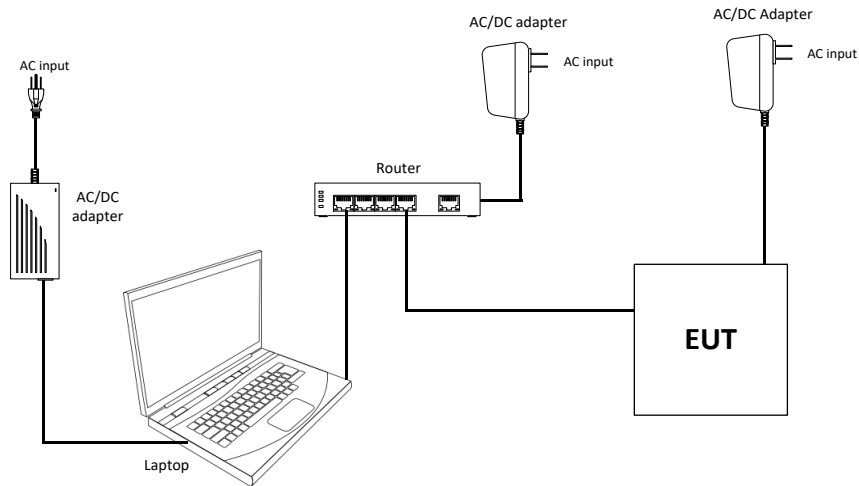


Figure 3.6-1: Setup diagram

3.7 EUT sub assemblies

Table 3.7-1: EUT sub assemblies

Description	Brand name	Model/Part number	Serial number
AC/DC Adapter	Ring	DSA-13PFG-05 050250	BHAB11930DV046916
Laptop	Dell	Inspiron 15	DW78NJ2
Router	D-Link	DIR-822	RZSC3IA001646

Section 4. Engineering considerations

4.1 Modifications incorporated in the EUT for compliance

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	86–106 kPa

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 $\pm 5\%$, for which the equipment was designed.

Section 6. Measurement uncertainty

6.1 Uncertainty of measurement

UKAS Lab 34 and TIA-603-B have been used as guidance for measurement uncertainty reasonable estimations with regards to previous experience and validation of data. Nemko Canada, Inc. follows these test methods in order to satisfy ISO/IEC 17025 requirements for estimation of uncertainty of measurement for wireless products.

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./Ver. cycle	Next cal./ver.
3 m EMI test chamber	TDK	SAC-3	FA003012	1 year	Nov. 12/19
Flush mount turntable	SUNAR	FM2022	FA003006	—	NCR
Controller	SUNAR	SC110V	FA002976	—	NCR
Antenna mast	SUNAR	TLT2	FA003007	—	NCR
Receiver/spectrum analyzer	Rohde & Schwarz	ESR26	FA002969	1 year	June 04/20
Spectrum analyzer	Rohde & Schwarz	FSW43	FA002971	1 year	June 21/20
Horn antenna (1–18 GHz)	ETS-Lindgren	3117	FA002911	1 year	Sept. 11/20
Preamplifier (1–18 GHz)	ETS-Lindgren	124334	FA002956	1 year	Sept. 26/20
Bilog antenna (30–2000 MHz)	SUNAR	JB1	FA003010	1 year	Sept. 17/20
50 Ω coax cable	Huber + Suhner	None	FA003047	1 year	Nov. 12/19
50 Ω coax cable	Huber + Suhner	None	FA003044	1 year	Nov. 12/19
Filter 2.4 – 2.4835 GHz	Microwave Circuits	N0324413	FA003027	1 year	Oct. 08/20
Horn antenna (18-25 GHz)	ETS-Lindgren	3116B	FA002948	1 year	July 09/20
Two-line v-network	Rohde & Schwarz	ENV216	FA002964	1 year	June 20/20
50 Ω coax cable	Rohde & Schwarz	None	FA003074	1 year	Dec. 21/19
AC Power source	Chroma	61605	FA003034	—	VOU

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

Section 8. Testing data

8.1 FCC 15.31(e) Variation of power source

8.1.1 Definitions and limits

FCC §15.31:

(e) For intentional radiators, measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission, as appropriate, shall be performed with the supply voltage varied between 85% and 115% of the nominal rated supply voltage. For battery operated equipment, the equipment tests shall be performed using a new battery.

8.1.2 Test date

Start date	October 16, 2019
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8.1.3 Observations, settings and special notes

The testing was performed as per ANSI C63.10 Section 5.13.

- a) Where the device is intended to be powered from an external power adapter, the voltage variations shall be applied to the input of the adapter provided with the device at the time of sale. If the device is not marketed or sold with a specific adapter, then a typical power adapter shall be used.
- b) For devices where operating at a supply voltage deviating $\pm 15\%$ from the nominal rated value may cause damages or loss of intended function, test to minimum and maximum allowable voltage per manufacturer's specification and document in the report.
- c) For devices with wide range of rated supply voltage, test at 15% below the lowest and 15% above the highest declared nominal rated supply voltage.
- d) For devices obtaining power from an input/output (I/O) port (USB, firewire, etc.), a test jig is necessary to apply voltage variation to the device from a support power supply, while maintaining the functionalities of the device.

For battery-operated equipment, the equipment tests shall be performed using a variable power supply.

8.1.4 Test data

The EUT AC Input supply voltage was varied between 85% and 115% of the nominal rated supply voltage. No change to transmitter performance was observed.

8.2 FCC 15.31(m) Number of frequencies

8.2.1 Definitions and limits

FCC §15.31:

(m) Measurements on intentional radiators or receivers, other than TV broadcast receivers, shall be performed and, if required, reported for each band in which the device can be operated with the device operating at the number of frequencies in each band specified in the following table:

Table 8.2-1: Frequency Range of Operation

Frequency range over which the device operates (in each band)	Number of test frequencies required	Location of measurement frequency inside the operating frequency range
1 MHz or less	1	Center (middle of the band)
1–10 MHz	2	1 near high end, 1 near low end
Greater than 10 MHz	3	1 near high end, 1 near center and 1 near low end

Notes: “near” means as close as possible to or at the centre / low end / high end of the frequency range over which the device operates.

8.2.2 Test date

Start date October 16, 2019

8.2.3 Observations, settings and special notes

Per ANSI C63.10 Subclause 5.6.2.1:

The number of channels tested can be reduced by measuring the center channel bandwidth first and then applying the following relaxations as appropriate:

- For each operating mode, if the measured channel bandwidth on the middle channel is at least 150% of the minimum permitted bandwidth, then it is not necessary to measure the bandwidth on the high and low channels.
- For multiple-input multiple-output (MIMO) systems, if the measured channel bandwidth on testing the middle channel exceeds the minimum permitted bandwidth by more than 50% on one transmit chain, then it is not necessary to repeat testing on the other chains.
- If the measured channel bandwidth on the middle channel is less than 50% of the maximum permitted bandwidth, then it is not necessary to measure the bandwidth on the high and low channels.

Per ANSI C63.10 Subclause 5.6.2.2:

For devices with multiple operating modes, measurements on the middle channel can be used to determine the worst-case mode(s). The worst-case modes are as follows:

- Band edge requirements—Measurements on the mode with the widest bandwidth can be used to cover the same channel (center frequency) on modes with narrower bandwidth that have the same or lower output power for each modulation family (e.g., OFDM and direct sequence spread spectrum).
- Spurious emissions—Measure the mode with the highest output power and the mode with the highest output power spectral density for each modulation family (e.g., OFDM and direct sequence spread spectrum).
- In-band PSD—Measurements on the mode with the narrowest bandwidth can be used to cover all modes within the same modulation family of an equal or lower output power provided the result is less than 50% of the limit.

8.2.4 Test data

Table 8.2-2: Test channels selection 20 MHz Channels

Start of Frequency range, MHz	End of Frequency range, MHz	Frequency range bandwidth, MHz	Low channel, MHz	Mid channel, MHz	High channel, MHz
2400	2483.5	83.5	2412	2437	2462

Table 8.2-3: Test channels selection 40 MHz Channels

Start of Frequency range, MHz	End of Frequency range, MHz	Frequency range bandwidth, MHz	Low channel, MHz	Mid channel, MHz	High channel, MHz
2400	2483.5	83.5	2422	2447	2452

8.3 FCC 15.203 Antenna requirement

8.3.1 Definitions and limits

FCC §15.203:

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with §15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this part are not exceeded.

8.3.2 Test date

Start date October 16, 2019

8.3.3 Observations, settings and special notes

None

8.3.4 Test data

- The EUT has an internal integrated antenna, non-detachable.
- The EUT will not be professionally installed

8.4 FCC 15.207(a) AC power line conducted emissions limits

8.4.1 Definitions and limits

FCC §15.207:

- a) 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 μ H/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.

ANSI: C63.10 subclause 6.2

If the EUT normally receives power from another device that in turn connects to the public utility ac power lines, measurements shall be made on that device with the EUT in operation to demonstrate that the device continues to comply with the appropriate limits while providing the EUT with power.

If the EUT is

operated only from internal or dedicated batteries, with no provisions for connection to the public utility ac power lines (600 VAC or less) to operate the EUT (such as an adapter), then ac power-line conducted measurements are not required.

For direct current (dc) powered devices where the ac power adapter is not supplied with the device, an "off-the-shelf" unmodified ac power adapter shall be used. If the device is supposed to be installed in a host (e.g., the device is a module or PC card), then it is tested in a typical compliant host.

Table 8.4-1: AC power line conducted emissions limit

Frequency of emission, MHz	Quasi-peak	Conducted limit, dB μ V	Average**
0.15–0.5	66 to 56*		56 to 46*
0.5–5	56		46
5–30	60		50

Notes: * - The level decreases linearly with the logarithm of the frequency.

** - A linear average detector is required.

8.4.2 Test date

Start date November 11, 2019

8.4.3 Observations, settings and special notes

Port under test – Coupling device	AC Input – Artificial Mains Network (AMN)
EUT power input during test	5 V _{DC} (Powered via external power adapter @ 120 V _{AC} 60 Hz)
EUT setup configuration	Table top
Measurement details	<ul style="list-style-type: none"> A preview measurement was generated with the receiver in continuous scan mode. Emissions detected within 10 dB or above the limit were re-measured with the appropriate detector against the correlating limit and recorded as the final measurement. No conducted emissions were overserved within 10 dB of limit. The spectral plots have been corrected with transducer factors.

Receiver settings:

Resolution bandwidth	9 kHz
Video bandwidth	30 kHz
Detector mode	Peak and Average (Preview measurement), Quasi-peak and CAverage (Final measurement)
Trace mode	Max Hold
Measurement time	<ul style="list-style-type: none"> 100 ms (Peak and Average preview measurement) 100 ms (Quasi-peak final measurement) 160 ms (CAverage final measurement)

8.4.4 Test data

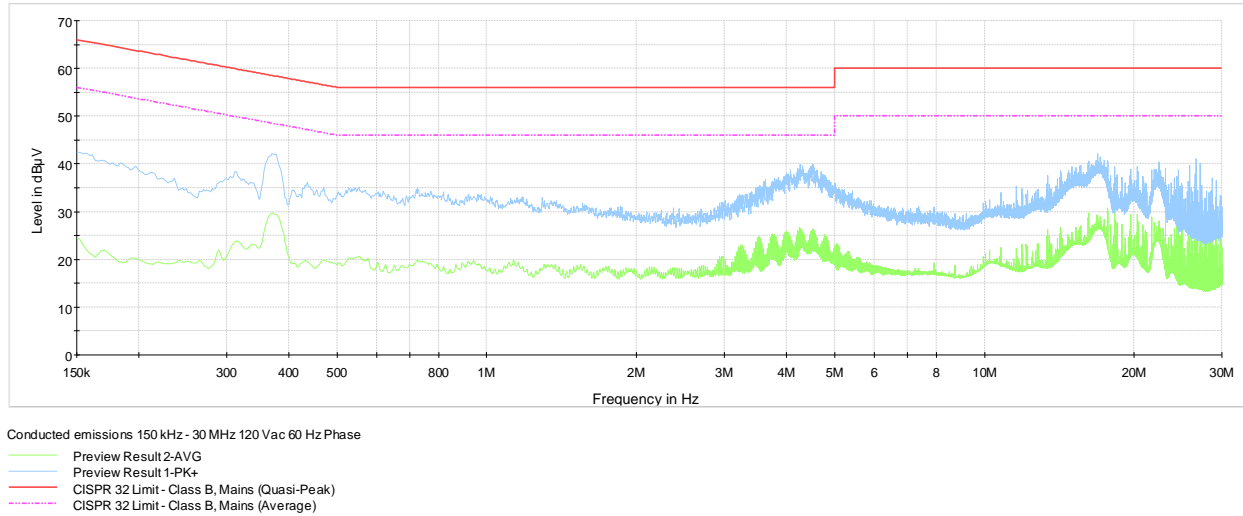


Figure 8.4-1: AC power line conducted emissions – spectral plot on phase line

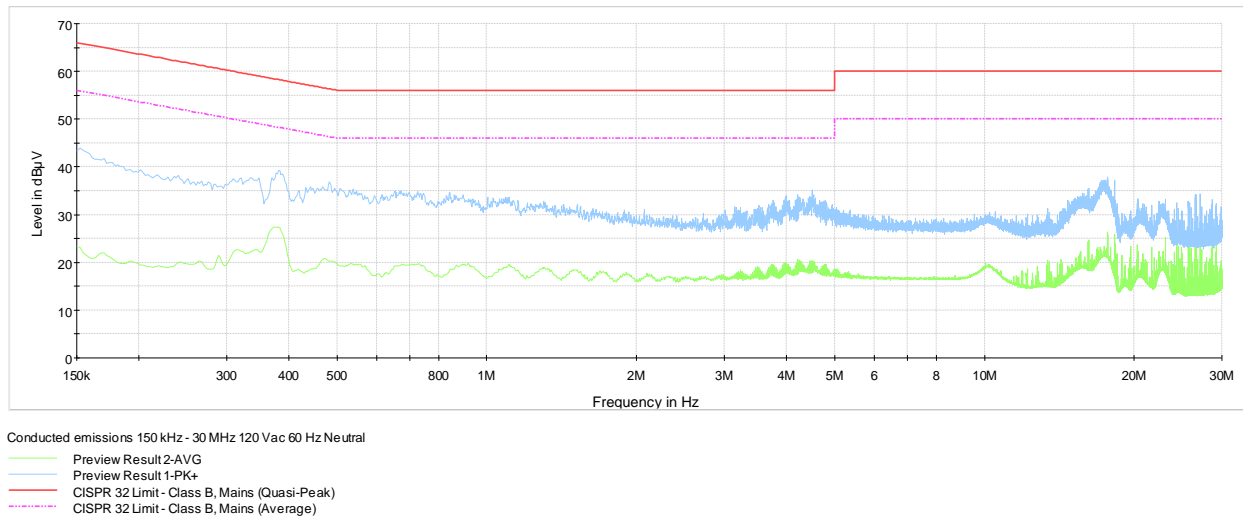


Figure 8.4-2: AC power line conducted emissions – spectral plot on neutral line

8.5 FCC 15.247(a)(2) Minimum 6 dB bandwidth for systems using digital modulation techniques

8.5.1 Definitions and limits

FCC §15.247 (a)(2):

- (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.

8.5.2 Test date

Start date	November 8, 2019
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8.5.3 Observations, settings and special notes

The test was performed as per KDB 558074, section 8.2 with reference to ANSI C63.10 subclause 11.8.

Spectrum analyser settings:

Resolution bandwidth	100 kHz
Video bandwidth	$\geq 3 \times \text{RBW}$
Frequency span	30 MHz for 20 MHz channel; 100 MHz for 40 MHz channel
Detector mode	Peak
Trace mode	Max Hold

8.5.4 Test data

Table 8.5-1: 6 dB bandwidth results

Modulation	Frequency, MHz	6 dB bandwidth, MHz	Minimum limit, MHz	Margin, MHz
802.11b	2412	10.1	0.5	9.6
	2437	10.1	0.5	9.6
	2462	10.1	0.5	9.6
802.11g	2412	16.5	0.5	16.0
	2437	16.5	0.5	16.0
	2462	16.5	0.5	16.0
802.11n HT20	2412	17.7	0.5	17.2
	2437	17.7	0.5	17.2
	2462	17.7	0.5	17.2
802.11n HT40	2422	36.4	0.5	35.9
	2447	36.3	0.5	35.8
	2452	36.4	0.5	35.9

Notes: None

Table 8.5-2: 99% Occupied bandwidth results

Modulation	Frequency, MHz	99% Occupied bandwidth, MHz
802.11b	2412	13.6
	2437	13.5
	2462	13.5
802.11g	2412	16.4
	2437	16.4
	2462	16.4
802.11n HT20	2412	17.6
	2437	17.6
	2462	17.6
802.11n HT40	2422	36.1
	2447	36.1
	2452	36.0

Notes: There is no 99% occupied bandwidth limit in the standard's requirements, the measurement results provided for information purposes only.

8.5.4 Test data, continued

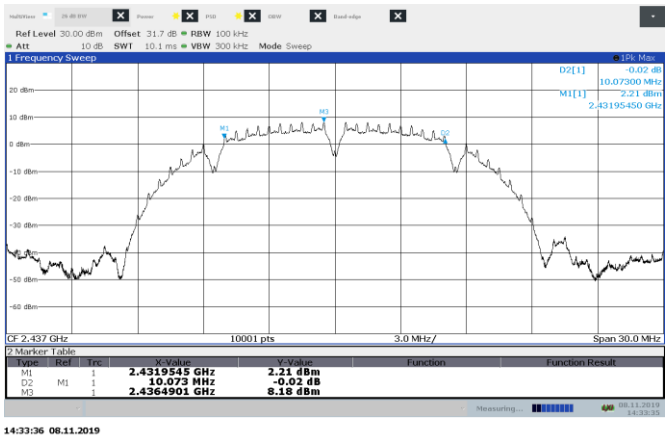


Figure 8.5-1: 6 dB bandwidth on 802.11b, sample plot

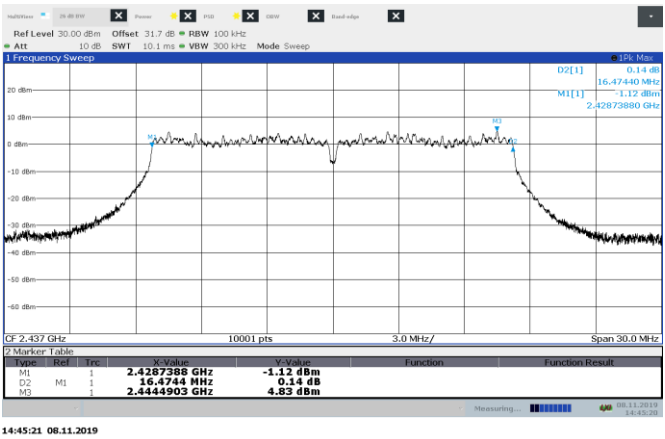


Figure 8.5-2: 6 dB bandwidth on 802.11g, sample plot

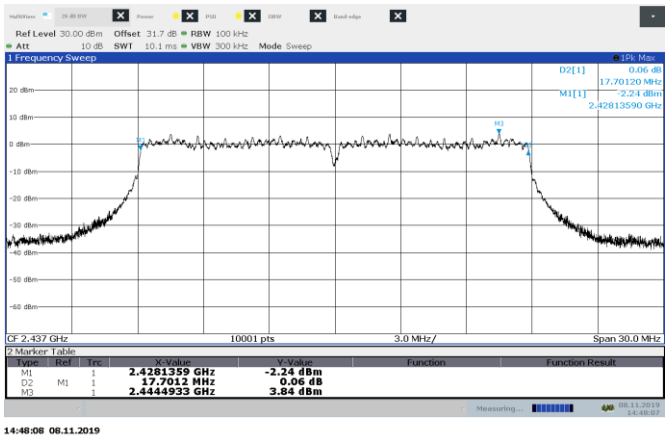


Figure 8.5-3: 6 dB bandwidth on 802.11n HT20, sample plot

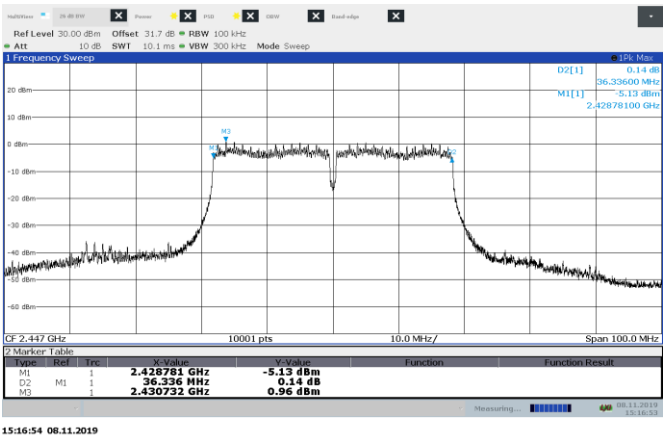


Figure 8.5-4: 6 dB bandwidth on 802.11n HT40, sample plot