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EMC Test Report

Application for FCC Grant of Equipment Authorization
Canada Certification
Class II Permissive Change/Reassessment

Innovation, Science and Economic Development Canada
RSS-Gen Issue 5 / RSS-247 Issue 2
FCC Part 15, Subpart E

Model: BotVac D7 Connected

IC CERTIFICATION #:	12757A-LVJPJ
FCC ID:	2ABSSLVJPJ
APPLICANT:	Neato Robotics 8100 Jarvis Avenue, Suite 100 Newark, CA 94560
TEST SITE(S):	National Technical Systems 41039 Boyce Road. Fremont, CA. 94538-2435
IC SITE REGISTRATION #:	2845B-4
PROJECT NUMBER:	PR087406
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FINAL TEST DATES:	December 11, 13, 14 and 17, 2018
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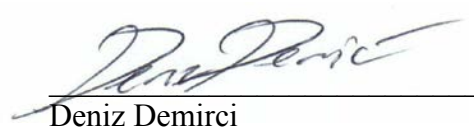
ACCREDITED
Testing Cert #0214.26

VALIDATING SIGNATORIES

PROGRAM MGR



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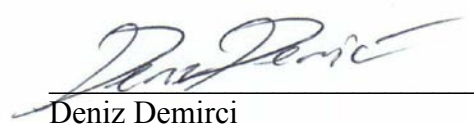

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REVISION HISTORY

Rev#	Date	Comments	Modified By
-	January 11, 2019	First release	

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SCOPE

An electromagnetic emissions test has been performed on the Neato Robotics model BotVac D7 Connected, pursuant to the following rules:

RSS-Gen Issue 5 " General Requirements for Compliance of Radio Apparatus"
RSS 247 Issue 2 "Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSS) and Licence-Exempt Local Area Network (LE-LAN) Devices"
FCC Part 15, Subpart E requirements for UNII Devices

Conducted and radiated emissions data has been collected, reduced, and analyzed within this report in accordance with measurement guidelines set forth in the following reference standards and as outlined in National Technical Systems test procedures:

FCC General UNII Test Procedures KDB789033

The intentional radiator above has been tested in a simulated typical installation to demonstrate compliance with the relevant Industry Canada performance and procedural standards.

Final system data was gathered in a mode that tended to maximize emissions by varying orientation of EUT, orientation of power and I/O cabling, antenna search height, and antenna polarization.

Every practical effort was made to perform an impartial test using appropriate test equipment of known calibration. All pertinent factors have been applied to reach the determination of compliance.

National Technical Systems is accredited by the A2LA, certificate number 0214.26, to perform the test(s) listed in this report, except where noted otherwise.

OBJECTIVE

The primary objective of the manufacturer is compliance with the regulations outlined in the previous section.

Prior to marketing in the USA, all unlicensed transmitters and transceivers require certification. Receive-only devices operating between 30 MHz and 960 MHz are subject to either certification or a manufacturer's declaration of conformity, with all other receive-only devices exempt from the technical requirements.

Prior to marketing in Canada, Class I transmitters, receivers and transceivers require certification. Class II devices are required to meet the appropriate technical requirements but are exempt from certification requirements.

Certification is a procedure where the manufacturer submits test data and technical information to a certification body and receives a certificate or grant of equipment authorization upon successful completion of the certification body's review of the submitted documents. Once the equipment authorization has been obtained, the label indicating compliance must be attached to all identical units, which are subsequently manufactured.

Maintenance of compliance is the responsibility of the manufacturer. Any modification of the product which may result in increased emissions should be checked to ensure compliance has been maintained (i.e., printed circuit board layout changes, different line filter, different power supply, harnessing or I/O cable changes, etc.).

STATEMENT OF COMPLIANCE

The tested sample of Neato Robotics model BotVac D7 Connected complied with the requirements of the following regulations:

RSS 247 Issue 2 "Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSS) and Licence-Exempt Local Area Network (LE-LAN) Devices"
FCC Part 15, Subpart E requirements for UNII Devices

Maintenance of compliance is the responsibility of the manufacturer. Any modifications to the product should be assessed to determine their potential impact on the compliance status of the device with respect to the standards detailed in this test report.

The test results recorded herein are based on a single type test of Neato Robotics model BotVac D7 Connected and therefore apply only to the tested sample. The sample was selected and prepared by Kelvin Law of Neato Robotics.

DEVIATIONS FROM THE STANDARDS

No deviations were made from the published requirements listed in the scope of this report.

TEST RESULTS SUMMARY

UNII / LELAN DEVICES

OPERATION IN THE 5.725 – 5.85 GHZ BAND

FCC Rule Part	RSS Rule Part	Description	Measured Value / Comments	Limit / Requirement	Result (margin)
15.407(e)	RSS-247 6.2.4 (1)	6 dB Bandwidth	n20: 15.083 MHz	≥ 500 kHz	Complies
15.407(a) (3)	RSS-210 A9.2(2)	Output Power (multipoint systems)	n20: 12.6 dBm (Max eirp: 0.019 W)	30 dBm (1 W) EIRP ≤ 4 W	Complies
15.407(a) (3)	RSS-247 6.2.3 (1)	Power Spectral Density	n20: 2.3 dBm/MHz	30 dBm / 500 kHz	Complies
15.407(b) (4) / 15.209	RSS-247 6.2.4 (2)	Spurious Emissions above 1 GHz	53.9 dBµV/m @ 22979.7 MHz (-0.1 dB)	Refer to the limits section (p21) for restricted bands, all others -17 dBm/MHz EIRP band edge and -27 dBm/MHz EIRP	Complies

REQUIREMENTS FOR ALL U-NII/LELAN BANDS

FCC Rule Part	RSS Rule Part	Description	Measured Value / Comments	Limit / Requirement	Result
15.407	RSS-247 6.1	Modulation	Digital Modulation is used (OFDM)	Digital modulation is required	Complies
15.407(b) (6) / 15.209	RSS-247 6.2.1 (2)	Spurious Emissions below 1 GHz		Refer to page 22	Complies
15.31 (m)	RSS-247 6.4 (1) RSS-Gen 6.9	Channel Selection	Emissions tested at outermost and middle channels in each band	Device was tested on the top, bottom and center channels in each band	N/A
15.407 (c)	RSS-247 6.4 (2)	Operation in the absence of information to transmit	Operation is discontinued in the absence of information (Refer to operational Description exhibit)	Device shall automatically discontinue operation in the absence of information to transmit	Complies
15.407 (g)		Frequency Stability	No change from original filing.	Signal shall remain within the allocated band	Complies
15.407 (h1)	RSS-247 6.2.2 (1) 6.2.3 (1)	Transmit Power Control	TPC is not required as the device does not operate at 5250 – 5350 MHz and 5470 – 5725 MHz bands.	The U-NII device shall have the capability to operate with a mean EIRP value lower than 24 dBm (250mW)	Complies
15.407 (h2)	RSS-247 6.3	Dynamic frequency Selection (device with radar detection)	Device does not operate in either 5470 – 5725 or 5250 – 5350 MHz bands.		N/A
FCC Rule Part	RSS Rule Part	Description	Measured Value / Comments	Limit / Requirement	Result

FCC Rule Part	RSS Rule Part	Description	Measured Value / Comments	Limit / Requirement	Result
	RSS-247 6.4 (5)	User manual information	Refer to manual for details	Warning regarding Tilt angle for EIRP compliance, Indoor use for 5150-5250 MHz band and Radar are primary user of some bands	Complies

GENERAL REQUIREMENTS APPLICABLE TO ALL BANDS

FCC Rule Part	RSS Rule part	Description	Measured Value / Comments	Limit / Requirement	Result (margin)
15.203	-	RF Connector	Integral antenna	Unique or integral antenna required	Complies
15.407 (b) (6)	RSS-Gen Table 4	AC Conducted Emissions	28.6 dBµV @ 0.485 MHz (-17.6 dB)	Refer to result pages	Complies
15.247 (i) 15.407 (f)	RSS 102	RF Exposure Requirements	Refer to MPE calculations in separate exhibit, RSS 102 declaration and User Manual statements.	Refer to OET 65, FCC Part 1 and RSS 102	Complies
-	RSS-Gen 6.8	User Manual	Integral antenna	Statement for products with detachable antenna	Complies
-	RSS-Gen 8.4	User Manual		Statement for all products	Complies
-	RSP-100 RSS-Gen 6.7	Occupied Bandwidth	n20: 18.802 MHz	Information only	N/A

MEASUREMENT UNCERTAINTIES

ISO/IEC 17025 requires that an estimate of the measurement uncertainties associated with the emissions test results be included in the report. The measurement uncertainties given below are based on a 95% confidence level and were calculated in accordance with UKAS document LAB 34.

Measurement Type	Measurement Unit	Frequency Range	Expanded Uncertainty
RF power, conducted (power meter)	dBm	25 to 7000 MHz	± 0.5 dB
RF power, conducted (Spectrum analyzer)	dBm	25 to 7000 MHz	± 0.7 dB
Conducted emission of transmitter	dBm	25 to 26500 MHz	± 0.7 dB
Radiated emission (field strength)	dBµV/m	25 to 1000 MHz	± 3.6 dB
		1000 to 40000 MHz	± 6.0 dB
Conducted Emissions (AC Power)	dBµV	0.15 to 30 MHz	± 2.4 dB

EQUIPMENT UNDER TEST (EUT) DETAILS

GENERAL

The Neato Robotics model BotVac D7 Connected is a Robotic Vacuum cleaner. It is a floor standing equipment. The EUT is positioned on the table, above the ground plane in order to get accurate measurement results and in conformance with ANSI C63.10 requirement. The electrical rating of the EUT is 100-240 Volts, 50/60 Hz, 0.5 Amps.

The sample was received on December 11, 2018 and tested on December 11, 13, 14 and 17, 2018. The EUT consisted of the following component(s):

Company	Model	Description	Serial Number	FCC ID
Neato Robotics	Botvac D7 Connected	Robotic Vacuum cleaner	IC9E (Conducted sample) OPS34417-E8EB111669A0 (Radiated sample)	FCC ID: 2ABSSLVJPJ IC: 12757A-LVJPJ
Neato Robotics	DELTA Power Charger	Battery Charger	-	-

ANTENNA SYSTEM

Internal antenna (chip) with maximum 0.1 dBi gain at 5725 – 5850 MHz operating range.

ENCLOSURE

The EUT enclosure is primarily constructed of plastic. It measures approximately 34 cm wide by 32 cm deep by 8 cm high.

MODIFICATIONS

No modifications were made to the EUT during the time the product was at NTS Silicon Valley.

SUPPORT EQUIPMENT

No support equipment was used during testing.

The following equipment was used as remote support equipment for emissions testing:

Company	Model	Description	Serial Number	FCC ID
DELL	Latitude	Laptop		

Note: The computer was used to configure the EUT for radio testing. It was not connected to the EUT during radiated emission tests.

EUT INTERFACE PORTS

The I/O cabling configuration during testing was as follows:

Port	Connected To	Cable(s)		
		Description	Shielded or Unshielded	Length(m)
None	-	-	-	-

EUT OPERATION

During emissions testing the EUT was transmitting in a rated power and modulation specified in the test cases.

TEST SITE

GENERAL INFORMATION

Final test measurements were taken at the test sites listed below. Pursuant to section 2.948 of the FCC's Rules and section 3.3 of RSP-100, construction, calibration, and equipment data has been filed with the Commission and with industry Canada.

Site	Designation / Registration Numbers		Location
	FCC	Canada	
Chamber 4	US0027	2845B-4	41039 Boyce Road Fremont, CA 94538-2435

ANSI C63.4 recommends that ambient noise at the test site be at least 6 dB below the allowable limits. Ambient levels are below this requirement. The test site(s) contain separate areas for radiated and conducted emissions testing. Results from testing performed in this chamber have been correlated with results from an open area test site. Considerable engineering effort has been expended to ensure that the facilities conform to all pertinent requirements of ANSI C63.4.

CONDUCTED EMISSIONS CONSIDERATIONS

Conducted emissions testing is performed in conformance with ANSI C63.10. Measurements are made with the EUT connected to the public power network through a nominal, standardized RF impedance, which is provided by a line impedance stabilization network, known as a LISN. A LISN is inserted in series with each current-carrying conductor in the EUT power cord.

RADIATED EMISSIONS CONSIDERATIONS

The FCC has determined that radiation measurements made in a shielded enclosure are not suitable for determining levels of radiated emissions. Radiated measurements are performed in an open field environment or in a semi-anechoic chamber. The test sites are maintained free of conductive objects within the CISPR defined elliptical area incorporated in ANSI C63.4 guidelines and meet the Normalized Site Attenuation (NSA) requirements of ANSI C63.4.

MEASUREMENT INSTRUMENTATION

RECEIVER SYSTEM

An EMI receiver as specified in CISPR 16-1-1 is used for emissions measurements. The receivers used can measure over the frequency range of 9 kHz up to 2000 MHz. These receivers allow both ease of measurement and high accuracy to be achieved. The receivers have Peak, Average, and CISPR (Quasi-peak) detectors built into their design so no external adapters are necessary. The receiver automatically sets the required bandwidth for the CISPR detector used during measurements. If the repetition frequency of the signal being measured is below 20 Hz, peak measurements are made in lieu of Quasi-Peak measurements.

For measurements above the frequency range of the receivers, a spectrum analyzer is utilized because it provides visibility of the entire spectrum along with the precision and versatility required to support engineering analysis. Average measurements above 1000 MHz are performed on the spectrum analyzer using the linear-average method with a resolution bandwidth of 1 MHz and a video bandwidth of 10 Hz, unless the signal is pulsed in which case the average (or video) bandwidth of the measuring instrument is reduced to onset of pulse desensitization and then increased.

INSTRUMENT CONTROL COMPUTER

Software is used to view and convert receiver measurements to the field strength at an antenna or voltage developed at the LISN measurement port, which is then compared directly with the appropriate specification limit. This provides faster, more accurate readings by performing the conversions described under Sample Calculations within the Test Procedures section of this report. Results are printed in a graphic and/or tabular format, as appropriate. A personal computer is used to record all measurements made with the receivers. The software used for radiated and conducted emissions measurements is NTS EMI Test Software (rev 2.10)

LINE IMPEDANCE STABILIZATION NETWORK (LISN)

Line conducted measurements utilize a 50 µH Line Impedance Stabilization Network as the monitoring point. The LISN used also contains a 250 µH CISPR adapter. This network provides for calibrated radio frequency noise measurements by the design of the internal low pass and high pass filters on the EUT and measurement ports, respectively.

FILTERS/ATTENUATORS

External filters and precision attenuators are often connected between the receiving antenna or LISN and the receiver. This eliminates saturation effects and non-linear operation due to high amplitude transient events.

ANTENNAS

A loop antenna is used below 30 MHz. For the measurement range 30 MHz to 1000 MHz either a combination of a biconical antenna and a log periodic or a bi-log antenna is used. Above 1000 MHz, horn antennas are used. The antenna calibration factors to convert the received voltage to an electric field strength are included with appropriate cable loss and amplifier gain factors to determine an overall site factor, which is then programmed into the test receivers or incorporated into the test software.

ANTENNA MAST AND EQUIPMENT TURNTABLE

The antennas used to measure the radiated electric field strength are mounted on a non-conductive antenna mast equipped with a motor-drive to vary the antenna height. Measurements below 30 MHz are made with the loop antenna at a fixed height of 1m above the ground plane.

ANSI C63.10 specifies that the test height above ground for table mounted devices shall be 80 centimeters for testing below 1 GHz and 1.5 m for testing above 1 GHz. During radiated measurements, the EUT is positioned on a motorized turntable in conformance with this requirement.

INSTRUMENT CALIBRATION

All test equipment is regularly checked to ensure that performance is maintained in accordance with the manufacturer's specifications. All antennas are calibrated at regular intervals with respect to tuned half-wave dipoles. An exhibit of this report contains the list of test equipment used and calibration information.

TEST PROCEDURES

EUT AND CABLE PLACEMENT

The regulations require that interconnecting cables be connected to the available ports of the unit and that the placement of the unit and the attached cables simulate the worst case orientation that can be expected from a typical installation, so far as practicable. To this end, the position of the unit and associated cabling is varied within the guidelines of ANSI C63.10, and the worst-case orientation is used for final measurements.

CONDUCTED EMISSIONS

Conducted emissions are measured at the plug end of the power cord supplied with the EUT. Excess power cord length is wrapped in a bundle between 30 and 40 cm in length near the center of the cord. Preliminary measurements are made to determine the highest amplitude emission relative to the specification limit for all the modes of operation. Placement of system components and varying of cable positions are performed in each mode. A final peak mode scan is then performed in the position and mode for which the highest emission was noted on all current carrying conductors of the power cord.

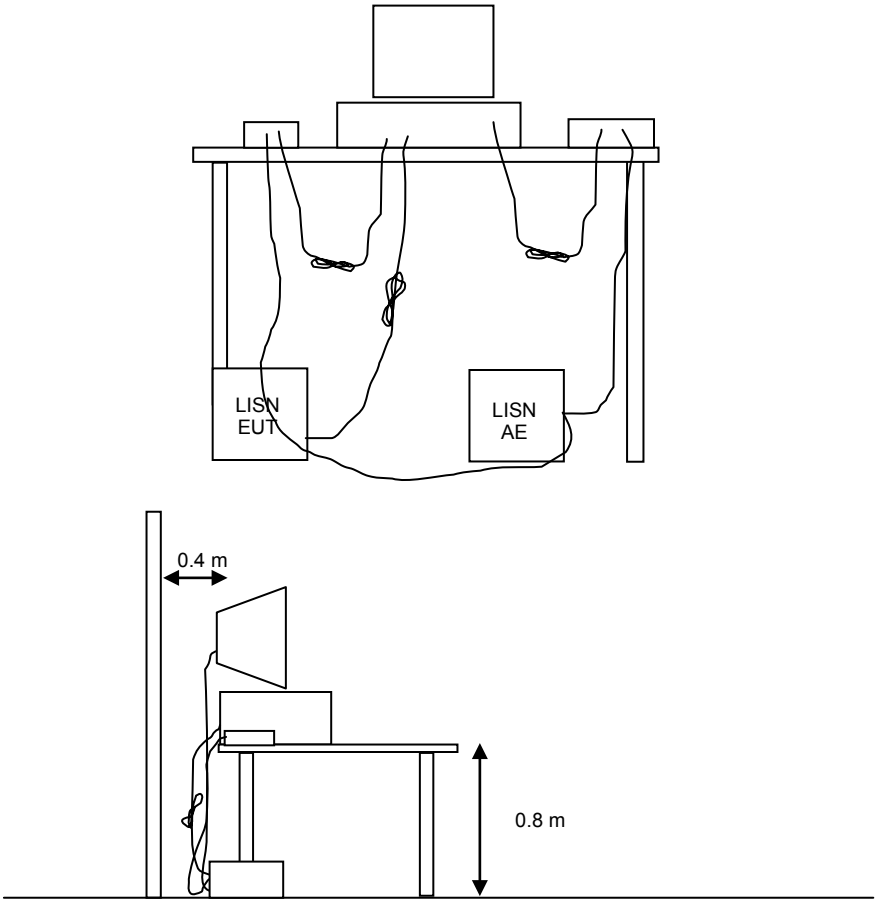


Figure 1 Typical Conducted Emissions Test Configuration

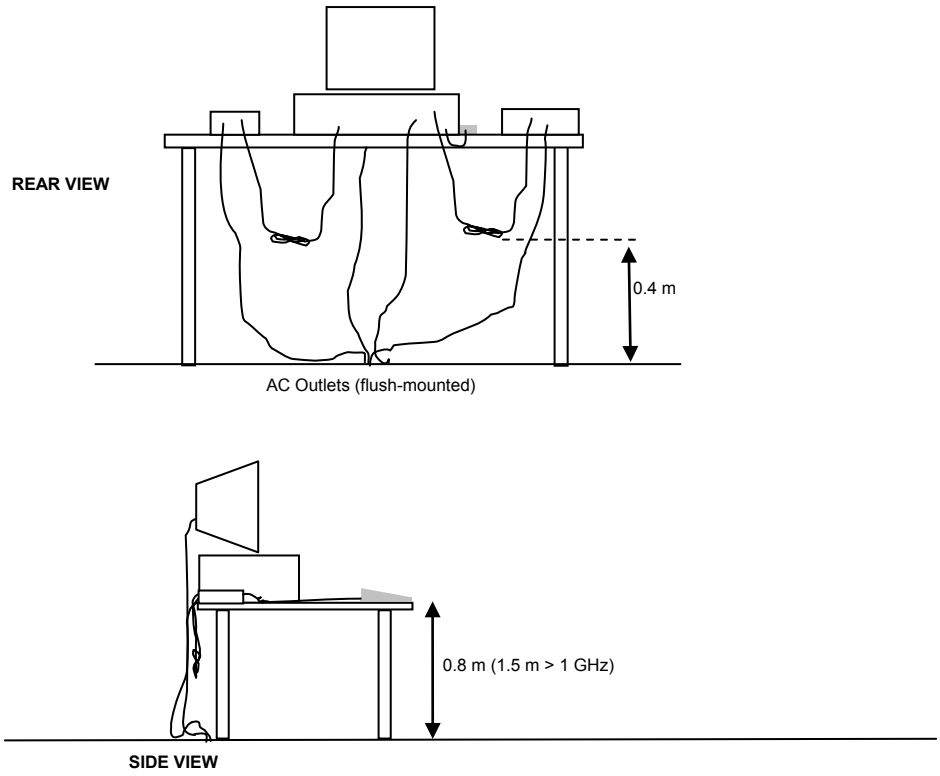
RADIATED EMISSIONS

A preliminary scan of the radiated emissions is performed in which all significant EUT frequencies are identified with the system in a nominal configuration. At least two scans are performed, one scan for each antenna polarization (horizontal and vertical; loop parallel and perpendicular to the EUT). During the preliminary scans, the EUT is rotated through 360˚, the antenna height is varied (for measurements above 30 MHz) and cable positions are varied to determine the highest emission relative to the limit. Preliminary scans may be performed in a fully anechoic chamber for the purposes of identifying the frequencies of the highest emissions from the EUT.

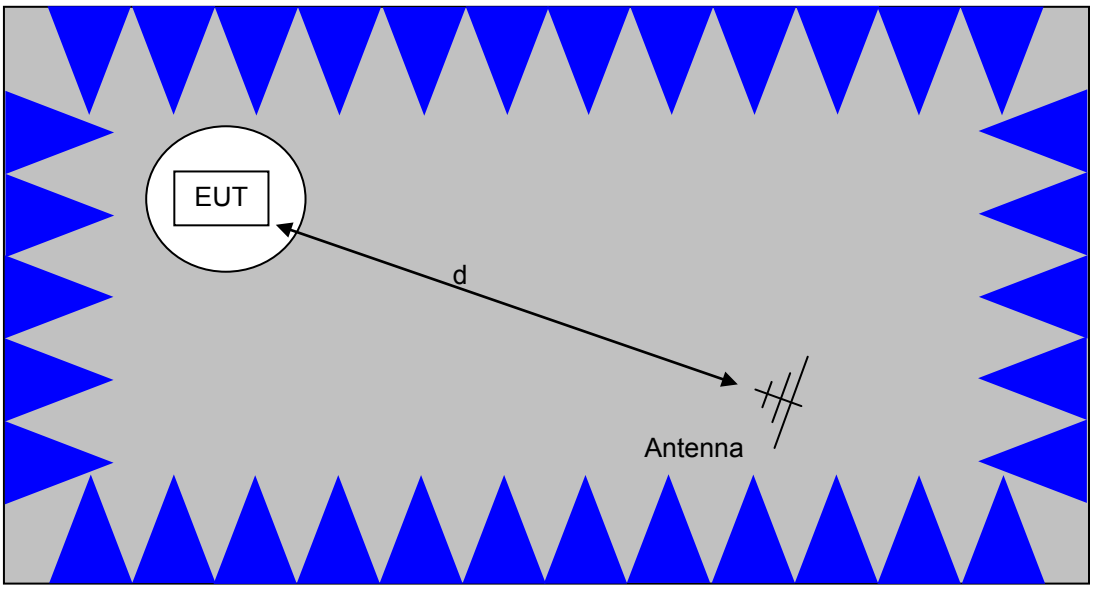
A speaker is provided in the receiver to aid in discriminating between EUT and ambient emissions. Other methods used during the preliminary scan for EUT emissions involve scanning with near field magnetic loops, monitoring I/O cables with RF current clamps, and cycling power to the EUT.

Final maximization is a phase in which the highest amplitude emissions identified in the spectral search are viewed while the EUT azimuth angle is varied from 0 to 360 degrees relative to the receiving antenna. The azimuth, which results in the highest emission is then maintained while varying the antenna height from 1 to 4 m (for measurements above 30 MHz, measurements below 30 MHz are made with the loop antenna at a fixed height of 1m). The result is the identification of the highest amplitude for each of the highest peaks. Each recorded level is corrected in the receiver using appropriate factors for cables, connectors, antennas, and preamplifier gain.

When testing above 18 GHz, the receive antenna is located at 1meter from the EUT and the antenna height is restricted to a maximum of 2.5 m.

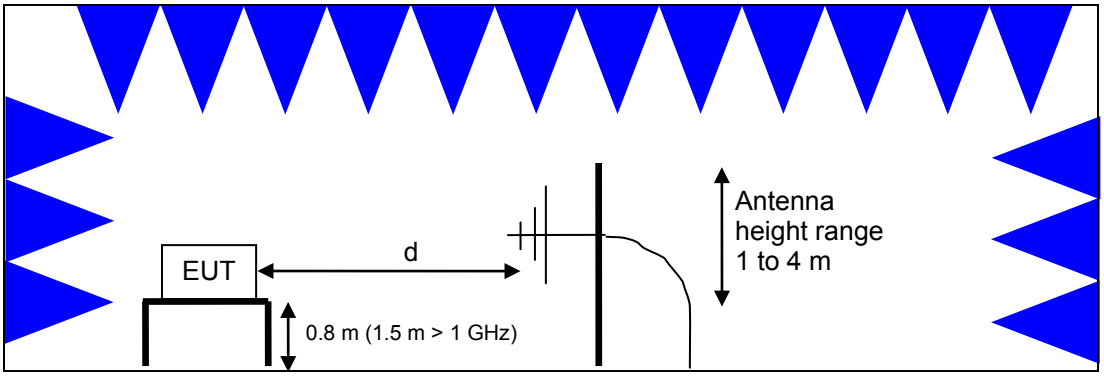


Typical Test Configuration for Radiated Field Strength Measurements



The anechoic materials on the walls and ceiling ensure compliance with the normalized site attenuation requirements of CISPR 16 / CISPR 22 / ANSI C63.4 for an alternate test site at the measurement distances used.

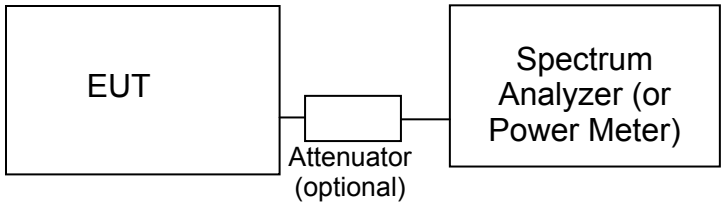
Floor-standing equipment is placed on the floor with insulating supports between the unit and the ground plane.



Test Configuration for Radiated Field Strength Measurements
Semi-Anechoic Chamber, Plan and Side Views

CONDUCTED EMISSIONS FROM ANTENNA PORT

Direct measurements of power, bandwidth and power spectral density are performed, where possible, with the antenna port of the EUT connected to either the power meter or spectrum analyzer via a suitable attenuator and/or filter. These are used to ensure that the front end of the measurement instrument is not overloaded by the fundamental transmission.



Test Configuration for Antenna Port Measurements

Measurement bandwidths (video and resolution) are set in accordance with the relevant standards and NTS Silicon Valley's test procedures for the type of radio being tested. When power measurements are made using a resolution bandwidth less than the signal bandwidth the power is calculated by summing the power across the signal bandwidth using either the analyzer channel power function or by capturing the trace data and calculating the power using software. In both cases the summed power is corrected to account for the equivalent noise bandwidth (ENBW) of the resolution bandwidth used.

If power averaging is used (typically for certain digital modulation techniques), the EUT is configured to transmit continuously. Power averaging is performed using either the built-in function of the analyzer or, if the analyzer does not feature power averaging, using external software. In both cases the average power is calculated over a number of sweeps (typically 100). When the EUT cannot be configured to continuously transmit then either the analyzer is configured to perform a gated sweep to ensure that the power is averaged over periods that the device is transmitting or power averaging is disabled and a max-hold feature is used.

If a power meter is used to make output power measurements the sensor head type (peak or average) is stated in the test data table.

BANDWIDTH MEASUREMENTS

The 6 dB, 20 dB, 26 dB and/or 99% signal bandwidth are measured using the bandwidths recommended by ANSI C63.10 and RSS GEN.

SPECIFICATION LIMITS AND SAMPLE CALCULATIONS

The limits for conducted emissions are given in units of microvolts, and the limits for radiated emissions are given in units of microvolts per meter at a specified test distance. Data is measured in the logarithmic form of decibels relative to one microvolt, or dB microvolts (dBµV). For radiated emissions, the measured data is converted to the field strength at the antenna in dB microvolts per meter (dBµV/m). The results are then converted to the linear forms of µV and uV/m for comparison to published specifications.

For reference, converting the specification limits from linear to decibel form is accomplished by taking the base ten logarithm, then multiplying by 20. These limits in both linear and logarithmic form are as follows:

GENERAL TRANSMITTER RADIATED EMISSIONS SPECIFICATION LIMITS

The table below shows the limits for the spurious emissions from transmitters that fall in restricted bands[1].

Frequency Range (MHz)	Limit (µV/m)	Limit (dBµV/m @ 3m)
0.009-0.490	$2400/F_{KHz}$ @ 300m	$67.6-20*\log_{10}(F_{KHz})$ @ 300m
0.490-1.705	$24000/F_{KHz}$ @ 30m	$87.6-20*\log_{10}(F_{KHz})$ @ 30m
1.705 to 30	30 @ 30m	29.5 @ 30m
30 to 88	100 @ 3m	40 @ 3m
88 to 216	150 @ 3m	43.5 @ 3m
216 to 960	200 @ 3m	46.0 @ 3m
Above 960	500 @ 3m	54.0 @ 3m

[1] The restricted bands are detailed in FCC 15.205 and RSS-Gen Table 7

FCC 15.407 (a) OUTPUT POWER LIMITS

The table below shows the limits for output power and output power density. For the 5250-5350 and 5470-5725 MHz bands, where the signal bandwidth is less than 20 MHz the maximum output power is reduced to the power spectral density limit plus 10 times the log of the bandwidth (in MHz).

Operating Frequency (MHz)	Output Power	Power Spectral Density
5150 – 5250	1 Watt (30 dBm)	17 dBm/MHz
5250 – 5350 and 5470-5725	250 mW (24 dBm)	11 dBm/MHz
5725 – 5850	1 Watt (30 dBm)	30 dBm/500 kHz

For system using antennas with gains exceeding 6dBi, the output power and power spectral density limits are reduced by 1dB for every dB the antenna gain exceeds 6dBi. Fixed point-to-point applications using the 5725 – 5825 MHz band may use antennas with gains of up to 23dBi without this limitation. If the gain exceeds 23dBi then the output power limit of 1 Watt is reduced by 1dB for every dB the gain exceeds 23dBi.

OUTPUT POWER LIMITS –LELAN DEVICES

The table below shows the limits for output power and output power density defined by RSS 247. Where the signal bandwidth is less than 20 MHz the maximum output power is reduced to the power spectral density limit plus 10 times the log of the bandwidth (in MHz).

Operating Frequency (MHz)	Output Power	Power Spectral Density
5150 – 5250	200 mW (23 dBm) eirp	10 dBm/MHz eirp
5250 – 5350 and 5470 - 5725	250 mW (24 dBm)[2] 1 W (30 dBm) eirp	11 dBm/MHz
5725 – 5850	1 Watt (30 dBm) 4 W eirp	30 dBm/500 kHz

Fixed point-to-point applications using the 5725 – 5850 MHz band may use antennas with gains of up to 23 dBi without this limitation. If the gain exceeds 23 dBi then the output power limit of 1 Watt is reduced by 1 dB for every dB the gain exceeds 23 dBi.

SPURIOUS EMISSIONS LIMITS –UNII and LELAN DEVICES

The spurious emissions limits for signals below 1 GHz are the FCC/RSS-Gen general limits. For emissions above 1 GHz, signals in restricted bands are subject to the FCC/RSS-Gen general limits. All other signals have a limit of –27 dBm/MHz, which is field strength of 68.3 dBuV/m/MHz at a distance of 3 m. For devices operating in the 5725-5850 MHz bands under the LELAN/UNII rules, the limit within 10 MHz of the allocated band is increased to –17 dBm/MHz.

[2] If EIRP exceeds 500mW the device must employ TPC

SAMPLE CALCULATIONS - CONDUCTED EMISSIONS

Receiver readings are compared directly to the conducted emissions specification limit (decibel form) as follows:

$$R_r - S = M$$

where:

R_r = Receiver Reading in dBµV

S = Specification Limit in dBµV

M = Margin to Specification in +/- dB

SAMPLE CALCULATIONS - RADIATED EMISSIONS

Receiver readings are compared directly to the specification limit (decibel form). The receiver internally corrects for cable loss, preamplifier gain, and antenna factor. The calculations are in the reverse direction of the actual signal flow, thus cable loss is added and the amplifier gain is subtracted. The Antenna Factor converts the voltage at the antenna coaxial connector to the field strength at the antenna elements.

A distance factor, when used for electric field measurements above 30MHz, is calculated by using the following formula:

$$F_d = 20*LOG_{10} (D_m/D_s)$$

where:

F_d = Distance Factor in dB

D_m = Measurement Distance in meters

D_s = Specification Distance in meters

For electric field measurements below 30MHz the extrapolation factor is either determined by making measurements at multiple distances or a theoretical value is calculated using the formula:

$$F_d = 40*LOG_{10} (D_m/D_s)$$

Measurement Distance is the distance at which the measurements were taken and Specification Distance is the distance at which the specification limits are based. The antenna factor converts the voltage at the antenna coaxial connector to the field strength at the antenna elements.

The margin of a given emission peak relative to the limit is calculated as follows:

$$R_c = R_r + F_d$$

and

$$M = R_c - L_s$$

where:

R_r = Receiver Reading in dBµV/m

F_d = Distance Factor in dB

R_c = Corrected Reading in dBµV/m

L_s = Specification Limit in dBµV/m

M = Margin in dB Relative to Spec

SAMPLE CALCULATIONS - FIELD STRENGTH TO EIRP CONVERSION

Where the radiated electric field strength is expressed in terms of the equivalent isotropic radiated power (eirp), or where a field strength measurement of output power is made in lieu of a direct measurement, the following formula is used to convert between eirp and field strength at a distance of d (meters) from the equipment under test:

$$E = \frac{1000000 \sqrt{30 P}}{d} \quad \text{microvolts per meter}$$

where P is the eirp (Watts)

For a measurement at 3 m the conversion from a logarithmic value for field strength (dBµV/m) to an eirp power (dBm) is -95.3 dB.

Appendix A Test Equipment Calibration Data

Manufacturer	Description	Model	Asset #	Calibrated	Cal Due
Power and duty cycle, 11-Dec-18					
National Technical Systems	NTS Capture Analyzer Software (rev 3.8)	N/A	0		N/A
Agilent Technologies	PSA, Spectrum Analyzer, (installed options, 111, 115, 123, 1DS, B7J, HYX,	E4446A	2139	7/27/2018	7/27/2019
Agilent Technologies	USB Average Power Sensor	U2001A	2442	1/4/2018	1/4/2019
Radiated Emissions, Band Edge, 13-Dec-18					
National Technical Systems	NTS EMI Software (rev 2.10)	N/A	0		N/A
EMCO	Antenna, Horn, 1-18 GHz	3115	1242	4/11/2017	4/19/2019
Rohde & Schwarz	EMI Test Receiver, 20 Hz-7 GHz	ESIB 7	1756	7/7/2018	7/7/2019
Radiated Emissions, 1,000 - 40,000 MHz, 13-Dec-18					
National Technical Systems	NTS EMI Software (rev 2.10)	N/A	0		N/A
EMCO	Antenna, Horn, 1-18 GHz	3115	1242	4/11/2017	4/19/2019
Hewlett Packard	Spectrum Analyzer (SA40) Blue 9 kHz - 40 GHz	8564E (84125C)	1393	12/8/2018	12/8/2019
HP / Miteq	SA40 B Head HF preAmplifier, 18-40 GHz (w/1393)	TTA1840-45-5P-HG-S	1620	1/9/2018	1/9/2019
Hewlett Packard	Microwave Preamplifier, 1-26.5GHz	8449B	1780	8/30/2018	8/30/2019
A. H. Systems	Blue System Horn, 18-40GHz	SAS-574, p/n: 2581	2159	9/5/2017	8/8/2020
Micro-Tronics	Band Reject Filter, 5725-5875 MHz	BRC50705-02	2241	8/17/2018	8/17/2019
Radiated Emissions, 1,000 - 40,000 MHz, 14-Dec-18					
National Technical Systems	NTS EMI Software (rev 2.10)	N/A	0		N/A
EMCO	Antenna, Horn, 1-18 GHz	3115	1242	4/11/2017	4/19/2019
Hewlett Packard	High Pass filter, 8.2 GHz (Blu System)	P/N 84300-80039 (84125C)	1392	5/1/2018	5/1/2019
Hewlett Packard	Spectrum Analyzer (SA40) Blue 9 kHz - 40 GHz	8564E (84125C)	1393	12/8/2018	12/8/2019
HP / Miteq	SA40 B Head HF preAmplifier, 18-40 GHz (w/1393)	TTA1840-45-5P-HG-S	1620	1/9/2018	1/9/2019
Hewlett Packard	Microwave Preamplifier, 1-26.5GHz	8449B	1780	8/30/2018	8/30/2019
A. H. Systems	Blue System Horn, 18-40GHz	SAS-574, p/n: 2581	2159	9/5/2017	8/8/2020
Micro-Tronics	Band Reject Filter, 5725-5875 MHz	BRC50705-02	2241	8/17/2018	8/17/2019

Manufacturer	Description	Model	Asset #	Calibrated	Cal Due
Radiated Emissions, 9 kHz - 1 GHz, 17-Dec-18					
National Technical Systems	NTS EMI Software (rev 2.10)	N/A	0		N/A
Sunol Sciences	Biconilog, 30-3000 MHz	JB3	1657	8/1/2018	8/1/2020
Rohde & Schwarz	EMI Test Receiver, 20 Hz-7 GHz	ESIB 7	1756	7/7/2018	7/7/2019
Com-Power	Preamplifier, 30-1000 MHz	PA-103	2465	5/24/2018	5/24/2019
Rhode & Schwarz	Magnetic Loop Antenna, 9 kHz-30 MHz	HFH2-Z2	WC062 457	1/5/2018	1/5/2020
Conducted Emissions - AC Power Ports, 17-Dec-18					
National Technical Systems	NTS EMI Software (rev 2.10)	N/A	0		N/A
EMCO	LISN, 10 kHz-100 MHz	3825/2	1292	8/16/2018	8/16/2019
Rohde & Schwarz	Pulse Limiter	ESH3 Z2	1401	1/8/2018	1/8/2019
Rohde & Schwarz	EMI Test Receiver, 20 Hz-7 GHz	ESIB 7	1756	7/7/2018	7/7/2019

Appendix B Test Data

TL087406 Pages 28 – 62

Client:	Neato Robotics, Inc.	PR Number:	PR087406
Product	BotVac D7 Connected	T-Log Number:	TL087406
System Configuration:		Project Manager:	Christine Krebill
Contact:	Kelvin Law	Project Engineer:	Deniz Demirci
Emissions Standard(s):	FCC 15E, RSS-247	Class:	-
Immunity Standard(s):	-	Environment:	-

EMC Test Data

For The

Neato Robotics, Inc.

Product

BotVac D7 Connected

Date of Last Test: 12/18/2018

Client:	Neato Robotics, Inc.	Job Number:	PR087406
Model:	BotVac D7 Connected	T-Log Number:	TL087406
		Project Manager:	Christine Krebill
Contact:	Kelvin Law	Project Coordinator:	Deniz Demirci
Standard:	FCC 15E, RSS-247	Class:	N/A

Power vs. Data Rate

In normal operating modes the card uses power settings stored on EEPROM to set the output power. For a given nominal output power the actual transmit power normally is reduced as the data rate increases, therefore testing was performed at the data rate in the mode with highest power to determine compliance with the requirements.
The following power measurements were made using a GATED average power meter and with the device configured in a continuous transmit mode on Chain 1 at the various data rates in each mode to verify the highest power mode:

Sample Notes

Sample S/N: IC9E
Driver: WL18

Date of Test: 12/11/2018
Test Engineer: Deniz Demirci
Test Location: FT Lab #4B

Mode	Data Rate (800ns GI, 1SS)	Power (dBm)	Power setting	
802.11n 20 MHz	6.5	**13.2**		
	13	13.1		
	19.5	12.9		
	26	12.8		
	39	12.3		
	52	12.3		
	58.5	11.9		
	65	11.7		
	78			<<-11ac mode only

Note : Power setting - the software power setting used during testing, included for reference only.

Client:	Neato Robotics, Inc.	Job Number:	PR087406
Model:	BotVac D7 Connected	T-Log Number:	TL087406
		Project Manager:	Christine Krebill
Contact:	Kelvin Law	Project Coordinator:	Deniz Demirci
Standard:	FCC 15E, RSS-247	Class:	N/A

Duty Cycle

Date of Test: 12/11/2018
Test Engineer: Deniz Demirci
Test Location: FT Lab #4B

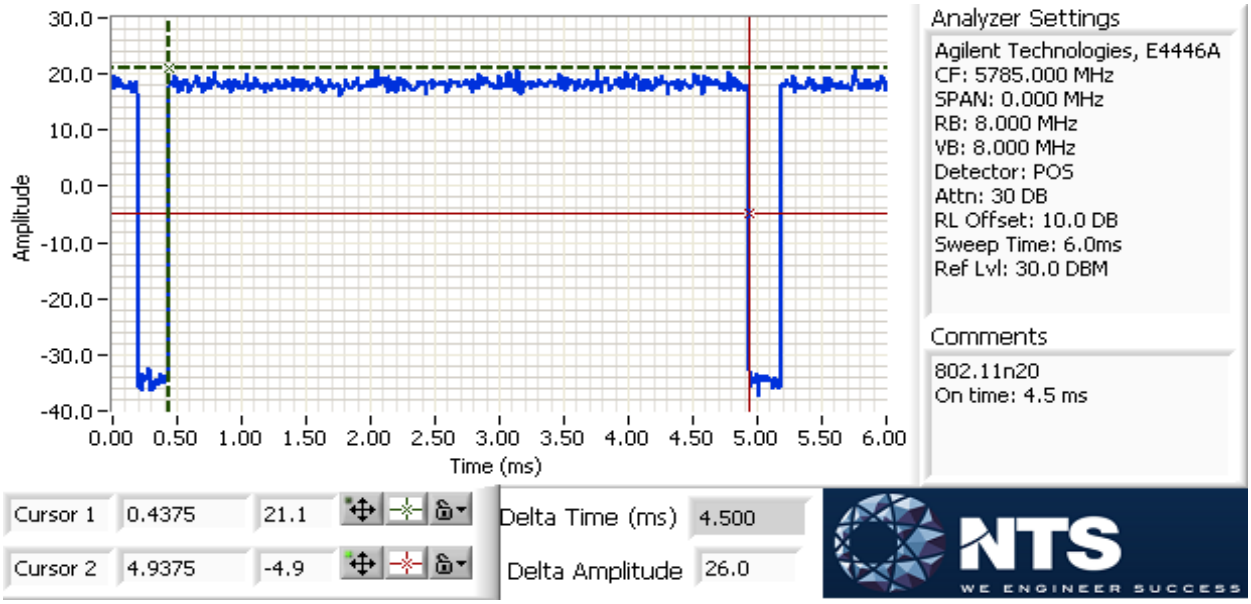
Duty cycle measurements performed on the worse case data rate for power.

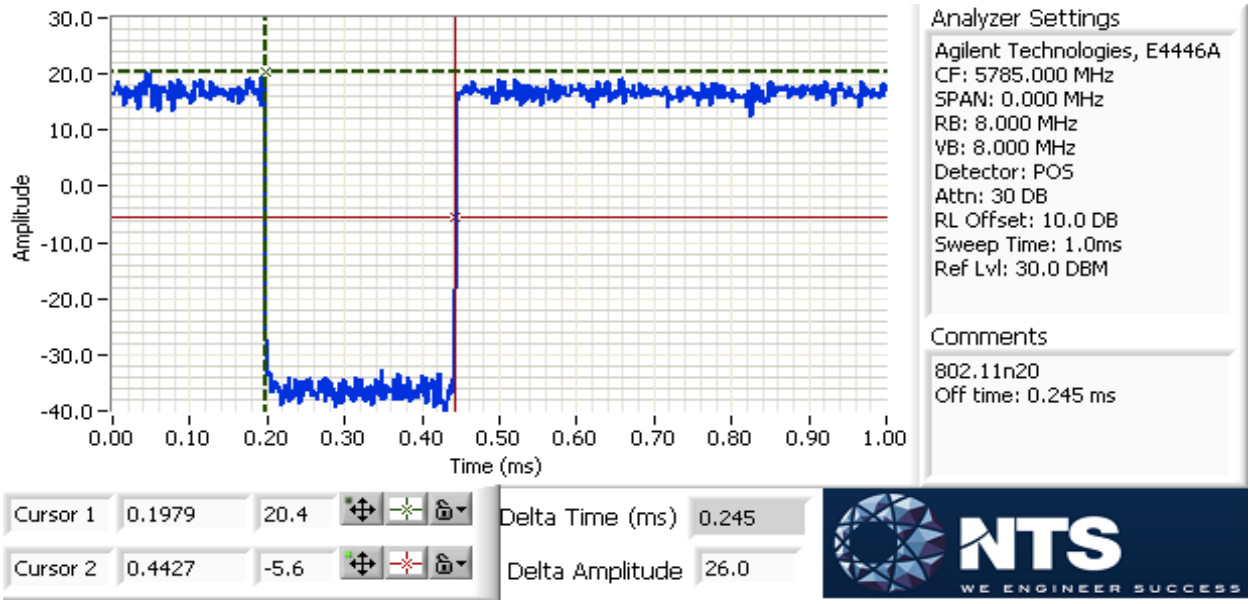
Notes: Measurements taken with maximum RBW/VBW settings allowed.

Mode	Data Rate	Duty Cycle (x)	Constant DC?	T (ms)	Pwr Cor Factor*	Lin Volt Cor Factor**	Min VBW for FS (Hz)
n20	MCS0	0.95	Yes	4.5	0.23	0.46	222

* Correction factor when using RMS/Power averaging - 10*log(1/x)
** Correction factor when using linear voltage average - 20*log(1/x)
T = Minimum transmission duration

Client:	Neato Robotics, Inc.	Job Number:	PR087406
Model:	BotVac D7 Connected	T-Log Number:	TL087406
		Project Manager:	Christine Krebill
Contact:	Kelvin Law	Project Coordinator:	Deniz Demirci
Standard:	FCC 15E, RSS-247	Class:	N/A





Client:	Neato Robotics, Inc.	Job Number:	PR087406
Model:	BotVac D7 Connected	T-Log Number:	TL087406
		Project Manager:	Christine Krebill
Contact:	Kelvin Law	Project Coordinator:	Deniz Demirci
Standard:	FCC 15E, RSS-247	Class:	N/A

RSS-247 (LELAN) and FCC 15.407(UNII)
Antenna Port Measurements
Power, PSD, Bandwidth and Spurious Emissions

Test Specific Details

Objective: The objective of this test session is to perform final qualification testing of the EUT with respect to the specification listed above.

Ambient Conditions:

Temperature: 21 °C
Rel. Humidity: 38 %

Summary of Results

Run #	Test Performed	Limit	Pass / Fail	Result / Margin
1	Power, 5725 - 5850MHz	15.407(a) (1), (2), (3) RSS-247 6.2	Pass	n20: 12.6 dBm
1	PSD, 5725 - 5850MHz	15.407(a) (1), (2), (3) RSS-247 6.2	Pass	n20: 2.3 dBm/MHz
1	6 dB Bandwidth	15.407(e) RSS-247 6.2.4.1	Pass	n20: 15.083 MHz
1	26 dB Bandwidth	15.407 (Information only)	-	n20: 31.500 MHz
1	99% Bandwidth	RSS 210 (Information only)	N/A	n20: 18.802 MHz

Modifications Made During Testing

No modifications were made to the EUT during testing

Deviations From The Standard

No deviations were made from the requirements of the standard.

Sample Notes

Sample S/N: IC9E
Driver: WL18

Client:	Neato Robotics, Inc.	Job Number:	PR087406
Model:	BotVac D7 Connected	T-Log Number:	TL087406
		Project Manager:	Christine Krebill
Contact:	Kelvin Law	Project Coordinator:	Deniz Demirci
Standard:	FCC 15E, RSS-247	Class:	N/A

General Test Configuration

When measuring the conducted emissions from the EUT's antenna port, the antenna port of the EUT was connected to the spectrum analyzer or power meter via a suitable attenuator to prevent overloading the measurement system. All measurements are corrected to allow for the external attenuators and cables used.

Procedure Comments:

Measurements performed in accordance with FCC KDB 789033

Mode	Data Rate	Duty Cycle (x)	Constant DC?	T (ms)	Pwr Cor Factor*	Lin Volt Cor Factor**	Min VBW for FS (Hz)
n20	MCS0	0.95	Yes	4.5	0.23	0.46	222

Note 1:	Constant Duty Cycle < 98%. Output power measured using a spectrum analyzer (see plots below). RBW=1MHz, VB=3 MHz, Span > OBW, # of points in sweep ≥ 2*span/RBW, RMS detector, trace average 100 traces, power averaging on and power integration over the OBW. Tthe measurements were adjusted by adding YY dB. This is based on 10log(1/x), where x is the duty cycle. (method SA-2 of ANSI C63.10)
Note 2:	Measured using the same analyzer settings used for output power.
Note 3:	99% Bandwidth measured in accordance with C63.10 - RB between 1-5 % of OBW and VB ≥ 3*RB, Span between 1.5 and 5 times OBW.

Client:	Neato Robotics, Inc.	Job Number:	PR087406
Model:	BotVac D7 Connected	T-Log Number:	TL087406
		Project Manager:	Christine Krebill
Contact:	Kelvin Law	Project Coordinator:	Deniz Demirci
Standard:	FCC 15E, RSS-247	Class:	N/A

Run #1: Bandwidth, Output Power and Power Spectral Density - MIMO Systems

Date of Test: 12/18/2018 0:00 Config. Used: 1
Test Engineer: Deniz Demirci Config Change: None
Test Location: FT Lab #4B EUT Voltage: 14.4 Vdc

SISO Device - 5725-5850 MHz Band - FCC

Antenna Gain (dBi): 0.1 Max EIRP: 18.7 mW 12.7 dBm

Frequency (MHz)	Software Setting	26 dB BW (MHz)	Duty Cycle %	Output Power[1] dBm			PSD[2] dBm/MHz			Result
				Measured	Calculated	Limit	Measured	Calculated	Limit /500 kHz	
802.11n 20MHz										
5745		29.250	95.0	12.4	12.6	30.0	2.1	2.3	30.0	Pass
5785		30.083	95.0	12.3	12.5	30.0	2.0	2.2	30.0	Pass
5825		31.500	95.0	12.2	12.4	30.0	1.9	2.1	30.0	Pass

SISO Device - 5725-5850 MHz Band - ISED Canada

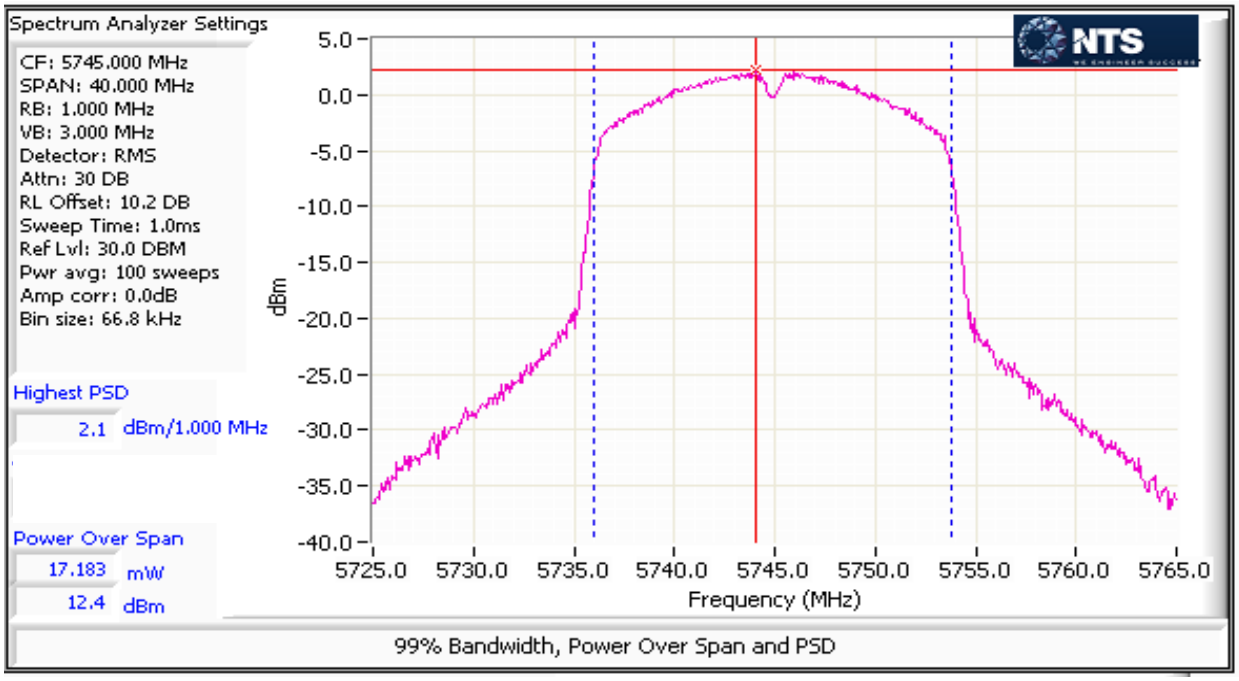
Antenna Gain (dBi): 0.1 Max EIRP: 18.7 mW 12.7 dBm

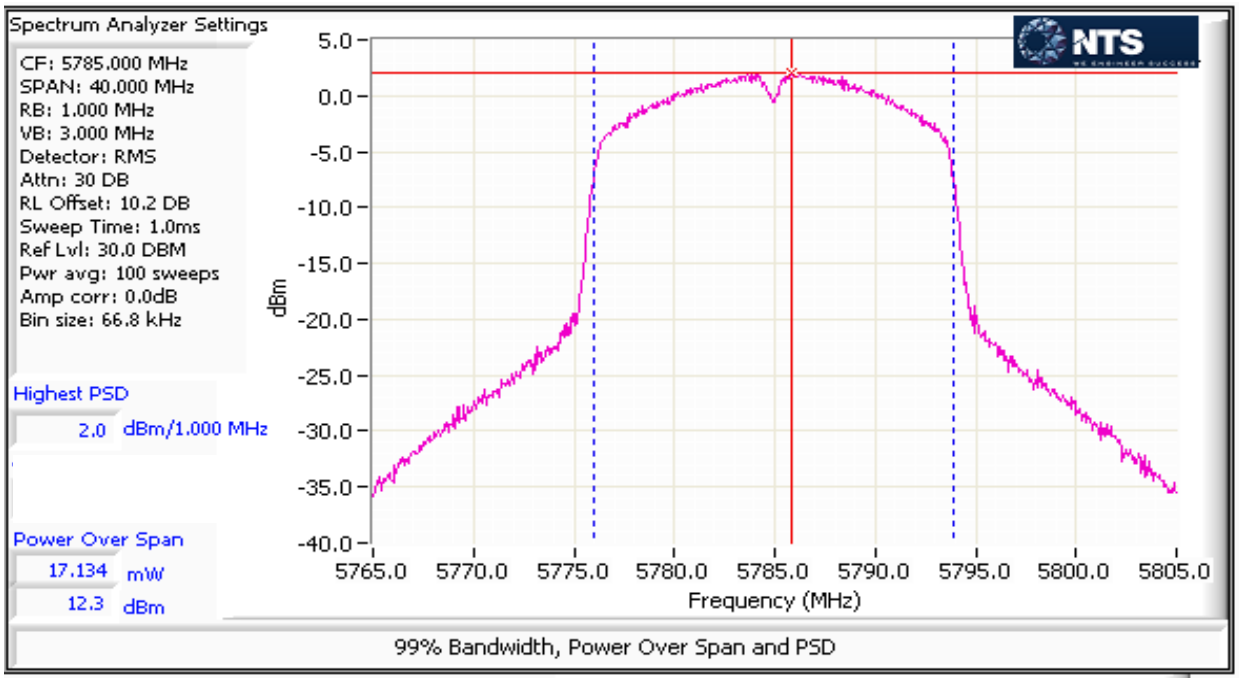
Frequency (MHz)	Software Setting	99% BW (MHz)	Duty Cycle %	Output Power[1] dBm			PSD[2] dBm/MHz			Result
				Measured	Calculated	Limit	Measured	Calculated	Limit /500 kHz	
802.11n 20MHz										
5745		18.802	95.0	12.4	12.6	30.0	2.1	2.3	30.0	Pass
5785		18.719	95.0	12.3	12.5	30.0	2.0	2.2	30.0	Pass
5825		18.802	95.0	12.2	12.4	30.0	1.9	2.1	30.0	Pass

SISO Device - 5725-5850 MHz Band

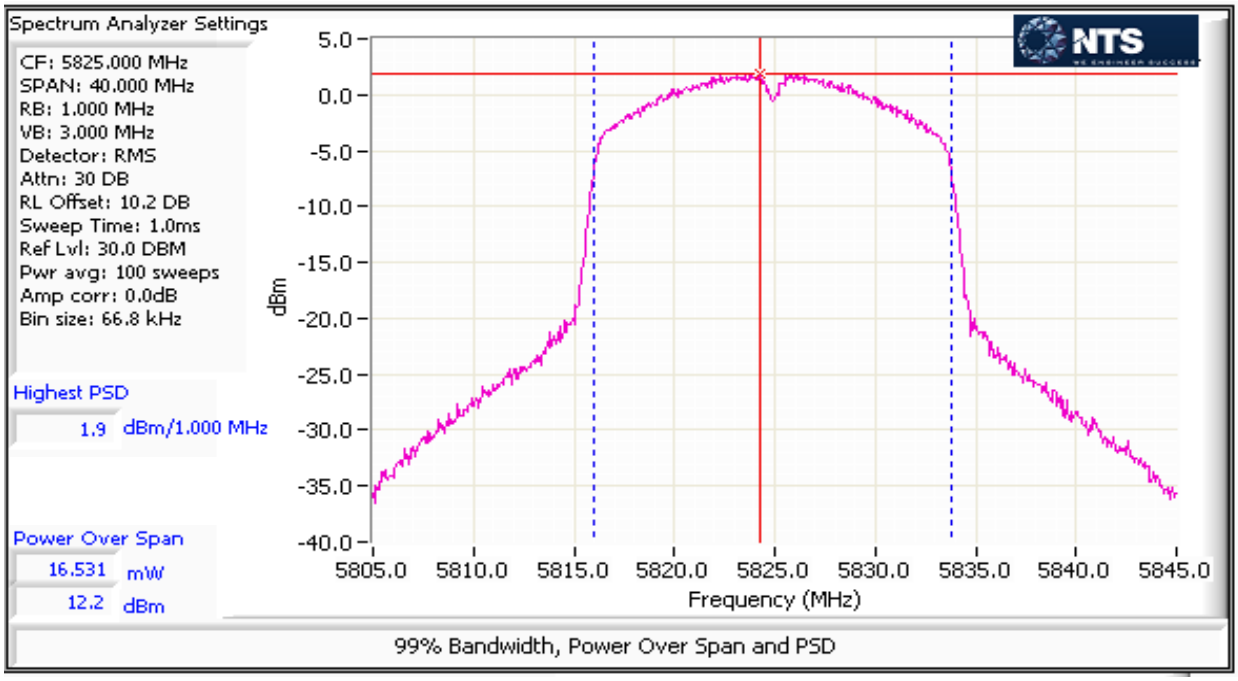
Frequency (MHz)	Software Setting	6 dB BW (MHz)	Min. Limit (MHz)	Output Power[1] dBm			PSD[2] dBm/MHz			Result
				Measured	Calculated	Limit	Measured	Calculated	Limit[3]	
802.11n 20MHz										
5745		15.083	0.500							Pass
5785		15.083	0.500							Pass
5825		15.083	0.500							Pass

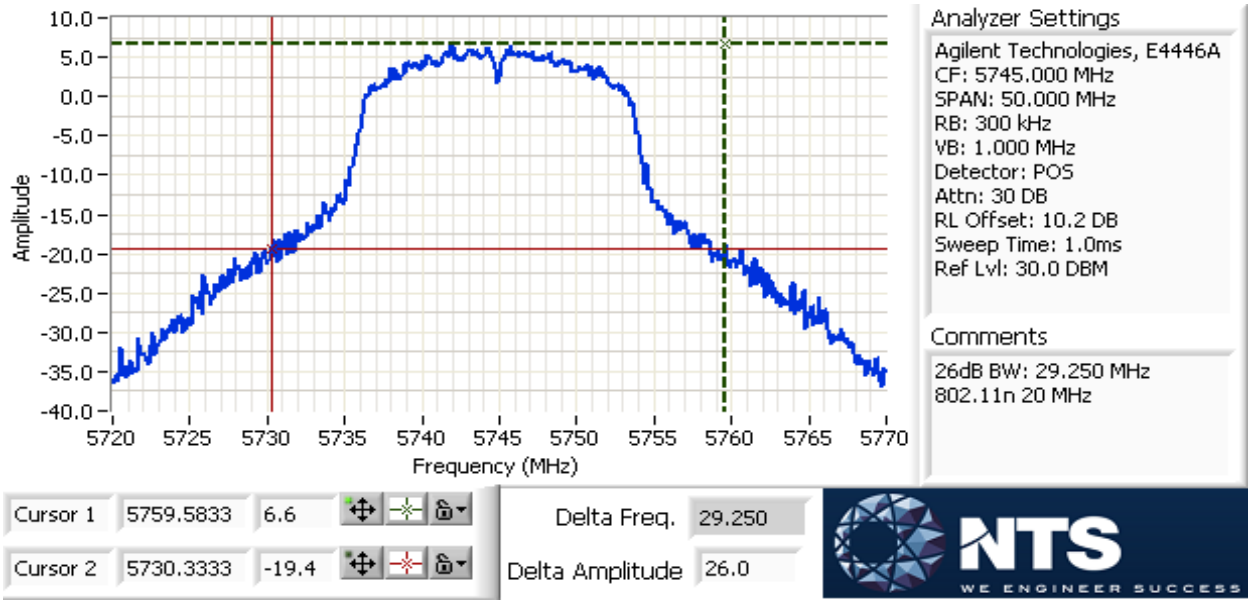
Client:	Neato Robotics, Inc.	Job Number:	PR087406
Model:	BotVac D7 Connected	T-Log Number:	TL087406
		Project Manager:	Christine Krebill
Contact:	Kelvin Law	Project Coordinator:	Deniz Demirci
Standard:	FCC 15E, RSS-247	Class:	N/A



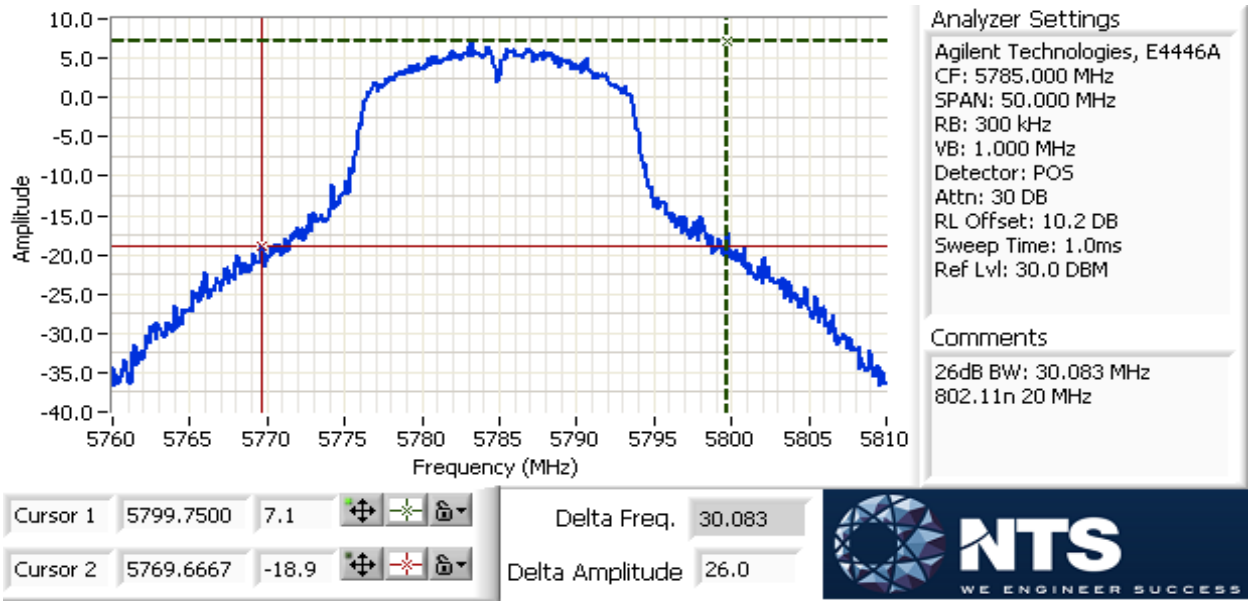


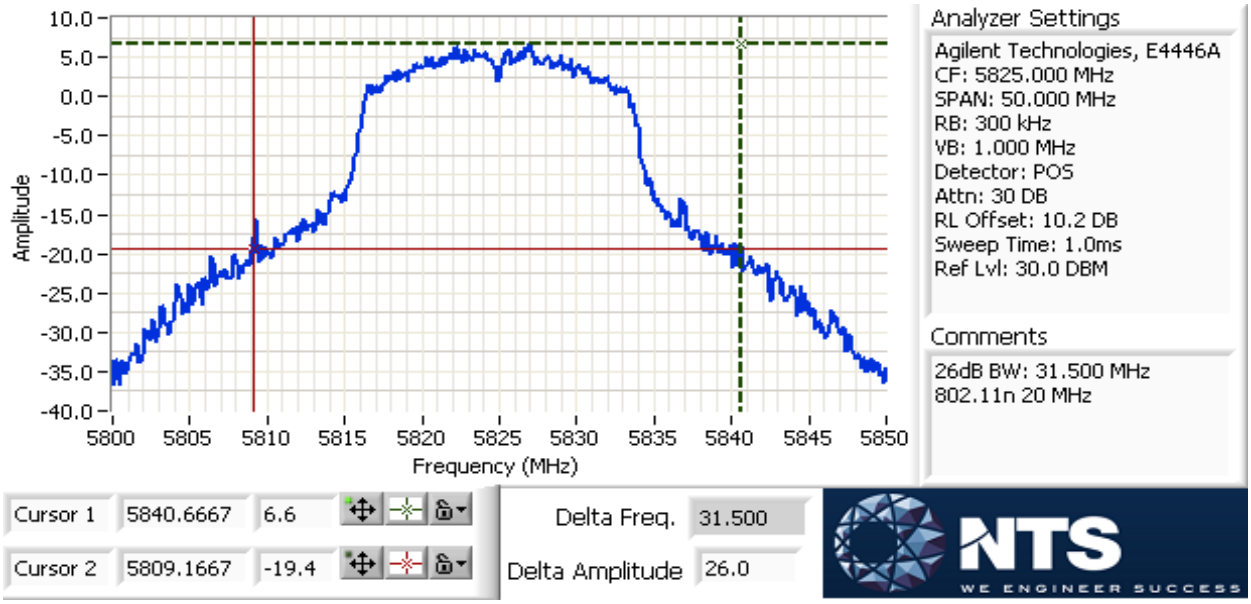
Client:	Neato Robotics, Inc.	Job Number:	PR087406
Model:	BotVac D7 Connected	T-Log Number:	TL087406
		Project Manager:	Christine Krebill
Contact:	Kelvin Law	Project Coordinator:	Deniz Demirci
Standard:	FCC 15E, RSS-247	Class:	N/A



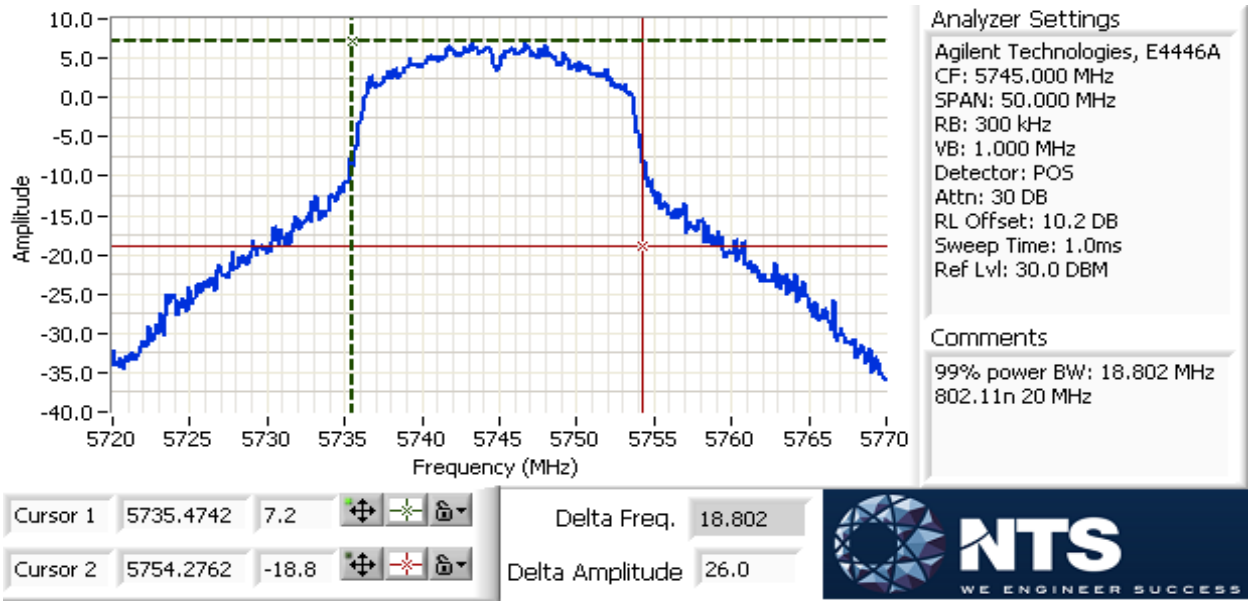


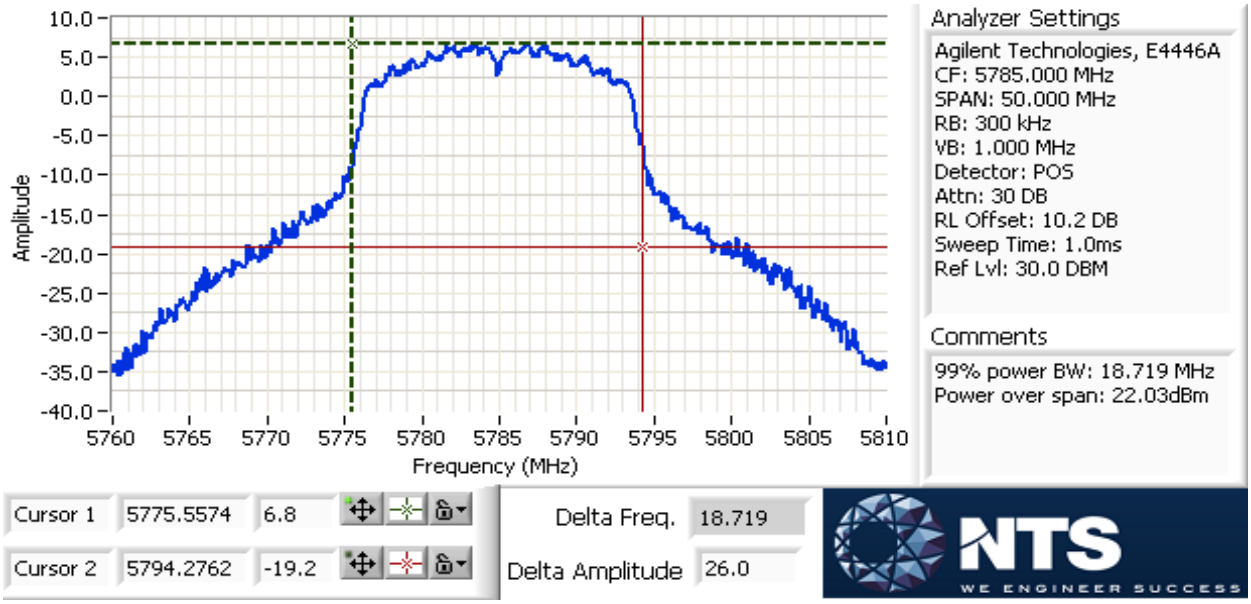
Client:	Neato Robotics, Inc.	Job Number:	PR087406
Model:	BotVac D7 Connected	T-Log Number:	TL087406
		Project Manager:	Christine Krebill
Contact:	Kelvin Law	Project Coordinator:	Deniz Demirci
Standard:	FCC 15E, RSS-247	Class:	N/A



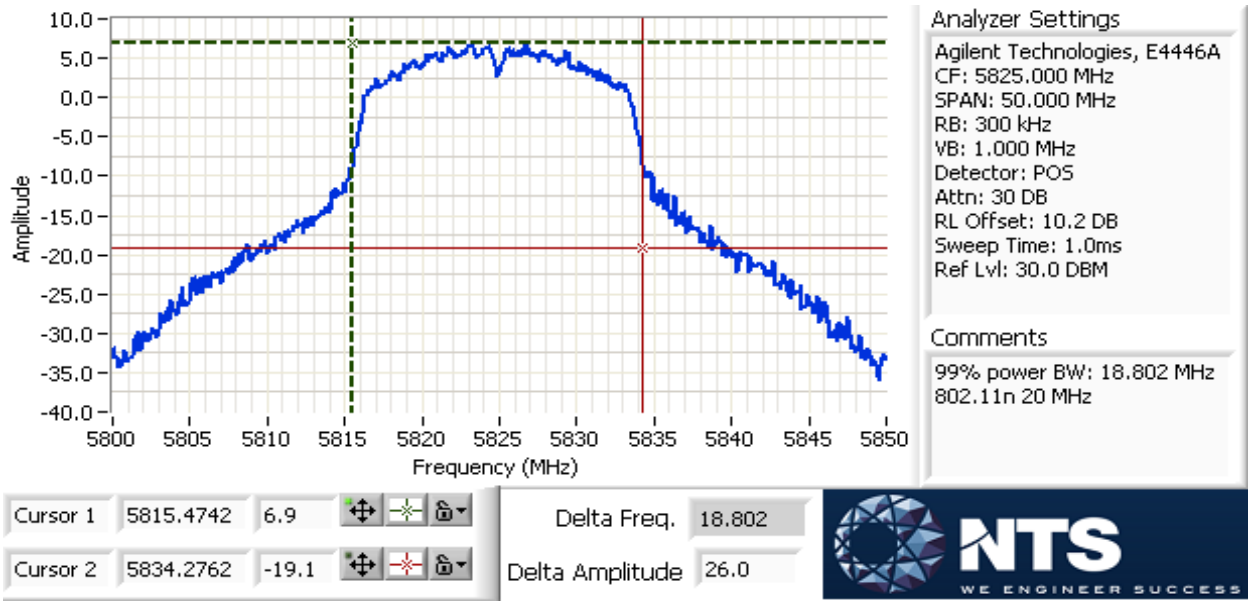


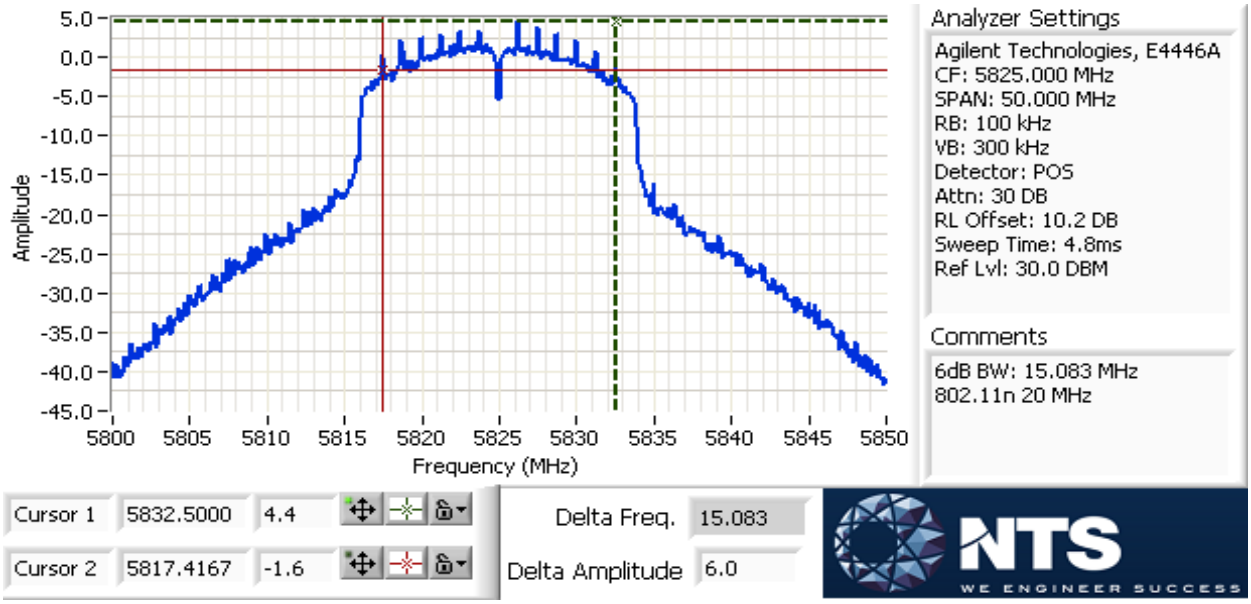
Client:	Neato Robotics, Inc.	Job Number:	PR087406
Model:	BotVac D7 Connected	T-Log Number:	TL087406
		Project Manager:	Christine Krebill
Contact:	Kelvin Law	Project Coordinator:	Deniz Demirci
Standard:	FCC 15E, RSS-247	Class:	N/A



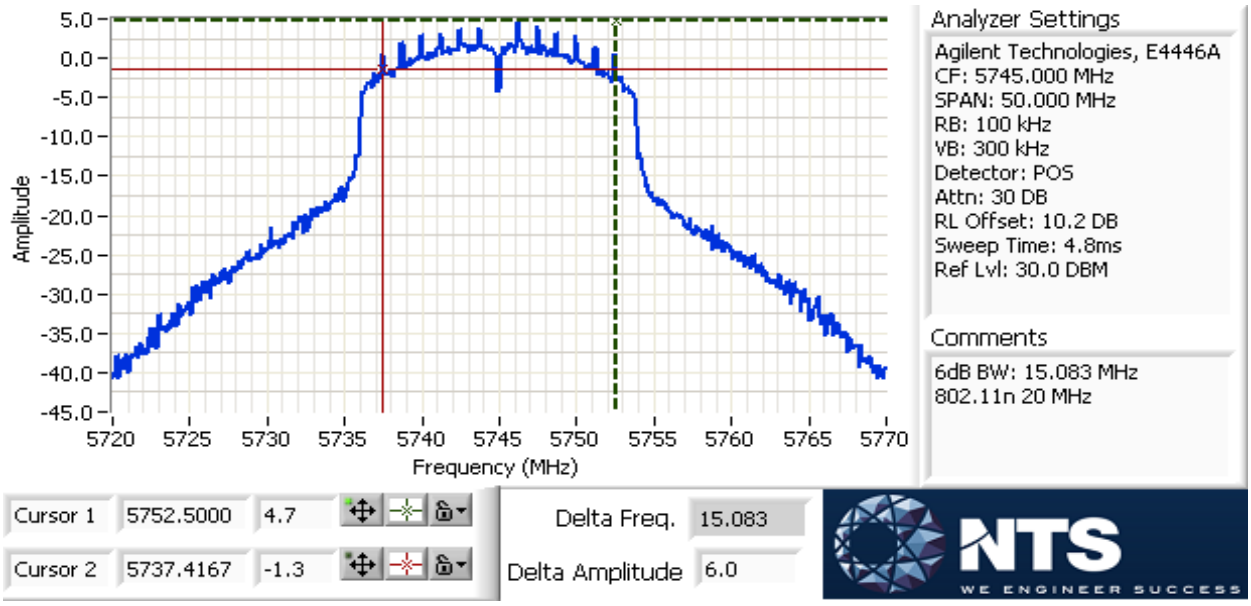


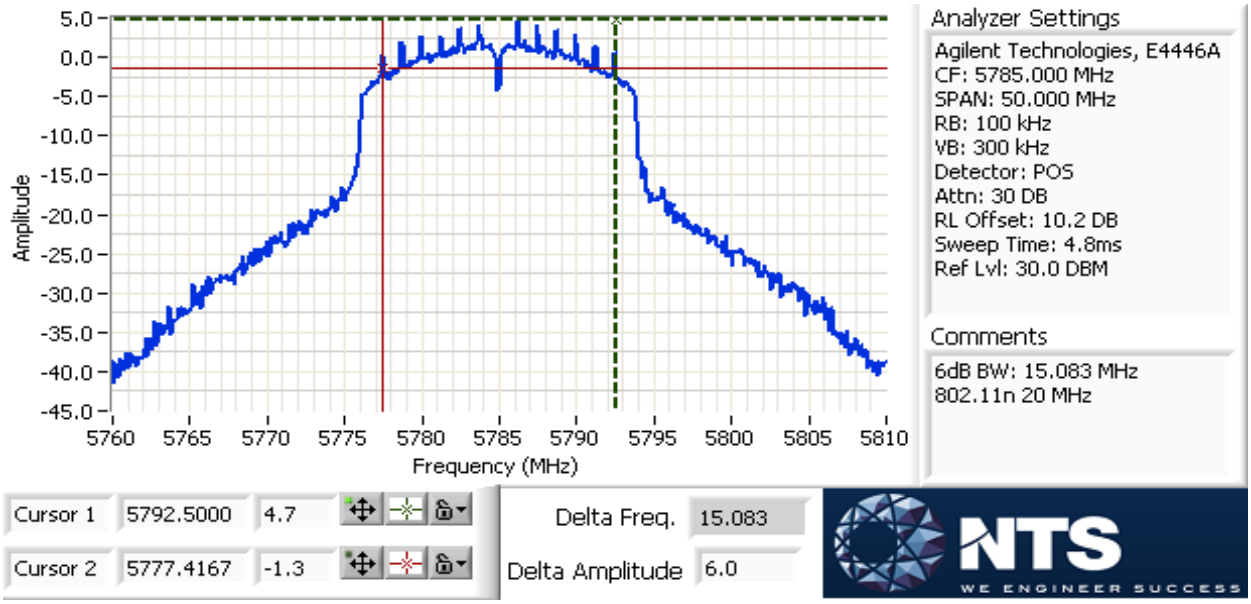
Client:	Neato Robotics, Inc.	Job Number:	PR087406
Model:	BotVac D7 Connected	T-Log Number:	TL087406
		Project Manager:	Christine Krebill
Contact:	Kelvin Law	Project Coordinator:	Deniz Demirci
Standard:	FCC 15E, RSS-247	Class:	N/A





Client:	Neato Robotics, Inc.	Job Number:	PR087406
Model:	BotVac D7 Connected	T-Log Number:	TL087406
		Project Manager:	Christine Krebill
Contact:	Kelvin Law	Project Coordinator:	Deniz Demirci
Standard:	FCC 15E, RSS-247	Class:	N/A





Client:	Neato Robotics, Inc.	Job Number:	PR087406
Model:	BotVac D7 Connected	T-Log Number:	TL087406
		Project Manager:	Christine Krebill
Contact:	Kelvin Law	Project Coordinator:	Deniz Demirci
Standard:	FCC 15E, RSS-247	Class:	N/A

RSS-247 and FCC 15.407 (UNII) Radiated Spurious Emissions

Test Specific Details

Objective: The objective of this test session is to perform final qualification testing of the EUT with respect to the specification listed above.

Date of Test: 12/13/2018
Test Engineer: Deniz Demirci
Test Location: FT CH #4

Config. Used: 1
Config Change: None
EUT Voltage: Battery operated

General Test Configuration

The EUT was located on the turntable for radiated spurious emissions testing.
For radiated emissions testing the measurement antenna was located 3 meters from the EUT, unless otherwise noted.

Ambient Conditions:

Temperature: 21 °C
Rel. Humidity: 39 %

Summary of Results

Run #	Mode	Channel	Power Setting	Measured Power	Test Performed	Limit	Result / Margin
20 MHz Bandwith Modes							
1	n20	149 - 5745 MHz		-	Band Edge 5725 MHz	15E	55.7 dBµV/m @ 5639.4 MHz (-12.6 dB)
	n20	165 - 5825 MHz		-	Band Edge 5850MHz	15E	55.3 dBµV/m @ 5926.8 MHz (-13.0 dB)

Modifications Made During Testing

No modifications were made to the EUT during testing

Deviations From The Standard

No deviations were made from the requirements of the standard.

Sample Notes

Sample S/N: OPS34417-E8EB111669A0
Driver: WL18
Antenna: Integral, 0.1 dBi @ 5850 MHz

Client:	Neato Robotics, Inc.	Job Number:	PR087406
Model:	BotVac D7 Connected	T-Log Number:	TL087406
		Project Manager:	Christine Krebill
Contact:	Kelvin Law	Project Coordinator:	Deniz Demirci
Standard:	FCC 15E, RSS-247	Class:	N/A

Procedure Comments:

Measurements performed in accordance with FCC KDB 789033
Peak measurements performed with: RBW=1 MHz, VBW=3 MHz, peak detector, max hold, auto sweep time

Mode	Data Rate	Duty Cycle (x)	Constant DC?	T (ms)	Pwr Cor Factor*	Lin Volt Cor Factor**	Min VBW for FS (Hz)
n20	MCS0	0.95	Yes	4.5	0.23	0.46	222

Measurement Specific Notes:

Note 1:	For emissions outside of the restricted bands the limit is -27 dBm/MHz eirp (68.3 dBuV/m). The measurement method required is a peak measurement (RB=1 MHz, VB≥3 MHz, peak detector). Per KDB 789033 2) c) (i),

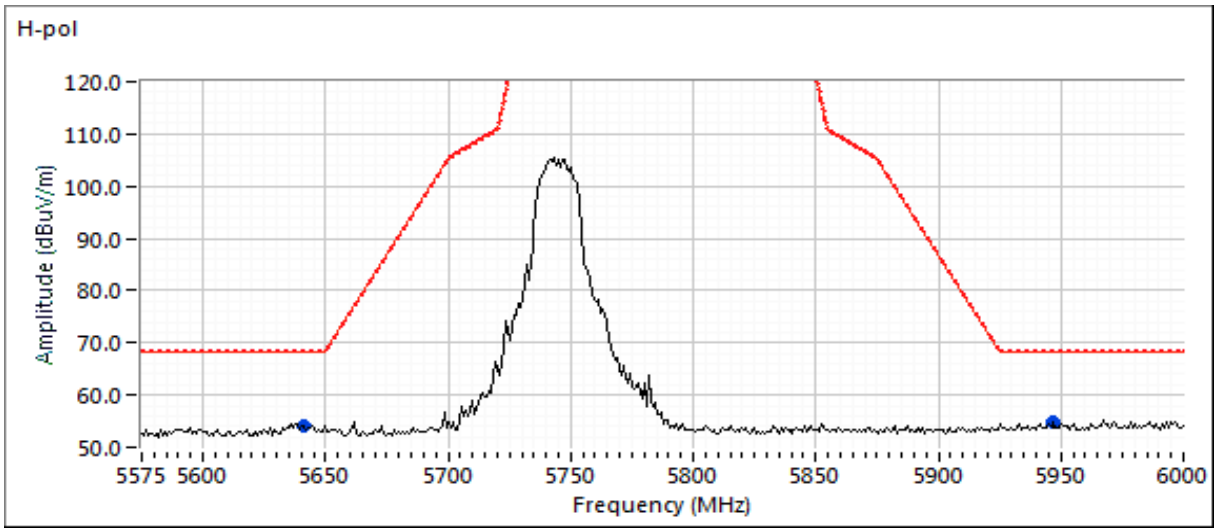
Client:	Neato Robotics, Inc.	Job Number:	PR087406
Model:	BotVac D7 Connected	T-Log Number:	TL087406
		Project Manager:	Christine Krebill
Contact:	Kelvin Law	Project Coordinator:	Deniz Demirci
Standard:	FCC 15E, RSS-247	Class:	N/A

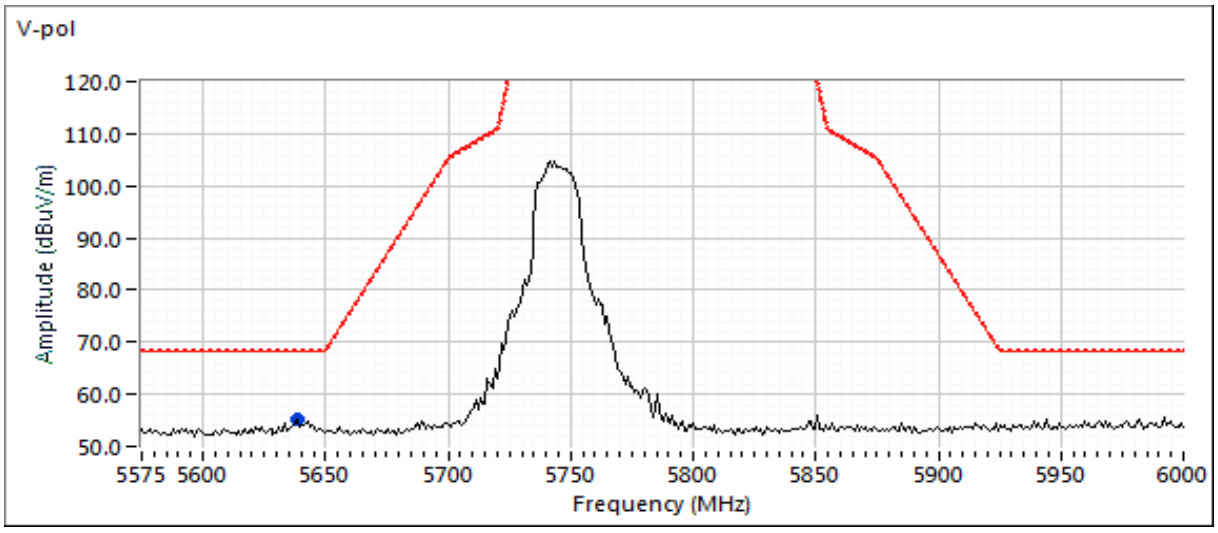
Run #1: Radiated Bandedge Measurements, 5725-5850 MHz

Channel: 149 - 5745 MHz Tx Chain: Main Mode: n20 Data Rate: MCS0

5725 MHz Band Edge Signal Radiated Field Strength

Frequency	Level	Pol	15.E		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
5639.390	55.7	H	68.3	-12.6	PK	99	1.1	POS; RB 1 MHz; VB: 3 MHz
5947.830	54.1	H	68.3	-14.2	PK	120	1.0	POS; RB 1 MHz; VB: 3 MHz
5639.520	54.8	V	68.3	-13.5	PK	205	1.9	POS; RB 1 MHz; VB: 3 MHz



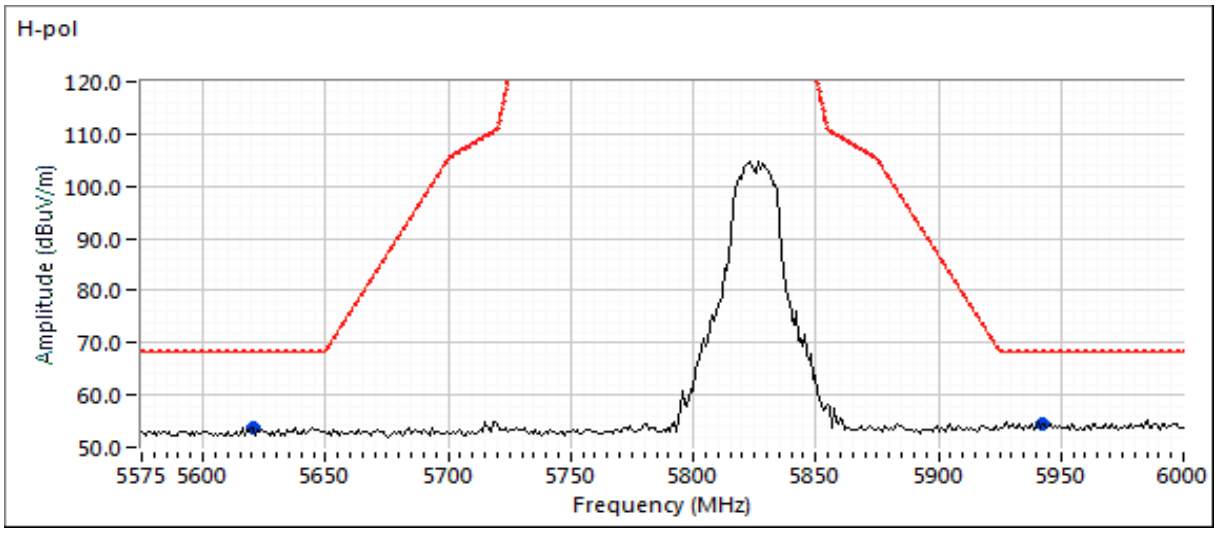


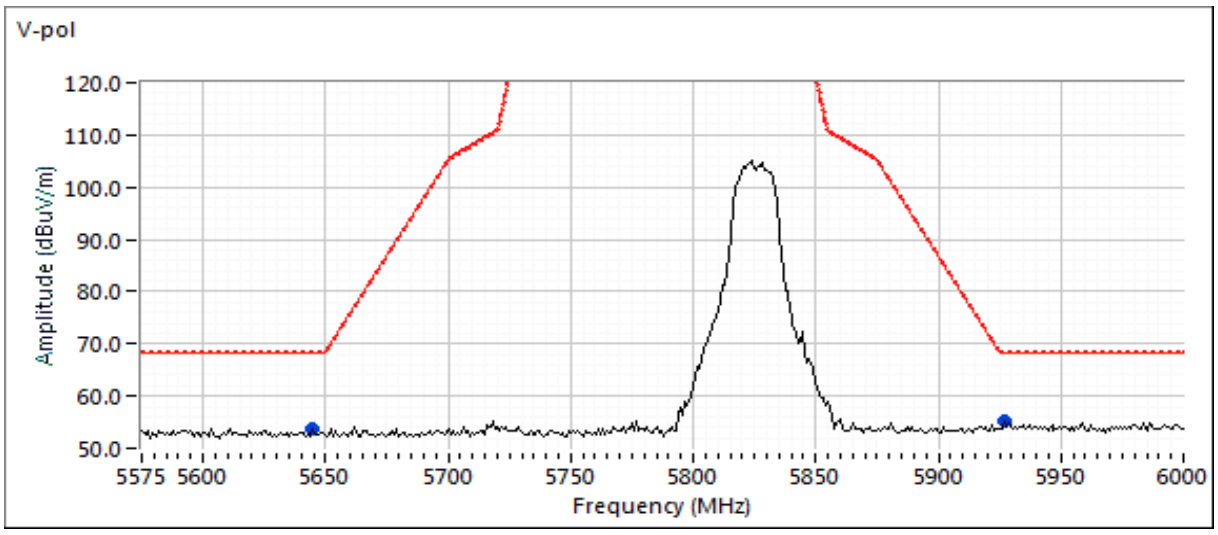
Client:	Neato Robotics, Inc.	Job Number:	PR087406
Model:	BotVac D7 Connected	T-Log Number:	TL087406
		Project Manager:	Christine Krebill
Contact:	Kelvin Law	Project Coordinator:	Deniz Demirci
Standard:	FCC 15E, RSS-247	Class:	N/A

Channel: 165 - 5825 MHz Tx Chain: Main Mode: n20 Data Rate: MCS0

5850 MHz Band Edge Signal Radiated Field Strength

Frequency	Level	Pol	15.E		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
5942.080	54.6	H	68.3	-13.7	PK	157	1.5	POS; RB 1 MHz; VB: 3 MHz
5620.140	53.8	H	68.3	-14.5	PK	276	1.8	POS; RB 1 MHz; VB: 3 MHz
5644.840	53.6	V	68.3	-14.7	PK	143	1.5	POS; RB 1 MHz; VB: 3 MHz
5926.750	55.3	V	68.3	-13.0	PK	6	1.8	POS; RB 1 MHz; VB: 3 MHz





Client:	Neato Robotics, Inc.	Job Number:	PR087406
Model:	BotVac D7 Connected	T-Log Number:	TL087406
		Project Manager:	Christine Krebill
Contact:	Kelvin Law	Project Coordinator:	Deniz Demirci
Standard:	FCC 15E, RSS-247	Class:	N/A

RSS-247 and FCC 15.407 (UNII) Radiated Spurious Emissions

Test Specific Details

Objective: The objective of this test session is to perform final qualification testing of the EUT with respect to the specification listed above.

Date of Test: 12/13/2018, 12/14/2018
Test Engineer: Deniz Demirci
Test Location: FT CH #4
Config. Used: 1
Config Change: None
EUT Voltage: Battery operated

General Test Configuration

The EUT and all local support equipment were located on the turntable for radiated spurious emissions testing.
For radiated emissions testing the measurement antenna was located 3 meters from the EUT, unless otherwise noted.

Ambient Conditions:

Temperature: 21 °C
Rel. Humidity: 39 %

Summary of Results

Run #	Mode	Channel	Power Setting	Measured Power	Test Performed	Limit	Result / Margin
1	n20	149 - 5745MHz			Radiated Emissions, 1 - 40 GHz	FCC 15.209 / 15 E	53.9 dBµV/m @ 22979.7 MHz (-0.1 dB)
		157 - 5785MHz			Radiated Emissions, 1 - 40 GHz	FCC 15.209 / 15 E	59.7 dBµV/m @ 23139.7 MHz (-8.6 dB)
		165- 5825MHz			Radiated Emissions, 1 - 40 GHz	FCC 15.209 / 15 E	45.9 dBµV/m @ 3883.3 MHz (-8.1 dB)

Modifications Made During Testing

No modifications were made to the EUT during testing

Deviations From The Standard

No deviations were made from the requirements of the standard.

Sample Notes

Sample S/N: OPS34417-E8EB111669A0
Driver: WL18
Antenna: Integral, 0.1 dBi @ 5850 MHz

Client:	Neato Robotics, Inc.	Job Number:	PR087406
Model:	BotVac D7 Connected	T-Log Number:	TL087406
		Project Manager:	Christine Krebill
Contact:	Kelvin Law	Project Coordinator:	Deniz Demirci
Standard:	FCC 15E, RSS-247	Class:	N/A

Procedure Comments:

Measurements performed in accordance with FCC KDB 789033
Peak measurements performed with: RBW=1 MHz, VBW=3 MHz, peak detector, max hold, auto sweep time

Mode	Data Rate	Duty Cycle (x)	Constant DC?	T (ms)	Pwr Cor Factor*	Lin Volt Cor Factor**	Min VBW for FS (Hz)
n20	MCS0	0.95	Yes	4.5	0.23	0.46	222

Measurement Specific Notes:

Note 1:	For emissions outside of the restricted bands the limit is -27 dBm/MHz eirp (68.3 dBuV/m). The measurement method required is a peak measurement (RB=1 MHz, VB≥3 MHz, peak detector). Per KDB 789033 2) c) (i), compliance can be demonstrated by meeting the average and peak limits of 15.209, as an alternative.
Note 2:	Emission has constant duty cycle < 98%, average measurement performed: RBW=1 MHz, VBW>1/T but not less than 10 Hz, peak detector, linear averaging, auto sweep,max hold 50*1/DC traces (method VB of KDB 789033)

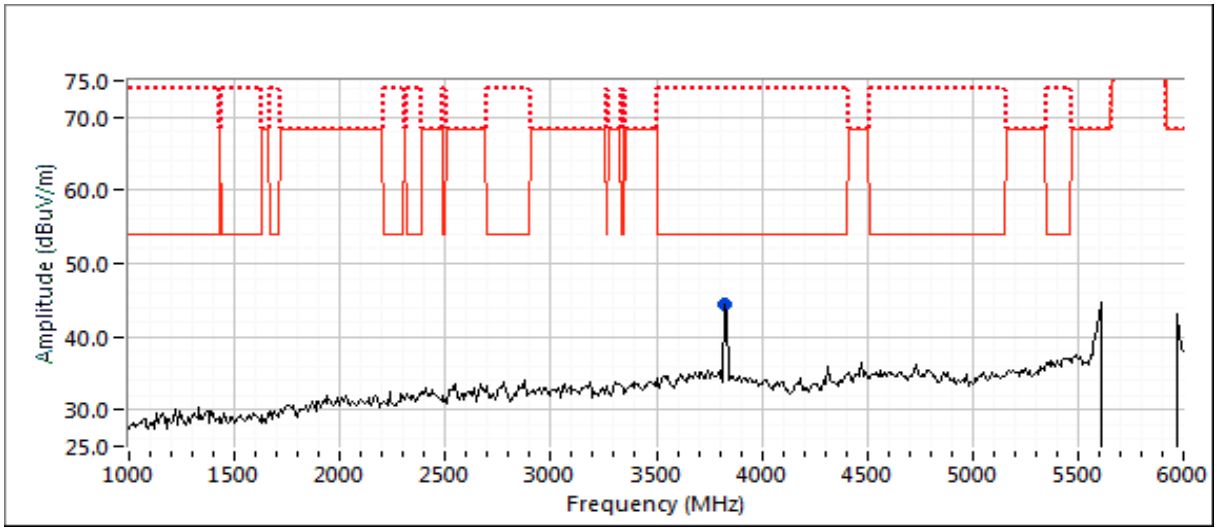
Client:	Neato Robotics, Inc.	Job Number:	PR087406
Model:	BotVac D7 Connected	T-Log Number:	TL087406
		Project Manager:	Christine Krebill
Contact:	Kelvin Law	Project Coordinator:	Deniz Demirci
Standard:	FCC 15E, RSS-247	Class:	N/A

Run #1: Radiated Spurious Emissions, 1,000 - 40,000 MHz

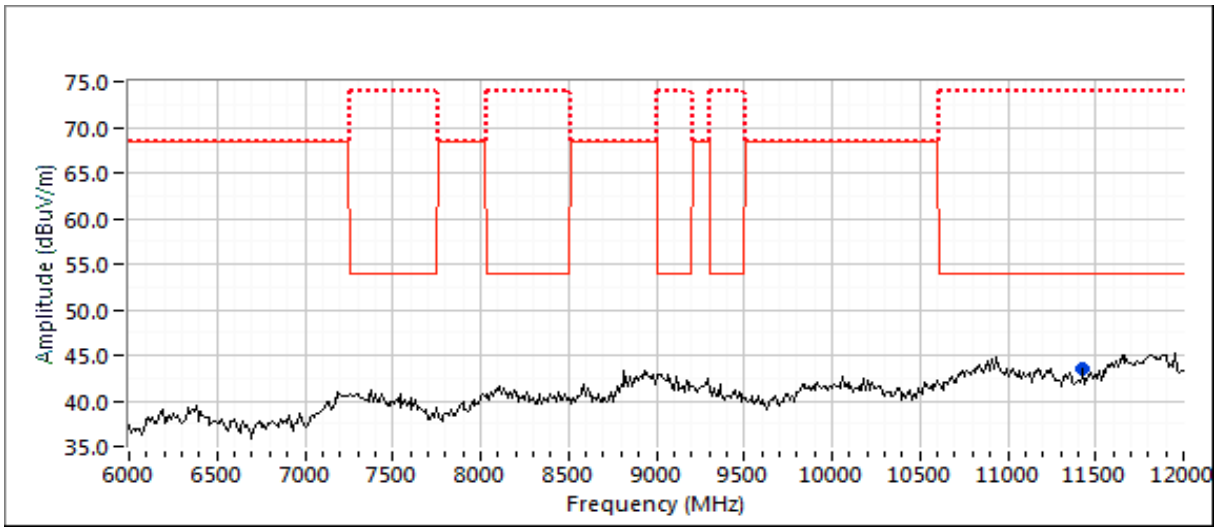
Run #1a: Low Channel

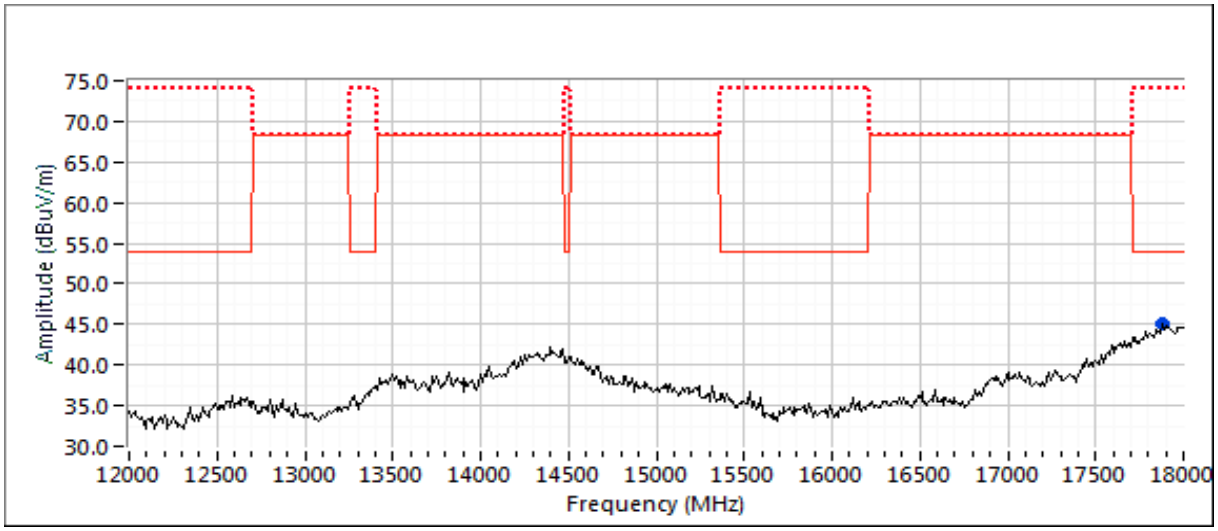
Channel: 149 Mode: n20
Tx Chain: Main Data Rate: MCS0

Frequency	Level	Pol	15.209 / 15E		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
3829.890	43.4	H	54.0	-10.6	AVG	102	1.0	RB 1 MHz;VB 300 Hz;Peak
3829.970	48.6	H	74.0	-25.4	PK	102	1.0	RB 1 MHz;VB 3 MHz;Peak
11430.000	43.5	H	54.0	-10.5	PK	16	1.0	Noise floor reading
17880.000	*45.0*	*V*	*54.0*	*-9.0*	PK	*310*	*1.2*	Noise floor reading
22979.720	53.9	V	54.0	-0.1	AVG	48	2.1	RB 1 MHz;VB 300 Hz;Peak
22979.850	57.1	V	74.0	-16.9	PK	48	2.1	RB 1 MHz;VB 3 MHz;Peak

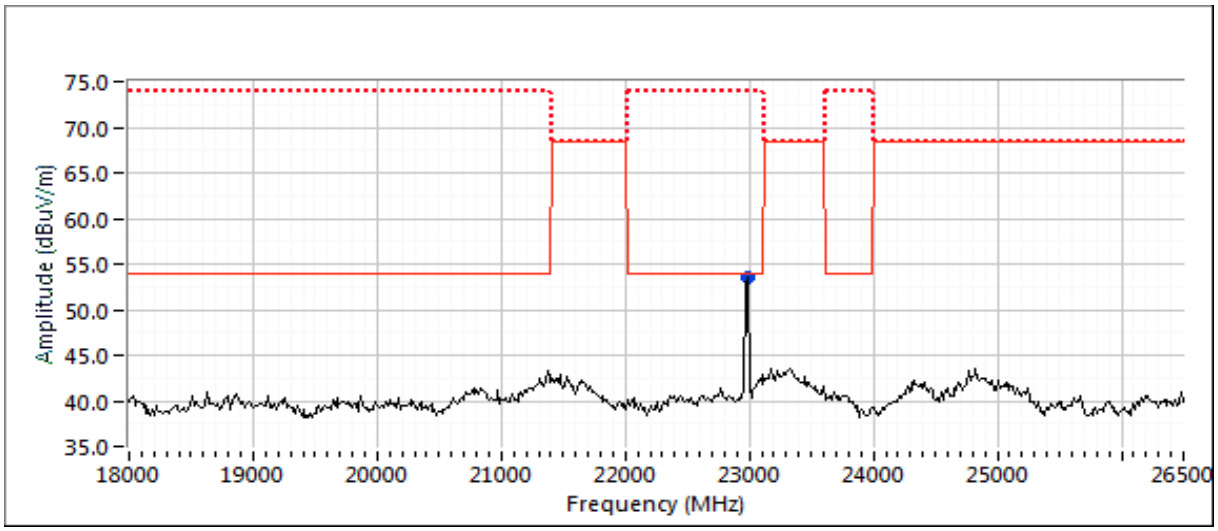


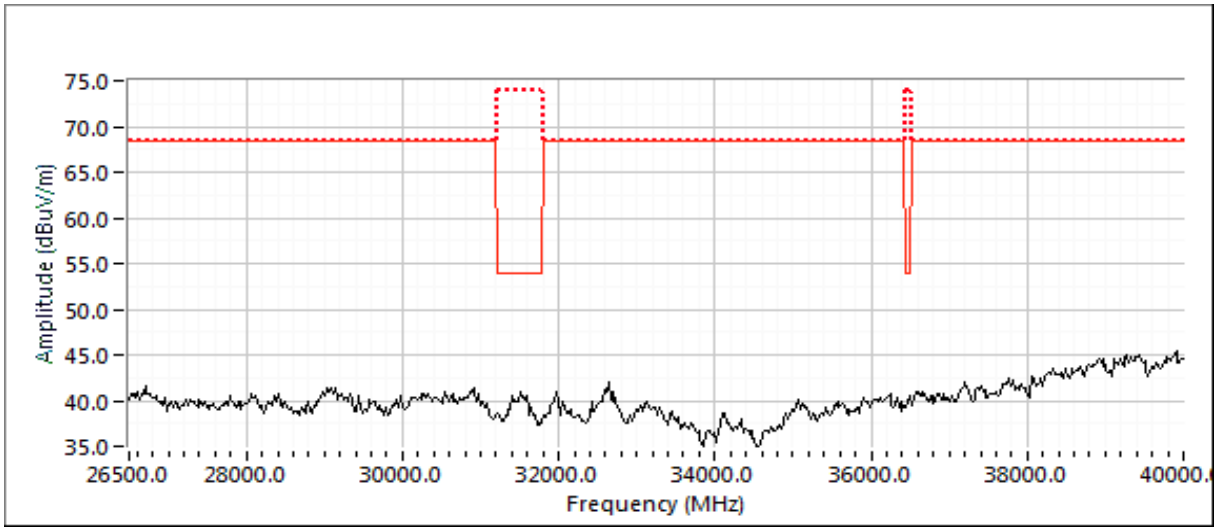
Client:	Neato Robotics, Inc.	Job Number:	PR087406
Model:	BotVac D7 Connected	T-Log Number:	TL087406
		Project Manager:	Christine Krebill
Contact:	Kelvin Law	Project Coordinator:	Deniz Demirci
Standard:	FCC 15E, RSS-247	Class:	N/A





Client:	Neato Robotics, Inc.	Job Number:	PR087406
Model:	BotVac D7 Connected	T-Log Number:	TL087406
		Project Manager:	Christine Krebill
Contact:	Kelvin Law	Project Coordinator:	Deniz Demirci
Standard:	FCC 15E, RSS-247	Class:	N/A



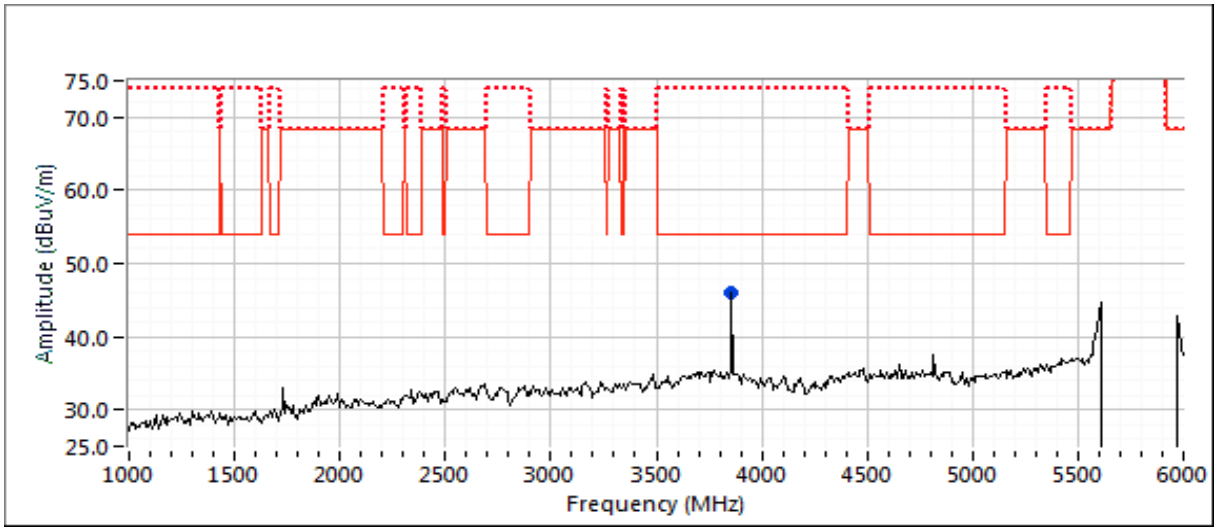


Client:	Neato Robotics, Inc.	Job Number:	PR087406
Model:	BotVac D7 Connected	T-Log Number:	TL087406
		Project Manager:	Christine Krebill
Contact:	Kelvin Law	Project Coordinator:	Deniz Demirci
Standard:	FCC 15E, RSS-247	Class:	N/A

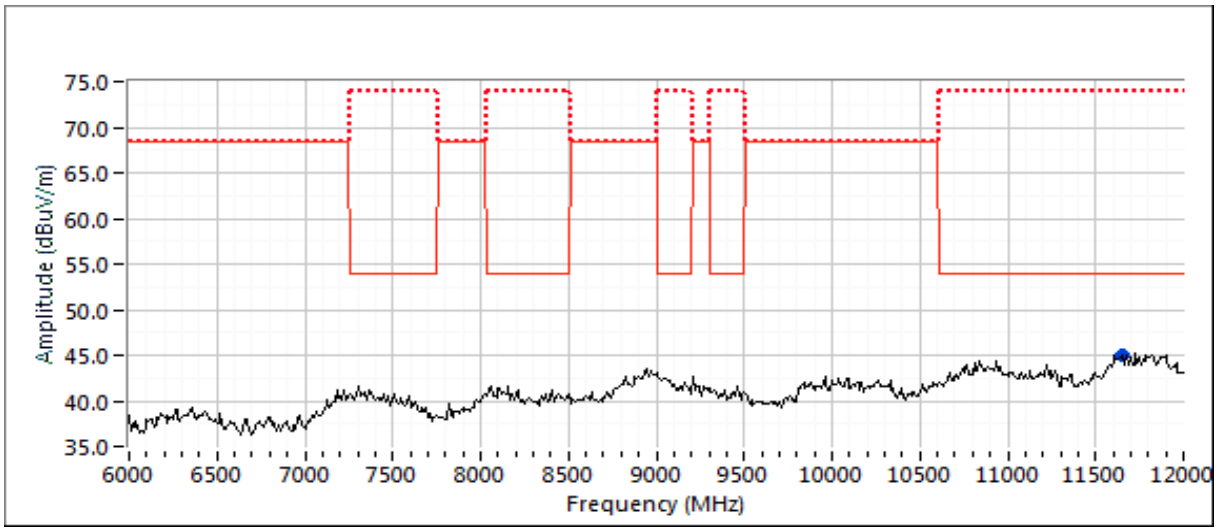
Run #1b: Center Channel

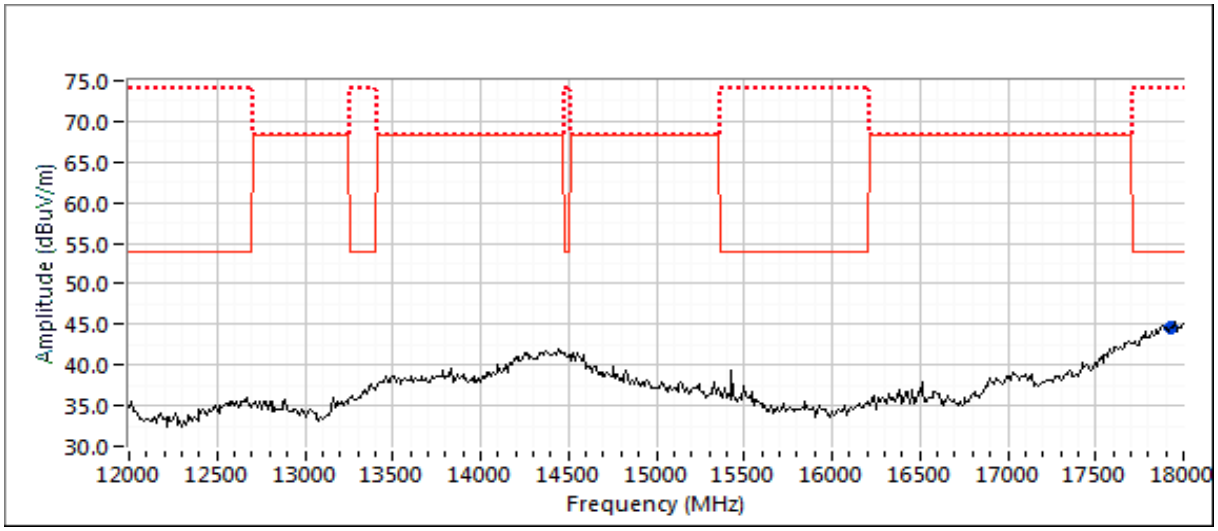
Channel: 157 Mode: n20
Tx Chain: Main Data Rate: MCS0

Frequency	Level	Pol	15.209 / 15E		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
3856.570	45.3	H	54.0	-8.7	AVG	106	1.0	RB 1 MHz;VB 300 Hz;Peak
3856.530	49.7	H	74.0	-24.3	PK	106	1.0	RB 1 MHz;VB 3 MHz;Peak
11568.000	45.1	H	54.0	-8.9	PK	80	1.0	Noise floor reading
17930.000	44.5	V	54.0	-9.5	PK	321	1.3	Noise floor reading
23139.660	59.7	V	68.3	-8.6	PK	51	2.0	RB 1 MHz;VB 3 MHz;Peak

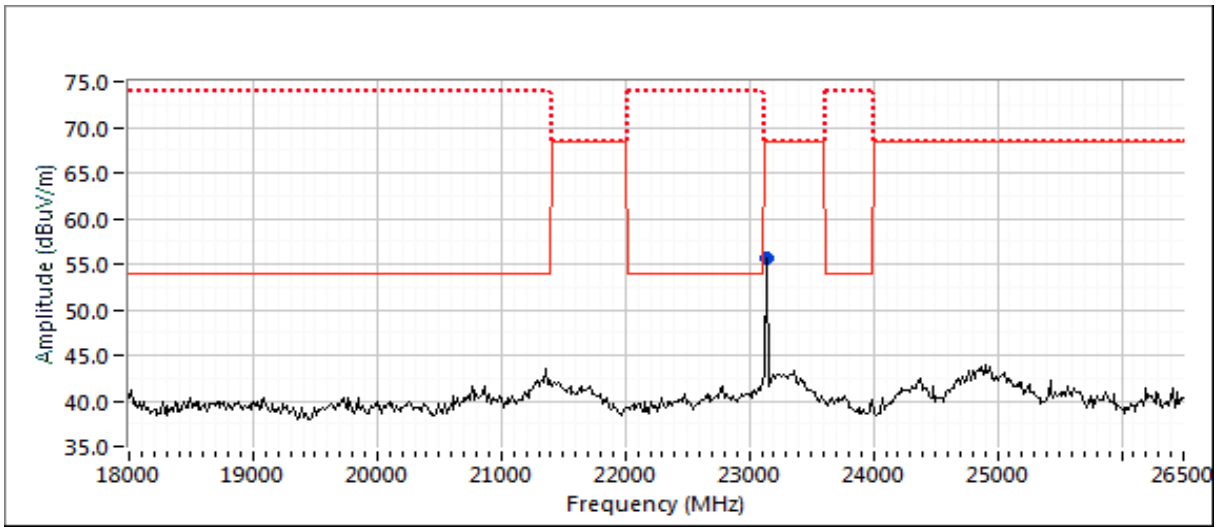


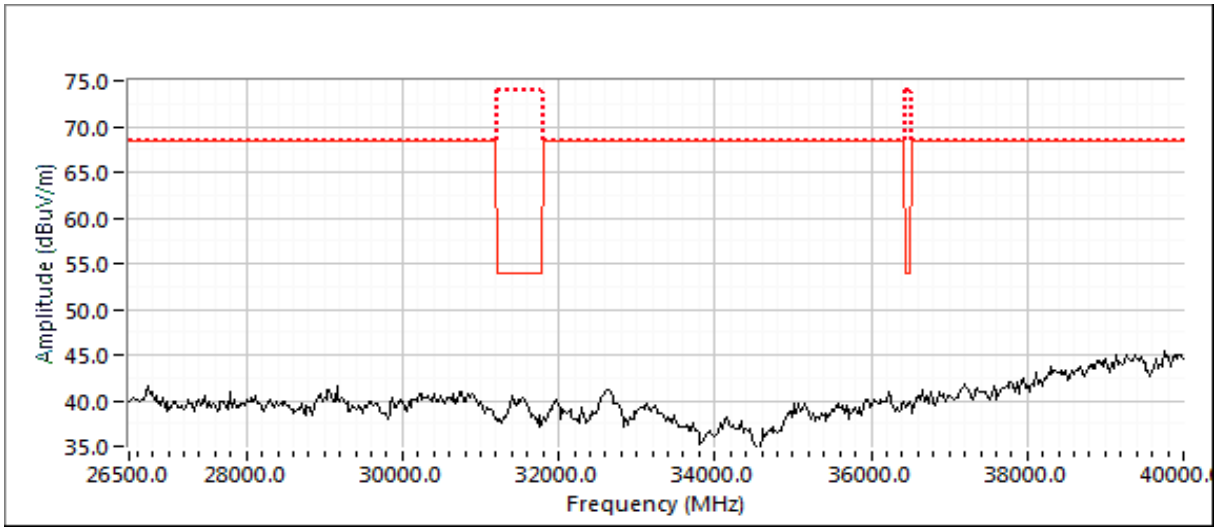
Client:	Neato Robotics, Inc.	Job Number:	PR087406
Model:	BotVac D7 Connected	T-Log Number:	TL087406
		Project Manager:	Christine Krebill
Contact:	Kelvin Law	Project Coordinator:	Deniz Demirci
Standard:	FCC 15E, RSS-247	Class:	N/A





Client:	Neato Robotics, Inc.	Job Number:	PR087406
Model:	BotVac D7 Connected	T-Log Number:	TL087406
		Project Manager:	Christine Krebill
Contact:	Kelvin Law	Project Coordinator:	Deniz Demirci
Standard:	FCC 15E, RSS-247	Class:	N/A



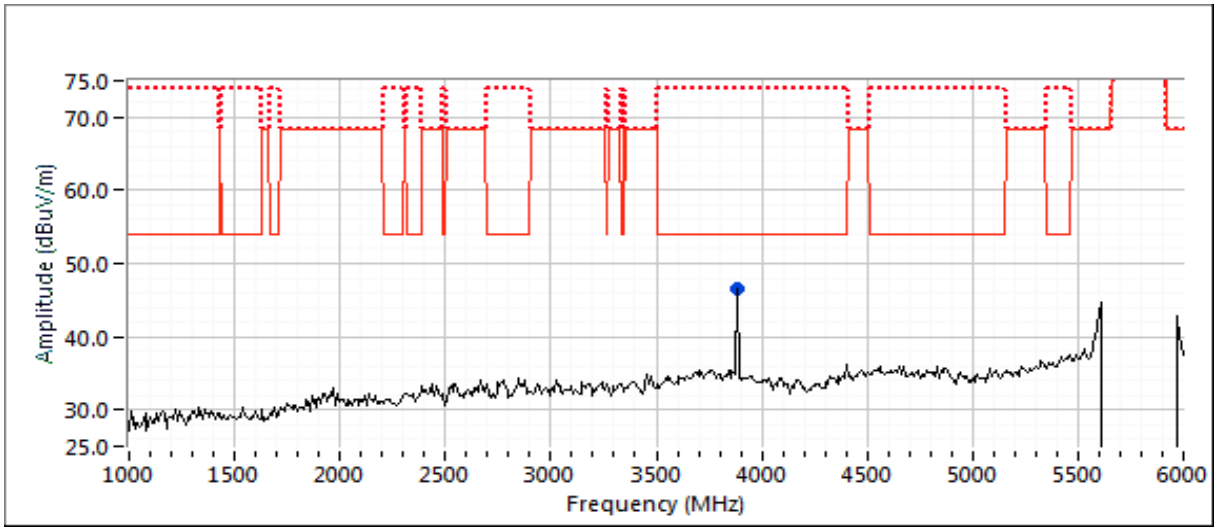


Client:	Neato Robotics, Inc.	Job Number:	PR087406
Model:	BotVac D7 Connected	T-Log Number:	TL087406
		Project Manager:	Christine Krebill
Contact:	Kelvin Law	Project Coordinator:	Deniz Demirci
Standard:	FCC 15E, RSS-247	Class:	N/A

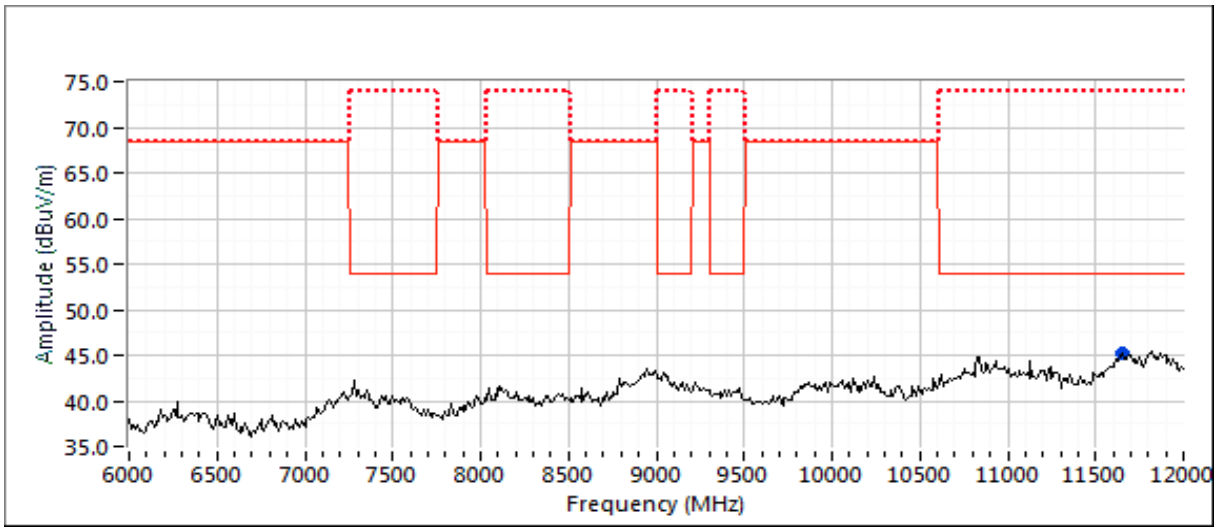
Run #1c: High Channel

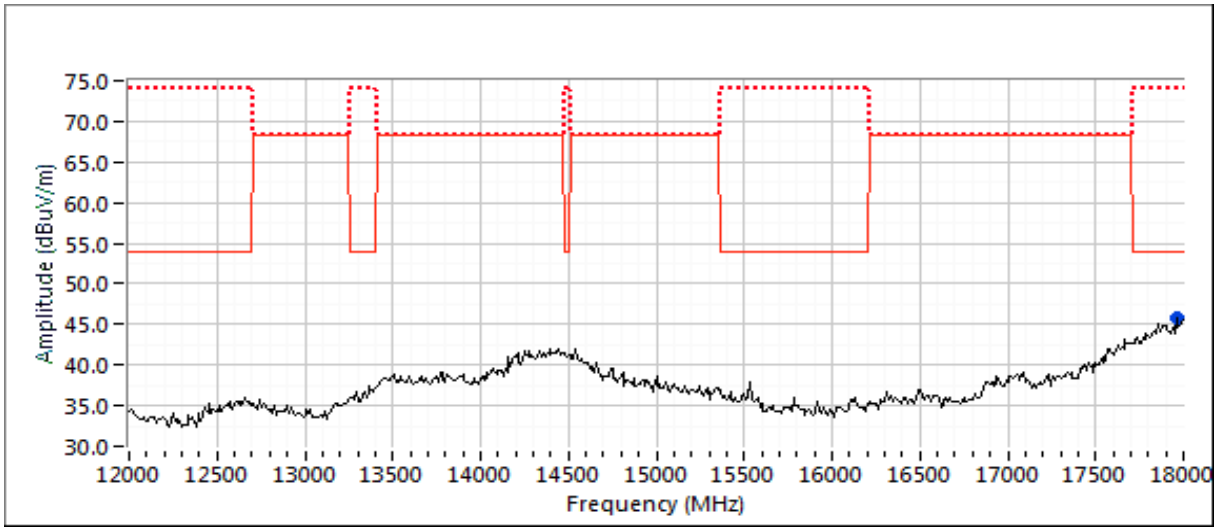
Channel: 165 Mode: n20
Tx Chain: Main Data Rate: MCS0

Frequency	Level	Pol	15.209 / 15E		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
3883.260	45.9	H	54.0	-8.1	AVG	104	1.1	RB 1 MHz;VB 300 Hz;Peak
3883.230	50.0	H	74.0	-24.0	PK	104	1.1	RB 1 MHz;VB 3 MHz;Peak
11650.000	45.3	H	54.0	-8.7	PK	5	1.0	Noise floor reading
17960.000	45.7	V	54.0	-8.3	PK	23	1.8	Noise floor reading
23299.680	60.9	V	68.3	-7.4	PK	48	2.0	RB 1 MHz;VB 3 MHz;Peak

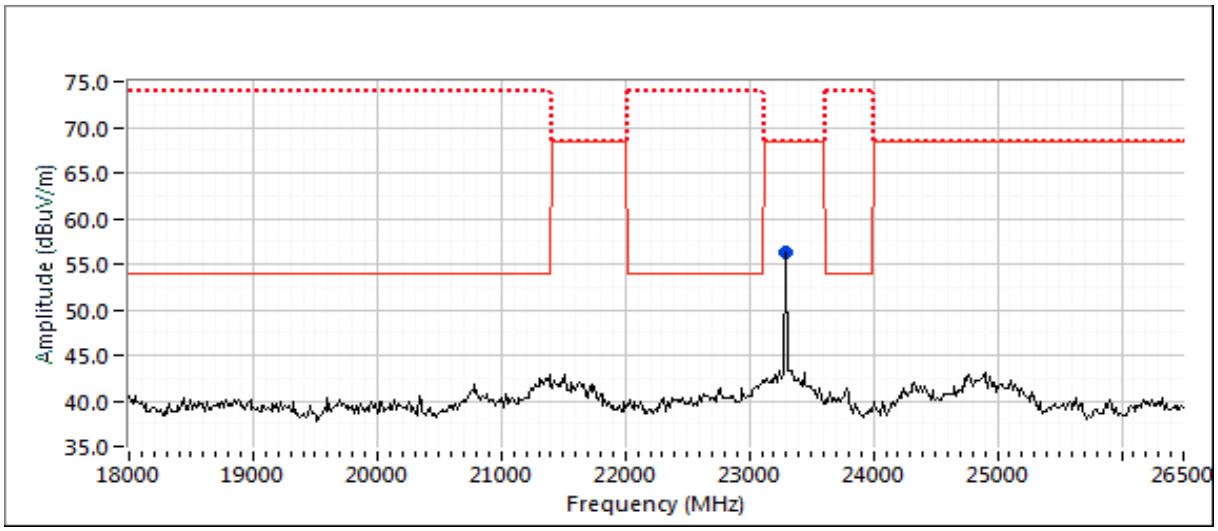


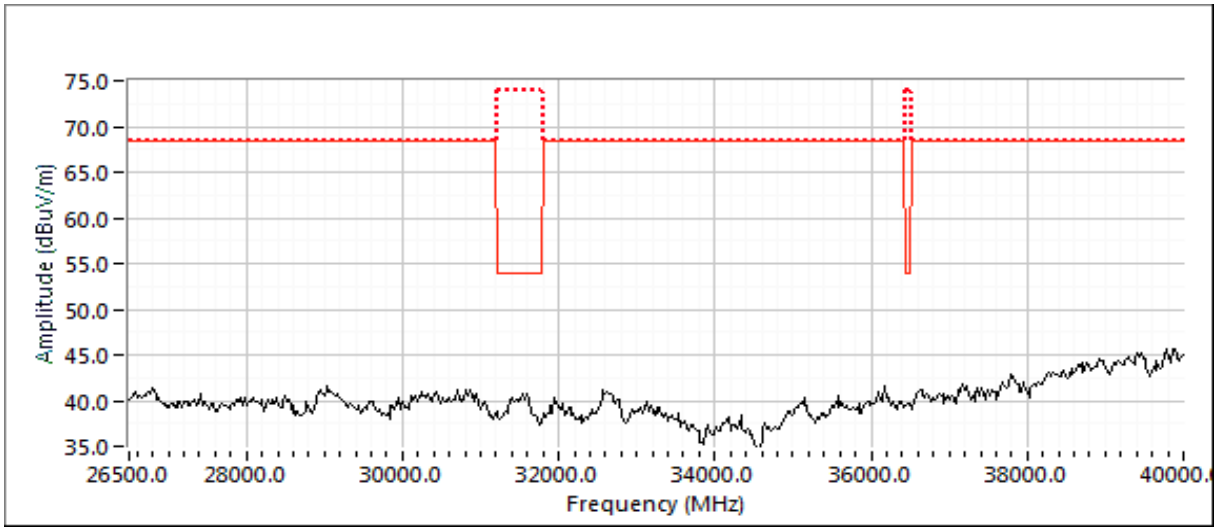
Client:	Neato Robotics, Inc.	Job Number:	PR087406
Model:	BotVac D7 Connected	T-Log Number:	TL087406
		Project Manager:	Christine Krebill
Contact:	Kelvin Law	Project Coordinator:	Deniz Demirci
Standard:	FCC 15E, RSS-247	Class:	N/A





Client:	Neato Robotics, Inc.	Job Number:	PR087406
Model:	BotVac D7 Connected	T-Log Number:	TL087406
		Project Manager:	Christine Krebill
Contact:	Kelvin Law	Project Coordinator:	Deniz Demirci
Standard:	FCC 15E, RSS-247	Class:	N/A





Client:	Neato Robotics, Inc.	PR Number:	PR087406
Model:	BotVac D7 Connected	T-Log Number:	TL087406
		Project Manager:	Christine Krebill
Contact:	Kelvin Law	Project Engineer:	Deniz Demirci
Standard:	FCC 15E, RSS-247	Class:	-

Radiated Emissions

(NTS Silicon Valley, Fremont Facility, Semi-Anechoic Chamber)

Test Specific Details

Objective: The objective of this test session is to perform final qualification testing of the EUT with respect to the specification listed above.

Date of Test: 12/17/2018
Test Engineer: Deniz Demirci
Test Location: Fremont Chamber #4
Config. Used: 1
Config Change: None
EUT Voltage: Battery operated

General Test Configuration

The EUT was located on the turntable for radiated emissions testing. No remote support equipment was used.
For radiated emissions testing the measurement antenna was located 3 meters from the EUT, unless otherwise noted.

Ambient Conditions:

Temperature: 22-23 °C
Rel. Humidity: 40-42 %

Summary of Results

Run #	Mode	Channel	Power Setting	Measured Power	Test Performed	Limit	Result / Margin
1	MCS0	157 - 5785 MHz			Radiated Emissions, 9 kHz - 1 GHz	FCC 15.209 / 15 E	32.2 dBµV/m @ 281.60 MHz (-13.8 dB)

Modifications Made During Testing

No modifications were made to the EUT during testing

Deviations From The Standard

No deviations were made from the requirements of the standard.

Sample Notes

Sample S/N: OPS34417-E8EB111669A0
Driver: WL18
Antenna: Integral, 0.1 dBi @ 5850 MHz

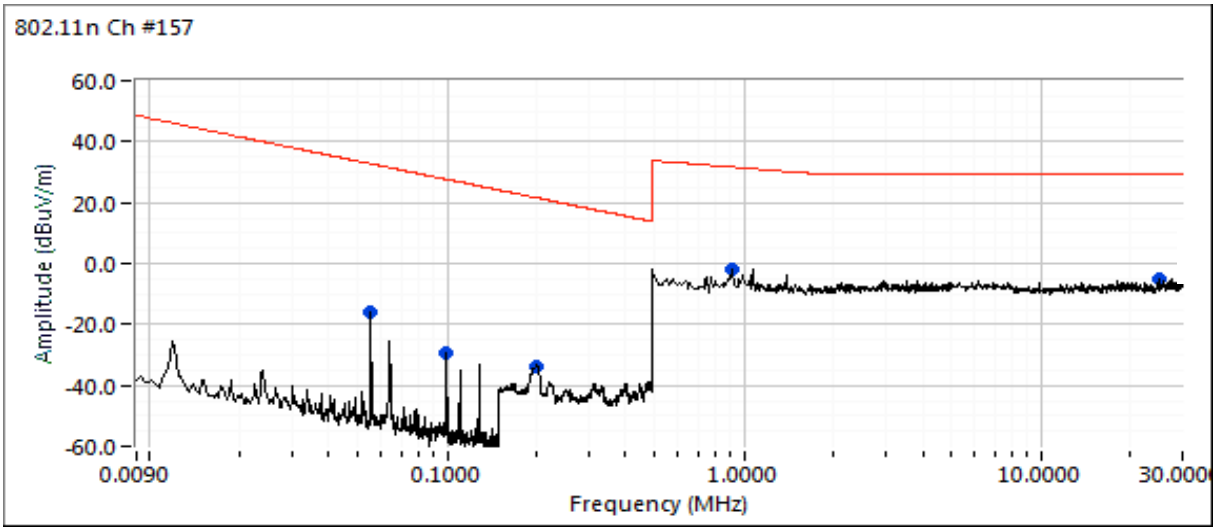
Client:	Neato Robotics, Inc.	PR Number:	PR087406
Model:	BotVac D7 Connected	T-Log Number:	TL087406
		Project Manager:	Christine Krebill
Contact:	Kelvin Law	Project Engineer:	Deniz Demirci
Standard:	FCC 15E, RSS-247	Class:	-

Run #1: Center Channel - Radiated Emissions, 9 kHz - 1000 MHz

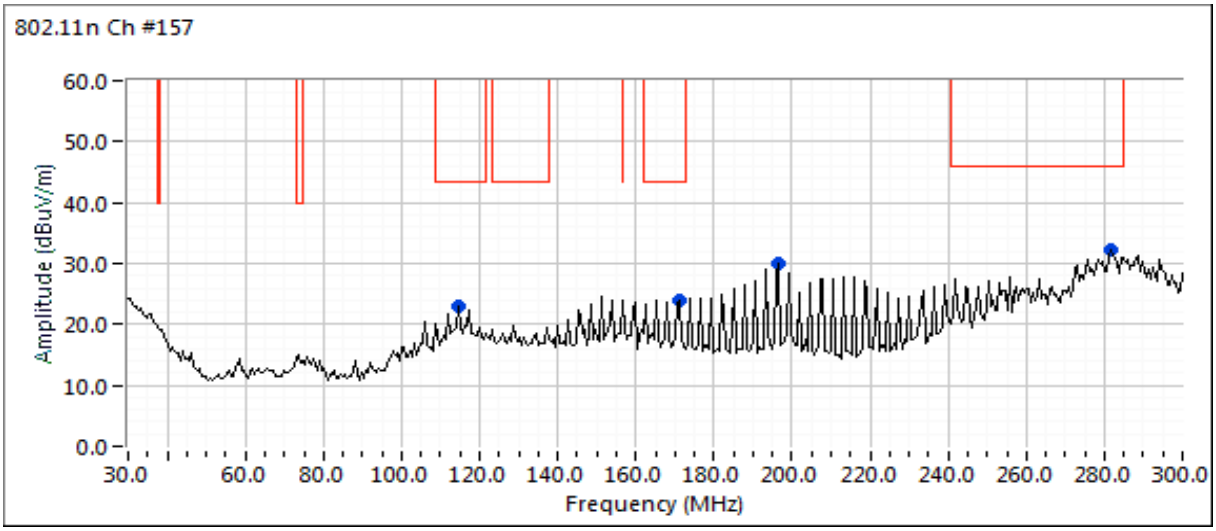
Channel: 157 Mode: n20
Tx Chain: Main Data Rate: MCS0

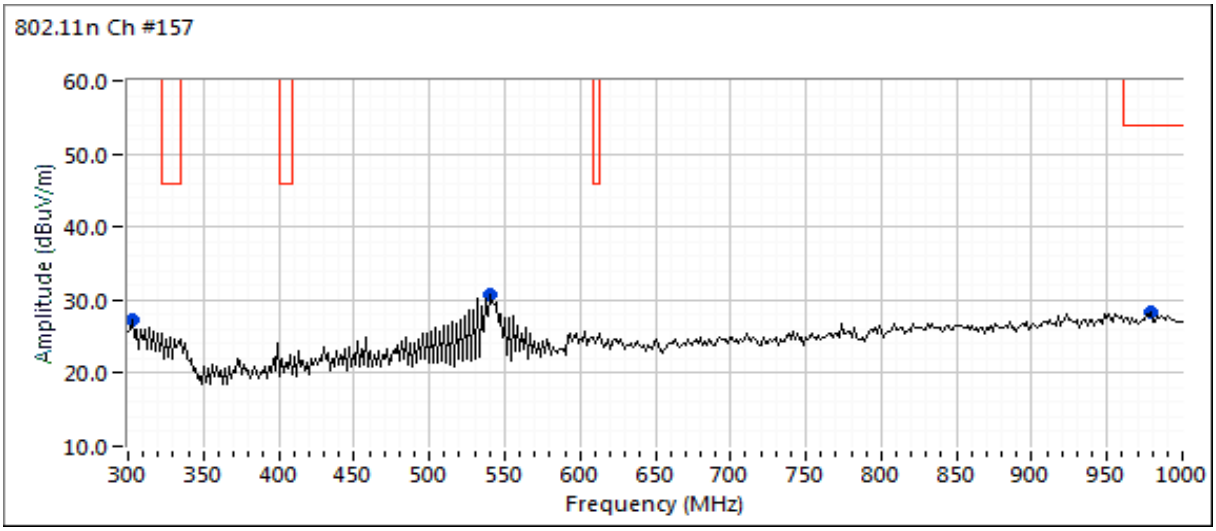
Frequency	Level	Pol	15.209 / 15E		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
0.055	-16.2	H	32.7	-48.9	PK	237	1.3	
0.099	-29.6	H	27.6	-57.2	PK	357	1.3	
0.201	-33.8	H	21.5	-55.3	PK	41	1.3	
0.906	-1.6	H	31.7	-33.3	PK	76	1.3	Noise floor reading
25.190	-5.1	H	29.5	-34.6	PK	15	1.3	Noise floor reading
114.409	22.9	H	43.5	-20.6	PK	288	3.5	
171.222	23.8	H	43.5	-19.7	PK	230	1.5	
196.653	30.0	H	46.0	-16.0	PK	347	1.5	Note 1
281.603	32.2	H	46.0	-13.8	PK	212	1.0	
302.806	27.3	H	46.0	-18.7	PK	23	1.0	Note 1
539.880	30.8	H	46.0	-15.2	PK	8	1.5	Note 1
978.958	28.3	H	54.0	-25.7	PK	12	3.5	Noise floor reading

Note 1:	Emission in non-restricted band, but limit of 15.209 used.



Client:	Neato Robotics, Inc.	PR Number:	PR087406
Model:	BotVac D7 Connected	T-Log Number:	TL087406
		Project Manager:	Christine Krebill
Contact:	Kelvin Law	Project Engineer:	Deniz Demirci
Standard:	FCC 15E, RSS-247	Class:	-





Client:	Neato Robotics, Inc.	PR Number:	PR087406
Model:	BotVac D7 Connected	T-Log Number:	TL087406
		Project Manager:	Christine Krebill
Contact:	Kelvin Law	Project Engineer:	Deniz Demirci
Standard:	FCC 15E, RSS-247	Class:	-

Conducted Emissions

(NTS Silicon Valley, Fremont Facility, Semi-Anechoic Chamber)

Test Specific Details

Objective: The objective of this test session is to perform final qualification testing of the EUT with respect to the specification listed above.

Date of Test: 12/17/2018
Test Engineer: Deniz Demirci
Test Location: Fremont Chamber #4
Config. Used: 1
Config Change: None
EUT Voltage: 120 V/60 Hz

General Test Configuration

The EUT was located on a table inside the semi-anechoic chamber, 40 cm from a vertical coupling plane and 8 0cm from the LISN. No remote support equipment was used

Ambient Conditions:

Temperature: 22-23 °C
Rel. Humidity: 40-42 %

Summary of Results

Run #	Test Performed	Limit	Result	Margin
1	CE, AC Power, 120V/60Hz	Class B	Pass	28.6 dBµV @ 0.485 MHz (-17.6 dB)

Modifications Made During Testing

No modifications were made to the EUT during testing

Deviations From The Standard

No deviations were made from the requirements of the standard.

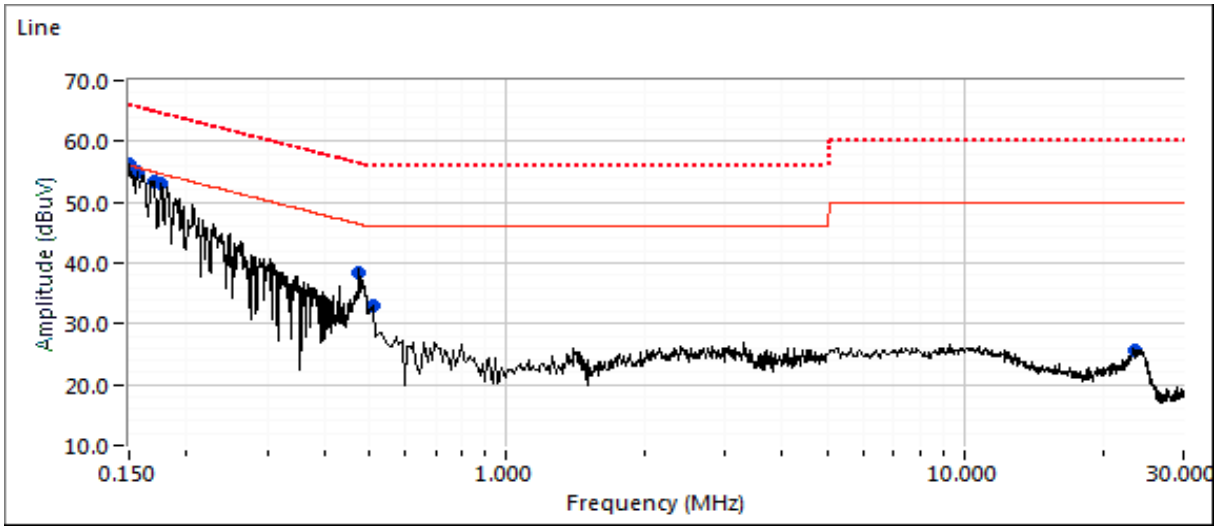
Sample Notes

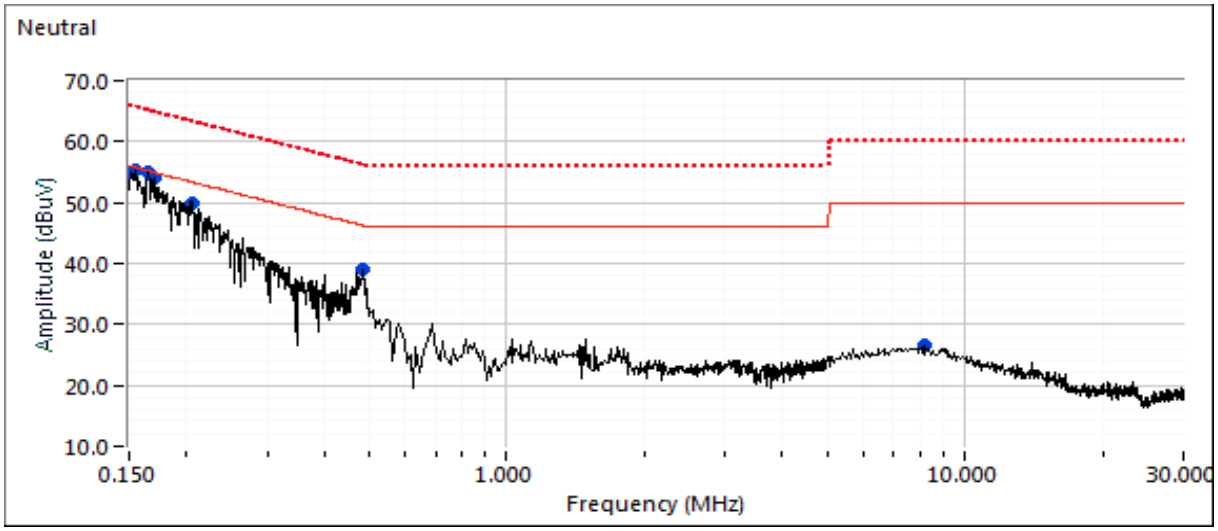
Sample S/N: OPS34417-E8EB111669A0
Driver: WL18
Antenna: Integral, 0.1 dBi @ 5850 MHz

Client:	Neato Robotics, Inc.	PR Number:	PR087406
Model:	BotVac D7 Connected	T-Log Number:	TL087406
		Project Manager:	Christine Krebill
Contact:	Kelvin Law	Project Engineer:	Deniz Demirci
Standard:	FCC 15E, RSS-247	Class:	-

Run #1: AC Power Port Conducted Emissions, 0.15 - 30 MHz, 120 V/60 Hz

Channel: 157 Mode: n20
Tx Chain: Main Data Rate: MCS0





Client:	Neato Robotics, Inc.	PR Number:	PR087406
Model:	BotVac D7 Connected	T-Log Number:	TL087406
		Project Manager:	Christine Krebill
Contact:	Kelvin Law	Project Engineer:	Deniz Demirci
Standard:	FCC 15E, RSS-247	Class:	-

Preliminary peak readings captured during pre-scan (peak readings vs. average limit)

Frequency	Level	AC	Class B		Detector	Comments
MHz	dBµV	Line	Limit	Margin	QP/Ave	
0.150	*56.2*	*Line 1*	*56.0*	*0.2*	*Peak*	
0.157	*54.9*	*Line 1*	*55.6*	*-0.7*	*Peak*	
0.170	*53.4*	*Line 1*	*55.0*	*-1.6*	*Peak*	
0.177	*53.2*	*Line 1*	*54.6*	*-1.4*	*Peak*	
0.476	*38.4*	*Line 1*	*46.4*	*-8.0*	*Peak*	
0.509	*33.1*	*Line 1*	*46.0*	*-12.9*	*Peak*	
23.487	*25.6*	*Line 1*	*50.0*	*-24.4*	*Peak*	
0.151	*54.9*	*Neutral*	*55.9*	*-1.0*	*Peak*	
0.156	*55.2*	*Neutral*	*55.7*	*-0.5*	*Peak*	
0.165	*55.1*	*Neutral*	*55.2*	*-0.1*	*Peak*	
0.170	*54.1*	*Neutral*	*55.0*	*-0.9*	*Peak*	
0.207	*49.8*	*Neutral*	*53.3*	*-3.5*	*Peak*	
0.487	*38.9*	*Neutral*	*46.2*	*-7.3*	*Peak*	
8.206	*26.6*	*Neutral*	*50.0*	*-23.4*	*Peak*	

Client:	Neato Robotics, Inc.	PR Number:	PR087406
Model:	BotVac D7 Connected	T-Log Number:	TL087406
		Project Manager:	Christine Krebill
Contact:	Kelvin Law	Project Engineer:	Deniz Demirci
Standard:	FCC 15E, RSS-247	Class:	-

Final quasi-peak and average readings

Frequency	Level	AC	Class B		Detector	Comments
MHz	dBµV	Line	Limit	Margin	QP/Ave	
0.485	28.6	Neutral	46.2	-17.6	AVG	AVG (0.10s)
0.152	47.6	Neutral	65.9	-18.3	QP	QP (1.00s)
0.151	47.6	Line 1	66.0	-18.4	QP	QP (1.00s)
0.155	47.2	Neutral	65.7	-18.5	QP	QP (1.00s)
0.474	27.8	Line 1	46.4	-18.6	AVG	AVG (0.10s)
0.158	46.7	Line 1	65.6	-18.9	QP	QP (1.00s)
0.169	45.6	Line 1	65.0	-19.4	QP	QP (1.00s)
0.165	45.7	Neutral	65.2	-19.5	QP	QP (1.00s)
0.169	45.0	Neutral	65.0	-20.0	QP	QP (1.00s)
0.178	44.4	Line 1	64.6	-20.2	QP	QP (1.00s)
0.485	35.2	Neutral	56.2	-21.0	QP	QP (1.00s)
0.474	35.0	Line 1	56.4	-21.4	QP	QP (1.00s)
0.207	41.2	Neutral	63.3	-22.1	QP	QP (1.00s)
0.500	20.3	Line 1	46.0	-25.7	AVG	AVG (0.10s)
0.500	29.2	Line 1	56.0	-26.8	QP	QP (1.00s)
0.151	27.9	Line 1	56.0	-28.1	AVG	AVG (0.10s)
0.152	27.8	Neutral	55.9	-28.1	AVG	AVG (0.10s)
0.207	24.7	Neutral	53.3	-28.6	AVG	AVG (0.10s)
0.155	27.0	Neutral	55.7	-28.7	AVG	AVG (0.10s)
0.169	26.0	Neutral	55.0	-29.0	AVG	AVG (0.10s)
0.165	26.1	Neutral	55.2	-29.1	AVG	AVG (0.10s)
0.169	25.7	Line 1	55.0	-29.3	AVG	AVG (0.10s)
0.158	26.2	Line 1	55.6	-29.4	AVG	AVG (0.10s)
0.178	25.1	Line 1	54.6	-29.5	AVG	AVG (0.10s)
23.496	15.6	Line 1	50.0	-34.4	AVG	AVG (0.10s)
8.267	14.4	Neutral	50.0	-35.6	AVG	AVG (0.10s)
8.267	22.2	Neutral	60.0	-37.8	QP	QP (1.00s)
23.496	21.1	Line 1	60.0	-38.9	QP	QP (1.00s)

End of Report

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