41039 Boyce Road
Fremont, CA. 94538

510-578-3500 Phone
510-440-9525 Fax

EMC Test Report

Application for FCC Grant of Equipment Authorization

FCC Part 15 Subpart C

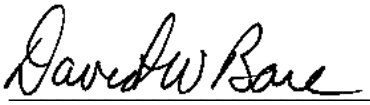
Model: TSM3000

FCC ID:	XKYEXTS3000
APPLICANT:	Nevro Corporation 1800 Bridge Parkway Redwood City, CA 94065
TEST SITE(S):	National Technical Systems 41039 Boyce Road. Fremont, CA. 94538-2435
PROJECT NUMBER:	PR111765
REPORT DATE:	April 22, 2020
FINAL TEST DATES:	March 25, 26, 27 and 30, 2020
TOTAL NUMBER OF PAGES:	42

A2LA ACCREDITED
Testing Cert #0214.26

VALIDATING SIGNATORIES

PROGRAM MGR

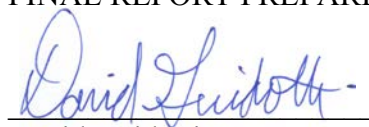


David W. Bare
Chief Engineer

TECHNICAL REVIEWER:

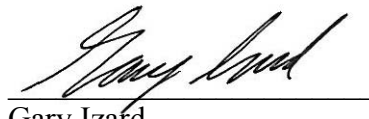
David W. Bare
Chief Engineer

FINAL REPORT PREPARER:



David Guidotti
Senior Technical Writer

QUALITY ASSURANCE DELEGATE



Gary Izard
Technical Writer

REVISION HISTORY

Rev#	Date	Comments	Modified By
-	April 22, 2020	First release	

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SCOPE

An electromagnetic emissions test has been performed on the Nevro Corporation model TSM3000, pursuant to the following rules:

FCC Part 15 Subpart C

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:

ANSI C63.10-2013
FCC DTS Measurement Guidance KDB558074

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.

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 Nevro Corporation model TSM3000 complied with the requirements of the following regulations:

FCC Part 15 Subpart C

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 Nevro Corporation model TSM3000 and therefore apply only to the tested samples. The samples were selected and prepared by Susan McGill of Nevro Corporation.

DEVIATIONS FROM THE STANDARDS

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

TEST RESULTS SUMMARY

DIGITAL TRANSMISSION SYSTEMS (2400 – 2483.5MHz)

FCC Rule Part		Description	Measured Value / Comments	Limit / Requirement	Result
15.247(a)		Digital Modulation	Systems uses GFSK modulation	System must utilize a digital transmission technology	Complies
15.247 (a) (2)		6dB Bandwidth	0.615 MHz	>500kHz	Complies
15.247 (b) (3)		Output Power (multipoint systems)	2.1 dBm (0.0016 Watts) EIRP = 0.002 W Note 1	1Watt, EIRP limited to 4 Watts.	Complies
15.247(e)		Power Spectral Density	Power less than 8 dBm	8dBm/3kHz	Complies
15.247(d)		Antenna Port Spurious Emissions 30MHz – 25 GHz	All > 30dBc	< -30dBc Note 2	Complies
15.247(d) / 15.209		Radiated Spurious Emissions 30MHz – 25 GHz	44.6 dBµV/m @ 2354.3 MHz (-9.4 dB)	Refer to the limits section (p18) for restricted bands, all others <-30dBc Note 2	Complies

Note 1: EIRP calculated using antenna gains of 1.3 dBi for the highest EIRP system.
Note 2: Limit of -30dBc used because the power was measured using the UNII test procedure (maximum power averaged over a transmission burst).

GENERAL REQUIREMENTS APPLICABLE TO ALL BANDS

FCC 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)		AC Conducted Emissions	Testing was not performed as the EUT is battery powered.		
15.247 (i) 15.407 (f)		RF Exposure Requirements	Refer to SAR exclusion calculations in separate exhibit	Refer to OET 65, FCC Part 1	Complies

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	± 0.52 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

EQUIPMENT UNDER TEST (EUT) DETAILS

GENERAL

The Nevro Corporation model TSM3000 is a body worn spinal cord stimulator that is designed to allow the evaluation of the therapy during a trial phase. Since the EUT would be placed near the body during operation, the EUT was treated as table-top equipment during testing to simulate the end-user environment. The electrical rating of the EUT is 3.6 Volts DC supplied from a non-rechargeable battery.

The samples were received on March 25, 2020 and tested on March 25, 26, 27 and 30, 2020. The following samples were used during testing:

Company	Model	Description	Serial Number	FCC ID
Nevro	TSM3000	Trial Stimulator	2000716	XKYEXTS3000
Nevro	TSM3000	Trial Stimulator	2000685	XKYEXTS3000

OTHER EUT DETAILS

The highest internal source of an EUT is defined as the highest frequency generated or used within the EUT or on which the EUT operates or tunes. In some cases, the highest internal source determines the frequency range of test for radiated emissions. The highest internal source of the EUT was declared as: 2480 MHz

ANTENNA SYSTEM

The antenna system consists of integral 1.3 dBi antenna.

ENCLOSURE

The EUT enclosure is primarily constructed of plastic. It measures approximately 6.0 cm wide by 2.0 cm deep by 8.5 cm high.

MODIFICATIONS

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

SUPPORT EQUIPMENT

The following equipment was used as support equipment for testing:

Configuration #1

Company	Model	Description	Serial Number	FCC ID
GWINSTEK	PSP-603	Power Supply	GET190269	-

Configuration #3

Company	Model	Description	Serial Number	FCC ID
-	-	Resistance Decade Box	16043531	-

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

Company	Model	Description	Serial Number	FCC ID
Dell	Latitude 5289	Laptop	11175824630	-

EUT INTERFACE PORTS

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

Configuration #1

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

Configuration #3

Port	Connected To	Cable(s)		
		Description	Shielded or Unshielded	Length(m)
Lead	Stim leads	Multiwire	Unshielded	0.4
Stim leads	Resistance Decade Box	Single wire	Unshielded	0.5

EUT OPERATION

Configuration #1: During emissions testing the EUT was operating in a continuous transmit mode (CW on a channel or Advertising) or in "Non-advertising" mode as needed for the test. The EUT mode was enabled on the device using the Laptop and BLE test scripts.

Configuration #3: During emissions testing the EUT was operating in a continuous modulated transmit mode or in "Non-advertising" mode as needed for the test. The EUT mode was enabled on the device using the Laptop and BLE test scripts.

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 6.2 of RSS-GEN, NTS has been recognized as an accredited test laboratory by the Commission and Innovation, Science and Economic Development Canada. A description of the facilities employed for testing is maintained by NTS.

Site	Company / Registration Numbers		Location
	FCC	Canada	
Chamber 5	US1031	2845B (Wireless Test Lab #US0027)	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.

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 20Hz, 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 1000MHz 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)

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 1.5m for testing above 1 GHz. Floor mounted equipment shall be placed on the ground plane if the device is normally used on a conductive floor or separated from the ground plane by insulating material from 3 to 12 mm if the device is normally used on a non-conductive floor as specified in ANSI C63.4. 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.

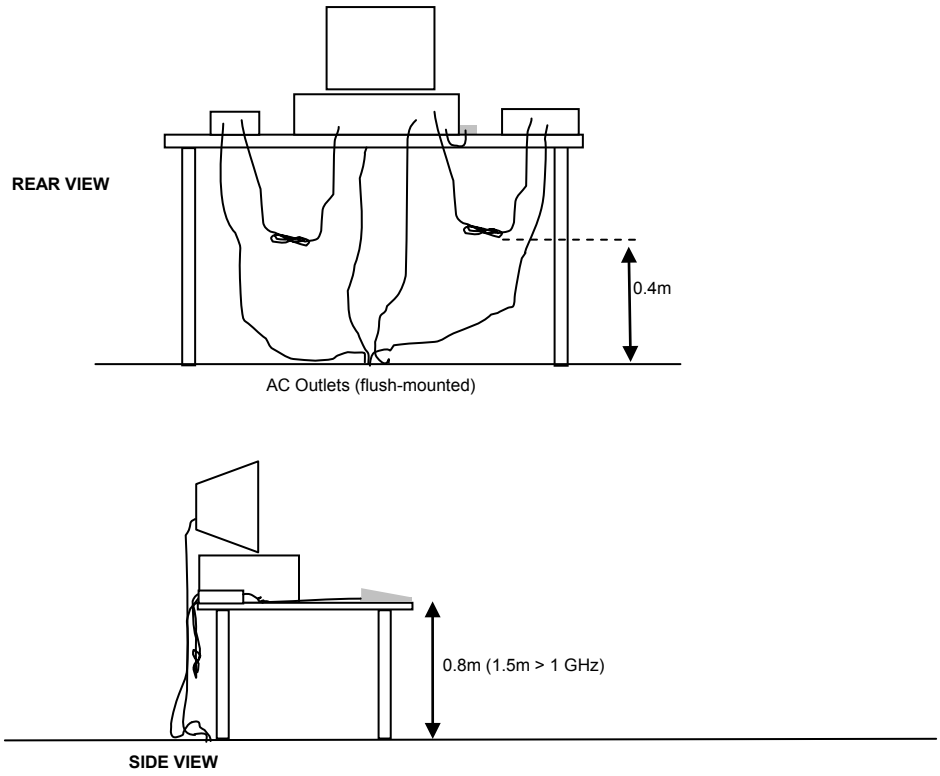
RADIATED EMISSIONS

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.

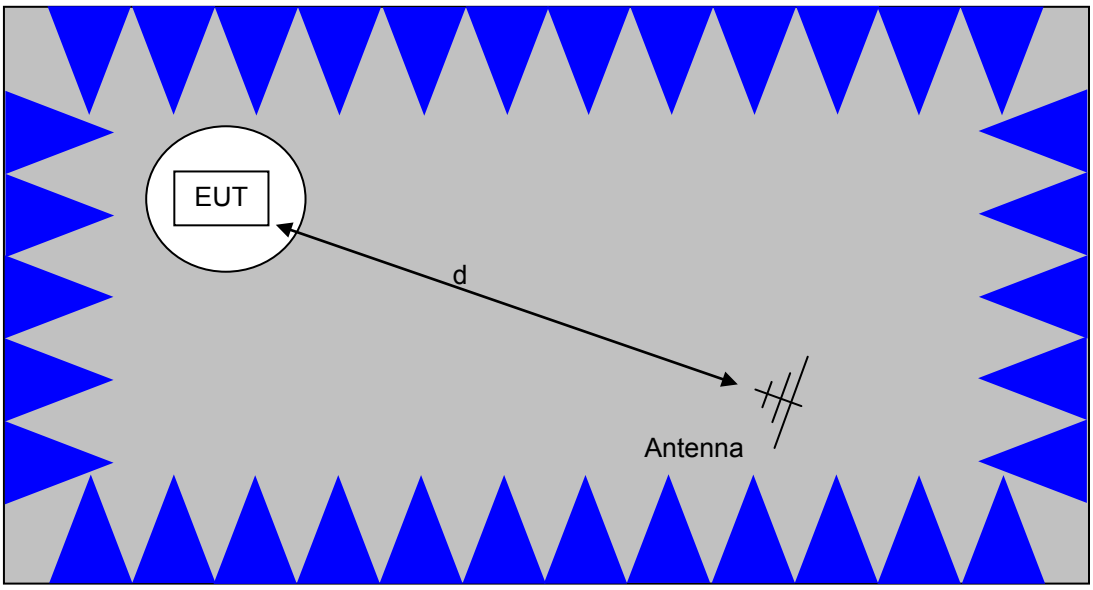
A speaker is provided in the receiver to aid in discriminating between EUT and ambient emissions. Other methods used during the preliminary scan for EUT emissions involve scanning with near field magnetic loops, monitoring I/O cables with RF current clamps, and cycling power to the EUT.

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 one to four meters (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 meters.

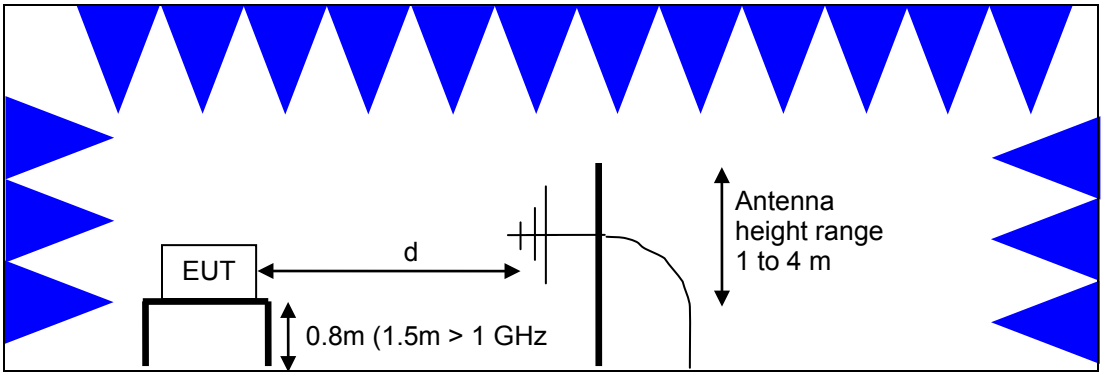


Typical Test Configuration for Radiated Field Strength Measurements



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.

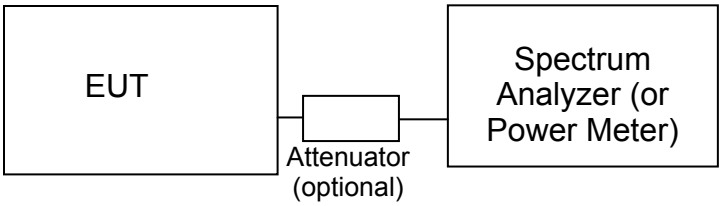
Floor-standing equipment is placed on the floor with insulating supports between the unit and the ground plane.



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 6dB, 20dB, 26dB 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 (dBuV). For radiated emissions, the measured data is converted to the field strength at the antenna in dB microvolts per meter (dBuV/m). The results are then converted to the linear forms of uV 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:

CONDUCTED EMISSIONS SPECIFICATION LIMITS: FCC 15.207; RSS GEN

The table below shows the limits for the emissions on the AC power line from an intentional radiator and a receiver.

Frequency (MHz)	Average Limit (dBuV)	Quasi Peak Limit (dBuV)
0.150 to 0.500	Linear decrease on logarithmic frequency axis between 56.0 and 46.0	Linear decrease on logarithmic frequency axis between 66.0 and 56.0
0.500 to 5.000	46.0	56.0
5.000 to 30.000	50.0	60.0

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 (uV/m)	Limit (dBuV/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

OUTPUT POWER LIMITS – DIGITAL TRANSMISSION SYSTEMS

The table below shows the limits for output power and output power density. 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
902 – 928	1 Watt (30 dBm)	8 dBm/3kHz
2400 – 2483.5	1 Watt (30 dBm)	8 dBm/3kHz
5725 – 5850	1 Watt (30 dBm)	8 dBm/3kHz

The maximum permitted output power is reduced by 1dB for every dB the antenna gain exceeds 6dBi. For FCC, fixed point to point applications using the 2400-2483.5 MHz band may use antennas with more than 6 dBi gain but output power is reduced by 1 dB for every 3dB that the antenna gain exceeds 6 dBi. For Canada, fixed point-to-point applications using the 2400-2483.5 MHz band are not subject to this restriction. Fixed point-to-point applications using the 5725 – 5850 MHz band are also not subject to this restriction. Certification of DTS systems operating in the 5725-5850 MHz band is no longer allowed under FCC Rules per §15.37(h).

TRANSMIT MODE SPURIOUS RADIATED EMISSIONS LIMITS – FHSS and DTS SYSTEMS

The limits for unwanted (spurious) emissions from the transmitter falling in the restricted bands are those specified in the general limits sections of FCC Part 15 and RSS GEN. All other unwanted (spurious) emissions shall be at least 20dB below the level of the highest in-band signal level (30dB if the power is measured using the sample detector/power averaging method).

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 dBuV/m
F_d = Distance Factor in dB
R_c = Corrected Reading in dBuV/m
L_s = Specification Limit in dBuV/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 3m the conversion from a logarithmic value for field strength (dBuV/m) to an eirp power (dBm) is -95.3dB.

Appendix A Test Equipment Calibration Data

Radio Antenna Port (Power and Spurious Emissions), 25-Mar-20

Manufacturer	Description	Model	Asset #	Calibrated	Cal Due
National Technical Systems	NTS EMI Software (rev 2.10)	N/A	WC022452	N/A	
National Technical Systems	NTS Capture Analyzer Software (rev 4.0)	N/A	WC022706	N/A	
Agilent Technologies	Analyzer (Spectrum)	E4446A	WC055650	7/18/2019	7/18/2020
Fluke	Fluke Mulitmeter, True RMS	175	WC064448	6/20/2019	6/20/2020
Agilent Technologies	USB Average Power Sensor	U2001A	WC064661	1/3/2020	1/3/2021
Watlow	Watlow Controller	F4	WC064560	5/8/2019	5/8/2020

Radiated Emissions, 30 - 25,000 MHz, 27, 30-Mar-20

Manufacturer	Description	Model	Asset #	Calibrated	Cal Due
National Technical Systems	NTS EMI Software (rev 2.10)	N/A	WC022452	N/A	
Hewlett Packard	Spectrum Analyzer (Red)	8564E (84125C)	WC055584	10/10/2019	10/10/2020
Hewlett Packard	Microwave Preamplifier Head, 18-40 GHz (Red)	84125C EMI Test Head	WC055586	10/4/2019	10/4/2020
EMCO	Horn Antenna	3115	WC062583	7/9/2018	7/9/2020
Hewlett Packard	Microwave Preamplifier, 1-26.5GHz	8449B	WC064416	7/18/2019	7/18/2020
A. H. Systems	Antenna, Horn, 18-40GHz	SAS-574	WC064555	7/8/2019	7/8/2021
Micro-Tronics	Band Reject Filter, 2400-2500 MHz	BRM50702-02	WC064593	11/21/2019	11/21/2020
Rohde & Schwarz	EMI Test Receiver, 20 Hz-7 GHz	ESIB 7	WC064989	11/4/2019	11/4/2020

Appendix B Test Data

TL111765-RA Pages 24 – 41

Client:	Nevro Corporation	PR Number:	PR111765
Product	TSM3000	T-Log Number:	TL111765-RA
System Configuration:	-	Project Manager:	Christine Krebill
Contact:	Susan McGill	Project Engineer:	David Bare
Emissions Standard(s):	FCC Part 15, EN 300 328	Class:	-
Immunity Standard(s):	EN 301 489-1, 17	Environment:	Radio

EMC Test Data

For The

Nevro Corporation

Product

TSM3000

Date of Last Test: 3/27/2020

Client:	Nevro Corporation	PR Number:	PR111765
Model:	TSM3000	T-Log Number:	TL111765-RA
		Project Manager:	Christine Krebill
Contact:	Susan McGill	Project Engineer:	David Bare
Standard:	FCC Part 15, EN 300 328	Class:	N/A

RSS-247 and FCC 15.247 (DTS) 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.

Date of Test: 3/25/2020
Test Engineer: David Bare
Test Location: Fremont EMC Lab #4B

Config. Used: 1
Config Change: None
EUT Voltage: 3.6 VDC

General Test Configuration

The EUT was connected to the spectrum analyzer or power meter via a suitable attenuator. All measurements were made on a single chain.
All measurements have been corrected to allow for the external attenuators used.

Ambient Conditions:

Temperature: 19 °C
Rel. Humidity: 41 %

Summary of Results

Run #	Pwr setting		Test Performed	Limit	Pass / Fail	Result / Margin
1			Output Power	15.247(b)		2.1 dBm
2			Power spectral Density (PSD)	15.247(d)		Power less than 8 dBm
3			Minimum 6dB Bandwidth	15.247(a)		0.615 MHz
3			99% Bandwidth	RSS GEN	-	1.058 MHz
4			Spurious emissions	15.247(b)		All > 30dBc

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.

Client:	Nevro Corporation	PR Number:	PR111765
Model:	TSM3000	T-Log Number:	TL111765-RA
		Project Manager:	Christine Krebill
Contact:	Susan McGill	Project Engineer:	David Bare
Standard:	FCC Part 15, EN 300 328	Class:	N/A

Procedure Comments:

Measurements performed in accordance with ANSI C63.10

Sample Notes

Sample S/N: 2000716

Driver: PyCharm (BLEContinuousTxPower.py)

Run #1: Output Power

Tested in CW mode (100% duty cycle)

Power Setting[2]	Frequency (MHz)	Output Power (dBm) [1]	Output Power mW	Antenna Gain (dBi)	Result	EIRP dBm	EIRP W		
4	2402	2.1	1.6	1.3	Pass	3.4	0.002		
4	2440	1.7	1.5	1.3	Pass	3.0	0.002		
4	2480	1.3	1.3	1.3	Pass	2.6	0.002		

Note 1:	Output power measured using a average power meter, spurious limit is -30dBc.
Note 2:	Power setting - the software power setting used during testing, included for reference only.

Run #2: Power spectral Density

Not required - output power is less than 8 dBm PSD limit

Note 1:	Test performed per method PKSPD, in KDB 558074. Power spectral density measured using: 3kHz ≤ RBW ≤ 100kHz, VBW=3*RBW, peak detector, span = 1.5*DTS BW, auto sweep time, max hold.

Run #3: Signal Bandwidth

Tested in Advertising mode

Power Setting	Frequency (MHz)	Bandwidth (MHz) 6dB	Bandwidth (MHz) 99%	RBW Setting (MHz) 6dB	RBW Setting (MHz) 99%
4	2402	0.705	1.053	0.1	0.03
4	2426	0.695	1.058	0.1	0.03
4	2480	0.615	1.058	0.1	0.03

Note 1:	DTS BW: RBW=100kHz, VBW ≥ 3*RBW, peak detector, max hold, auto sweep time, Span 2-5 times measured BW. 99% BW: RBW=1-5% of 99%BW, VBW ≥ 3*RBW, peak detector, max hold, auto sweep time. Span 1.5-5 times OBW.

Client:	Nevro Corporation	PR Number:	PR111765
Model:	TSM3000	T-Log Number:	TL111765-RA
		Project Manager:	Christine Krebill
Contact:	Susan McGill	Project Engineer:	David Bare
Standard:	FCC Part 15, EN 300 328	Class:	N/A

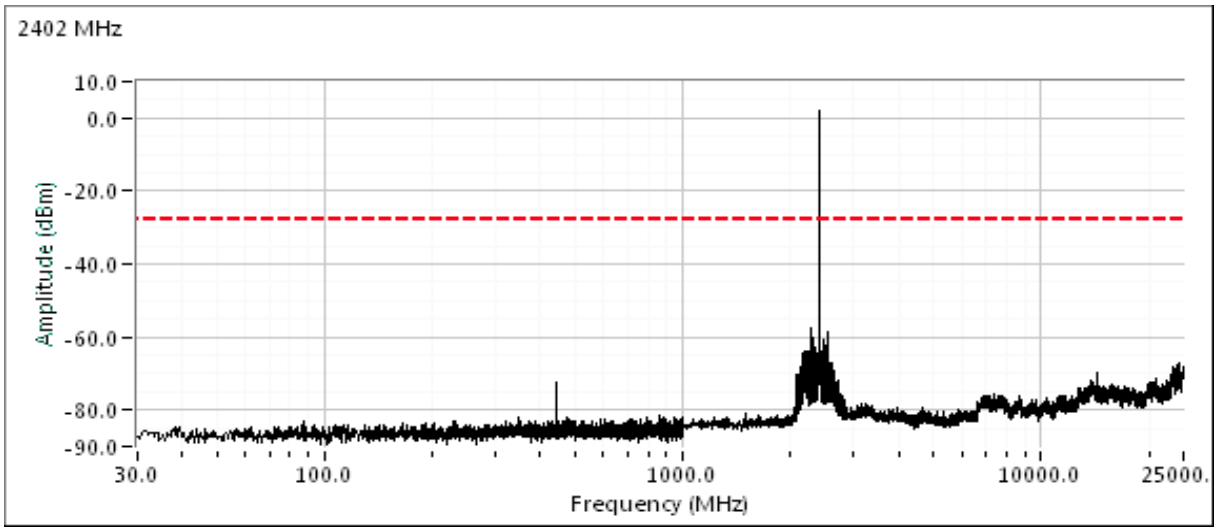
Run #4a: Out of Band Spurious Emissions

Tested in CW mode (100% duty cycle)

Frequency (MHz)	Power Setting	Mode	Limit	Result
2402	4	BLE	-30dBc	Pass
2440	4	BLE	-30dBc	Pass
2480	4	BLE	-30dBc	Pass

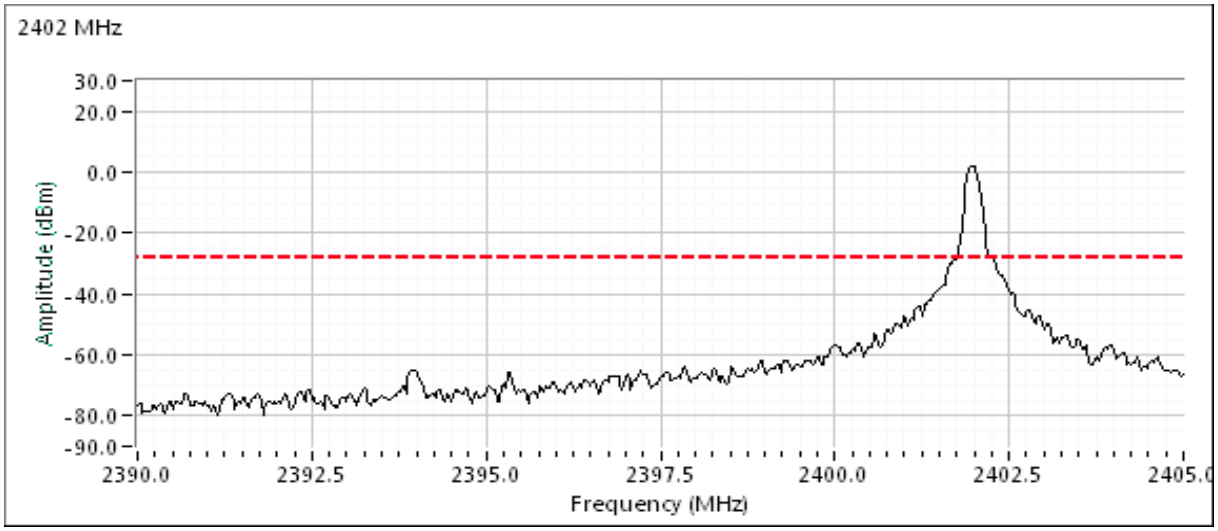
RBW = 100 kHz and VBW = 300 kHz for all plots.

Plots for low channel

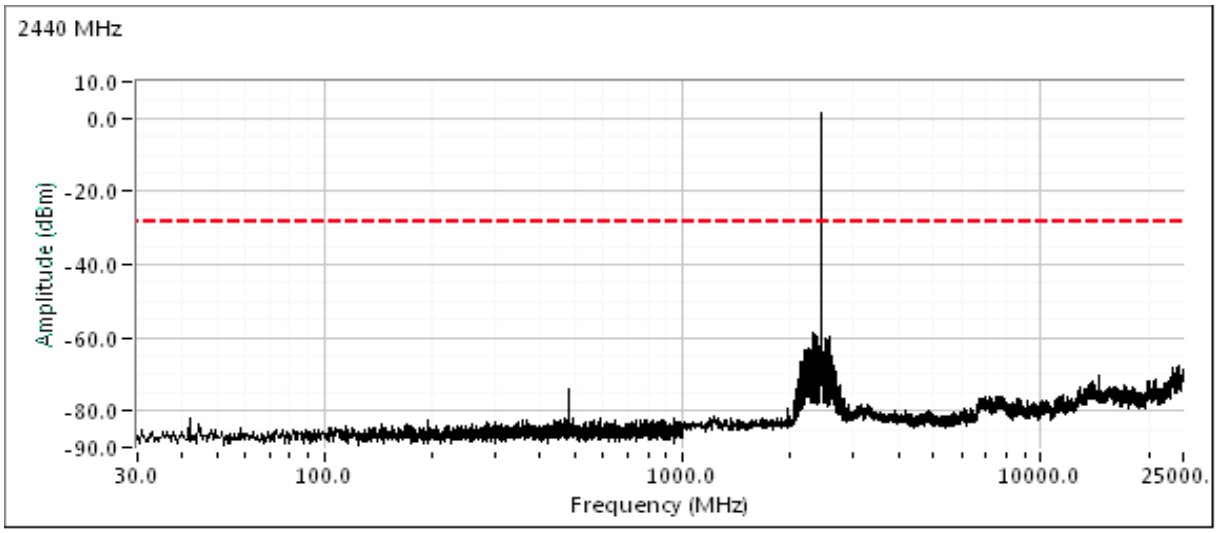


Client:	Nevro Corporation	PR Number:	PR111765
Model:	TSM3000	T-Log Number:	TL111765-RA
		Project Manager:	Christine Krebill
Contact:	Susan McGill	Project Engineer:	David Bare
Standard:	FCC Part 15, EN 300 328	Class:	N/A

Additional plot showing compliance with -30dBc limit from 2390 MHz to 2400 MHz. Radiated measurements used to show compliance with the limits in the restricted band below 2390 MHz.

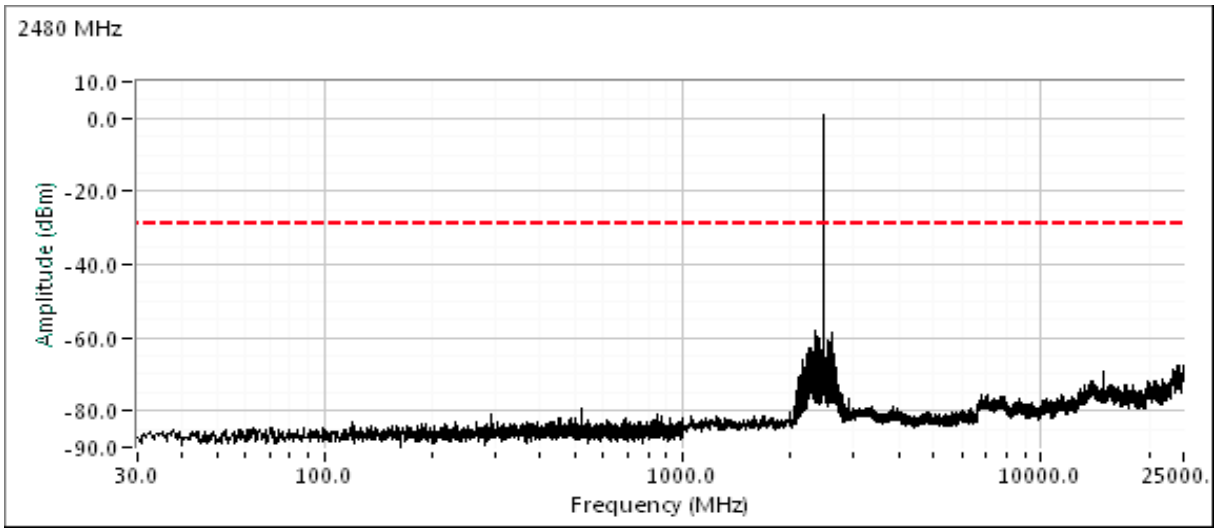


Plots for center channel



Client:	Nevro Corporation	PR Number:	PR111765
Model:	TSM3000	T-Log Number:	TL111765-RA
		Project Manager:	Christine Krebill
Contact:	Susan McGill	Project Engineer:	David Bare
Standard:	FCC Part 15, EN 300 328	Class:	N/A

Plots for high channel



Client:	Nevro Corporation	PR Number:	PR111765
Model:	TSM3000	T-Log Number:	TL111765-RA
		Project Manager:	Christine Krebill
Contact:	Susan McGill	Project Engineer:	David Bare
Standard:	FCC Part 15, EN 300 328	Class:	N/A

RSS-247 and FCC 15.247 (DTS) 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.

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: 20 °C
Rel. Humidity: 40 %

Summary of Results - Device Operating in the 2400-2483.5 MHz Band

Run #	Mode	Channel		Power Setting	Test Performed	Limit	Result / Margin
1	BLE	37 - 2402MHz		4	Restricted Band Edge (2390 MHz)	FCC Part 15.209 / 15.247(c)	44.6 dBµV/m @ 2354.3 MHz (-9.4 dB)
	BLE	39 - 2480MHz		4	Restricted Band Edge (2483.5 MHz)	FCC Part 15.209 / 15.247(c)	42.9 dBµV/m @ 2484.1 MHz (-11.1 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: 2000685
Driver: PyCharm (BLEContinuousTxPower.py)

Client:	Nevro Corporation	PR Number:	PR111765
Model:	TSM3000	T-Log Number:	TL111765-RA
		Project Manager:	Christine Krebill
Contact:	Susan McGill	Project Engineer:	David Bare
Standard:	FCC Part 15, EN 300 328	Class:	N/A

Procedure Comments:

Measurements performed in accordance with ANSI C63.10
Peak measurements performed with: RBW=1MHz, VBW=3MHz, peak detector, max hold, auto sweep time
Unless otherwise stated/noted, emission has a duty cycle ≥ 98% and average level was measured using RBW=1MHz, VBW=10Hz, peak detector, linear voltage average mode, auto sweep time, max hold.

Mode	Data Rate	Duty Cycle (x)	Constant DC?	T (ms)	Pwr Cor Factor*	Lin Volt Cor Factor**	Min VBW for FS (Hz)
BLE	1 Mbps	0.64	Yes	0.394	1.9	3.9	2538

Measurement Specific Notes:

Note 4:	Emission has constant duty cycle < 98%, average measurement performed: RBW=1MHz, VBW>1/T but not less than 10Hz, peak detector, linear averaging, auto sweep, trace average 100 traces, measurement corrected by Linear voltage correction factor
Note 8:	Plots of the average and peak bandedge do not account for any duty cycle correction. Refer to the tabular results for final measurements.

Client:	Nevro Corporation	PR Number:	PR111765
Model:	TSM3000	T-Log Number:	TL111765-RA
		Project Manager:	Christine Krebill
Contact:	Susan McGill	Project Engineer:	David Bare
Standard:	FCC Part 15, EN 300 328	Class:	N/A

Run #1: Radiated Bandedge Measurements

Date of Test: 3/30/2020 13:30 Config. Used: 3

Test Engineer: David Bare Config Change: None

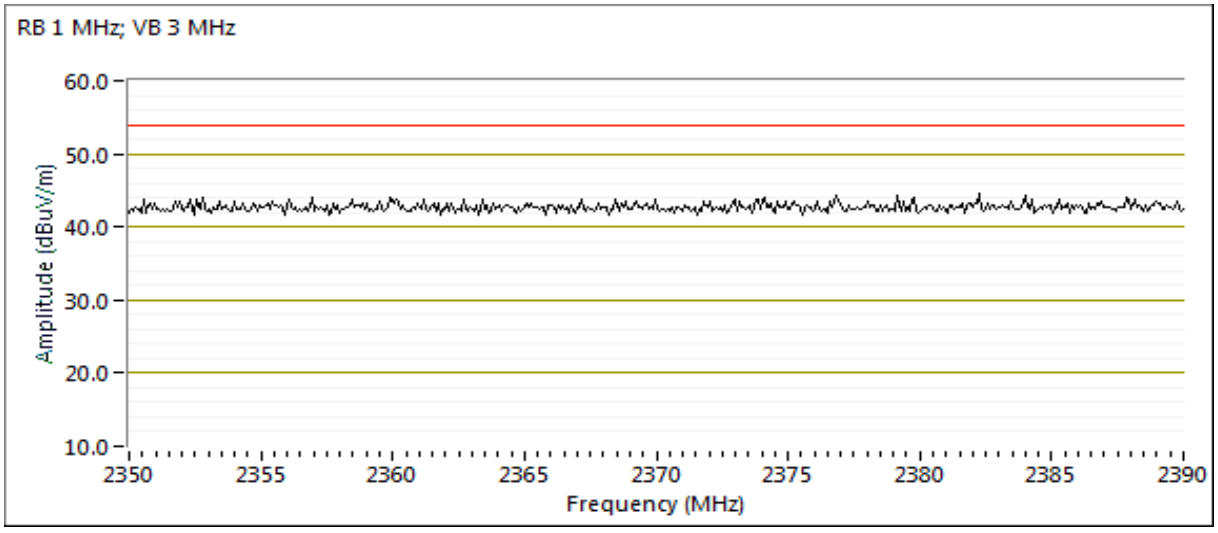
Test Location: Fremont Chamber #5 EUT Voltage: 3.6 V from battery

Channel: 37

Band Edge Signal Field Strength - Direct measurement of field strength

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBµV/m	V/H	Limit	Margin	Pk/QP/Avg	degrees	meters	
2354.330	44.6	V	54.0	-9.4	PK	0	1.0	POS; RB 1MHz; VB: 3MHz; Note 1
2387.200	44.0	H	54.0	-10.0	PK	0	1.0	POS; RB 1MHz; VB: 3MHz; Note 1

Note 1: Emission peak reading compared to the average limit.

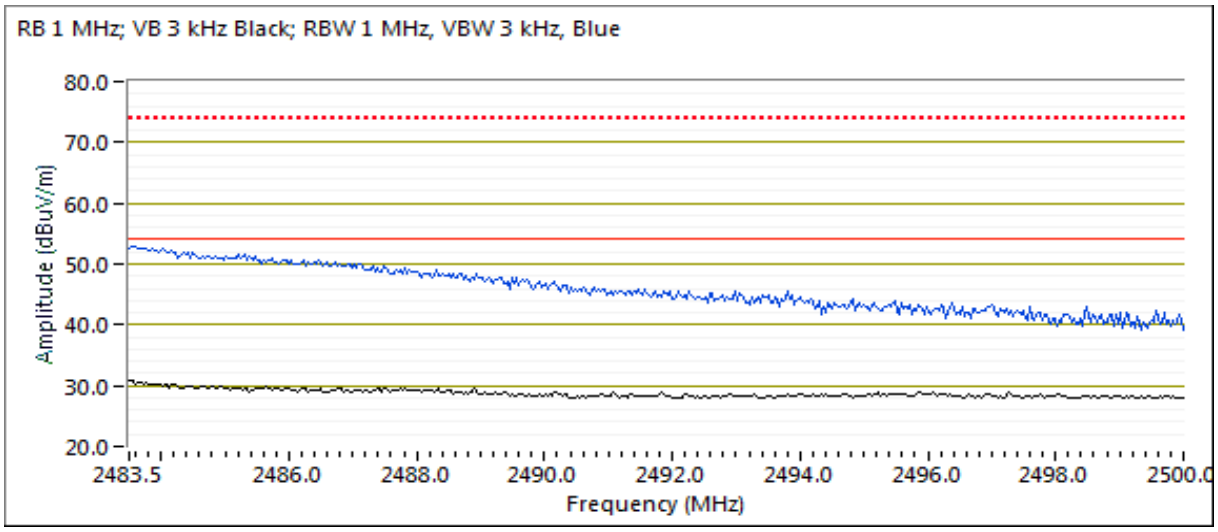


Client:	Nevro Corporation	PR Number:	PR111765
Model:	TSM3000	T-Log Number:	TL111765-RA
		Project Manager:	Christine Krebill
Contact:	Susan McGill	Project Engineer:	David Bare
Standard:	FCC Part 15, EN 300 328	Class:	N/A

Channel: 39

Band Edge Signal Field Strength - Direct measurement of field strength

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBµV/m	V/H	Limit	Margin	Pk/QP/Avg	degrees	meters	
2484.080	42.9	V	54.0	-11.1	PK	33	1.5	POS; RB 1MHz; VB: 3MHz; Note 1
2483.530	34.1	H	54.0	-19.9	Avg	171	1.1	POS; RB 1 MHz; VB: 3 kHz; Note 4
2483.600	53.3	H	74.0	-20.7	PK	171	1.1	POS; RB 1 MHz; VB: 3 MHz



Note 1:	Emission peak reading compared to the average limit.

Client:	Nevro Corporation	PR Number:	PR111765
Model:	TSM3000	T-Log Number:	TL111765-RA
		Project Manager:	Christine Krebill
Contact:	Susan McGill	Project Engineer:	David Bare
Standard:	FCC Part 15, EN 300 328	Class:	N/A

RSS-247 and FCC 15.247 (DTS) 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.

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: 19 - 21 °C
Rel. Humidity: 41 - 44 %

Summary of Results - Device Operating in the 2400-2483.5 MHz Band

Run #	Mode	Channel		Power Setting	Test Performed	Limit	Result / Margin
1	BLE	37 - 2402MHz		4	Radiated Emissions, 30 MHz - 25 GHz	FCC Part 15.209 / 15.247(c)	44.3 dBµV/m @ 4804.0 MHz (-9.7 dB)
		17 - 2440MHz		4	Radiated Emissions, 30 MHz - 25 GHz	FCC Part 15.209 / 15.247(c)	43.6 dBµV/m @ 7319.4 MHz (-10.4 dB)
		39 - 2480MHz		4	Radiated Emissions, 30 MHz - 25 GHz	FCC Part 15.209 / 15.247(c)	42.4 dBµV/m @ 4960.0 MHz (-11.6 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: 2000685
Driver: PyCharm (BLEContinuousTxPower.py)

Client:	Nevro Corporation	PR Number:	PR111765
Model:	TSM3000	T-Log Number:	TL111765-RA
		Project Manager:	Christine Krebill
Contact:	Susan McGill	Project Engineer:	David Bare
Standard:	FCC Part 15, EN 300 328	Class:	N/A

Procedure Comments:

Measurements performed in accordance with ANSI C63.10
Peak measurements performed with: RBW=1MHz, VBW=3MHz, peak detector, max hold, auto sweep time
Unless otherwise stated/noted, emission has duty cycle ≥ 98% and was measured using RBW=1MHz, VBW=10Hz, peak detector, linear voltage average mode, auto sweep time, max hold.
2.4GHz band reject filter used

Mode	Data Rate	Duty Cycle (x)	Constant DC?	T (ms)	Pwr Cor Factor*	Lin Volt Cor Factor**	Min VBW for FS (Hz)
BLE	1 Mbps	0.64	Yes	0.394	1.9	3.9	2538

Measurement Specific Notes:

Note 1:	Emission in non-restricted band, but limit of 15.209 used.
Note 2:	Emission in non-restricted band, the limit was set 30dB below the level of the fundamental and measured in 100kHz.
Note 4:	Emission has constant duty cycle < 98%, average measurement performed: RBW=1MHz, VBW>1/T but not less than 10Hz, peak detector, linear averaging, auto sweep, trace average 100 traces, measurement corrected by Linear voltage correction factor

Client:	Nevro Corporation	PR Number:	PR111765
Model:	TSM3000	T-Log Number:	TL111765-RA
		Project Manager:	Christine Krebill
Contact:	Susan McGill	Project Engineer:	David Bare
Standard:	FCC Part 15, EN 300 328	Class:	N/A

Run #1: Radiated Spurious Emissions, 30 MHz - 25000 MHz

Date of Test: 3/27 - 3/30/2020 Config. Used: 3

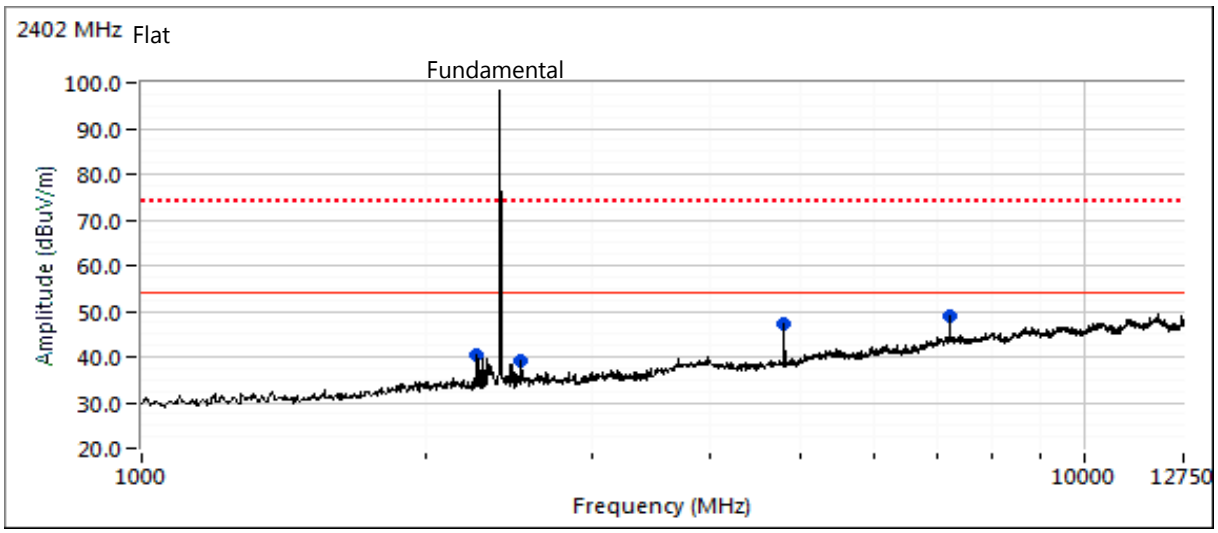
Test Engineer: David Bare Config Change: None

Test Location: Fremont Chamber #5 EUT Voltage: 3.6 V Battery

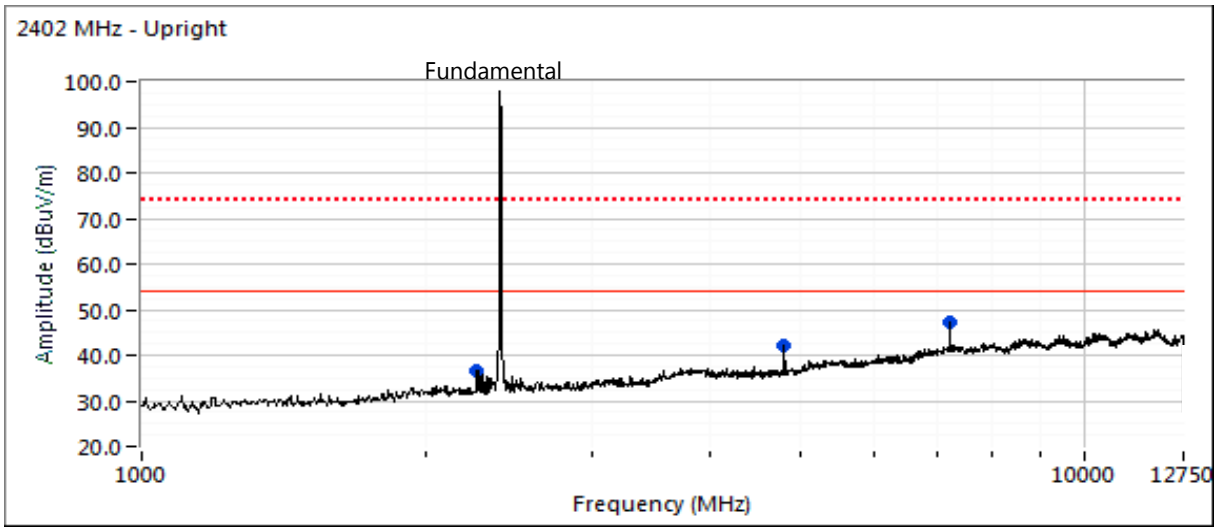
Run #1a: Low Channel

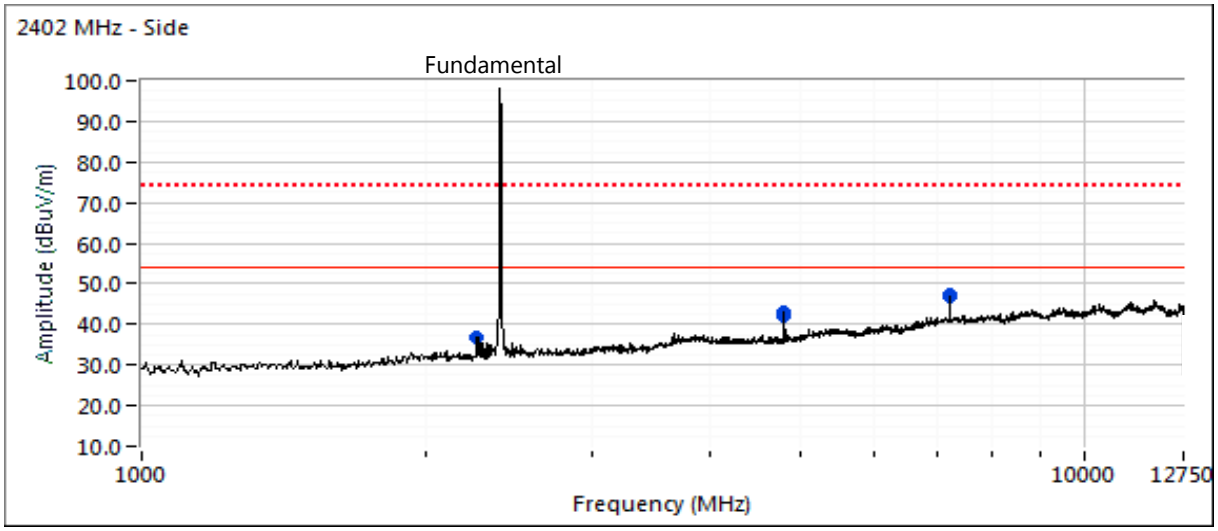
Channel: 37

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBµV/m	V/H	Limit	Margin	Pk/QP/Avg	degrees	meters	
2274.000	40.6	H	54.0	-13.4	Peak	103	2.2	Prelim Reading Flat
2530.000	39.0	H	54.0	-15.0	Peak	95	1.9	Prelim Reading Flat
4804.000	47.3	H	54.0	-6.7	Peak	358	1.6	Prelim Reading Flat
7206.000	49.0	V	54.0	-5.0	Peak	204	1.0	Prelim Reading Flat
2274.000	36.7	V	54.0	-17.3	Peak	91	1.3	Prelim Reading Upright
4804.000	42.0	H	54.0	-12.0	Peak	337	1.9	Prelim Reading Upright
7206.000	47.2	V	54.0	-6.8	Peak	201	2.5	Prelim Reading Upright
2274.000	35.2	V	54.0	-18.8	Peak	249	1.3	Prelim Reading Side
4804.000	43.0	V	54.0	-11.0	Peak	237	1.3	Prelim Reading Side
7206.000	47.0	H	54.0	-7.0	Peak	185	1.0	Prelim Reading Side
Maximized readings with EUT flat (worst case)								
4803.950	44.3	H	54.0	-9.7	Avg	349	1.6	RB 1 MHz;VB 3 kHz;Peak; Note 4
4803.580	48.2	H	74.0	-25.8	PK	349	1.6	RB 1 MHz;VB 3 MHz;Peak
7205.300	42.9	V	54.0	-11.1	Avg	204	1.3	RB 1 MHz;VB 3 kHz;Peak; Note 4
7206.020	49.8	V	74.0	-24.2	PK	204	1.3	RB 1 MHz;VB 3 MHz;Peak

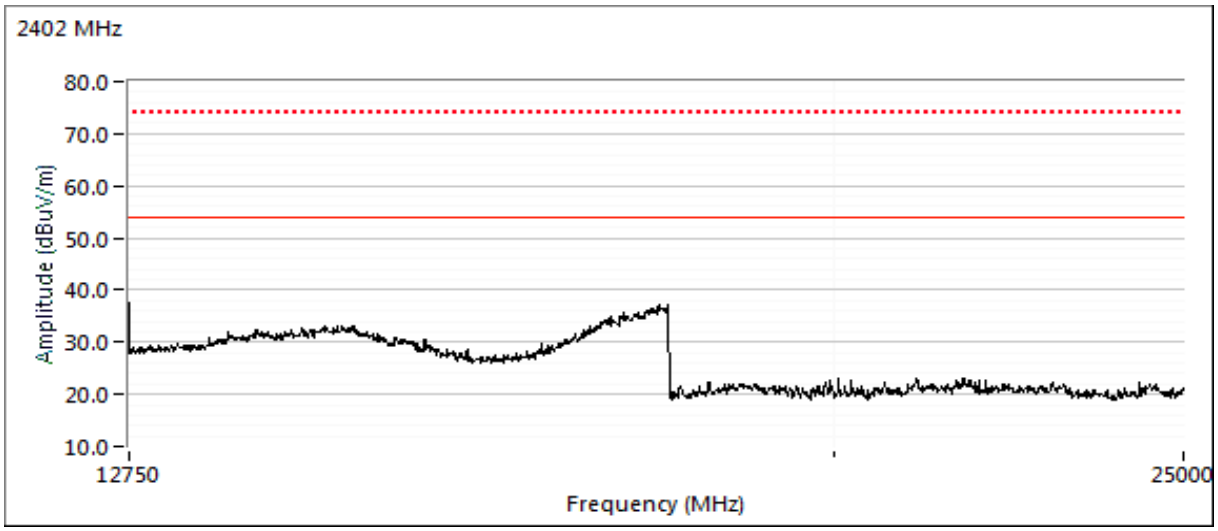


Client:	Nevro Corporation	PR Number:	PR111765
Model:	TSM3000	T-Log Number:	TL111765-RA
		Project Manager:	Christine Krebill
Contact:	Susan McGill	Project Engineer:	David Bare
Standard:	FCC Part 15, EN 300 328	Class:	N/A





Client:	Nevro Corporation	PR Number:	PR111765
Model:	TSM3000	T-Log Number:	TL111765-RA
		Project Manager:	Christine Krebill
Contact:	Susan McGill	Project Engineer:	David Bare
Standard:	FCC Part 15, EN 300 328	Class:	N/A

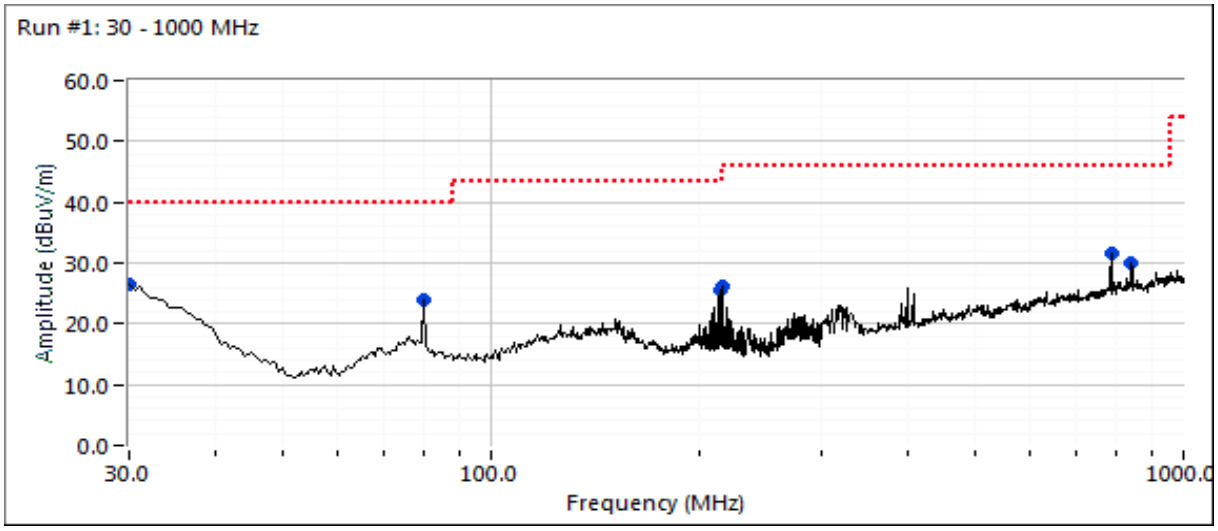


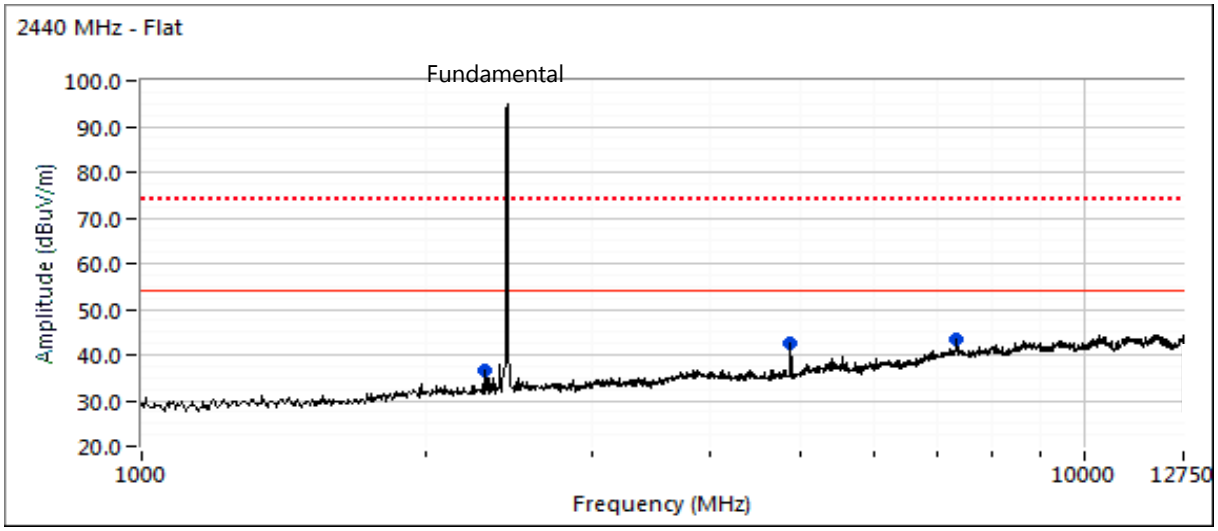
Note:	Scans made between 12.75 - 25 GHz with the measurement antenna moved around the EUT 30cm from the device indicated there were no significant emissions in this frequency range.
Note:	Above plot limit lines are from FCC Rules §15.209.

Client:	Nevro Corporation	PR Number:	PR111765
Model:	TSM3000	T-Log Number:	TL111765-RA
		Project Manager:	Christine Krebill
Contact:	Susan McGill	Project Engineer:	David Bare
Standard:	FCC Part 15, EN 300 328	Class:	N/A

Run #1b: Center Channel

Channel: 17





Client:	Nevro Corporation	PR Number:	PR111765
Model:	TSM3000	T-Log Number:	TL111765-RA
		Project Manager:	Christine Krebill
Contact:	Susan McGill	Project Engineer:	David Bare
Standard:	FCC Part 15, EN 300 328	Class:	N/A

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBµV/m	V/H	Limit	Margin	Pk/QP/Avg	degrees	meters	
30.000	21.6	H	40.0	-18.4	QP	270	2.0	QP (1.00s)
79.822	12.8	H	40.0	-27.2	QP	112	2.2	QP (1.00s)
214.079	25.8	H	43.5	-17.7	QP	114	1.4	QP (1.00s)
216.083	25.3	H	46.0	-20.7	QP	310	1.5	QP (1.00s)
786.631	21.5	H	46.0	-24.5	QP	206	2.0	QP (1.00s)
840.843	21.8	H	46.0	-24.2	QP	154	1.0	QP (1.00s)
2312.000	36.5	H	54.0	-17.5	PK	110	1.0	RB 1 MHz;VB 3 MHz;Peak
4879.980	43.4	H	54.0	-10.6	Avg	350	1.9	RB 1 MHz;VB 3 kHz;Peak; Note 4
4879.730	49.0	H	74.0	-25.0	PK	350	1.9	RB 1 MHz;VB 3 MHz;Peak
7319.400	43.6	H	54.0	-10.4	Avg	173	1.5	RB 1 MHz;VB 3 kHz;Peak; Note 4
7319.160	50.7	H	74.0	-23.3	PK	173	1.5	RB 1 MHz;VB 3 MHz;Peak

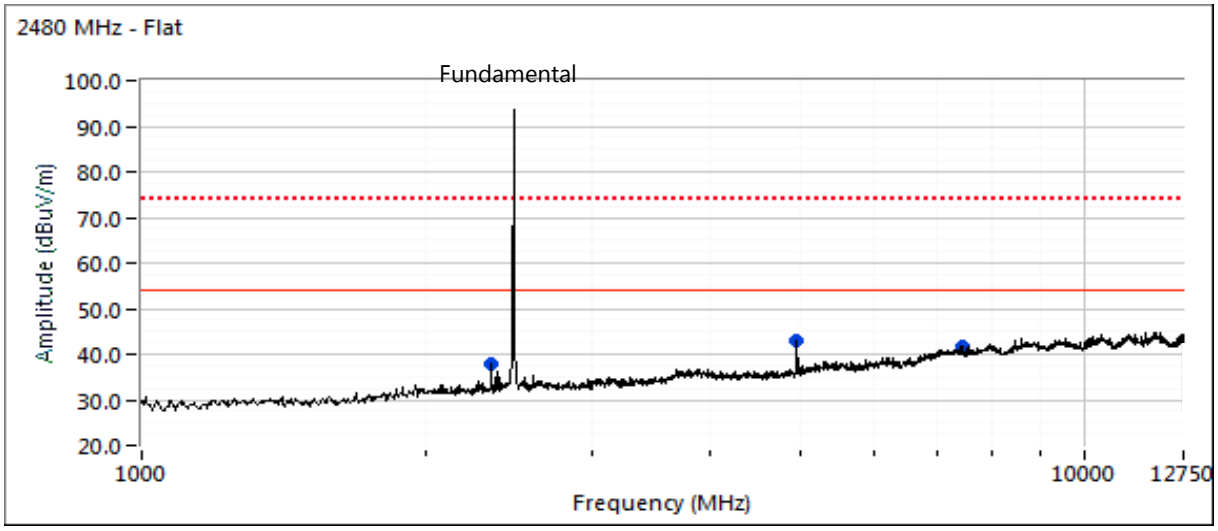
Note: Above plot limit lines are from FCC Rules §15.209.

Note: None of the emissions from 30-1000 MHz are related to the BLE radio.

Client:	Nevro Corporation	PR Number:	PR111765
Model:	TSM3000	T-Log Number:	TL111765-RA
		Project Manager:	Christine Krebill
Contact:	Susan McGill	Project Engineer:	David Bare
Standard:	FCC Part 15, EN 300 328	Class:	N/A

Run #1c: High Channel

Channel: 39



Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBµV/m	V/H	Limit	Margin	Pk/QP/Avg	degrees	meters	
2352.000	40.1	H	54.0	-13.9	PK	115	1.9	RB 1 MHz;VB 3 MHz;Peak
4959.950	42.4	H	54.0	-11.6	Avg	335	2.5	RB 1 MHz;VB 3 kHz;Peak; Note 4
4960.200	46.8	H	74.0	-27.2	PK	335	2.5	RB 1 MHz;VB 3 MHz;Peak
7439.330	41.0	H	54.0	-13.0	Avg	252	1.0	RB 1 MHz;VB 3 kHz;Peak; Note 4
7440.350	48.6	H	74.0	-25.4	PK	252	1.0	RB 1 MHz;VB 3 MHz;Peak

End of Report

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